

Unconscious Persuasion by Ambient Persuasive Technology: Evidence for the Effectivity of Subliminal Feedback

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Abstract. In this paper we explore a fundamental characteristic of Ambient Persuasive Technology: Can it persuade the user without receiving the user's conscious attention? In a task consisting of 90 trials, participants had to indicate which of three household appliances uses the lowest average amount of energy. After each choice, participants in the supraliminal feedback condition received feedback about the correctness of their choice through presentation of a smiling or a sad face for 150 ms. Participants in the subliminal feedback condition received identical feedback, but the faces were presented only for 25 ms, which prohibited conscious perception of these stimuli. The final third of the participants received no feedback. In the next task, participants rated the energy consumption of all presented appliances. Results indicated that supraliminal feedback and subliminal feedback both led to more correct energy consumption ratings as compared to receiving no feedback. Implications are discussed..

1 INTRODUCTION

Since B. J. Fogg [1] introduced the concept, a multitude of research has investigated persuasive technology. For example, recent research indicates that feedback provided by an embodied robotic agent has persuasive effects on behavioral change [22]. That is, in this research people were given feedback about their energy conservation when carrying out washing tasks on a virtual washing machine [22]. Results indicated that social feedback (e.g., when the robot says "Your energy consumption is bad") leads to decreased energy consumption, and that social feedback had even stronger persuasive effects than factual feedback (directly indicating the amount of kWh).

Recently, researchers have started to investigate persuasive technology that makes use of Ambient Intelligence: The increasing pervasion of everyday live with information technology [see 3]. Computers—and thereby persuasive technology—are no longer bound to a specific location, but can be integrated unobtrusively into the environment. This allows new forms of influencing and offers some important advantages over more focal persuasive technologies. One of these advantages is the ability to deploy influence attempts at exactly the right time and place. For example, a device called WaterBot aims to reduce water consumption by tracking and displaying information about water consumption at the sink itself [2]. In

line with the possibilities of Ambient Intelligence, scientists have developed new influencing concepts like implicit interaction [5], environmental persuasion [6], and ambient displays [4]. For example, ambient displays provide users with information by making it available in an environment through "subtle changes in form, movement, sound, color, smell, temperature or light" [4].

An example of an ambient display is perFrame [7], a persuasive picture frame to persuade people into proper sitting posture. More specifically, the perFrame is an unobtrusive interactive picture frame that displays a moving portrait of a close other. This portrait provides affective feedback dependent on the participants' sitting posture (e.g., the close other smiles when the participant sits correctly).

In line with Davis [8], we argue that a clear label for this new type of persuasive technology is Ambient Persuasive Technology. The goal of the current article is to improve the conceptual clarity about this form of persuasive technology. Therefore, we shall present a study that investigates one of the features of this concept.

We argue that one of the most fundamental characteristics of this kind of persuasive technology is that ambient persuasive technology is able to influence attitudes or behavior without conscious attention to that persuasive technology by the person being influenced. For example, the perFrames [7] described above should be persuasive without the necessity of the full, focal and conscious attention to the perFrame. However, in earlier research of ambient persuasive technology, the possibility of spending conscious attention to the persuasive technology always existed. For example, the described perFrames [8] may have been unobtrusive but were nevertheless clearly visible, and participants could easily focus their attention on it. In the current research, we will investigate this question: Can ambient persuasive technology persuade the user without receiving the user's conscious attention?

