Designing feedback

Multimodality and specificity

Geke D.S. Ludden*

** University of Twente, g.d.s.ludden@utwente.nl*

Abstract: Now that many of us carry around devices that are equipped with sensors (e.g., smartphones with accelerometers) we can use these sensors to measure behavior. The data thus captured can be used to give someone feedback about this behavior. These feedback mechanisms are often used in so called smart coaches, a growing group of product-service systems within the domain of persuasive technology. Despite decades of research on persuasive systems, challenges remain for designers of feedback systems. Little is known about how to design feedback in such a way that it is most effective in motivating people to change their behavior. In this paper, we give a categorization of feedback systems based on the modality that the feedback is offered in and on the specificity of the feedback. We discuss under what circumstances the different types of feedback may be most effective considering the context a feedback system is used in and the goals that users of the system have. Finally, we discuss future research on feedback systems aimed at find more specific design guidelines for feedback systems that apply to persuasive technology in different situations.

Key words: Feedback, Persuasive Technology, Multimodality , Specificity

1. Introduction

We live in a world of continuous information overflow. A reasonable part of the information we receive is aimed to influence us in some way. Guadagno and Cialdini [7] report how a colleague counted over 500 influence appeals over an hour. Due to the large amount of (influential) information that reaches us during our busy daily routines, we can easily miss out on the information that we DID want to notice. On the other hand, one can still imagine a more quiet situation where information can be annoyingly obtrusive and direct, perhaps even to the extent that we decide to ignore it or shut down the information source. In both cases, when it comes to information that gives us feedback about our behavior, with the intention to help us change this behavior, the pleasantness of dealing with such a system as well as its effectiveness will probably diminish.

Now that many of us carry around devices that are equipped with sensors (e.g., smartphones with accelerometers) we can use these sensors to measure behavior. The data thus captured can be used to give someone feedback about this behavior. These feedback mechanisms are often used in so called smart coaches, a growing group of product-service systems within the domain of persuasive technology.

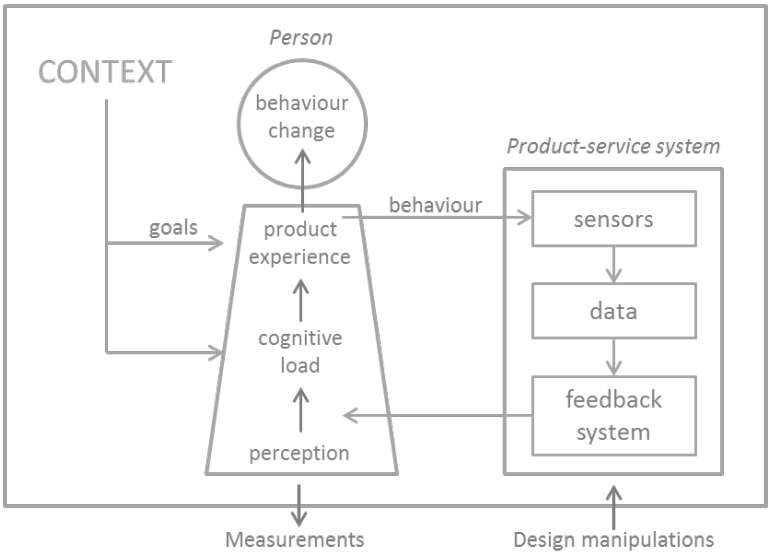

Figure 1. Interaction between user and product-service system

Figure 1 sketches the elements that play a role in a persuasive system: a person and a system that interact with each other. The system measures the behavior of the person and gives feedback. The person perceives the system (the feedback), and this will lead to a certain product experience influencing his motivation to change behavior. Because these are typically systems that are used throughout the day, the context the system is used in is important; a person is at a certain place, possibly doing other things (adding to their cognitive load) and has certain goals.

Within this field, building amongst others on the work of Fogg [6] research has been done into how technology can persuade people to lead a healthier lifestyle or to increase environmental awareness. For example, with their Ubifit prototype Consolvo et al [2], tried to persuade people to be more active by linking the physical activity of people to the display of a growing garden on their mobile phone. When people were more active, their garden would have more flowers and even butterflies. Toscos et al [24] designed a prototype especially for teenage girls with the same aim. They particularly tried to motivate teenage girls by acknowledging their need to socialize with one another. These are just two of numerous studies that aim to design smartcoaches that help people to lead a healthier lifestyle. Next to this, a large number of studies have tried to investigate how persuasive technology can be used to increase environmental awareness. Or, more in particular, how people can be persuaded to save energy [14, 15].

