Empowering Assistance Dogs: An Alarm Interface for Canine Use

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Abstract. This paper explores the intersection of assistance dog welfare and intelligent systems with a technological intervention in the form of an emergency canine alert system. We make the case that assistance dog welfare can be affected by the welfare of their human handlers, and examine the need for a canine alert system that enables the dog to take control over a potentially distressing situation thus improving assistance dog welfare. We focus on one specific subset of assistance dogs, the Diabetes Alert Dog, who are trained to warn their diabetic handlers of dangerously low or high blood sugar levels.

1 INTRODUCTION

Having co-evolved for at least 10,000 years, dogs and humans share a social bond that make them especially attuned with one another [13]. For example, dogs have been found to trust the visual cues of their owners over their own independent reasoning or olfactory input [22, 29, 30]. This special relationship is both the result and manifestation of the fact that dogs are entrusted by humans with many tasks, some of which are critical for humans' health and safety, as is the case with assistance dogs. These are specially trained dogs who are paired with and assist a human handler with a disability: i.e. Hearing Dogs, Seeing Dogs, Mobility Service Dogs, and Medical Detection Dogs [1]. A particular kind of assistance dog is the Diabetes Alert Dog (DAD); a dog that is trained to respond to the need of their diabetic human handler and whose primary job is to warn them of on-coming hypoglycaemic or hyperglycaemic attacks [28]. Dogs can often tell when blood sugar levels in their handler are changing dangerously before the handler themselves can [7]. Frequently, the dog is able to warn or "alert" the handler in time to prevent hypoglycaemic coma, which can occur if blood sugar drops too low [3].

For DADs and other assistance dogs, the welfare of the animal and that of the human are linked. The canine-human relationship is often mutually beneficial, having been found to benefit not only the health and welfare of humans [17, 23] but also the overall welfare of assistance dogs [18]. However, assistance dogs may on occasion experience stress, such as when guide dogs are separated from their blind owners [12, 14]. Similarly, it is possible that when the diabetic owner of a DAD falls unconscious into a hypoglycaemic coma, DAD's may experience distress. This could partially be because the dog experiences a temporary separation from their assisted human combined with an inability to predict when and whether the human will "come back" and a lack of control over the situation [15, 31]. But what if there was a system that allowed dogs to regain control in such a situation, a system that the dog could use to actively call for outside help?

We envisage such an emergency alert alarm system to be physically triggered by an assistance dog to start a software sequence to call for outside help, such as friends, family, or emergency services. The system could respond differently depending on the human's particular situation and therefore on the dog's interaction with the system. Following from our previous work [26], here we posit that such a device would be beneficial not only for the human (who could have their life saved) but also for the dog who might otherwise experience prolonged distress when their human becomes incapacitated.

In developing such a system, we envisage benefitting the welfare of assistance dogs in two ways: firstly, by providing a practical tool to enable the dog to improve their own and their handler's immediate situation by calling for outside help. Secondly, by endeavouring to design a system with a dog-friendly interface, which is not only ergonomically appropriate for the dog to engage with, but also cognitively accessible to the dog, by which we mean that the system is capable of communicating to the dog that he has successfully engaged with it and accomplished the task of calling for help. We propose that, combined with appropriate training, good system design could potentially give the dog an enhanced sense control of the situation and predict that help is on the way, thus reducing stress.

2 BACKGROUND

Lack of predictability and control of their environment can cause stress in dogs [2]. When a dog learns that he or she has no control of the outcome of a stressful situation, this can result in a phenomenon called "learned helplessness", which is considered a depressive state [21, 25]. In working dogs, environmental factors that the dog cannot control such as unpredictable behaviour of the humans around them can contribute to stress [5, 8, 9, 15]. In the particular case of DADs, when their owner experiences hypoglycaemia, the dogs are at risk for finding themselves in a potentially stressful situation where their owner has decreased cognitive function or even becomes completely unconscious. It is possible that repeated occurrences of such situations - where the dog is unable to wake up their owner or successfully alert them as they are trained to do - contributes to overall stress in DADs. Thus, creating a device to "give back" some of this control may prove useful to the dog.

However, any such device needs to be ergonomically easy for the dog to use and cognitively accessible for them to engage

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with, in order to effectively decrease rather than increase stress, which could be possible if the device is hard to use. Indeed, there is evidence that undue stress can be placed on assistance dogs while performing the tasks required of them; especially when they are required to perform tasks that have a high risk of performance failure [27]. For example, one type of potentially stressful task that assistance dogs face is assisting their humans in using technologies that were designed for humans, not dogs. For example, mobility service dogs learn how to execute tasks such as opening doors, loading laundry machines and pressing buttons to operate things like elevators or button-operated doors [6, 10]. Assistance dogs are often performing such tasks at a deficit because their own physical capabilities are very different from those of the human users the tools were intended for. In spite of animals' adaptability, using human technologies present considerable challenges for them (e.g. a cash machine is designed for slim agile fingers, not "chunky" paws). Developing user-centred technology that can support animals, such as working dogs, in various tasks is one of the aims of the emerging area of Animal-Computer Interaction (ACI) [20].