2 THE CURRENT RESEARCH

In the current research, we will use an embodied virtual agent to give participants feedback about their behaviour. Earlier research suggests that these social agents are able to function as persuasive technology [e.g., 22, 9, 10], or even as ambient persuasive technology [7]. More specifically, participants performed a task that consists of 90 trials. In each trial, participants were asked to make a straightforward choice: They were to indicate which of three household appliances uses the lowest amount of energy in an average family in a average week. These household appliances were chosen in such a way that this was not a very easy task. Participants were presented with sets of

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three household appliances consisting of various combinations of three appliances that use little electricity, and six appliances that use more electricity. Each trial always had one correct answer. An embodied virtual agent (called “Robin SaveEnergy”) was introduced to participants as someone who cares about energy consumption. After each choice, participants (except those in the control condition) received feedback about the correctness of their choice from the virtual agent. That is, some participants (in the supraliminal condition) received feedback about the correctness of their choice through presentation of a smiling or a sad face for 150 ms. Presenting the social feedback for this period of time allows participants to spend conscious attention to it. For participants in the control condition, no social feedback was presented, that is, these participants saw no smiling or sad faces. So, these participants received no information about energy consumption levels of these household appliances.

Importantly, we also devised a version of this persuasive technology in which the user cannot spend conscious attention to the social feedback, because it is simply presented for too short a duration to be consciously noticed. That is, participants in the subliminal condition received the same social feedback as those in the supraliminal condition, but for them the smiling or sad faces were presented only for 25 ms. Presenting information for very short durations is called subliminal priming [for an overview, see 11, 12]. When information is presented only very briefly, people are not able to consciously perceive it [11, see also, 13]. Research has indicated that when faces are presented for very short presentation times of for example 33 ms. [14] and less [e.g., 16, 17, 15], participants are not consciously aware of them being presented. A large literature suggests that concept activation by means of subliminal priming techniques can be quite influential [see, 13]. For example, Murphy and Zajonc [15] found that participants liked Chinese ideographs that were preceded by a subliminally presented smiling face better than the same ideographs preceded by a subliminally presented scowling face.

More recently, research showed that subliminal priming can also be used to prime goal-relevant cognitions, and that when the motive to pursue that goal is active, subliminal priming can be used as subliminal persuasion. For example, Karremans [18] showed that subliminal priming with the brand name of a drink increased people’s choices for the primed brand, but only for participants who were thirsty.

In the current research, we will investigate whether persuasive technology that provides people with interactive feedback about their choices can influence people’s attitudes without the need for conscious attention to the feedback. We argue that this research contains two innovations. First, as described, we will assess one of the most fundamental characteristics of ambient persuasive technology. Second, we will assess a completely new usage of subliminal priming. That is, earlier studies of subliminal priming and subliminal persuasion have all presented people with fixed information [e.g., a brand name, 18]. The current research (to our knowledge) will be the first to investigate whether subliminal priming can successfully be used to give interactive feedback.

After 90 of trials of choice and feedback (supraliminal, subliminal or none), we assessed participant’s attitudes by asking them to rate the energy consumption of all presented appliances. Considering that ambient persuasive technology is able to influence attitudes without the need for conscious attention to the

persuasive technology, we expected not only participants who received supraliminal feedback but also those who received subliminal feedback to rate the energy consumption levels of these appliances more in line with their actual energy consumption levels than participants who received no feedback.

2.1 Method

2.11 Participants and design

Sixty-one participants (39 men and 22 women) were randomly assigned to one of three experimental conditions: a supraliminal feedback condition, a subliminal feedback condition, and no feedback condition. All participants were native Dutch speakers. The experiments lasted 25 minutes, for which participants were paid 5 Euros (approximately \$6.75 U.S. at the time this study was conducted).

2.11 Materials and procedure

Participants were invited to engage in an experiment ostensibly testing their knowledge about household appliances. Upon arrival, they were seated individually in a small room in front of a computer. Next, participants in all three conditions were asked to perform a first task. The purpose of this task was to make the participants familiar with nine household appliances, each depicted on a different picture. In this task, the picture of a household appliance was presented on screen, and participants were asked to indicate how often they used (per week) this type of appliance. Participants could answer by choosing a category (ranging from ‘several times a day’ to ‘less than once a week’). Trials were presented in random order.

