Exploring the Effects of Strategy and Arousal of Cueing in Computer-Human Persuasion

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Abstract
In this paper, we explore how different strategy (explicit vs. implicit) and arousal (high vs. low) of cueing influence the process of Computer-Human Persuasion. In particular, we study the impact of various combinations of text-based reminder and screen motions at different speed on the attention, comprehension, yielding, retention, as well as perception of heavy computer users in terms of the need of stretch and change sitting posture. Results suggest that hybrid cueing mechanics, especially with low arousal, were more effective and acceptable in general, while high-arousal cueing may be more suitable for less motivated users.

Author Keywords
Computer-Human Persuasion; explicit; implicit; arousal; reminder; physical motion; posture; adherence.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

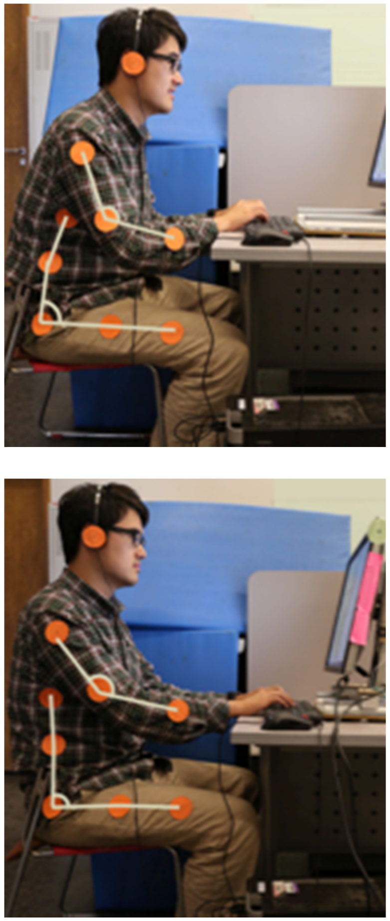

Figure 1: The different behavior of user's stting posture caused by the motion of computer screen.

INTRODUCTION

There has been a growing interest in developing persuasive systems, i.e., information systems designed to reinforce, change or shape attitudes or behaviors or both [14, 5]. While many persuasive systems are designed for behaviors not directly related to information technology e.g., healthy eating, some research has looked into whether computers can help resolve negative consequences of heavy computer usage - in particular, musculoskeletal discomfort [7]. Many researchers followed the Computer-Human Persuasion (CHP) paradigm [5, 14], and utilized the fact that computer users do apply social rules to their interactions with computers [6, 13]. For example, chat agent [2], animations [13], avatar that mimics one's posture [11] and social game [3] were designed to encourage various health behaviors that can reduce muscle/joint pains while using a computer.

According to Fogg's Behavioral Model [5], sufficient motivation, sufficient ability, and an effective trigger are the three key factors for a target behavior to occur. In the case of using a computer to persuade certain behavior that aims to interrupt or reduce computer usage, people may be less motivated due to the confliction with their primary task. In addition, it is difficult for users to abandon bad habits formed after prolonged repetition. Therefore, it is critical to design a trigger that can increase awareness of the problem as well as the willingness and ease to act.

In this paper, we explore how different designs of triggers may affect users' behavior adherence in the context of advocating frequent stretch and sitting posture change to heavy computer users [11] (Figure 1). We designed a CHP system – an intelligent computer screen that can sense users' sitting posture and prompt them to stretch whenever necessary via physical movements, while they are performing a typing task on the computer. Particularly, we investigated the influence of two factors on users' acceptance and adherence: the strategy (i.e., with or without explicit textual reminder) and arousal of cueing (i.e., abrupt screen motion that can be easily detected vs. hard-to-sense slow motion). Results suggest that hybrid cueing mechanics, especially with low arousal, were more effective and acceptable in general, while high-arousal cueing may be more suitable for less motivated users.

PERSUASIVE SYSTEM DESIGN

This section gives an overview of our computer screen-based CHP system for posture correction.

Persuasive Mechanism

Our design of explicit versus implicit cueing strategies corresponds to the two routes of persuasion [15]. We implemented a popup reminder on the screen - one of the simplest, most frequently used interventions [2] - to enable the direct, central route to persuasion [15]. The reminder explicitly informs computer users the benefits of the target behavior. However, it may not always provoke reaction [18] in tradeoff with the primary task. Therefore, we created an indirect, peripheral route to persuasion via screen movement based on the Proxemics Theory [9]. We envision that when the screen moves towards the users, they may consciously or unconsciously sit back to keep a distance from the screen. In this case, the system does not clearly notify users of their bad posture; instead, it gets users to react without profound thinking [15].