Clearly, undertaking the effort to address the severe problems that our society faces when it comes to health, healthcare and the environment is of importance and persuasive technology can play a role here. However, little is known about long-term effectiveness of persuasive systems. Several researchers [12, 25] state that the way people experience persuasive technologies influences their effectiveness.

2. Different types of feedback

The role of feedback in (health) behavior change is an important one [5]. Furthermore, research has shown that computer-based, individualized and interactive interventions seem promising in health behavior change [19]. Using technology to provide feedback has many opportunities. Feedback can easily be made more personal,

using technology allows designers of an intervention to make the feedback interactive and the feedback can be given at a for a user suitable moment in both time and place. However, in any case, giving feedback through technology will add to the amount of information that someone has to process. In this article, we explore options to make feedback less intrusive and easier to process. To do so we take a look at two variables that can be influenced by designers of feedback systems; modality and specificity.

2.1 Multimodality

As much as we experience the whole world around us through all of our senses, we experience (persuasive) technology through all of our senses. However, most feedback in current persuasive systems is given in the visual modality (often as graphs or numbers on a screen). There are many possibilities for the design of feedback in other modalities. For example, feedback through tactile information and feedback presented through colour changing or position changes of light have been explored.

Using other modalities than (the often used) visual modality could lower the cognitive load needed to process this feedback. Alternatively, using multiple modalities to provide feedback may cause this feedback to be noticed better. In various studies and reviews, Charles Spence and his coworkers have described how our sensory modalities each can contribute to the information we acquire during product use [e.g., 22]. In several studies, they describe situations where it could be beneficial to use another modality than the visual to inform users about certain events. For example, one of their studies [10] describes the effects of using multisensory warning signals for car drivers. In their study, participants initiated their braking responses significantly more rapidly when they were presented with a combination of auditory and tactile warning signals than when they were presented with either unimodal auditory or unimodal vibrotactile warning signals. Although this study describes only one particular situation, one could argue that under certain circumstances offering feedback through other or through multiple modalities is preferable. The information could be acquired faster or people would need to do less effort. This could also be the case for offering feedback about behavior.

2.2 Specificity

In literature on learning Davis et al. [4] show that more specific feedback leads to a better performance. In the design of feedback for persuasive technology, specific forms of feedback would be presenting measured data as exact numbers or as a graph or a bar on a display. This is an approach that is often used in devices and applications that are currently on the market. In contrast, in their work on lifestyle behavior change technologies, Consolvo et al. [2] define four design strategies and argue that presenting ‘abstract’ feedback rather than specific feedback would have a positive effect on the effectiveness of persuasive systems. This is in line with the view some other designers have on presenting feedback to users. So far, research on effects of specificity of feedback in the case of persuasive technology has been limited. Ham and Midden [8] compared reactions towards factual (numeric) feedback and ambient feedback (light changing color) in the case of energy consumption feedback and argue that giving ambient (less specific) feedback can be more influential because it requires less cognitive capacity to process this feedback. Following their line of reasoning, one could argue that for persuasive systems, context (and the cognitive load that is felt within this context) will have an effect on whether or not more specific feedback is the better option.

3. Matrix of types of feedback

To explore the types of feedback that could be used in smart coaches and to get some idea about the effects that these may have on experience of such systems, we take a step back to look at types of feedback that are currently used. Figure 2 shows a matrix of types of feedback with the before described variables modality and specificity on the horizontal and vertical axes. To fill this matrix, we have not limited ourselves to products within the persuasive technology domain. To ensure a broad view, products from other categories such as communication products and awareness systems, that also transfer information were added.

Figure 2. Matrix of types of feedback.

Please note that this matrix is not meant as an extensive overview of existing feedback systems. Rather, it presents examples of existing feedback systems. We have tried to fill the matrix, thus, to find examples for each modality that are high in specificity and that are low in specificity of information. We will use the matrix to discuss the existing types of feedback and their possible use in persuasive systems. We first discuss feedback systems within each modality separately and conclude with an overall discussion. In our discussion, we refer to the numbers in Figure 2 on the left of each example as numbers placed between round brackets ().