After this task, participants were asked to conduct a second task. This task started with the introduction of a drawn figure (see Figure 1). This drawn figure was introduced as ‘Robin SaveEnergy’, and participants were told that this manikin had a strong opinion about saving energy. That is, they were told that for Robin SaveEnergy it is very important to save energy. Also, they were told that to be able to save energy, it is vital to have knowledge on the energy use of a household appliance during an average week in an average household, and that Robin has this knowledge.

Participants were told that the task (choice task) they were about to begin with would measure their knowledge on the average energy use of a certain appliance in an average household per week. After this introduction, the task was explained in detail. Participants were told that on each screen of this task, they would be presented with the pictures of three household appliances, and their task was to indicate which one used the lowest amount of energy in an average household in an average week. More specifically, participants were asked to press a key on the keyboard corresponding to their choice as quickly as possible. In addition, they were told that Robin SaveEnergy would be

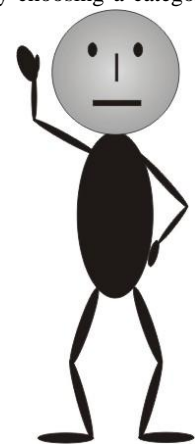


Figure 1.
Robin SaveEnergy



Figure 2. A screenshot of the choice-task

watching their performance in this task. Participants were told that after making their choice, a dot would appear for half a second above the three appliances, and that the face of Robin SaveEnergy would appear next at that same location. They were instructed to press the spacebar as quickly as possible when Robin's face appeared to acknowledge that they had seen him. Participants first completed five practice trials, and then the 90 trials of the experimental task started.

Each trial (of the practice task and the experimental task) consisted of a screen on which three pictures of three different household appliances were presented (see Figure 2). Participants could indicate the one that used the least amount of energy by pressing either the '1', '2', or '3' key.

After one of these keys was pressed, a (focus) dot was presented for 500 ms above the middle one of the three pictures. More specifically, participants in the supraliminal feedback condition were given feedback by presenting a picture showing the smiling face of Robin (see Figure 3) was presented in case of a correct answer, or a picture showing the sad face of Robin (see Figure 4) was presented in case of an incorrect answer. In both cases, the face was presented for 150 ms. For participants in the subliminal feedback condition, the same faces were presented, but only for 25 ms. In all conditions, feedback (a smiling or sad face) was preceded by a premask and immediately followed by a postmask. These masks were used to tightly control the duration of the presentation of the faces (presented for 22 ms), and consisted of a square (equal in size to the faces) filled with random dots. Each mask was presented for 110 ms (for a detailed discussion of subliminal priming methods, see [11]). For participants in the no feedback condition, the procedure of these trials was identical (including presentation of the masks), but no feedback was given, that is, neither smiling faces nor sad faces were presented. Finally, for participants in all conditions the neutral face of Robin (see Figure 3) was presented until they pressed the spacebar. Premask, feedback, postmask, and the neutral face of Robin were all presented at the same location as the (focus) dot.

Previous research using similar subliminal presentation procedures has demonstrated that participants are unable to consciously perceive



Figure 3.
Happy face



Figure 2.
Sad face



Figure 5.
Neutral face

a presentation of 50 ms or less [e.g. 18, 23, 24]. To check whether our participants had consciously perceived the presentation of sad or smiling faces, participants in the supraliminal and subliminal feedback conditions were debriefed and checked for awareness of these faces using a funnelled debriefing procedure. Results of this debriefing indicated that all participants in the subliminal feedback condition were unaware of these sad or smiling faces, whereas all participants in the supraliminal feedback condition reported having seen these faces.

