Dogs Using Touchscreens in the Home: A Case Study for Assistance Dogs Operating Emergency Notification Systems

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ABSTRACT
Medical alert dogs can save lives by alerting their human partners of impending seizures, diabetic crises, the presence of allergens, and other medical emergencies. Recent research has shown that dogs can also alert emergency services or family members through body-worn sensors. In the home, however, service dogs do not typically wear their service dog vests. In this study we show that dogs can be trained to operate touchscreens mounted in the home to alert in emergencies. We performed a home-based field study, training three medical alert dogs to perform a specific pattern of interactions with virtual objects randomly throughout the day on a cue. We showed that it is feasible for a dog to understand the task of locating the touchscreen from anywhere in the home and performing the alert interaction. We also report our training methods and challenges in creating fluency for the touchscreen alert interaction skill.

Author Keywords
Interactive systems; Working dogs; Touchscreens; in-home.

ACM Classification Keywords
Human-centered computing > Ubiquitous and mobile computing > Ubiquitous and mobile computing design and evaluation methods.

INTRODUCTION
Medical alert dogs are trained to assist their human partners in a variety of emergency situations. Epilepsy dogs are trained to sense seizures before they start, and to nudge their owners into a safe location and try to rouse them once the seizure begins. Diabetic alert dogs can detect blood sugar anomalies and alert their owners to take medications before they pass out. Allergen detection dogs can detect substances that could trigger anaphylaxis, such as peanuts, and alert their owners before a crisis occurs. These highly-trained dogs can literally save lives. Recent research in animal-computer interaction technologies [5] has shown that medical alert dogs can also activate body-worn sensors to call emergency services with a GPS location, or to notify family members that a crisis is occurring. This vital ability may not translate to a home environment, however, because service dogs do not typically wear a vest at home. To mitigate this, researchers have studied touchscreens as a possible way for service dogs to alert in emergency situations without depending on wearable technology. Preliminary work [18] has focused on designing hardware and interaction techniques for virtual interfaces, showing that a variety of dogs can learn to operate a touchscreen in a laboratory setting.

Our goal for this work was to determine the feasibility of employing a touchscreen running in the home as a real-time medical alert system. Our evaluation criteria were that the interactions should be easily trainable and adaptable across dog ages and sizes; and that the system is able to handle running and capturing interactions for extended periods of time. To study the reliability and effectiveness of an in-home system, we broke the study into two components. First, we investigated the trainability and usability of the system with three dogs of varying experience. Secondly, we conducted a 3-week study on a single canine participant to determine the practicability of a realistic in-home alert scenario, and to observe how well the dog's training would hold up with sparse and random practice.

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BACKGROUND AND RELATED WORK
Assistance dogs are an important part of many people's lives, helping their owners with life skills and providing independence [15,16]. Although service dogs are probably best known for guide dog work, they also help with mobility, hearing, PTSD, and medical alert. To help assistance and working dogs better communicate with their owners,

researchers have developed wearable systems that allow the dogs to send messages. These studies determined the best on-body interaction style for dogs [5,6]. This research has led to other experiments with on-body interaction including dog snout to body reachability [14] and two-way communication between dogs and their handlers through haptics in the form of wearables with vibration [1]. A recent survey of canine computer interaction [3] summarizes the field and provides an overview of interaction techniques that have been studied for dogs. These techniques allowed researchers and designers to create potentially useful systems for working and assistance dogs in the field [17].

In home environments, dogs prefer to be comfortable without their service dog vests. However, the need for medical alert capabilities is still pressing. Robinson et. al started to investigate the idea of an in-home notification system with a tangible tug interface [10,11]. Many of their findings centered around dogs' ability to use a tug interface, distractions in the home environment, and designing the system around the individual dog's abilities. Earlier work has proposed an in-home system in which a dog is trained to use a touch screen [18,19]. This research focused on dogs' ability to interact with a touch screen, and how to design a touch screen so that a dog can use it reliably and accurately. This study compared findings from dogs using touchscreens to humans using touchscreens and also related the findings to human-computer interaction theory, specifically Soukeoreff and MacKenzie's tapping task [13]. The goal of this work was to develop the knowledge to aid in creating touchscreen interfaces that are able to be used by dogs. We hope to further develop this research by experimenting with an in-home touchscreen alert system design informed by those previous studies.