3.1 Visual feedback

Visual feedback is the type of feedback that is currently most used in persuasive systems. As said before, the feedback often consists of numbers on a screen or placed in a graph. Example (1) in our matrix, the Wattcher [28], also uses numbers to give feedback (in this case about energy consumption) and is very specific in its feedback. The numbers display exactly how many kWh you are using at that point in time. However, the designers of the Wattcher have added a feature that allows users to process the information more easily. When the amount of kWh that you use rises, the numbers start flashing more rapidly, urging you to take notice of the amount of energy you are using. Nike visualizes the amount of energy that a user of the NikePlus system uses in so called NikeFuel [16]. The bracelet that is part of this persuasive system (2) displays the amount of fuel that you have used either as numbers or in a series of LED's ranging from green to yellow to red in color. Herewith, although they a specific number of fuel, it is not exactly clear what this number tells you. The coloring of the LED's however will let a user know if he or she has used enough fuel (i.e., if he or she has moved enough).

Mickael Boulay designed a device called 'measuring less to feel more' (3) for people with diabetes to check their blood sugar level that uses the position of a LED light to express if the blood sugar level is high (LED light in the top of the device is on), moderate (LED light in the middle is on) or low (LED light in the bottom of the device is on). Although this device is much less specific than other blood suger level meters (which mostly display an exact number on a screen), users of this device reported that they found the device accurate enough and easier to understand than traditional meters [1].

The last two products in the visual domain are examples of devices that use feedback that is low in specificity. The Philips rationalizer [18] is a device that gives its user feedback about the 'intensity of the user's feelings'. By measuring skin conductivity, an indication of physiological arousal can be found, which is used in this product to display intensity of feelings. The feedback in this device is low in specificity. A dynamic light pattern on the bracelet or on a bowl (4) indicate changes in 'intensity of feelings'. The aim of the rationalizer is to alert the user that it may be wise to take a time-out and re-consider their actions when the intensity of feelings is high. The dynamic light pattern may well be enough to communicate just this.

Many awareness systems make use of visual feedback that tells a person about the activity or presence of other people at a distant location. An example is Snowglobe (5) [27], a globe that displays information about the presence of others by floating 'snow'. The 'active' floating snow represents activity in another place.

3.2 Tactual feedback

Our sense of touch tells us more than we often realize about the world we live in and about the products we use. However, the sense of touch is not often used to give feedback or to communicate information. Since we started to wear mobile phones in our pockets, we all know that one of the benefits of using tactual feedback is that we can be notified (of calls, for example) unobtrusively in a busy or in a very quiet environment (8). The information that is communicated through the buzzing of the phone is direct; the pattern of the buzz can indicate that someone is calling or that a text message is coming in. However, the information is not very specific, the buzz doesn't tell you who is calling, for example.

Fabian Hemmert and his colleagues of the T-mobile design research Lab [9] developed other forms of tactile feedback in their shape changing (9) and weight shifting phones. We could imagine a phone communicating the amount of data that is stored on that phone by thickening. Again, the information that is communicated through the thickening of the phone is not very specific. We cannot feel exactly how thick the phone is and how that

relates to the exact amount of data that is stored. However, having said that, the thickness of the phone may for many people be easier to understand than a certain amount of MB.

A more specific type of tactile feedback is given by the TNO tactile torso display (TTTD) (7). The TTTD is a tactile display integrated in a vest, that can give the user information about his or her orientation. It was developed for a military setting to aid pilots [26]. However, TNO also made a version that could help deaf people 'hear' music in a disco by letting the vest vibrate according to the music that is paying.

The last example of communication though touch that we discuss is the most specific in what it communicates. F+R Hugs system (6) is smart jacket that simulates a hug by recreating the physical pressure of a hug through inflation and deflation of cushions embedded in the jacket [20]. A distant love one can activate the 'hug' by sending a text message. In this system, the information that a person wants to send (the hug) is copied by the jacket.

3.3 Auditory feedback

Auditory feedback probably is, after visual feedback, the type of feedback that we are most used to. From the moment we wake up in the morning because our alarm clock is beeping (10) to the moment that our microwave oven beeps to let us know that our dinner is ready, we are reacting to product sounds all day. Most of these sounds indicate a specific event and we immediately know what the sounds tell us.

An innovative way to use auditory feedback was described by Stienstra et al. [23]. They created a system where skating movements were translated into auditory feedback in order to improve effective movements in speed skating (11).

