Supporting interspecies social awareness: Using peripheral displays for distributed pack awareness

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ABSTRACT

In interspecies households, it is common for the non *homo sapien* members to be isolated and ignored for many hours each day when humans are out of the house or working. For pack animals, such as canines, information about a pack member's extended pack interactions (outside of the nuclear household) could help to mitigate this social isolation. We have developed a Pack Activity Watch System: Allowing Broad Interspecies Love In Telecommunication with Internet-Enabled Sociability (PAWSABILITIES) for helping to support remote awareness of social activities. Our work focuses on canine companions, and includes, *paw*ticipatory design, *lab*radory tests, and *canid* camera monitoring.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces. - Graphical user interfaces.

General terms: Design, Human Factors

Keywords: Interspecies interaction, dogs, peripheral displays, awareness

INTRODUCTION

Many *homo sapiens* develop interspecies relationships of a social nature during their lives, often to great benefit of the human (see Beck and Katcher for a summary [1]). A particular synergy may occur in the case of *homo sapien*/canine relationships [1,14]. It is believed that canines may have even taught *homo sapiens* how to benefit from the stronger social relations of a pack structure [18]. However, working *homo sapiens* are absent from their habitat and immediate pack (spouse, children, canines, *etc*.) for an average of 8.5 hours per day (work [19] plus commute [1]). While humans typically have the benefit of social contact and pack relations in their work setting, their canine or other non-*homo sapien* companions may feel isolated and lonely. In fact, canine companions have been known to demonstrate destructive behavior as a result, including eating of homework, climbing the walls, inappropriate elimination, barking at postmen and so on.

We present the *paw*ticipatory, or dog-centered, design of a Pack Activity Watch System: Allowing Broad Interspecies Love In Telecommunication with Internet-Enabled Sociability (PAWSABILITIES) intended to help dogs maintain a sense of connection to their remote pack members. Our system focuses on a key component of pack behavior -- social interaction with other beings. We include support to inform a home-bound pet about human-human interactions in the owner's remote workplace. Additionally, we enable interaction between dog and owner through an owner-controlled tennis-ball release system. Our design choices were informed by a *paw*ticipatory design approach involving pets in the choice of media and representation of our awareness applications[1], a theoretical investigation, a study of dog physiology and a *lab*radory study.

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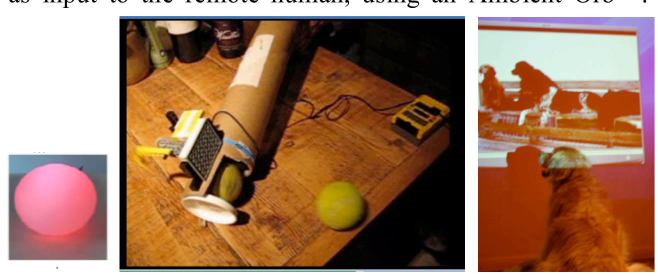
Approach

PAWSABILITIES consists of a Human User Interface (HUI, pronounced "Who?"), and a Dog User Interface (DUI, pronounced "Doo"). The HUI combines implicit and explicit input with ambient output (Figure 1a). The DUI combines implicit input with ambient and explicit output (Figure 1b). We found this paragraph confusing. For example, who does the HUI show, and does the DUI show it too? [2] Hopefully the next paragraph will clarify this.

A camera is used to sense the presence of multiple humans in the remote human's office (currently our system is unable to detect the presence of canines, felines, or other species), and a microphone is used to sense spoken interaction with other entities. The remote human's activities are output to the dog in the form of a *canid* camera (video/audio feed) from the officeplace.

Pressure sensors are used to determine when a dog is lying on her dog bed, implying a sense of boredom. This is sent as input to the remote human, using an Ambient Orb™.



(a) (b) (c)

Figure 1: A view of PAWSABILITIES on the (a) human/owner side, and on the (b) dog/pet side.

[1] No dogs were harmed in this work, however the second author believes that the first author may have growled at him several times menacingly.

[2] We recommend reading this sentence out loud if you find it at all confusing. Remember: HUI→Who and DUI→Doo

The remote human can respond by activating a Canine Activity Toy (CAT) that releases tennis balls into the dog's environment, to help alleviate canine ennui (patent pending).