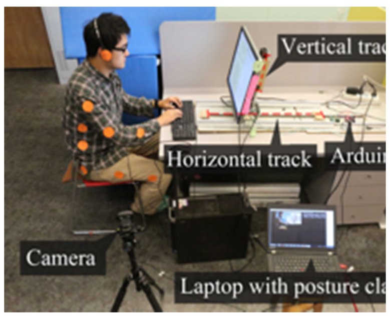

Figure 2. Apparatus and experiment

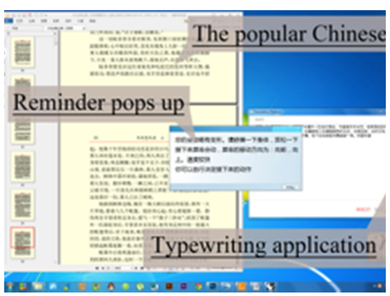

Figure 3. Task interface with popup reminder.

The arousal of cueing is another dimension that we are interested in. On one hand, researchers have studied the use of subliminal cueing in CHP, i.e. influence behavior in an unobservable manner without entering consciousness [17, 9]. In our system, we implemented covert cueing as the slow, hard-to-detect screen movement that recedes into the background of experience. On the other hand, some designers made systems that create dramatic experiences to evoke attention and empathy (e.g., [1]). Such techniques often incite interpretation rather than providing information [16]. In our system, abrupt screen movement serves as a strong stimulation to automate users' behavior change.

In summary, we designed five types of persuasive triggers: 1) reminder followed by abrupt motion (RAM: explicit cueing with high arousal); 2) reminder followed by slow motion (RSM: explicit cueing low arousal); 3) abrupt motion only (AM: implicit cueing with high arousal); 4) slow motion only (SM: implicit cueing with low arousal); and 5) reminder only as the baseline condition (RM).

Apparatus

The main component of our persuasive system is a Dell U2412Mb 24in computer monitor that can freely move along an 80cm-long horizontal track and a 30cm-long vertical track (Figure 2). A Thinkpad T430U laptop communicates with an Arduino Uno board via USB, and controls a motor (6V, 0.4A, 2.4W) that powers the movements of the screen. The laptop also collects live video stream data from a Dostyle CA101 video camera which captures users' posture from the side. The laptop runs a classifier to detect postural distortion from natural sitting posture in real time by tracking a set of markers attached to the participants. The classifier was trained on data collected in a pilot study with 10 people. When the laptop senses that a slumped posture has persisted for more than 30 seconds, it will signals the screen to initiate one of the five triggers. Given the big individual differences in poor posture, we allow manual control of the screen based on human judgment when the confidence level of the classifier is low. We also set the speed of abrupt screen motion to 300mm/s and slow motion to 1mm/s based on pilot study results.

Task Interface

For primary task, we ask participants to enter texts from some popular Chinese novels in a typing application (Figure 3), which automatically logs every key stroke event in the backend. When the reminder pops up in the center of the screen, the message box will keep shaking until users close it manually (Figure 3). In the RM condition, the message sent is *"There is some distortion in your posture. Please relax your body."* In the RAM/RSM conditions, the reminder tells users that *"There is some distortion in your posture. The screen is about to move forward and up rather rapidly / very slowly. You can decide to follow it or not."* If users take actions as instructed immediately after the reminder pops up, the system will inform them that *"Since you have adjusted your posture, the screen will stay. You can decide what to do next."*

EXPERIMENT

To study the effects of different persuasive triggers, we conducted a controlled lab experiment. Generally speaking, people are processing information when being persuaded [13]. Therefore, we evaluated the efficacy of different persuasive triggers on the different aspects of an information processor [15]: 1) attention;

Attention (5-pt Likert Scale)
I am aware of the need to relax and change my posture.
I feel distracted by the reminder.
I feel annoyed by the reminder.
Comprehension (5-pt Likert Scale)
I get confused by the reminder about what to do next.
I feel that the reminder is appropriate.
Yielding (Video analysis)
Level of sitting posture change
Numbers of repetition of posture change
Retentions
I stretch on my own without being reminded again. (**5-pt Likert Scale**)
Duration of maintaining the natural posture (**video analysis**)
Perception (5-pt Likert Scale)
I enjoy using the reminder.
I find the reminder very effective.