Sounds can be less specific in for example a hospital (12) sounds can than tell the doctors that something is wrong but they still have to find out what exactly is the matter. The sound is only a trigger. Similarly, the sound that we hear when someone is calling (13) tells us just this but not who is calling, unless we set different ring tones for different people.

3.4 Olfactory feedback

An example of a specific type of feedback using olfaction is the odor that is added to our household gas (14). Without this distinct smell we would notice gas leaking. Thus, this odor gives us feedback (a warning signal) about the presence of gas in our environment. Another product that can give olfactory notification signals is Olly (15) [17]. Olly is a device that is connected to your social media (e.g., Facebook, Twitter) and that releases a scent whenever someone mentions you or comments on one of your posts. Olly is stackable s that you can use different fragrances for multiple events. A similar device is made by Sensory Acumen [21], the Gameskunk (16). This device has a range of scents that it can release during game play to make the game more realistic and to let a player take notice of certain events.

Finally, an example of olfactory feedback that is not specific is given by the scentsory dress developed by Jenny Tillotson (17). This dress is 'using olfaction as a communication tool, with a focus on the relationship between Aromachology (the science of smell) and emotional wellbeing'[11]. The dress emits different scents that represent the emotional state of its user.

4. Discussion

Our matrix of feedback systems has shown that feedback can be designed for multiple sensory modalities. Furthermore, it shows that for most sensory modalities it is possible to design more specific or less specific feedback. We have argued that for different contexts different forms of feedback may be more efficient in delivering the message. The examples have shown that more specific information is not in all cases necessary and may sometimes even delay the message because users first have to figure out what the specific information means and what action they have to take. At the same time, the examples have shown that not all modalities are equally suitable to communicate more specific information. This is particularly true for touch and olfaction. However, these modalities have their own distinct qualities and may for other reasons (unobtrusiveness in the case of touch, subtlety in the case of olfaction) be very suitable in some cases. In his article on the use of scent in Human Computer Interaction, Joseph Kaye [13] mentions that 'scent is an excellent medium for ambient or calm display'. One could, for example, imagine a product-service system aimed at helping people to reduce their stress level that emits a lavender scent at times where a stress level is too high for too long. Probably, this scent would be easy to interpret and the message would not be too obtrusive. However, differences in scent recognition, interpretation and preference could be a barrier in designing more specific feedback using scents. Next to this, scent as feedback is not appropriate for rapidly changing information.

The type of information that has to be communicated for some part determines the options that designers of feedback systems have both in choosing a particular modality and the specificity of the feedback. We have seen in the examples that the information communicated ranged from 'a hug' to 'the amount of kWh used in a house at a specific moment'. When designing feedback systems it is very important to determine what the feedback that the system communicates should consist of. What is the minimal amount of information that a user needs and wants to know and in what situation. Asking these questions has to guide the choices in the design of a feedback system.

Our future research is set up in such a way that it will help to find more specific design guidelines for feedback systems that apply to persuasive technology that is used in different situations. Different forms of feedback will be designed which will systematically vary on the two dimensions discussed.

5. References

[1] Boulay, M. Available at <http://mickaelboulay.fr 16> [Accessed 26March 2013] and personal communication 2013.

[2] Consolvo, S., McDonald, D. W., & Landay, J. A. (2009). Theory-Driven Design Strategies for Technologies that Support Behavior Change in Everyday Life. *Chi2009: Proceedings of the 27th Annual Chi Conference on Human Factors in Computing Systems, Vols 1-4*, 405-414.

[3] Consolvo, S., McDonald, D. W., Toscos, T., Chen, M. Y., Froehlich, J., Harrison, B., . . . Landay, J. A. (2008). Activity Sensing in the Wild: A Field Trial of UbiFit Garden. *Chi 2008: 26th Annual Chi Conference on Human Factors in Computing Systems Vols 1 and 2, Conference Proceedings*, 1797-1806.

[4] Davis, W. D., Carson, C. M., Ammeter, A. P., & Treadway, D. C. (2005). The interactive effects of goal orientation and feedback specificity on task performance. *Human Performance, 18*(4), 409-426.

[5] DiClemente, C. C., Marinilli, A. S., Singh, M., & Bellino, L. E. (2001). The role of feedback in the process of health behavior change. *American Journal of Health Behavior, 25*(3), 217-227.

[6] Fogg, B. J. (2002). *Persuasive Technology. Using computers to change what we think and do.*: Morgan Kaufmann.