Before designing the DUI, we explored abstract and specific representations of human social interaction. We compared video and audio of humans, images of dog packs, images of human packs, images of mixed-species packs, video of dogs, and barking sounds. Our results showed that sounds and video were most effective for engaging canine companions. We also explored a range of potential input techniques to allow homebound canines to communicate with their distant human pack members, before selecting the pressure-based system as most appropriate.

Pawticipatory design

The first author, a canine, was involved in all stages of this project. In addition to video, audio, and image-based representations, she indicated that the following media might be appropriate for representing human social interactions:

- Tennis ball motion
- Smell output
- Dog treats, in quantities matching number of humans present
- A cat or squirrel release system that would provide entertaining objects of chase
- Marking of territory

It was suggested that the first and last representations could be triggered by an affective computing system tuned to indicate when the human appeared to be experiencing high levels of enjoyment.

Our canine companion also participated in879dx

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/R<> the writing of this paper, and helped to insert some bugs into our code. We attempted to teach her to use a keyboard more effectively than her initial attempts. However, due to her limited grasp of spoken English, and lack of written language, this proved impossible during the time frame of the research.

Overview

We now present a description of our multi-pronged approach for designing PAWSABILITIES, including the scientific basis for DUIs, and our labradory study. We end by discussing the resulting PAWSABILITIES design and implementation and demonstrate through a qualitative evaluation how well PAWSABILITIES supports pack awareness.

SCIENTIFIC BASIS FOR DUIS

In addition to our focus on canine-based design, because of the extreme differences between ourselves and the canine users of our system, we carefully grounded our design in scientific knowledge.

GOMS analysis

We attempted to do a GOMS analysis to help with the planning of our system [5]. However, we found ourselves running into several challenges. First, we could not find an existing GOMS model that directly dealt with the issue of distractions. For example, if a squirrel or tennis ball appears in their peripheral vision or smell, many dogs will suddenly and completely task switch, requiring them to start over, if they even remember the initial task they set out to accomplish. In addition, since our display really falls into the category of peripheral displays and is not directly task-based (until the animal chooses to retrieve information from it), it is not clear if GOMS is an appropriate approach to modeling it. Lastly, we attempted to find data on the mental structure and timings of dog actions. However, this data was quite limited, and an extensive literature survey was only able to turn up the theory, among many retriever owners (confirmed by the first author, who is, after all, an expert in this area) that in the case of golden retrievers obsessed with tennis balls, normal neurons in their head are actually replaced with rapidly moving, tiny tennis balls (see Figure 2).

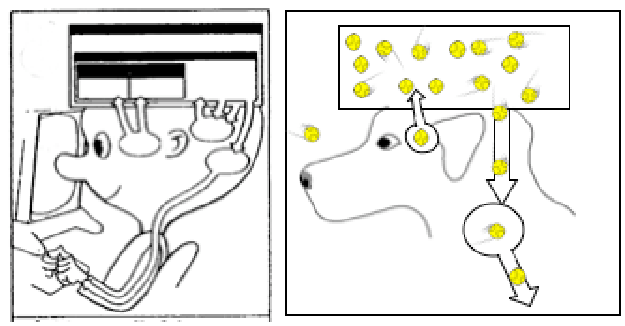

Figure 2: A comparison of the model human processor (left) and the model dog processor (right).

Given this dearth of data, we had to completely eliminate the keystroke-level model and related models from our set of available techniques.

Fitts law study

We also attempted to run a Fitts-law experiment. However, the only way we could get our participants to move quickly between two points was to throw a tennis ball to random locations, and it was difficult to do this with the consistent speed and location required by this type of experiment.

Canine Physiology

An understanding of canine physiology helped us learn how to best convey information to dogs. In this section, we describe how each sense differs between dogs and humans[3].

Sight: While humans can see and distinguish an extraordinary number of colors, dogs are only able to see blues and greens to greys and creams (Figure 3 (left)). Dogs have their eyes placed more towards the sides of their heads than humans, providing them a wider field of view. As a result, however, the view from each overlaps less, causing less of

[3] Most of the information in this section was collected by the first author via Google [7], but we do not know this for sure, because we do not understand much of what she says, hence the need for pawticipatory design.

what they can see to be in focus. This is an issue with close-up vision, in particular.