ACI design aims to meet both the physiological and psychological requirements of animal users. For example, one device developed to support working dogs in their task is FIDO (Facilitating Interactions for Dogs with Occupations), a wearable canine vest interface which aims to support two-way communication between dogs and their handlers [16]. There are parts of the vest that the dog can interact with to communicate with his handlers, for example, the vest can be fitted with different types of attachments such as a biteable or tug-able attachment that, when the dog bites, tugs, or noses it, sends a signal back to the human. This sort of technology could allow rescue dogs to communicate remotely back to their handler if they have found an injured person, or allow guide dogs to tell their human what sort of object is in front of them, as well having potential application for other types of assistance dogs. In designing this vest, the needs of the dog were considered in terms of their physiological requirements (i.e. in terms of interface wearability and ergonomics). However, it was not clear how the psychological requirements of the dog were considered (e.g. how easily he might learn to use the interface independently in a real life situation). Also, testing did not include use-cases of the dog being alone whilst using the device, but rather there was always a handler present and directing use of the interface. A successful interface for an emergency alert system will allow the dog to interact independently with the system without the help of a handler to guide its use.

Other devices designed to allow dogs to communicate to their handlers include Pet2Ring and PetChime [24], which are available on the pet market and which were developed primarily for use by companion cats to "ring the doorbell" to be let in, but have also been adapted to enable DADs to alert their owner when they cannot reach them physically (e.g. when the owner is driving a car or in another room). Such devices are large, mountable buttons that the dog can either leverage their body weight to press with a paw, or nudge with their nose to trigger. However, they do not allow a dog to call for outside help, but rather trigger a localized auditory alarm. Also, they cannot be configured to trigger different responses or enable different modes of interaction.

Both the aforementioned wearable vest and pet doorbell systems enable the dog to successfully interact with it, thus effectively communicating a particular message to his handler. However, for an emergency alert system, we explore the idea that the dog also needs to be able to successfully interact with the system when they are alone in a real-life, emergency situation. Also, we posit that additional functionality that allows the system to interpret a dog's present situation or environment may support the dog in its task at hand, and by extension, overall welfare.

3 AN ALARM TO SUPPORT DADS

In order to begin to understand what specific affordances a canine alert system might need to have in order to appropriately support DADs' work, we conducted exploratory research at a leading assistance dog training centre in the UK. We held interviews with DAD trainers as well as individual diabetic clients, participated in training sessions, and observed general interactions between the dogs, their handlers, and the trainers. From this information, we began to understand what basic requirements such a system might need to meet, based on which we then created several different rough physical prototypes for a dog-friendly interface. We discussed and tested these prototypes with trainers and assistance dogs to see what type of design features might work best for the dog. Although we considered options such as press-able buttons or an interface triggered solely by biting pressure, we eventually concluded that a prototype based on the dogs' ability to tug and pull would make sense. Indeed, we found that similar objects called bringsels or "tuggies", which can be held in the mouth or tugged on when working dogs wish to alert, are already widely in use. Thus, our initial designs all consisted of a hanging base attached to a tuggy that the dog could take in his mouth and pull on to trigger the system. Through our interviews and testing, we were able to begin to identify potential DAD welfare issues as well as potential solutions through an emergency alert system. Here we examine one particular case study in detail for illustrative purposes; additional case studies are in progress to further understand individual partnership's requirements.

Client Background

Diane, an adult female with Type 1 Diabetes, has a male DAD, Fred. Fred is trained to detect the scent of low blood sugar and alert her when he can sense Diane is "going hypo", i.e., when her blood sugar is getting below safe levels. Fred alerts Diane by staring at her intently or by both placing his paws on her and staring intently until she acknowledges him. Fred's alerts are important to Diane as they could make the difference between her falling into coma or not. To add to this importance, Diane lives in a flat alone with only Fred, so if she does slip into a coma, no human would usually be there to call for help.

During interviews, Diane reported that on the occasions that she missed Fred's alert and slipped into hypoglycaemic coma, the moment she woke up the dog was right by her side or face, "staring at her worriedly". Diane also reported waking up with bruises on her arm consistent with the dog nudging and pawing her. Additionally, medical response teams reported that when they found the Diane unconscious, the dog was lying by her side. From this information, Diane and Fred's trainers reason that Fred routinely makes an extended effort to wake his owner up; and also that he then does not leave her side until she either wakes up on her own or someone arrives to help.

Testing Process

In training sessions to test our prototypes, we setup mock situations to test how Fred interacted with a hanging system where he needed to grab a hanging "tuggy" in his mouth and pull in order to set off an alarm (see Figure 1). Diane pretended to collapse, and a trainer told Fred to interact with the system with the verbal command "Fred, pull tuggy!". When he did as instructed, Diane would immediately 'awake', sitting up and praising Fred (demonstrated in Figure 2). Thus the dog was being reinforced to perform this behaviour when it appeared that Diane needed help. After a few sessions, Fred was observed immediately going over to the system and triggering it to "wake up" Diane, without any verbal commands or prompting from the trainer.

