A persuasive approach for indoor environment tidiness

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Reza Rawassizadeh
Institute of Software Technology and Interactive Systems Vienna University of Technology Vienna, Austria
rrawassizadeh@acm.org

Soheil Khosravipour
Institute of Software Technology and Interactive Systems Vienna University of Technology Vienna, Austria
s.khosravipour@acm.org

A Min Tjoa
Institute of Software Technology and Interactive Systems Vienna University of Technology Vienna, Austria
amin@ifs.tuwien.ac.at

ABSTRACT
The tidiness of an environment can provide important information about individuals who are involved in the target environment, such as their behavior, health and mental condition. In this paper, we describe a vision-based approach for measuring tidiness and persuading users to be tidy. Tidiness measurement is based on analyzing changes in an image series and comparing them to an image from an ideally ordered environment. The persuasion process will be carried out by a combination of notifications and rankings. The existing personal and social communication channels of users, such as email and social networking accounts will be employed to persuade them to change their behavior and become more obliged to tidiness.

Categories and Subject Descriptors
H.4 [**Information Systems Applications**]: Miscellaneous

General Terms
Measurement, Design, Experimentation, Human Factors

Keywords
Persuasive Technology, Self-Awareness, Ubiquitous Sensing, Tidiness

1. INTRODUCTION
Nowadays, we benefit from using computers in many ways such as information processing, entertainment, social communication, information retrieval, etc. An interesting usage of personal computers is to integrate them into our daily life and store our personal information. We do this in order to be able to retrieve it in the future and benefit from archiving it. The process of sensing and recording our life information digitally is a form of self quantification. Self quantification tools such as life-logs can be used to assist users in many ways such as altering their behavior. Behavioral psychology (behaviorism) describes behavior as anything a human can do such as feeling, acting, etc.

According to the behaviorism philosopher, Burrhus F. Skinner [20] individuals learn behavior by reinforcement and punishment. The process of getting reinforcement, and producing a new behavior by reinforcement, is called "Operant Conditioning". In simple terms, operant conditioning forms an association between the behavior and the consequences of this behavior. Operant conditioning constitutes the foundation of this work. In this research an application will be employed to continuously record a personal behavior and control consequences of this behavior by encouraging users to change their behavior and become more obliged to tidiness.

Unlike childern, mature individuals are clean and tidy their indoor environmental objects such as desks or rooms as a personal preference and no or little external input can affect their behavior. However, tidying an indoor environment has high potential for procrastination. Self-monitoring which causes self-awareness reduces procrastination [16]. Moreover, Fogg [6] described that self-monitoring is a type of persuasion because it can help users to become self aware, which assists them in behavior modification. He described three things that can prevent a behavior to be changed [7]: lack of motivation, lack of ability and lack of a well-timed trigger to perform a behavior.

Here we assume that the target users are individuals who are motivated towards tidiness. They should be physically and mentally able to change their indoor environment or there should be an ability to perform this task, but they need extra motivation and willingness to change this behavior. Lack of motivation and lack of a well-trigger to perform the behavior are assumed to be reasons that prevent individuals from considering their tidiness status or in particular changing this behavior. Fogg proposed a terminology [5] that indicates that persuasive technologies and methods can employ computers to assist individuals in altering their behaviors. He described the use of computers as persuasive media having many advantages over other media such as interactivity, being more persistent than human beings in interacting with humans, etc.

In this research we employ a still camera to capture pictures from the target environment daily and continuously. The camera is supposed to capture pictures from the indoor environments of users. Then we will describe a method that can measure the target environment tidiness. The measurement process is based on comparing the recent picture with a picture that has been taken when the target environment was ideally ordered. The comparison process will be done through change detection in an image series, but we

do not delve deeply into the change detection algorithms. We describe a persuasive approach as an application that can motivate users to order and clean their environment. The application will provide feedback in the users' available communication channel such as their email. No new communication channel will be employed. Feedback could assist users in self-monitoring and thus self-controlling. This means that we combine suggestion, self-monitoring and tailoring methods to encourage users to alter their behavior.
The remainder of this paper is organized as follows: The next section discusses the design principals. Then the conceptual architecture of the proposed system will be described. Afterwards, related work will be introduced. Subsequently the implemented prototype of the system will be explained. Finally, we conclude this paper and describe future work.

2. DESIGN PRINCIPLES

As a principle of design, the sensing and persuasion process should easily integrate into individuals' daily life. Besides, ethical issues must be taken into account. The following are other design considerations which constitute the foundation of this work.