Motivation

Imagine the following scenario: Rashida has a severe allergy to peanuts, and peanut products, and even small exposure could cause her to collapse and even die. She has a specially trained dog named Azzam who licks her hand when he smells peanut in any of its forms to alert her of the problem. Rashida's allergic reactions are complicated and even when she is alerted, there is not always enough time for her to take Epinephrine before she starts to present symptoms. In case Rashida goes into anaphylactic shock, Azzam wears a special vest that he can activate to alert health care authorities and bystanders who might be able to help [4]. However much of Rashida's time is spent in the home, where she and Azzam can relax. In the home, the risk for Rashida to come into contact with peanuts is low, and Azzam doesn't wear his special wearable technology vest so he can be comfortable.

Figure 1. Rashida and Azzam, her allergy alert dog.

However, Rashida often orders takeout from different restaurants. She has had allergic reactions to food in her home before, and even to visitors who have eaten peanuts before coming over. In case she has a severe allergic reaction in the home, Azzam has been trained to use a special touchscreen to call for help. When the screen is activated it can alert emergency service, but also call and text her neighbor who knows the location of her Epi-pen and has agreed to help out in an emergency. Azzam practices on the system once a week. He touches the large blue, yellow, and green 'buttons' on the specially designed touchscreen to make an activation [18,19]. Rashida feels safer knowing that Azzam can call and communicate if she needs help.

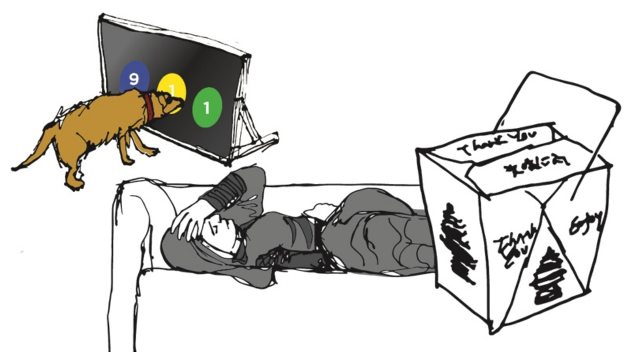

Figure 2. Azzam alerting before Rashida goes into shock.

DESCRIPTION OF THE IN-HOME SYSTEM

The purpose of this study was to understand the challenges of integrating a touchscreen-based medical alert system into a home. We start with a description of the in-home system and the technical specifications required for capturing interactions. The in-home system consists of two components: the hardware, which is comprised of a display, a controller, and a multi-touch screen; and the user interface, which leveraged Unity to display and capture the dogs' interactions.

Hardware

The in-home system consists of three components: a display, a controller, and an infrared sensor-based multi-touch screen. We leveraged our previous implementation research to determine which components were the most effective for the home [18,19]. We reduced the footprint and size of the system to fit in an average home or apartment. We built a rugged display frame to hold the touch surface and the television, as shown in Fig. 3. The frame was made out of

5/8th" plywood, cut into a stand, with cross braces to support the weight of the display as well as absorbing pressure from the dogs.

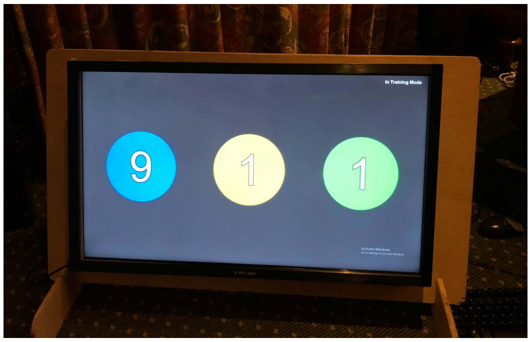

Figure 3. Setup.

The Display

We used a 32" 60 Hz direct LED backlit display with full HD resolution. The screen had a flat bezel, which made it significantly easier to attach the touchscreen to the front of the display. The display also had mounting points which were used to securely mount it to a stand. Additionally, we confirmed that the backlight didn't prevent the dogs from being able to perceive the difference between the colors on the screen. The display was designed to remain on for extended periods of time without burn-in or overheating.