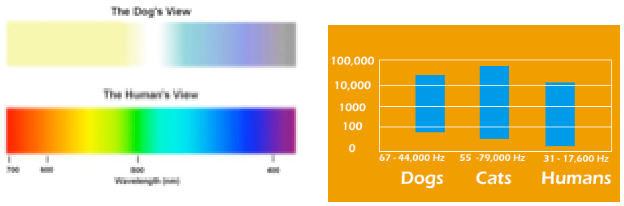

Figure 3: Differences in color vision (left) and hearing (right) between dogs and humans

Hearing: Dogs are able to move their ears independently and have 15 different muscles in each ear that allow them to move an ear in all directions. They can also hear sounds that humans cannot, including both higher-pitched sounds (Figure 3 (right)) and sounds at a greater distance. Dogs are able to hear sounds at four times the distance of humans.

Touch: While sensitivity to touch varies widely among dog species, in general, it is less than a human's. Most dogs like being scratched behind the ears and on the belly.

Smell: Smell is a dog's most prominent sense and is the most different from humans. A dog's sense of smell is estimated to be 100000 times more sensitive than human smell. Dogs often sniff their owner's legs when the owner comes home as a way of determining where the owner has been and how the owner feels.

Taste: Similar to humans, a dog's sense of taste is linked to smell, however humans' sense of taste is better. The biggest difference between dogs and humans is that dogs prefer smelly food – in fact, the smellier the better!

Time and space: It is a well known fact that dogs age approximately seven times faster than humans. However it is less well known (perhaps only to the authors of this paper) that dogs perceive space to be seven times smaller than humans. Thus, for example, despite the fact that a technote should only be four pages long, from a dog's perspective, it may fill twenty-eight pages of space.

It should be obvious from Table 1, that the only practical methods for conveying information to dogs is through audio and visuals, despite a dog's love of touch, its vastly superior sense of smell and its appreciation for disgusting smells.

Table 1: Methods for Presenting Information to Dogs

Sense	Leverage for Dogs	Difficulties in Implementation
Sight	Wide field of views, see at a distance, lots of motion, not using color as distinguishing factors	None
Hearing	Quiet sounds or sounds outside human audible range so only noticeable to dogs	None
Touch	Scratch ears and belly	Dogs tend to move – tend not to like being scratched in the wrong place
Smell	Smells of owner's location and people around owner	Despite improvements in olfactory devices, dogs unlikely to trust fabricated scents
Taste	Tastes of owner's food	Not practical, and do not want dogs to gain weight

LABRADORY TESTING

We felt it would be best to balance our pawticipatory design work and study of canine physiology with more formal labradory testing, to verify the results from these efforts. We first alpha-tested a number of interaction techniques from the HCI literature with a beta-dog in our pack (the first author). We then consulted and ran a study with several other canines (extended pack members of the first author) about the output alternatives described in the previous section. We discuss both these tests here.

Alpha Test of Input Techniques

Due to the lack of existing research about DUI design (based on a survey of the entire CHI, UIST and CSCW proceedings), we decided to explore and adapt the set of well-known HUI techniques for DUI input. The following table presents our results. Note that these techniques were studied and simulated with a Wizard-of-Oz approach (Figure 4 illustrates some examples of this).

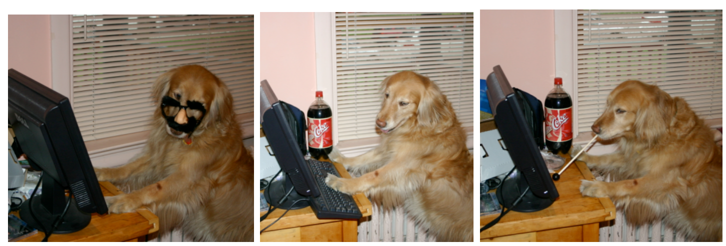

Figure 4: Testing interaction techniques. (Left) DATANOSE; (Middle) Typing; (Right) Sip & Puff stick

Table 2: Exploration of Interaction Techniques for Input

Input technique	Modifications	Results
Sip & puff switch[]	Addition of peanut butter	Failed: dog could not be trained to use straw
Mouse	Put tennis ball wrapper around device	Failed: no opposable thumbs. Drool caused electronic failure.
Keyboard	None	Failed: dog demonstrated difficulty pressing individual keys (bludge errors []).
DATANOSE [10]	Inserted wet sponge in nose-piece to keep dog nose moist	Failed: device interfered with dog's sense of smell, resulting in disorientation
Direct Manipulation of buttons and switches, tilting devices [9]	None	Failed: training time too long