- Low cognitive load: Clutter of an object can be perceived immediately by users. Unlike other measurements which are based on persuasive approaches, here there is no need to provide visualization. Similar ubiquitous approaches [10, 15, 22] employed ambient displays to provide perceivable information to users. These types of information presentation are used when the information is not easily perceivable by the user and it contains a high cognitive load. Our approach has a low cognitive load because the target object status is easily perceivable by a psychologically healthy user. In particular, the target environment tidiness can map to a numerical range, therefore there is no need to reduce the cognitive load. The method of mapping tidiness to a numerical format will be explained in more detail in the "Measuring Tidiness" section.

- Sharing Influence: According to Zimbardo's *Social Influence* theory [26], sharing information (in our case tidiness status) will have better effects on motivating individuals than not sharing. Besides, Zajonc proposed *Social Facility* theory [25], which describes that individuals perform better when other individuals observe them or participate in performing the same task. These theories lead us to conclude that sharing the output of the system in a social community motivates users to alter their behavior more. In the implementation of the prototype, users are able to send their target object tidiness status to their social network (Twitter or Facebook). We performed a small survey to establish if sharing this information in a social community increases users' motivation to consider their tidiness more or not. This will be described more in the "Evaluation" section.

- User Intervention: A persuasive approach which requires self-survey or any form of user intervention burdens the user unless it encourages the user to perform the required task. According to the *Valence Instrumentality Expectancy* theory [4], humans by nature are not keen to perform tasks which do not entertain or engage them. With this system we tried to prevent such a burden. Therefore we need a mechanism to continuously notify users. This mechanism should require no or little user intervention. In the implemented prototype there is no need for user intervention, after the initial setup of the system.

- Notification Policy: As has been described, indoor tidiness status is something that can be easily identified by the user and unlike electricity or water consumption it does not require any additional effort to make the target information perceivable. Here the intention is to notify users about something of which they are already aware. Hence there is no need to give additional information to users. According to the *Operant Conditioning* theory, individuals change their behavior based on reinforcement and punishment. Here, as a personal motivator, we use an interrupting mechanism, which can be interpreted as a punishment. In the implemented prototype if users' target environment is untidy they will get an email on a daily basis, which notifies them to order their target environment. An additional email in the inbox or an SMS on the mobile phone might cause a little discomfort to users. Since this level of discomfort is not coercive and causes persuasion, it is appropriate motivation for users to consider their target environment tidiness. In addition, based on the operant conditioning theory, using a stimulus repeatedly might cause satiation. Satiation means users have less motivation to change their behavior and the former motivation approach does not encourage them to change their behavior. Hence we believe a light form of obtrusion such as sending an email is an appropriate form of obtrusion and prevents satiation. In other words, creating a strong emotional response or implying force might cause psychological reactance and prevent users to change their behavior [2]. However our approach is a small trigger (stimulus) to assist users in altering their behavior.

- Output Channels: To our knowledge, this information object is not listed as privacy-sensitive information [21]. However in order to abide by ethical issues and respect users' privacy, sharing this information in a social community is not enabled by default and during the prototype installation users can decide to use which output channel they would like e.g. email, Facebook, etc. Moreover studies [11, 23] revealed that users are skeptical to use new tools or systems for their home computing. Therefore, no new communication channel will be introduced in this research and we will use users' available communication channels. Nonetheless the architecture is flexible enough to accept new output channels or configure existing output channels. Output channels could be software applications or external hardware devices.

- Maintaining Data: Captured images are stored in a file system and are not removed. Keeping images has two advantages. First, further studies can be done on combining the tidiness status of the target environment with other users' life-log information. For instance, a life-log system can sense the biological information of

Date	Tidiness Status
12-5-2010	Perfect
13-5-2010	Perfect
14-5-2010	Good
15-2010	Good
16-2010	Good
17-5-2010	Good
18-5-2010	Good
19-5-2010	Bad
20-5-2010	Bad
21-5-2010	Bad
22-5-2010	Jungle
23-5-2010	Perfect

Table 1: Tidiness Status of the Target Environment

the user and the status of the target environment. A knowledge extraction method can be used to check if there is any relation between the users' health and the target environment tidiness status. In simple terms, this information can be used as life-log input data and it could be combined with other life-log data for further knowledge extraction.
Second, keeping a history about the target environments status might be more persuasive to users and provide them with better self-insight. For instance, in the implemented prototype an email will be sent to the user which contains a report as shown in Table 1. This table shows the tidiness status of a user's target environment during this time.