In "Going to the dogs: Towards an interactive touchscreen interface for working dogs," we show that off-the-shelf tablets won't work using current technology because they use a capacitive touchscreen which is sensitive to the dog's nose [18]. We also considered using smaller screens and while different, more condensed layouts could still be usable by working dogs, these screens would potentially require the dogs to be trained to be more precise.

The Controller

To control what was displayed on the screen, manage the interactions, and upload the data to our servers, we used the Intel Next Unit of Computing (NUC) KIT NUC5i3RYH. It has 16 Gb of memory, HDMI and mini-display ports, and WiFi capabilities. We chose to run Windows 10 on the NUC because we wanted the better native touchscreen support that Windows 10 offered, which we couldn't get from Windows 7. Additionally, the NUC was ideal because its small form factor allowed it to be easily mounted to the display stand, minimizing the footprint of the in-home system.

The Multi-Touch Screen

Lastly, we used a PQ Labs 32" G4 6-touch Multi-Touch Player for capturing the interactions. This touch screen has a sampling rate of around 200 samples per second. Most importantly, the touchscreen uses Infrared (IR) beams to detect where a touch occurs, so the dog's wet nose touches do not influence its capture capabilities, as they would with a standard capacitive touchscreen. The scratch-resistant hard glass allowed the dogs to paw at the screen without risking damage to the display. The screen was also capable of registering multiple touch points at once, enabling us to capture the full scale of the dog's interactions.

Software and the User Interface

Unity

When we were designing the interface for the medical alert system, there were several considerations. With several members on the project team, we wanted a cross-platform system to make it easier to develop, test, and deploy the touchscreen software. This limited our development choices to tools and languages like Java and Unity. In the end we decided to go with Unity. While there are other cross-platform options, Unity made it easy to develop the simple graphics we needed, as well as easily provide the real-time feedback to the dogs, which was necessary for training.

The User Interface

As shown in Fig. 5, the primary interface was designed to have 3 touch buttons that the dog was expected to touch in sequence. The colors of blue, yellow, and green are fixed, and cannot be changed. Order of button presses were important and to visually reinforce this order distinction, in addition to button location, we chose to use different colors for each button as a double encoding method [2]. These colors were chosen explicitly because they correspond to canine visual capabilities, as dogs can easily differentiate blue and yellow, and are green-red colorblind [8].

Configuration Panel. We wanted the ability to flexibly handle the size and placement of the different buttons for different sized screens, screen resolutions, and sizes of the dogs using the system, shown in Fig. 4. As such, the size of each button, the distance between the buttons, and height (from the midline of the screen) could be configured. Figs. 6 and 7 showcase a medium and smaller-build dog using the user interface.

Figure 4. Testing Mode Configuration Panel.

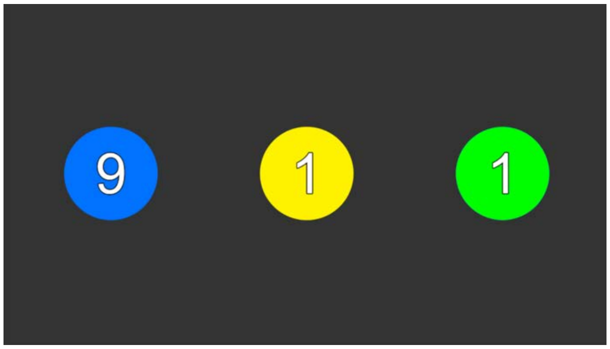

Figure 5. Testing Mode User Interface.

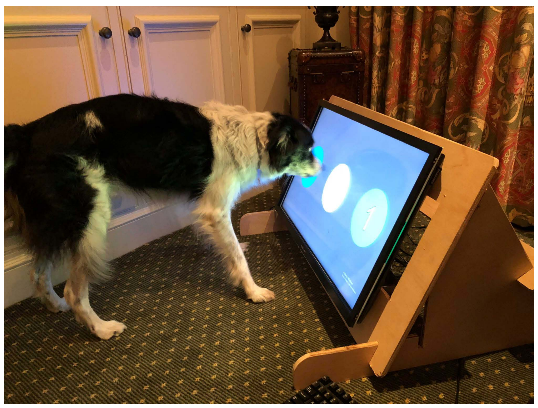

Figure 6. S1, a border collie, using the touchscreen, with the buttons centered on the user interface.