[7] Guadagno, R. E., & Cialdini, R. B. (2002). Online persuasion: An examination of gender differences in computer-mediated interpersonal influence. *Group Dynamics-Theory Research and Practice, 6*(1), 38-51.

[8] Ham, J., & Midden, C. (2010). Ambient Persuasive Technology Needs Little Cognitive Effort: The Differential Effects of Cognitive Load on Lighting Feedback versus Factual Feedback. *Persuasive Technology, Proceedings, 6137*, 132-142.

[9] Hemmert, F., Hamann, S., Löwe, M., Wohlauf, A., Zeipelt, J., & Joost, G. (2010). *Take me by the Hand: Haptic Compasses in Mobile Devices through Shape Change and Weight Shift.* Paper presented at the Sixth Nordic Conference on Human-Computer Interaction. NordiCHI '10., Reykjavik, Iceland.

[10] Ho, C., Reed, N. & Spences, C. (2007). Multisensory In-car warning signals for collision avoidance. *Human Factors 49*(6), 1107-1114.

[11] Hughes, B., & Tillotson, J. (2006). *Design as a Means of Exploring the Emotional Component of Scent.* Paper presented at the 5th Conference on Design and Emotion Chalmers University of Technology, Gothenburg, Sweden.

[12] IJsselsteijn, W., de Kort, Y., Midden, C., Eggen, B., & van den Hoven, E. (2006). Persuasive technology for human well-being: Setting the scene. *Persuasive Technology, 3962*, 1-5.

[13] Kaye, J. (2004). Making scents. Aromatic output for HCI. *Interactions*, 49-61.

[14] McCalley, L. T., & Midden, C. J. H. (2004). Goal-setting theory and product-integrated feedback: A field study of household energy conservation. *International Journal of Psychology, 39*(5-6), 86-86.

[15] Midden, C. J. H., Meter, J. E., Weenig, M. H., & Zieverink, H. J. A. (1983). Using Feedback, Reinforcement and Information to Reduce Energy-Consumption in Households - a Field-Experiment. *Journal of Economic Psychology, 3*(1), 65-86.

[16] Nike. Available at < http://nikeplus.nike.com/plus/what_is_fuel/> [Accessed 26 March 2013].

[17] Ollyfactory. Available at < http://www.ollyfactory.com/> [Accessed 27 March 2013].

[18] Philips. Available at <http://www.design.philips.com/about/design/designportfolio/design_futures/rationalizer.page> [Accessed 26 March 2013].

[19] Prochaska, J.O. & Velicer, W.F., (1997) The Transtheoretical Model of Health Behavior Change. *American Journal of Health Promotion, 12(1)*, pp. 38-48.

[20] Rosella, F. (2004). F+R Hugs: *How to Communicate Physical and Emotional Closeness to a Distant Loved One?* In A. Kurtgozu (Ed.), Proceedings of the 4th International Conference on Design and Emotion. Ankara: METU Press.

[21] Sensoryacumen. Available at <http://sensoryacumen.com/index.php?option=com_content&view=article&id=89&Itemid=62> [Accessed 27 March 2013]

[22] Spence, C. (2002). Multisensory attention and tactile information-processing. *Behavioural Brain Research, 135*(1-2), 57-64.

[23] Stienstra, J. T., Overbeeke, K., & Wensveen, S. (2011). *Embodying Complexity Through Movement Sonification: Case Study on Empowering the Speed-skater*. Paper presented at the CHItaly, Alghero, Italy.

[24] Toscos, T., Faber, A., An, S., & Gandhi, M. P. (2006, April 22-27). *Chick Clique: Persuasive Technology to Motivate Teenage Girls to Exercise.* Paper presented at the CHI 2006, Montréal, Québec, Canada.

[25] Tromp, N., Hekkert, P., & Verbeek, P.-P. (2011). Design for Socially Responsible Behaviour: A Classification of Influence Based on Intended User Experience. *Design Issues, 27*(3), 3-19.

[26] Van Erp, J. (2005). Presenting directions with a vibrotactile torso display. *Ergonomics* 48(3), 302-13.

[27] Visser, T., Vastenburg, M. H., & Keyson, D. V. (2011). Designing to Support Social Connectedness: The Case of SnowGlobe. . *International Journal of Design, 5*(3), 129-142.

[28] Wattcher. Available at <https://www.wattcher.nl/en/> [Accessed 26 March 2013].