3. SYSTEM DEFINITION

In this research a still camera will be employed to capture pictures from the target environment. Pictures will be taken based on specific time intervals (the default is one picture per day). In order to establish the tidiness status of the target environment images will be analyzed, and if the target environment is messy, the system will encourage users to tidy it. The process of encouragement will be done by sending a message to users' predefined output channels.
This system tries to reflect the long-term consequences of the behavior, therefore feedback is created based on the channel type and usage. For instance an email will be sent once a day, and a Facebook status, which contains the tidiness status, will be created once every three days. We hypothesize that this frequency of status update on Facebook, motivates friends to comment on users' status. However these are default system settings and users can configure feedback creation frequency as well as output channels.
Figure 1 shows the conceptual architecture of the system. The "Change Detection" component is used to detect changes based on the target environment (desk or room). Settings and configuration of the system such as location of images, etc. will be kept in "Application Configuration". "Tidiness Calculation" is responsible for converting the result of image comparison to a human readable number. The "feedback Generator" component is used to create a message and the "Output Channel Manager" streams the message to the related output channels.
In the implemented prototype the camera position is supposed to be fixed. This means that the camera should be mounted at a fixed location, such as a wall, to take a picture of the target environment. Therefore we do not need to perform the image registration, which means no geometric adjustments are required. Image registration is the process of aligning several images into the same coordinate frame [18]. Additionally, our method handles intensity adjustment, but we suggest to users to capture images with a fixed amount of light (e.g. in the night when the light comes from lamps).
The ideal picture is a one that has been captured from the target environment when it is tidied perfectly. Users should manually select the ideal picture. We suggest tiding the target environment as much as possible and then to start using the system. All other pictures will be compared to the ideal picture and the number of changes indicates the clutter status of the target environment.
This metaphor could be interpreted as a sentient artefact [11], because it is an actuator for tidiness and it provides information about the state of the target environment. It provides information about a part of users' personality which is based on the clutter status of their target environment. Furthermore, these pictures are a valuable information source for a life-log dataset, especially when they are annotated and combined with other information. The result of the combination might enable researchers to extract novel information about users' life styles.

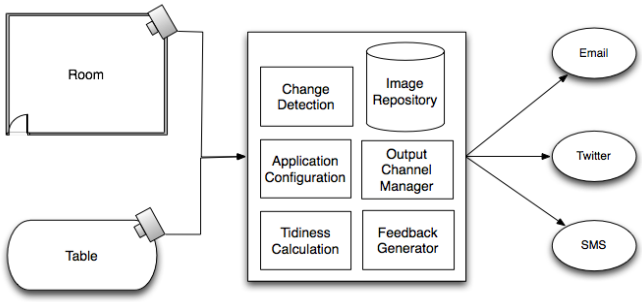

Figure 1: Conceptual Architecture of the System

4. PROTOTYPE IMPLEMENTATION

To implement the prototype, we employ the webcams A4Tech and LogiTech Webcam C260. The Image processing and change analysis is done by MATLAB Image Processing Toolbox [1].
As has been described, the camera location is assumed to be fixed and thus no geometric adjustment is needed. Additionally the camera is connected to the personal computer and the implemented prototype takes pictures automatically with no user intervention (when the picture is being taken, the hosting system should be turned on). In order to ensure a fix amount of light pictures will be taken at specific time

[1]http://www.mathworks.com/products/image

intervals. The system has light adjustment capabilities, but a fix amount of light could improve the change detection quality. It is possible to use any webcam or even a still camera which can be connected to the computer and is able to capture pictures by using the command line.
The system will take a picture every day, based on the predefined time. Pictures will be compared to the ideal picture and clutter status will be calculated and streamed to output channels. Figure 2 shows two images from a desk, the result for which returns as "Bad".

We employ users' Twitter, Facebook and email as output

Figure 2: The image on the left is an ideal image from the desk and the image on the right is the same desk when it is unordered with more than 90% changes.

channels in the prototype. Twitter and Facebook accounts are disabled by default, but users should provide their email addresses to the system. It is possible to extend the output channels and to add a new medium e.g. an application for a home media player.
The prototype sends email notification with (1) a table 1 about the tidiness status of last month and (2) the following message: "Your room has had the status Bad for THREE days. Take a short break to tidy up.". The content of the message which will be streamed to the social output channel could be: "My desk has had jungle status for TWO days". We use low-controlling and concrete messages because high controlling language and long messages could increase reactance and diminish persuasion [14, 17].
It is notable that the architecture is flexible enough to allow developers to add new output channels. We assume that emails is a useful channel in comparison with others, because users are keen to check them and keep them in order. Output channels depend on the target group who use this system, e.g. if they are children, the output might change from email to another such as a software application with visual features.