Training Mode. We also created a training mode, which can be seen in Figs. 8 and 9, where a subset of the buttons could be shown. This allowed us to create the *behavior chain* explained in 4.4.1.

Figure 7. S3, a papillon, using the touchscreen in training mode, with the buttons lowered for small dog access.

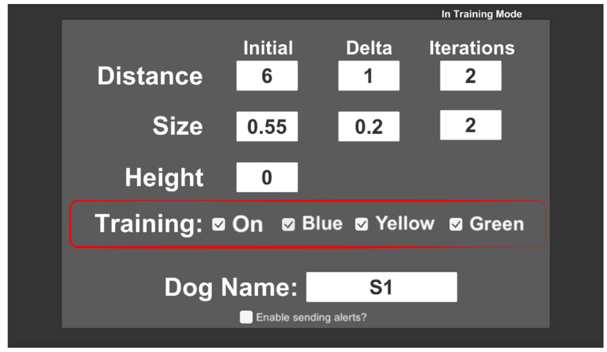

Figure 8. Training Mode Configuration Panel: Turning Training Mode On.

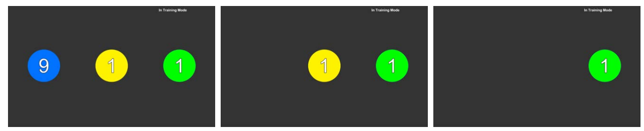

Figure 9. Various Stages of the Training Mode User Interface.

EXPERIMENTAL METHODOLOGY

We conducted a two-part experiment: a training protocol study and a longitudinal operational study. There were multiple aspects to the longitudinal study; however, the basic premise of the experimental methodology was to randomly alert the dog to “Get help” from various places in the house and observe whether the dog could move to the correct location, and quickly and accurately dial 911 on the touchscreen. In addition to understanding if the system can effectively be used in a realistic scenario in the home, we wanted to establish a training protocol for new dogs and determine how long it takes to train a medical alert dog who is unfamiliar with touchscreen interactions.

Participants

Three dogs participated in this study, ranging from an 18-month-old puppy to a 10-year-old veteran. All participants were trained to be operant [12] by human participant P1, meaning that they are trained to offer behaviors through positive reinforcement techniques. Canine participant S1 worked in the longitudinal study and two others (S2 and S3) demonstrated that they could learn the medical alert interaction behaviors. Tables 1 and 2 provide details about the subjects.

Subject ID	Training Experience and Years of Experience with Each Method
P1	Service Dog (23 years), Agility (7 years), Nosework (2 years)

Table 1. Touchscreen Study Human Participant.

Training

S1 had extensive experience using the touchscreen due to involvement in prior studies and therefore didn’t require training in performing the touchscreen interaction before testing. However, he did need to be trained to locate the touchscreen from a distance in the house, and to perform the touchscreen interaction without the presence of his trainer.

Subject	Breed	Gender	Size	Age	Training	Training Experience with Touchscreens
S1	Border Collie	M	45 lbs	10 years	Service Dog, Agility, Nosework	Extensive
S2	Border Collie	F	30 lbs	18 months	Obedience, Agility, Nosework	None
S3	Papillon	M	9 lbs	6 years	Medical Alert, Agility, Nosework	Minimal

Table 2. Touchscreen Study Canine Participants.

S2 did not have any prior training experience using the system; however, she has a basic obedience background and has been trained for nosework and agility. S3 has had very minimal experience using the touchscreen in a previous study. He is an active medical alert dog, for detecting specific molds that his handler is allergic to, and has also competed in both agility and nosework.

Testing

S1 has had years of experience as a service dog, has participated in agility, and has spent the last few years training to do nosework.