To describe the nine appliances, we used pictures of a microwave oven, a water cooker, a flatiron, a coffee making machine, a computer, an audio set, a washing machine, a vacuum cleaner, and a television set. The first three of these are household appliances that use little energy in an average family in an average week, whereas the last six use more (www.milieucentraal.nl). In every trial (of the practice task and the experimental task), one of three low-energy-consumption appliances was presented in any possible combination with two of the six high-energy-consumption appliances. Furthermore, the three low-energy-consumption appliances were never displayed together. For each low-energy-consumption appliance, 15 combinations with the other appliances were possible. The total of 45 (3 times 15) combinations was presented twice to form the 90 trials of the experimental task. For the five practice trials, five random selections of possible combinations between five different household appliances were presented.

Next, all participants answered the questions that served as the dependent measures. More specifically, participants were asked to rate the energy consumption levels of all nine household appliances. On nine different screens, the picture of a household appliance was presented together with the question "How much energy does this appliance use in an average household in an average week?" and participants could indicate their answer on a 5-point rating scale (1=very low energy consumption, 5=very high energy consumption). So, three of these questions were about the three household appliances that used little energy, and the mean answer to these three questions was our first dependent variable. The mean ratings of the energy consumption of the six appliances that use more energy functioned as the second DV.

Finally, participants answered several demographic questions, were debriefed and thanked for their participation.

2.1 Results

The average energy consumption ratings for the low energy consumption appliances and the average energy consumption ratings for the high energy consumption appliances were submitted to a 3 (feedback condition: supraliminal feedback vs. subliminal feedback vs. no feedback) x 2 (appliance type: low energy consumption vs. high energy consumption) MANOVA, with the last variable within-subjects. This analysis showed that all participants correctly rated the low energy consumption appliances as consuming less energy ($M = 2.7$, $SD = .7$) than the high energy consumption appliances ($M = 3.6$, $SD = .5$), $F(1, 58) = 51.54$, $p < .001$, $\eta^2 = .47$. However, this effect was qualified by condition, that is, we found a significant interaction of Appliance Type x Feedback Condition, $F(2, 58) = 4.39$, $p = .017$, $\eta^2 = .13$. As expected, special contrast analyses indicated that participants who had received *supraliminal* feedback indicated a bigger

difference in energy consumption ratings between the low energy consumption appliances and the high energy consumption appliances ($M = 2.6, SD = .5$ vs. $M = 3.8, SD = .4$) as compared to participants who had received no feedback ($M = 3.0, SD = .8$ vs. $M = 3.3, SD = .5$), $F(1, 58) = 8.24, p = .006, \eta^2 = .12$. Intriguingly, as expected, participants who had received *subliminal* feedback also indicated a bigger difference in energy consumption ratings between the low energy consumption appliances and the high energy consumption appliances ($M = 2.6, SD = .7$ vs. $M = 3.6, SD = .5$) as compared to participants who had received no feedback, $F(1, 58) = 4.52, p = .038, \eta^2 = .07$. Finally, a direct comparison did not suggest that participants who had received *subliminal* feedback indicated a bigger difference in energy consumption ratings between the low energy consumption appliances and the high energy consumption appliances as compared to participants who had received *supraliminal* feedback, $F < 1$. All means and standard deviations are presented in Table 1.

Table 1 Mean Energy Consumption Rating (and Standard Deviations) for Low Energy Consumption Appliances and High Energy Consumption Appliances by Feedback Type

Appliance Type	Feedback Type		
	Supraliminal	Subliminal	No Feedback
Low Energy Consumption Appliances	2.6 (.5)	2.6 (.7)	3.0 (.8)
High Energy Consumption Appliances	3.8 (.4)	3.6 (.5)	3.3 (.5)

Note. Standard deviations between brackets.

3 GENERAL DISCUSSION

Results of the current study indicate that not only participants who received *supraliminal* feedback but also those who received *subliminal* feedback gave more correct ratings of the energy consumption levels of household appliances than participants who received no feedback. Remarkably, feedback that was presented *subliminally*--only for 25 ms.--led to an influence on energy consumption ratings that was similar to the one caused by *supraliminal* feedback that was presented for 150 ms. and could clearly receive conscious attention and processing. This *subliminal* feedback was presented too short to receive conscious attention [see e.g., 14], nor did any of the participants in this condition indicate having (consciously) seen the smiling faces or the sad faces. The current research is in line with earlier work that shows that *subliminally* presented faces can influence attitudes or behaviour [e.g., 14, 15, 16, 17].