4.1 Measuring Tidiness

In order to measure the tidiness of a target environment, differences between the ideal image and the recent image will be calculated. The calculation will be done based on two methods; one is for the desk and one is for other environments such as the whole room. In particular, we measure color intensity differences between two images [24], in percentage. First this method converts the image to a gray scale, then it compares two pictures pixel by pixel. The intensity difference is calculated between pixels of the same coordinate. Then we calculate the arithmetic mean of intensity differences of all pixels. Nonetheless the change percentage is not shown to users and instead some adjectives will be used. If the result is more than 50%, the term "jungle" will be used. Between 50% and 40%, "Bad" between 40% and 20%, "Good" less than 20%, "Perfect".
This approach is our general approach, but because of the importance of desk tidiness, we develop a specific method to calculate the tidiness status of users' desks. The desk tidiness calculation will be done by detecting changes of objects in two images using SIFT algorithm [12], which can detect objects on the desk. First we threshold the image, then objects on the target desk are identified by detecting their edges and stored in a repository. This process will be continued for all objects that are located on the desk. Afterward, objects in the ideal image will be compared with objects in the current image by using SIFT algorithm. The tidiness status of the target environment is measured by calculating the percentage of object changes between images.
To realize the desk scenario let N(i) be the number of objects, which were on the ideally ordered desk and let N(c) be the number of objects, which are currently on the desk. N(s) is the number of objects, which are in both ideal and current situation images and N(n) is the number of objects, which are only in the current situation. The tidiness status of a desk (T) will be defined as follow:

$$T = N(s)/N(i) - N(n)/N(c) \quad (1)$$

T is a real number between -1.0 and +1.0. We assume that the desk has one of the following statuses:

1. **Perfect:** $1.0 \geq T \geq 0.66$
2. **Good:** $0.66 > T \geq 0.33$
3. **Bad:** $0.33 > T \geq 0$
4. **Jungle:** $0 > T \geq -1.0$

5. EVALUATION

In order to evaluate the system, five users installed and used the prototype for one month. They are between 24 and 31 years of age, and active in using social network sites. They have good or average computer skills. Three of them were women and two were men. Two of them installed the prototype on their desk, one of them in the room, and one for both. The system was tested for one month without changing the predefined settings. It sent an email a day (if the result was not Perfect or Good) and a Facebook status update once every three days.
After using the system for one month, we conducted a small survey to evaluate the system and asked them to answer some questions about (1) prototype quality and (2) persuasive effect. Four users ranked the prototype quality good or very good and one ranked it below average. In another question we asked them to describe the prototype usability and problems. Two users argued that keeping the lights turned on at a specific time is a cumbersome task.
In another question we asked them to describe the influence of this system on their environment status. Three of them described that sharing the status in their social network was interesting and they would like to continue using the system. They described that other users' comments and feedback

motivated them to change their behavior. One user decided not to share anything on the Facebook and she argued that sharing was a threat to her privacy. Another user claimed the system was not useful at all, but she shared her information. Although we can not generalize the results of this small user group evaluation, the results show that sharing this kind of information could have better persuasive effects than not sharing it at all.
Assigning a number to the tidiness status is not easy, because individuals interpret tidiness differently. Therefore we asked users about the quality of the prototype for tidiness calculation. Four users stated that they were satisfied with the result and it was acceptable for them.

6. RESTRICTIONS AND CONTROVERSIES

Although the framework and its functionality satisfies most users, we have identified the following challenges and shortcomings. They have been identified based on users feedback after using the prototype for one month.

- Evaluating tidiness is superficial: It might be argued that employing technology and additional hardware devices to monitor and persuade users to be tidier is a superficial approach. But the tidiness status provides interesting information about a user's personality [19]. Moreover, this information in combination with other user's information could provide details about the user's mental state [13]. For instance it can assist psychologists in studying patient health or combining this information with other longitudinal detail of the user, enabling researchers to extract knowledge about the user's life e.g. room tidiness could have direct relation to the amount of time the user spends away from the target environment.
- Environment decoration changes: Changing the decoration of the target environment and moving objects could affect the tidiness calculation, so users should take a new ideal picture to restart the calculation process. For instance buying a new couch for the room has a significant impact on the ideal image, and makes it necessary to create another ideal image.
- Different objects with similar visual properties: Another problem which has been identified is objects of similar color, size and shape. For instance, if the user puts a black doll on a black keyboard this may not be registered as a change in the picture.
- Nuisance changes of the target environment: This approach supports only rigid objects. Non-rigid objects such as fruits and flowers in the room are not covered by this research, because over time the visual appearance changes and this affects the tidiness calculation. It is usual that rooms or desks contain nonrigid objects.

