Toward the Zero Attention Interface: Wearable Subliminal Cuing for Short Term Memory Support

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Abstract

In this paper we summarize the results of an experiment showing that subliminal cuing using short-duration masked video fields on a head mounted display can be effective in improving short term memory performance. We found that our subjects did 1.8 *times as well on subliminally cued memory trials as uncued trials, a result statistically significant at the* $\alpha = 0.1$ *confidence level. This suggests subliminal cuing holds promise as a low-attention alternative to overt reminders for some wearable and mobile applications.*

1. Introduction

We conducted an experiment to investigate the application of subliminal visual cuing[3] to short-term memory enhancement using a wearable computer and head-mounted display. Although subliminal cuing has been investigated for use in desktop applications, *e.g.* subliminal help displays for learning a text editor[4], to the best of our knowledge this is the first such study to investigate subliminal cuing in a mobile/wearable context.

2. Experimental Design

We wanted to investigate the application of subliminal cuing to face/name memory support, a typical hypothetical application for a wearable memory aid.

For our test we asked the subject to memorize twenty one women's names and faces chosen at random from the FERET[1] face database and a list of historically popular women's names.

The subliminal output device was was a MicroOptical QVGA clip-on head mounted display driven by custom display hardware on the MIThril wearable computer[2].

The head mounted display was worn for the duration of the experiment (both memorization and memory trials) but only active during the trials.

To simplify the experiment, we used a desktop computer with a 21 inch flat panel display to present the faces for memorization, to present the memory trials, and to log the subject's responses to the trials.

2.1. Procedure

The subject was told that the experiment involved subliminal cuing using the head mounted display. We gave the subject two minutes to memorize all twenty one faces and names. We then tested the subject on their memory of each face, resulting in twenty one memory trials. Each trial lasted twenty seconds.

During the trials the subject received subliminal visual cues. The nature of the cue depended on the experimental category of the trial (unknown to the subject or investigator). There were three categories, each containing seven trials:

1. The "n" trial category (first control group) for which no cuing was provided.
2. The "P" trial category (experimental group) for which correct cuing was provided.
3. The "X" trial category (second control group) for which misleading cuing was provided.

Figure 1. Cue and Mask Image

[1]The FERET face database was provided by the US Army Research Laboratory.

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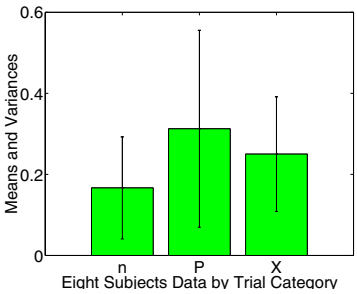

Figure 2. Performance by Category.

During each trial the HMD cycled through ten static masking images, one every two seconds. Depending on the experimental category of the trial, a 1/180th second subliminal frame was dropped in during the transition of one masking image to the next (See Figure 1 for example cue/masking images) resulting in in ten subliminal cues during each twenty second trial period.

For "n" category trials, the subliminal frame was black. For "P" category trials, the subliminal cue was the correct name. For "X" category trials the subliminal frame contained an *incorrect* name.

Our hypothesis was that the subjects would do better on the cued "P" trials than the uncued "n" trials, and that subjects would do about as well on the "X" trials as on the "n" trials if the cues were subliminal. We expected a different pattern of answers on the "X" trials for subjects who could consciously read the cues (see below).

3. Results

Data was collected from seventeen original subjects, of which six were thrown out for violations of protocol. Three more were eliminated because of evidence of conscious cue perception in the form of questionnaire evidence and a tendency to change answers from correctly remembered to incorrectly cued on the "X" trials.

This strongly corroborating questionnaire and "X" trial evidence suggests that no other subjects were able to consciously perceive the cues, and is important to establishing that the cuing was, in fact, subliminal.

For the remaining eight subjects we computed means and variances for each experimental category, and used a one-tailed T-test was used to test the hypothesis that the performance on the "P" and "X" trials was better than the "n" trials. The results are shown in Table 1.

The analysis of the eight-subject data is summarized in Table 1. Performance on the correctly cued "P" trials was $\bar{x} = 0.313$, 1.8 times better than

	"n"	"P"	"X"
$\bar{x}$	0.167	0.313	0.250
σ^2	0.016	0.059	0.020
T		1.410	1.164
p		0.090	0.131

Table 1. Eight subject data analysis

$\bar{x} = 0.167$ for the uncued "n" trials, significant at an $\alpha = 0.1$ confidence level. The performance on the "X" group was better than expected, showing a factor of 1.49 improvement, not statistically significant at the $\alpha = 0.1$ level.

Although not statistically significant, the increased performance on the "X" trials was unexpected. Because the incorrect cues in the "X" trials were correct names for other trials, this increase may be due to a spreading activation[1] effect.

4. Conclusions

Our results suggest that wearable video displays may be used to deliver effective subliminal cues for memory support with little or no conscious perception on the part of the wearer. Further study is needed to confirm this result and to investigate the cognitive load of such cuing. We expect the cognitive load to be quite low, making subliminal cuing useful in a range of task-support applications where overt reminders or alarms would be distracting and inappropriate.

References

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