Location

The touchscreen was placed in an unobtrusive location in P1's living room (see Fig 10). The goal was for it to be accessible, but not disruptive in the home. As discussed earlier, we reduced the footprint of the touchscreen so that it would be minimally intrusive, allowing it to easily fit in the corner of a room or behind a couch. The system was oriented at an angle in order to not reflect off of the living room's regular TV screen.

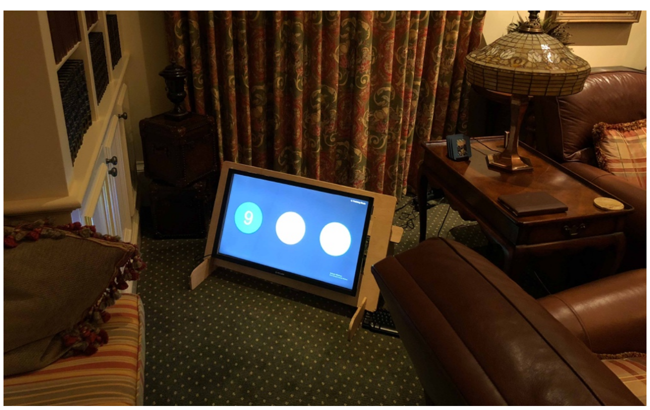

Figure 10. Setup in the Home.

Data Collected from the Touchscreen

Unity allowed us to log a variety of interactions. The infrared screen granted us the ability to capture up to 6 different simultaneous screen touches. We logged the start position, trajectory, and ending position of each individual touch with different identifiers, whether the touch was on a button or not, which button the dog was touching, and lastly, the time at which each interaction took place.

Touchscreen Study Companion iPhone Application

To track the speed and accuracy of the dog, we created a study companion application to randomly alert the human participant to tell the dog to "get help." This random alert could happen in any room of the house. We built the application to operate on an iPhone 6 using Swift 3.3. The application logged the start time of the trial, when P1 said "Get help," and the end time of the trial, once S1 came back to P1 for his reward, see Fig. 11. Once the trial was over, the application allowed P1 to log notes on how the session went.

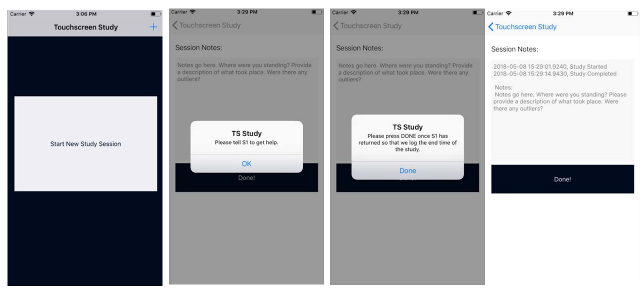

Figure 11. Study Companion Application Experimental Flow.

Experimental Design

Our first experiment tested the training protocol used to introduce dogs to the touchscreen task, and the second longitudinal experiment tested the ability of a dog to respond to an emergency in a natural home setting over time.

Training Experiment

Dogs explore the world primarily with their noses, so touching objects in the environment is a natural behavior. However, making the transition to touching virtual objects requires some training. We used positive reinforcement with the technique of *shaping* [12] which entails rewarding successive approximations of the desired behavior, raising criteria until the final behavior is achieved. When the dogs understood the task of activating a virtual object on the touchscreen with their noses, we created a *behavior chain* [9], which is a defined sequence of behaviors, to teach the dogs to activate the three icons in the correct sequence.

Initial Training. We introduced the dogs to the touchscreen and used a reward marker (a clicker) to mark correct behavior. All of the dogs in this study had been previously trained with clickers and understood that a click means primary reinforcement (food) is coming. The dogs were "operant" [12], meaning they had learned to offer novel behaviors in their daily training. Consequently, when presented with the touchscreen, the dogs began to investigate it and we clicked and rewarded any interaction with the screen at first.

We implemented a training mode for the touchscreen, which allowed us to control the number of icons and their positions on the screen. We began training by displaying only one icon and shaped the dogs to activate it with their noses. The touchscreen emitted a short "beep" when the dogs touched the icon correctly. We initially used a clicker to mark the correct activation, but over time, the dogs began to associate the beep as a marker for correct activation, and the dogs would attempt to touch the icon until they heard the beep. This allowed us to discontinue the clicker and use the beep as a reward marker.