7. RELATED WORK

Related works can be analyzed from two perspectives. First we describe approaches that record an activity or a set of users' activities in the long-term. These systems give feedback to users based on their past activities. In a more technical sense, they are persuasive approaches which record information continuously, and the persuasion process is done based on past records. Second, we describe approaches, which have been used for image comparison.

7.1 Persuasive Behavior Modification

ViTo [9] uses a PDA as a home entertainment remote control device which records T.V viewing duration and music player usage. It was designed to assist users in altering their behavior by embedding behavior change strategies into their interaction with the device.
UbiFit [3] is a ubiquitous based approach, which uses the mobile phone to record users' physical activity. It provides an aesthetic representation of users' physical activities to encourage them (by positive reinforcement) to perform physical activities. An external hardware device can be used to detect types of activities. A garden will be shown on users mobile phone screen, and flowers represents users physical activities. Each flower maps an individual event. The more activities users perform the more flowers they see on their screen.
show-me metaphor [10] employs a simple ambient display to show how much water users use when they take a shower. The ambient display shows in the form of LEDs on a stick. This display is used to encourage users to use less water.
Nakajima et al. [15] propose two persuasive approaches, "Viral Aquarium" and "Mona Lisa Bookshelf". Viral Aquarium is composed of an ambient display and toothbrushes with an accelerometer sensor. It is designed to motivate users to consider their toothbrushing pattern. If users brush their teeth according to a specific pattern, fishes in the aquarium multiply otherwise they die. Mona Lisa Bookshelf uses a still camera, video camera, distance sensor and a flat display to monitor the book shelf and record changes on the book shelf. It tries to encourage users to keep books on the bookshelf organized and return missing books. If the book order is wrong or they are tilted, Mona Lisa's picture start tilting, and if the books are not removed from the bookshelf over a week then Mona Lisa's face starts getting older.

7.2 Vision-Based Change Detection

Different type of applications are relying on image change detections, especially remote sensing and video surveillance [18]. Our approach is very simple, because the background of images do not change and due to a fix camera position no geometric adjustment is needed. Here we refer to research which uses either a video camera or a still camera to record and extract information from image series or videos.
VIOLAS [8] proposed vision-based sensing for object location in sentient buildings. It employs different types of cameras to extract contextual information from objects in a target environment. It provides a model to support facility management and indoor-environmental controls.
Kidsrooms [1] is an interactive play space which focuses on kids entertainment in a room. A room similar to a child's room was built in the Lab and developers proposed some interaction scenarios to study construction of complex spaces. This project employed video cameras for tracking children and detecting their motions.

8. CONCLUSION AND FUTURE WORK

In this research we introduced a method for measuring indoor environment tidiness. It measures changes in image series and uses them to induce tidiness. Like other persuasive

approaches we focus on a very small aspect of personal behavior changes via self-monitoring. The proposed approach can be used as a component on a smart home platform. Tidiness status can be shared in social networks to motivate individuals' tidiness, e.g. a group of children can be challenged to keep their room tidy. A potential study subject could be to combine this information with other resources, thus extracting knowledge about individuals' behavior. For instance, aggregate this information with a user's mental state, and establish if the mental state of the user can affect his/her tidiness status or not.

9. REFERENCES

[1] A. Bobick, S. Intille, J. Davis, F. Baird, C. Pinhanez, L. Campbell, Y. Ivanov, A. Schütte, and A. Wilson. The KidsRoom: A Perceptually-based Interactive and Immersive Story Environment. *Presence*, 8(4):369–393, 1999.

[2] J. Brehm. *A Theory of Psychological Reactance*. Academic Press New York, 1966.

[3] S. Consolvo, D. McDonald, T. Toscos, M. Chen, J. Froehlich, B. Harrison, P. Klasnja, A. LaMarca, L. LeGrand, R. Libby, I. Smith, and J. Landy. Activity Sensing in the Wild: A Field Trial of Ubifit Garden. In *Proceeding of the Twenty-sixth Annual SIGCHI Conference on Human Factors in Computing Systems*, pages 1797–1806, 2008.