Table 1. Measurements of attention, comprehension, yielding, retention, and perception.

2) comprehension; 3) yielding to the position presented; 4) retention of targeted behavior; and 5) perception.

We used a within-subject design, and counter-balanced the order of the five conditions. The study consisted of five 10-minute sessions, one for each condition with a 3-minute break in between. The entire study took about 80 minutes.

Participants
Via posting on social networking sites and online forums, we prescreened and recruited 15 paid participants who were self-reported to be heavy computer users that suffer from posture problems. Of all participants (nine females), 53% were in the 21-25 age range, 27% in 26-35, and 20% below 20. All participants used computer for more than six hours per day, mostly for text processing and web browsing. We made sure that all participants experienced postural distortion within three minutes in front of a computer before they took part in the study.

Procedure
We informed the participants that they were going to evaluate five designs of intelligent screen that aim to help users correct their postures when working at a desktop computer. We instructed participants that their primary task was typing a novel word-by-word on the computer, and that we would keep track of their performance. Prior the main task, we recorded the natural posture (with the screen 60cm away) of each participant as a positive example for the classifier. We told participants that the screen would prompt them to exercise their back and change their sitting postures if necessary, but it was up to them to decide whether to take the action or not.

During each session, the persuasive cueing mechanism was triggered every time the system observed a deviation from a participant's natural posture of more than five degrees of lumbar flexion angle [3] for more than 30 seconds. Each cueing method was tested at least once, and we would manually start one in the last two minutes of the session if none had been started. At the end of each session, participants filled out a post-session questionnaire regarding their experiences on a 5-point Likert scale. Upon the completion of the entire study, we interviewed the participants, asking them to compare the different design of triggers. We video recorded participants' behaviors and interview responses, and logged all the Arduino control signals as well as the results of real-time posture analysis.

Analysis and Results
We evaluated the efficacy of different persuasive triggers [15] in terms of attention, comprehension, yielding to the position presented, retention of targeted behavior, and perception through analysis of post-study questionnaire and video logs (Table 1).

Manipulation Check
In the three conditions with explicit cueing, all participants reported that they spotted the popup reminder. In the two conditions with abrupt screen movement, all participants, except two in the RAM condition, stated that they captured the screen movement. Only 20% of the participants in SM and 40% in RSM thought they noticed some screen motion. Participants' level of confidence in different conditions varied significantly ($F(3,56)=4.13$, $p<0.05$, $\eta^2=0.18$).

Post-hoc Tukey HSD analysis showed that people in RSM were significantly less sure about their observation ($p<0.05$) than those in AM and RAM. Post-study interviews revealed that users noticed the slow motion only if they are sensitive about the distance between their eyes and the screen.

Attention

Participants reported that persuasion mechanics had significant influence on their awareness of the need to relax and change posture (Repeated Measures MANOVA: $F(4,70)=2.50$, $p<0.05$, $\eta^2=0.12$). Results also suggest that different types of screen motion lead to significantly different perception of interruption (Repeated Measures MANOVA $F(3,56)=9.40$, $p<0.05$, $\eta^2=0.35$) and annoyance ($F(3,56)=8.56$, $p<0.05$, $\eta^2=0.31$). Post-hoc Tukey HSD test and post-study interviews both showed that all users found abrupt motions to be significantly more attention catching and compulsive ($p<0.05$). They were often surprised and interrupted by the sudden change distance and screen brightness. All but two users considered such interruption to be uncomfortable. However, some users suggested that they got used to the rapid motion and found it less disturbing later in the study.

Comprehension

Repeated Measures MANOVA results suggest different types of screen motion lead to significantly different level of confusion ($F(3,56)=7.26$, $p<0.05$, $\eta^2=0.28$) and perceived appropriateness ($F(3,56)=4.07$, $p<0.05$, $\eta^2=0.18$). Post-hoc Tukey HSD analysis suggests that abrupt motion were significantly more confusing than slow motions ($p<0.05$). RSM was thought to be significantly more appropriate than the other motion-based mechanics ($p<0.05$).