Creating the Behavior Chain. When the dogs were proficiently activating one icon on cue, we began adding a second icon in a process called backchaining [Pryor]. In order to build a behavior chain, which is a defined sequence of behaviors, the trainer teaches the last skill first, then adds on the next-to-last skill, and so on, until the behavior chain is complete. Initial training began with the last icon, the third one in the sequence. When the dog was ready, we added the second icon in the sequence, initially rewarding activating just the second icon, but rapidly progressing to asking the dog to touch both icons before being rewarded. Once the dogs understood the two-icon chain, adding the first icon in the sequence completed the behavior chain.

Cue Discrimination. When the dogs were reliably performing the three-icon sequence, we put it on one cue. During training, we used the cue "dot" to mean touch the icons that are on the screen. However, for the medical alert scenario, we wanted "Get Help!" to be the cue. This cue was easily added for all three dogs by presenting the cue "Get Help" as an antecedent to the "dot" cues. The dogs quickly learned that "Get Help" predicted that they should activate the three icons. Other cues could be taught this way, even physical cues such as the handler falling to the floor. This would cause the dogs to respond and trigger a medical alert if their owner collapses and is unable to prompt them verbally. We also "proofed" the "Get Help" cue by issuing other cues to the dogs, rewarding correct behavior, to ensure they did not falsely alert. We ignored spontaneous activations that were not on cue, which served to extinguish false positive behaviors. When the dogs were initially learning the sequence, at the end of a training session, we removed the icons from the screen (changing to a settings mode). However, when training our longitudinal study dog, the icons were displayed on the screen pervasively, so he had to be trained to respond only on the "get help" cue.

Adding Distance. Our longitudinal study dog needed to be able to locate and activate the touchscreen when he was cued from other rooms. We began this training by issuing the "Get Help" cue from a few feet away, and then moving to the touchscreen to reward the dog. We then issued the cue from across the room, then just outside the room, and so on, until the dog understood that he was to always go into the living room where the touchscreen was set up, and activate it, even if the handler was in another part of the house. The dog learned to go and activate the touchscreen and return to his handler for his reward.

Longitudinal Study

For the longitudinal study, we first re-trained S1 to activate the new, smaller touchscreen in our lab. Then we placed the touchscreen in the home with the dog in the room to see where it was placed. We made sure to put the touchscreen in a room that would not be closed off, so the dog could always access the screen when cued. Then we performed a few trials in the home to generalize the trained task from the lab to the home. We wanted to ensure that the dog understood that the task was the same, as well as to help the dog remember where the touchscreen was in the home when he was given the cue during the study.

The study's companion iPhone app generated 16 different calendar reminders at random intervals as prompts for the handler to direct the dog to "get help". For the first three days, we randomly cued "Get help" three times. For the next 5 days, we cued "Get help" once a day, and then during the next week, we randomly chose two dates and times to cue the participant.

TRAINING EXPERIMENT RESULTS

We trained both S2 and S3 concurrently (but in separate training sessions). S2 is a young dog with no experience with a touchscreen. She learned the entire behavior chain in seven five-minute sessions across six different days. S3 had participated in a Fitts law study with two icons [18] two years before this study but had not trained on the touchscreen since then. S3 learned the new behavior chain in four five-minute sessions over four days. Table 3 shows the progression of their training.

Dog	Icon 1	Icon 2	Icon 3
S2	3 sessions	3 sessions	1 session
S3	2 sessions	1 session	1 session

Table 3. Progression of Training for S2 and S3.