[4] C. Finder. Valence-Instrumentality-Expectancy Theory Craig C. Finder. *Motivation and work behavior*, page 144, 1991.

[5] B. Fogg. Persuasive Technology: Using Computers to Change what we Think and Do. *Ubiquity*, 3(44), 2002.

[6] B. Fogg. *Persuasive Technology: Using Computers to Change What We Think and Do.*, page 32. Morgan Kaufmann, 2003.

[7] B. Fogg. Creating Persuasive Technologies: An Eight-Step Design Process. In *Proceedings of the 4th International Conference on Persuasive Technology*. ACM New York, NY, USA, 2009.

[8] O. İçoğlu and A. Mahdavi. VIOLAS: A Vision-based Sensing System for Sentient Building Models. *Automation in Construction*, 16(5):685–712, 2007.

[9] N. Jason, S. Intille, and K. Larson. Embedding Behavior Modification Strategies into a Consumer Electronic Device: A Case Study. In *UbiComp 2006: Ubiquitous Computing*, pages 297–314, 2006.

[10] K. Kappel and T. Grechenig. "show-me": Water Consumption at a glance to promote Water Conservation in the Shower. In *Proceedings of the 4th International Conference on Persuasive Technology*, 2009.

[11] F. Kawsar, K. Fujinami, and T. Nakajima. Augmenting Everyday Life with Sentient Artefacts. In *sOc-EUSAI '05: Proceedings of the 2005 joint conference on Smart Objects and Ambient Intelligence*, pages 141–146, 2005.

[12] D. Lowe. Object Recognition from Local Scale-Invariant Features. In *IEEE International Conference on Computer Vision*, pages 1150–1159, 1999.

[13] C. MacCann, A. Duckworth, and R. Roberts. Empirical Identification of the Major Facets of Conscientiousness. *Learning and Individual Differences*, 19(4):451–458, 2009.

[14] C. Miller, L. Lane, L. Deatrick, A. Young, and K. Potts. Psychological Reactance and Promotional Health Messages: The Effects of Controlling Language, Lexical Concreteness, and the Restoration of Freedom. *Human Communication Research*, 33(2):219–240, 2007.

[15] T. Nakajima, V. Lehdonvirta, E. Tokunaga, and H. Kimura. Reflecting human behavior to motivate desirable lifestyle. In *Proceedings of the 7th ACM conference on Designing interactive systems*, pages 405–414, 2008.

[16] T. O'Donoghue and M. Rabin. Self-Awareness and Self-Control. *Time and Decision: Economic and Psychological Perspectives on Intertemporal Choice.*, pages 217–243, 2003.

[17] B. Quick and J. Considine. Examining the Use of Forceful Language When Designing Exercise Persuasive Messages for Adults: A Test of Conceptualizing Reactance Arousal as a Two-Step Process. *Health Communication*, 23(5):483–491, 2008.

[18] R. Radke, S. Andra, O. Al-Kofahi, and B. Roysam. Image Change Detection Algorithms: a Systematic Survey. *Image Processing, IEEE Transactions on*, 14(3):294–307, 2005.

[19] S. Sitton. The Messy Desk Effect: How Tidiness Affects the Perception of Others. *Journal of Psychology: Interdisciplinary and Applied*, 117(2):263–267, 1984.

[20] B. Skinner. Are Theories of Learning Necessary ? *Psychological Review*, 57(4):193–216, 1950.

[21] D. Solove. Conceptualizing Privacy. *California Law Review*, 90:1087–1155, 2002.

[22] M. Stringer, G. Fitzpatrick, D. Chalmers, E. Harris, R. Krishna, and M. Haarlander. Kuckuck–Exploring Ways of Sensing and Displaying Energy Consumption Information in the Home. In *Proceedings of Ubiquitous Computing, Workshop on Ubiquitous Sustainability: Technologies for Green Values (UbiComp 2007)*, 2007.

[23] E. Tapia, S. Intille, and K. Larson. Activity Recognition in the Home Using Simple and Ubiquitous Sensors. *Pervasive Computing*, pages 158–175, 2004.

[24] J. Walker. *A Primer on Wavelets and Their Scientific Applications*, pages 141–144. CRC press, 2008.

[25] R. Zajonc. Social Facilitation. *science*, 149(3681):269–274, 1965.

[26] P. Zimbardo and M. Leippe. *The Psychology of Attitude Change and Social Influence*. McGraw-Hill New York, 1991.