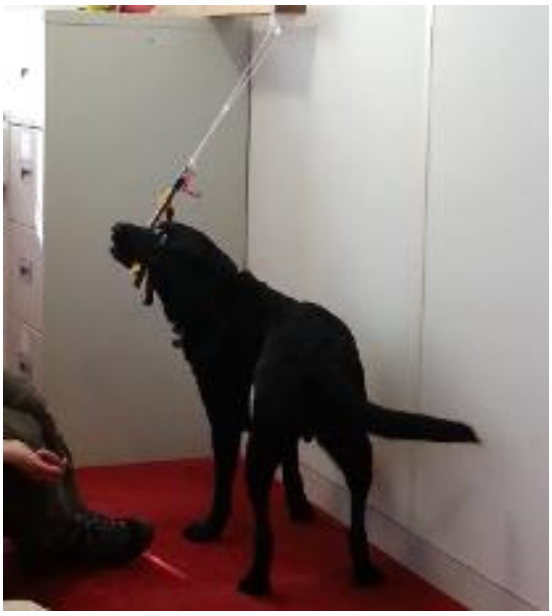

Figure 1. Fred interacting with a hanging prototype by gripping the "tuggy" part in his mouth and pulling until it clicks.

Figure 2. Fred successfully pulls off the tuggy in the basic prototype and receives praise from his handler.

Context of Use

However, in one training session, when Diane pretend-collapsed slightly around a corner from the prototype, we saw that Fred no longer quickly engaged with the tuggy; rather, he exhibited hesitant body language and would not approach the tuggy as before. Given the aforementioned patterns of behaviour when the dog was found with Diane after being unconscious, trainers interpreted that leaving her out of his sight was too stressful for Fred, due to years of him being used to staying by her side and watching her whenever she would pass out. This is just one example of a situation where the psychological, as well as physical, requirements of the dog as a user need to be accounted for by system design.

Canine-Friendly Feedback

In another training session, one of the tuggies failed to detach as intended when Fred pulled on it. Rather than stop pulling, Fred continued to pull and exert more and more pressure until the base of the prototype actually broke from the wall. Fred's trainer interpreted this as him not understanding that his initial pull on the interface was enough to sound the alarm; but rather that he wanted the tuggy to actually come detached from the interface and that he thus escalated his pulling until something 'happened'. This highlights the need for a system to provide clear, canine friendly feedback to let the dog know that he has completed his action using the system.

4 DISCUSSION

From our initial interviews and testing, it is apparent that in order for a system to be useful and user friendly to the dog, it will need to be clear to the dog how to use it; a successful system will make it clear to the dog not only *how* he can interact with the system, but also clear *when* he has interacted with the system successfully. To contribute to these goals, our system can potentially use sensory input to understand the dog's intentions based on patterns of interaction or body language. This might be helpful in a case where the dog is hesitant to interact with the system for whatever reason (such as it being out of the line of vision of his owner in the example above). It has been suggested that working dogs' physiology can be read to help trainers interpret canine welfare. Brugarolas et al [4] have worked to develop a "canine body area network" to use sensors to develop real time feedback about canine behaviour to trainers. They have utilized machine learning algorithms to identify canine posture through wireless inertial sensing with 3-axis accelerometers and 3-axis gyroscopes, with the intent that future work can build on this to be able to evaluate and improve on working dogs' welfare. An emergency alarm system could use similar approaches in evaluation of the assistance dog's welfare. Features like these would mean the alert system was not only easy for the dog to use, but also have sensory or state information about the dog and its environment that could be helpful to the dog.

Additionally, although in the included illustrative example Fred and Diane lived alone, many DAD owners have children or other (pet) dogs in the home that share the same environment as the DAD [26]. Another diabetic client we interviewed told us that before acquiring a trained DAD, she had a pet dog at home that became very distressed whenever she was incapacitated. In these type of households, children or non-working pets may be

tempted to interact with the system as well, which may hinder the dog from accomplishing his task or make training confusing. To address this, RFID or other reader technology could be leveraged to scan a dog's implanted microchip (legally mandated for all dogs in the UK from 2015) [11], or non-implanted microchip on the collar, to tell which dog is interacting with the system, thus avoiding confusion if other animals or children that are not the DAD are tempted to interact with the system but are not trying to call for help.

5 CONCLUSIONS & FUTURE WORK

This paper has drawn from exploratory research with assistance dogs to begin developing a system that allows a trained DAD to call for help remotely when their owner is unable to. This is one instance of many where a well-designed system intended for canine use could not only assist in improving human welfare, but also benefit canine welfare. Future work can further explore the specific needs of these canine users and implement working models for more rigorous testing and real-life applications, performing well-designed technological interventions with intelligent systems to empower dogs and address welfare concerns within the assistance dog community.

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