Stylus as input to IM client	Stylus shaped like bone	Failed: dogs can't read or write
Two handed gestures	Multiple cameras to watch 4 paws	Failed: dog body often obscures paws
Natural language	None	Failed: dog speech hard to understand (despite existence of Bowlingual™ device)
Voice as sound [11]	Played country music to encourage sing-along howling	Failed: too difficult for dog to control pitch of voice
Pick and Drop [16]	Tennis balls used as information vessels	Failed: dog didn't want to drop tennis ball
Finger point [19] and Fingerprint [20]	None	Failed: dogs do not have fingers
Holowall [12]	None	Failed: dog has limited stamina to stand on hind paws and interact with fore paws
Natural behavior	None	Success: wagging tail, lying down, chasing balls and squirrels, barking

Of all the input techniques tested and envisioned, only natural behavior appeared to be successful as an input technique. For our particular task of notifying the owner that attention is needed, barking and lying down seem to be the most appropriate behaviors to monitor. Wagging a tail and chasing objects tend to be behaviors associated with happy behavior, where little or no attention is needed.

Output Study Method

As part of a controlled study, three dogs were presented with 12 second long clips of sounds, images, or movies (with and without sound) of both human and canine pack members. Figure 5 shows the set-up for our study. Two human experimenters recorded all reactions to each clip. Our analysis looked for any instances of increased wags per minute (WPM), interaction between pack members and the display, and interaction amongst pack members. "[Tail wagging] is the state of the body vibrating with more energy than the body at that moment is able to conduct given whatever action is currently available to it. In other words, there is more energy trying to go through the pipe, the dog's body, then the pipe can accommodate. Wagging the tail is the body's physiological response for dissipating the excess energy [2]." See Equation 1 for a model of tail wagging.

$$\nabla^2\psi = \frac{1}{v^2}\frac{\partial^2\psi}{\partial t^2}$$

Equation 1: Gratuitous Math

Output Study Results & Discussion

The participants only responded to media that included audio, throughout the study. Mighty, in particular, reacted quite violently to the two audio clips of dogs barking, which both contained barks of dogs not part of his pack. He barked an average of 9 times (stdev 2.828427125), his tail wagged at an average of 27 WPM (stdev 10.60660172), and he also looked to and from the screen. This caused the sleeping BoomBoom to raise his head and perk his ears up, the only sign of life from BoomBoom during the entire study. Eager watched Mighty throughout this episode.

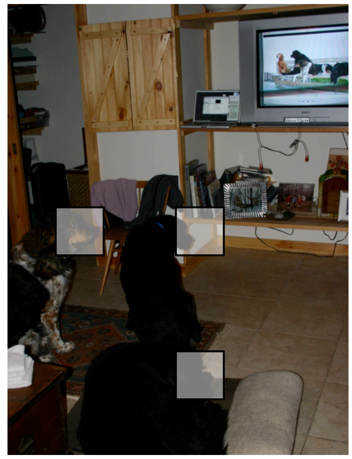

Figure 5: Our 3 participants. Eager (left) watched Mighty (middle) go wild in response to recorded barks while the elderly BoomBoom (bottom) fell asleep during the study. Names and faces are psuedonomized to protect the innocent.

The participants also reacted to audio and audio+video of familiar pack members (humans only, or humans and themselves). In fact, the reaction to familiar pack members was much less agitated, and included panting, more attention to the video/sound source, and perked ears.

Based on this study, our primary conclusion is that dogs are not like people. In addition, we decided to focus on displaying *canid* camera (video/audio) of familiar pack members (in particular, the remote human) to the homebound canine.

DESIGN AND IMPLEMENTATION OF PAWSABILITIES

Based on our extensive formative evaluation and studies, we designed and implemented PAWSABILITIES. PAWSABILITIES was developed in Java using the peripheral display toolkit [13]. Owner interaction with colleagues at the office is captured and analyzed in real-time using a microphone and a camera. The audio is analyzed to determine the volume of the conversations occurring and the video is analyzed to determine the amount of motion and the number of people in the scene. When social activity is detected, the canine is notified by the appearance of video/audio of the remote office.