So, can persuasive technology persuade the user without receiving the user's conscious attention? The current results suggest that it can. In addition, these results suggest that (at least in the current task) *interactive* feedback that people can spend attention to has the same influence as *interactive* feedback that people cannot spend attention to. Of course, future research should further investigate this first and intriguing finding. But the current results do suggest that *ambient* persuasive technology of which people are not consciously aware may have an influence on people's attitudes, and that influence could (under

certain conditions) be comparable to the influence of persuasive technology that needs focal attention.

We argue that persuasive messages that people do not have to spend conscious attention to can have various advantages. That is, people do not have to spend cognitive effort on it, and can still process it when low on cognitive resources. For example, the current results suggests that the *perFrames* described earlier [7] might have an influence on sitting posture even when people do not spend conscious attention to this interactive picture frame (e.g., after it has been on their desk for 6 months). Also, people may not become annoyed by the persuasive attempts of *ambient* persuasive technology--at least there is no focal influencing technology to become annoyed about, and the same might hold for becoming reactant [see, 19] towards influence attempts.

We argue that there are at least two possible social cognitive mechanisms for the influence of *subliminal* feedback in the current study. First, the *subliminal* feedback given to participants in the current study may have exerted its influence through *subliminal evaluative conditioning* [see e.g., 12]. In *evaluative conditioning*, the pairing of presentation of an object with presentation of a negatively or positively valenced stimulus will eventually lead to the acquisition by that object of the same positive or negative experienced value. An example of *subliminal evaluative conditioning* is research by Krosnick [20] that demonstrated that the evaluation of a target person can be influenced by repeatedly pairing photographs of that target person with positively or negatively evaluated events. So, the influence of *subliminal* feedback in the current research may have occurred through *subliminal evaluative conditioning* [see also, 15]. By pairing the household appliances that use little energy with smiling faces, and the other household appliances with sad faces, the general evaluation of these appliances may have been conditioned, and that may have influenced the energy consumption ratings made by our participants. Second, the *subliminal* feedback given to participants may have exerted its influence through *goal-striving* related processes [see e.g., 21]. That is, earlier research indicated that *non-conscious* goal pursuit can occur. For example, Hassin [21] primed participants with the goal to be flexible without making them aware that this goal had been activated. In a next task, without knowing why, participants showed to be more open minded towards other people. In the current research, comparable *non-conscious* goal-striving processes may have been at work. But in contrast to earlier research, people were aware of activation of the goal, but unaware of being (*subliminally*) primed with the feedback information that they needed to attain their goal.

A remaining issue concerns the social nature of the feedback. Our study cannot distinguish between the *evaluative* and the *social* nature of the feedback. Recent studies by Vossen, Ham and Midden [25] and Midden and Ham [26] demonstrated that both the *evaluative* and the *social* nature of feedback could add to the total feedback effect. This evokes for future work the question whether both effects would occur as well at the *subliminal* level.

Finally, we like to point at potential ethical issues of *subliminal* information. Interventions that go beyond the control of the receiver should be regulated carefully. The most important reason for this is that *subliminal* priming manipulations clearly lack in transparency. In particular, this will be necessary for applications that are beneficial for the sender. Informed consent by the receiver seems a crucial aspect of *subliminal* persuasion.

Obviously, ethical issues should be an issue for further consideration.

This research sheds light on a fundamental characteristic of ambient persuasive technology: It is able to influence attitudes *without conscious attention* to that persuasive technology by the person being influenced. Future research could investigate whether also behaviour can be influenced this way. With this work, we want to help improve the conceptual clarity about this form of persuasive technology, and we have laid out a methodology to investigate related issues.

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