Trial #	Date (m/d/y) and Time (hh:mm AM/PM)	Success / Failure	Insertions	Location of Alert
1	02/09/2018, 01:14 PM	Success	0	Living Room
2	02/09/2018, 02:41 PM	Success	11	Living Room
3	02/09/2018, 05:21 PM	Success	0	Living Room
4	02/10/2018, 04:00 PM	Success	0	Living Room
5	02/10/2018, 05:11 PM	Success	2	Living Room
6	02/10/2018, 05:32 PM	Success	0	Living Room
7	02/11/2018, 01:57 PM	Success	0	Living Room
8	02/11/2018, 03:40 PM	Success	1	Living Room
9	02/11/2018, 05:19 PM	Success	0	Living Room
10	02/12/2018, 11:46 PM	Success	0	Living Room
11	02/13/2018, 04:39 PM	Success	0	Living Room
12	02/14/2018, 08:24 PM	Success	0	Kitchen
13	02/15/2018, 01:17 PM	Success	0	Kitchen
14	02/17/2018, 08:31 PM	Success	0	Living Room
15	02/19/2018, 11:50 PM	Success	0	Living Room
16	02/23/2018, 09:46 PM	Success	0	Living Room

Table 4. Longitudinal Study Success.

The touchscreen beeps when an icon is touched, but we used a clicker to mark successful behaviors because it was a familiar marker for both dogs. Both dogs already knew how to touch their noses to their trainer's hand in response to the "touch" command. We took advantage of this by pointing at the icon target and saying "touch" at first. We then transitioned to "dot" to differentiate touching the screen from touching a hand. When the behavior chain was complete, and the dogs were activating all three icons in sequence, we transferred to the cue "Get Help".

After the training sessions, we left the touchscreen system in a neutral state (the settings screen) so that the dogs could not falsely activate when outside of a training session. As with S1 in the longitudinal study, once S2 and S3 were fluent with the behavior chain, we would need to train the cue discrimination, so they would not activate it spontaneously.

LONGITUDINAL STUDY RESULTS

The goal of this study was to assess the feasibility of having a touchscreen in the home for dogs to send an alert if anything happened to their owners. Table 4 shows the time and location the "Get help" command was given to S1, their success or failure in completing the trial, and how many times S1 had sent an alert. Additional alerts after the first successful alert are described as insertions. We find that S1 was successful 100% of the time at completing the touchscreen task and sending an alert to the respective authorities (in this case it was just an alert message) regardless of where he was in the house when cued. On average, it took S1 less than 10 seconds to complete the task once the command "Get help" was given, depending upon the location with which the cue had been given.

DISCUSSION

The training study showed that dogs can be trained to fluency on the medical alert behavior chain in less than 40 minutes total training time, spread out over less than a week, even with no prior experience with a touchscreen. It also showed that both large and small dogs can effectively operate a touchscreen.

The longitudinal study demonstrated that a dog can be reliably trained to respond in an emergency and to activate an alert on a touchscreen within 10 seconds of being cued, which could summon emergency responders and/or family members or neighbors to assist early enough to help someone survive. It also showed that a dog can learn to locate the touchscreen in the house and activate it even though the handler is not in the same room. The progression of the frequency of activations from three per day, to one per day, to two in a week showed that a dog can remember and perform a task without constantly practicing it.

Daily Life

We found that S1 activated the touchscreen regardless of what he was doing. For example, despite that P1 and S1 were watching a loud movie on 02/11/2018, P1 logged that "movie is very loud, so I had to give him the cue twice before he heard me" and 6 seconds later, S1 had activated an alert on the touchscreen. To demonstrate the robustness of the training further, on 2/10/2018, P1 reported "Still watching Olympics, [S1] was asleep. Called his name to wake him up and gave 'get help' cue. He stood up, and I gave the cue again."

Training Challenges and Results

We observed some anticipated training challenges and several surprises. Predictably, our longitudinal study dog began activating the touchscreen spontaneously (without a cue), see Trial # 2 in Table 4. We ignored these false positive activations, which created what is called an “extinction burst” [12], where the dog activated the touchscreen many times without reward before finally giving up. We did not use any form of punishment or non-reward markers for false activations.

The dog quickly learned that he would be rewarded only if the cue was given, and after that he was very reliable and did not often falsely activate the touchscreen. One surprise was that the puppy (S2) observed the older dog (S1) during the longitudinal study and began emulating him, activating the touchscreen on her own. She was not rewarded for these behaviors, but not corrected either. When it came time to train her, she learned quickly, possibly because she had seen the older dog performing the task. We know from Miklosí that dogs are social learners [7]. Allowing dogs to watch another dog activate the touchscreen could help new dogs learn the alert task more efficiently. However, this illuminates an interesting possibility for a problem in multiple-dog homes. The active medical alert dog will need to be trained to interact with the touchscreen on cue (or in an emergency), and all other dogs in the home will need to be trained NOT to activate the touchscreen, to prevent false activations.