The homebound dog indicates that he/she is bored and requires interaction by using a very natural behavior, lying down (as noted above, natural behavior was the only feasible dog input to implement). Dogs often lie down and sleep when bored. In PAWSABILITIES, a dog bed, instrumented with Phidget-based pressure sensors [8], detects when the dog is lying down and notifies the owner via an Ambient Orb™. The orb pulses pink and blue to get the owner's attention and otherwise stays green. Upon seeing the dog's activity (or lack of it), the owner has the ability to release a tennis ball in the vicinity of the dog, using our (patent pending) ball release device (CAT) to engage the dog in play (Figure 1(b)).

CAT was implemented using LEGO Mindstorms™ and a poster tube. A command to release a ball is sent to the control computer over the Internet from the human's office. The release command is then transmitted to the LEGO RCX brick. This in turn drives a motor moving an arm that pushes one ball from the end of the poster tube. The current poster tube is capable of holding approximately 10 tennis balls, but simple additions or modifications with PVC piping should allow several hundred tennis balls to be enqueued for the device. Used tennis balls can be obtained cost-effectively by the hundreds over eBay for as little as 14 cents per ball [6].

CONCLUSIONS & FUTURE WORK

In conclusion, we have developed an interspecies social awareness system. Attempts in the past have been made to give humans digital or robotic pet substitutes (e.g. Sony Aibo™, Tamagotchi™, Alive project at MIT [3]). However, the gentle reader may be surprised to discover, as the authors were when they started this research effort late last night, that interspecies remote awareness is a burgeoning research field. The Poultry Internet system was designed to support interaction between humans and their poultry companions [15]. However, it did not convey information about remote human social and pack behavior. Instead, it allowed humans to remotely pet their feathered pets (through a local, physical representation), and showed humans a miniaturized representation of the bird's location in the human's yard. A Pavlovian approach to testing showed that the poultry preferred to wear the tactile vest used to convey touch over. The Rover@Home system is much more closely related to PAWSIBILITIES [17]. It enables a human to provide remote output to a dog, for the purposes of behavioral training. Our work is unique in that it uses dog-centered design in every phase of the research, and focuses on providing pack awareness and engagement, in *both* directions, between man and dog.

While our work is preliminary in nature, it has enabled us to explore interaction and display techniques for conveying pack behavior. The challenges of interspecies design were difficult to overcome, particularly the lack of a common spoken language among participating species. However, we believe that DUIs have an important role to play in helping humans to provide their animal companions with increased quality of life, and, therefore, in improving their own.

We plan to deepen our understanding of the right approaches to pawticipatory design, through further studies with different species of dogs. We feel that our approach to human-canine awareness has tremendous potential and can be extended to other species like birds (BUI), fish (FUI) and cats (CUI). In fact, we believe it has so much potential, that the second and third authors are abandoning all other areas of research and are focusing their tenure cases on this. The first author is looking forward to making squirrels (SUI) and cats (CUI) suffer the same indignities she did, while the fourth author is looking forward to the day when he can apply our results to extra-terrestrials.

ACKNOWLEDGMENTS

Thanks to our canine participants, Makko, Eiger, and Boomer (oops, that should be Mighty, Eager and Boomboom). Thanks as well to Mark and Ruth Mankoff for their help in running the study. Finally, thanks to the Romans for their calendar, which placed April 1, 2005 on a Friday providing us with enough time to finish this paper in one night.

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Dog d??? user interface → dog dui/doo?

Pack leader vs. owner?

random images of a dog

"On the Internet, nobody knows you're a dog."

Tail wagging quote from http://www.naturaldogtraining.com/wag.html, Why do dogs wag their tails?, for justifying why tail wags is a reasonable metric for engagement.

There is some disagreement in the scientific community about why dogs wag their tails. Some believe that they do it because they are friendly, while others believe they do it to indicate submissiveness. We, among others, believe the following: "[Tail wagging] is the state of the body vibrating with more energy than the body at that moment is able to conduct given whatever action is currently available to it. In other words, there is more energy trying to go through the pipe, the dog's body, then the pipe can accomodate. Wagging the tail is the body's physiological response for dissipating the excess energy."

Dogs are extremely good at detecting motion, but can have difficulty seeing prey if it remains still. Dogs also have much better night vision than humans, having a greater number of rods and an additional reflective layer in the eye called the tapetum lucidum, that reflects light back into the eye receptors (makes eyes seem to glow in the dark, Figure 2b).

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HUI, DUI and LUI: rationale for why we pronounce them who, doo, and possibly loo (for Labrador user interface). People might not take the work seriously if we talked about huey, duey and looey.