Users' interpretation of the reminder also affected their attitude. For example, S7, S14 and S15 resented the text reminder as it reminded them of popup advertisements. In contrast, S12 was more positive about the reminder "*Sometimes I even want to reply to the reminder, since I feel that I am chatting with the computer and am emotionally connected to it.*" How users interpreted the screen motion also influenced their behavior. We observed that S13 approached the screen after it suddenly moved to her. "*I knew that the screen wanted me to sit back, but I tried to frighten it in return*," she explained her favor towards abrupt motion in the interview. This suggested that she was undergoing a typical computer-human persuasion.

Yielding

We found that persuasion methods had a marginal effect on the level of behavior adherence ($F(4,70)=2.03$, $p=0.09$, $\eta^2=0.10$) and significant effect on the number of repetition of targeted behaviors ($F(4,70)=2.84$, $p<0.05$, $\eta^2=0.14$) after the first stimulation. We assessed users' posture change actions in four levels through manual video analysis: 0 - no reaction, 1 - some reaction but no obvious posture change, 2 - some posture change, and 3 - completely relaxed and back to the natural sitting posture. Post-hoc Tukey HSD test suggests that RSM were marginally more likely to make users stretch and bring them back to the natural posture ($p=0.09$), and to motivate people (e.g. S2, S4, S7, S8, S10 and S13) to repeat such action throughout the entire session ($p=0.07$) than AM. S10 explained that RSM always kept her alert, "*it did not interrupt my work, but from time to time I got the hint and it reminded me to straight up my back. With the text reminder beforehand, I stay more alert, and I think I* *notice the screen moving more often.*" Similar situations happened to S12 and S14 as well.

Post-study interviews indicated that motivation has an impact on individuals' yielding to persuasion. Highly motivated users (S8, S10, S12, S14) preferred subtle persuasion messages, as S12 said, "*I always pay attention to my sitting pose. A gentle text reminder or slow motion is more helpful for me. The sudden movement is a bit too much.*" In contrast, people with lower motivation (S2, S6 and S13) preferred the abrupt motion, "*A sudden forward movement of the screen forced me to sit back and stretch. I find it very comfortable to relax at that moment.* (S13)" As proposed in Fogg's Behavioral Model [4], a stronger trigger is needed to persuade a less motivated person.

Retention

Participants felt that persuasive mechanics had a significant impact on their intention to retain good behaviors (Repeated Measures MANOVA $F(4,70)=2.78$, $p<0.05$, $\eta^2=0.14$), with RSM significantly more effective than RM (Tukey HSD $p<0.05$). Video analysis showed that the maintenance of the relaxing natural posture after relaxation and stretch varied from user to user. Some (S2, S3, S9 and S13) deviated shortly after (<5s), while others (S6, S8, S11, S15) maintained it for a longer time (>1min). S8 said that AM had a persistent effect on her after the first stimulation, "*The movement was so dramatic that I kept warning myself to avoid a second strike.*" Similar learning effect occurred to S3 and S6 in RSM. They tried to avoid "the surprise" by straightening up immediately after the text reminder.

Perception

Generally, participants indicated that persuasion mechanics had a significantly impact on their efficiency at work (Repeated Measures MANOVA $F(4,70)=5.20$, $p<0.05$, $\eta^2=0.23$), and thus resulted in significantly different levels of enjoyment ($F(4,70)=6.16$, $p<0.05$, $\eta^2=0.26$) and perceived efficacy ($F(4,70)=4.18$, $p<0.05$, $\eta^2=0.19$). In particular, SM and RSM significantly outperformed the other conditions in terms of intention to use again, and were significantly more acceptable (Tukey HSD $p<0.05$). Participants found SM to be significantly more pleasant than all the other methods ($p<0.05$). However, the results did not reveal any significant differences in participants' fondness and perceived effectiveness caused by the reminder across RM, RAM, and RSM.

CONCLUSION AND FUTURE WORK

In summary, our study on the effect of strategy and arousal of persuasive cueing suggests that: 1) a hybrid of explicit and implicit cueing may achieve better attention and comprehension; 2) cueing with low arousal can lead to better behavior yielding and retention as well as more enjoyable experiences; and 3) high-arousal cueing may be more effective and acceptable for less motivated users.

There were several limitations of this study. In the future, we plan to use better sensing techniques to automate the whole process, conduct larger-scale, longer-term field studies, and explore other designs that may better affect users' behavior and attitudes. We will also explore the effect of different persuasive cueing in other scenarios to assess the generality of our findings.

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