Another surprise was that the papillon (S3), who had some brief experience with the touchscreen two years before this study, offered a very accurate front foot target, a rear foot target, and activating with his (quite large) ears. Papillons are increasingly being trained as medical alert dogs because of their intelligence and small size, which makes them more portable. However, when he touched the correct icons with his nose, his ears also touched the screen sometimes, causing multiple activations. The front foot touch could be a legitimate interaction method for a small dog, particularly one with large ears that could accidentally activate an adjacent icon when attempting with his nose. However, a large dog would possibly push the touchscreen over or damage it. For the purposes of this study, we quickly extinguished the foot touch behaviors and focused on the nose touch by only rewarding the nose touch, but foot interaction methods warrant further study. This opens the possibility of multi-touch as well, using the foot and the nose simultaneously, which could expand the “vocabulary” of messages available to the dog. Training different patterns of icon activation could allow a dog to communicate what type of allergen he has detected, for example, peanuts or mold.

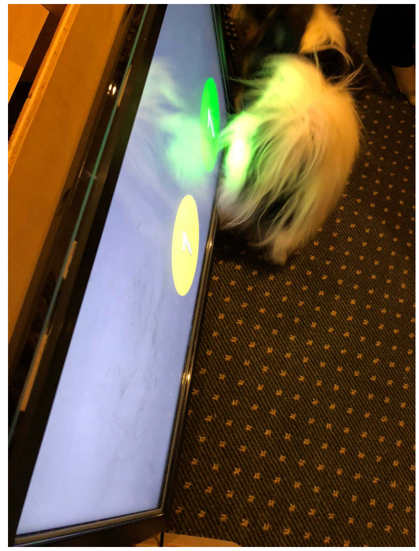

Figure 12. Tail Touch Activation.

We also discovered a flaw in the design of our training program – the program assumed that we would always backchain the icons, so the first icon (green) could not be removed. Particularly for the young dog S2, we needed to be able to train each component of the chain individually. When we first added the middle (yellow) dot, it was very confusing for S2 because the green dot was also displayed. We focused on training her to only activate the yellow dot, but it took longer because she was distracted by wanting to activate only the green dot because of its reinforcement history. Going forward, we will modify the training program to be able to display only one dot at a time, and to be able to vary its position on the screen.

CONCLUSION AND FUTURE WORK

In this two-part study, we demonstrated first that dogs can be trained to activate a series of icons on a touchscreen with their noses to communicate a medical alert. We observed that even dogs with no experience with a touchscreen can be trained on a complex alert behavior chain in less than a week, with only five-minute daily training sessions.

In our longitudinal study, we showed that a dog can learn to locate the touchscreen from other rooms of the house and activate a touchscreen only on the trained cue. The dog does not need to train every day to maintain the behavior. This has tremendous implications for medical alert dogs, implying that it is feasible to use touchscreens in the home rather than wearable technology, enabling them to summon emergency services, family members, or neighbors to assist in a health crisis, with the potential to save lives.

Future studies will focus on other means of interacting with a touchscreen, such as a paw touch for smaller dogs. We will also investigate better ways of training complex patterns of icons, in order to prevent false activations. We plan to explore multi-touch interactions, such as simultaneous foot and nose targets, and to test whether dogs can differentiate cues to perform different activation patterns to produce multiple messages.

Additionally, while this is a proof-of-concept system, we imagine that a permanent home solution would be clearly and visibly marked if this were to be the primary safety device the person requires. This could compliment a system, such as the vest system proposed by Jackson et al [6], and have both methods use the same process to contact someone else for help. Furthermore, design research with individuals who would most directly benefit should be conducted to ensure that the system is designed to meet the specifics of their needs beyond just the capabilities of the dog, such as living situation, home layout, and other various conditions.

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