Differences between a Young and Older Computer Users' Recognition Rate of Tactons

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Abstract. Effective tacton parameters of stimuli have been identified for a young population of computer users. However, studies have shown that the detection of vibrations degrades as a natural part of the aging process. This work used stimulus parameters similar to those which have been shown to be effective in a young population, and conducted a comparison study between 40 test subjects composed of a young population of computer users between 18 and 25 years old and an older population of computer users between 55 and 75 years old. The study compared both groups' recognition rates of modulated sinusoidal waveforms and found that the older group had a significant decrease in recognition rates of modulated sinusoidal waveforms.

Keywords: Tactons, vibrotactile devices, older computer users.

1 Introduction

There is an increasing amount of research that centers on vibrotactile devices that produce vibrotactile cues known as tactons. Tactons rely on cutaneous sensation as a haptic form of output that can be used as an additional modality in Human- Computer Interaction (HCI) [1]. Tactons and vibrotactile devices can have wide-ranging potential in HCI in areas like gaming, virtual reality, navigational aids, and mobile devices. Tactons are of particular usefulness for older populations. A few examples include: supplementing visual displays, which naturally lends itself to enhancing HCI for older adult users with vision impairment. Tactons can potentially be used in multimodal design to reduce cognitive overload and as an additional sensory stimuli. Older populations are known to have additional challenges with sensory degradation and cognitive overload and thus including tactons as part of a multimodal interface could potentially be of benefit to this population [2]. The tacton works in conjunction with a vibrotactile device, which is placed on the body and mechanically produces sensations on the skin surface; these sensations can then be associated with computer functions. Defining tacton stimuli parameters and data structures as well as determining tacton recognition rates and detection thresholds, is an ongoing pursuit [5].

Studies have shown that declines can be seen in vibrotactile thresholds as well as vibrotactile recognition and discrimination with advancing age [4]. Indeed, persons over the age of 55 years old have significantly higher detection thresholds of

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sinusoidal waveforms than younger groups. In their studies, both Stuart et al. [9] and Goble et al. [7] found statistically significant differences of approximately 10 dB in actuator displacement from 10 to 400 Hz of detection thresholds of sinusoidal waveforms, between a young group under the age of 40 years old and an older group between the ages of 55 and 90 years old.

Hoggan & Brewster [8] and Brown, et al., [3] found modulated sinusodial waveforms to be effective parameters of stimuli using a C2 Tactor from EAI systems. These results were based on a young population under the age of 40 years old. Since various studies indicate that older adults over the age of 55 years old have significantly higher detection thresholds, tacton parameters that incorporate modulated sinusoidal waveforms should be tested for their effectiveness in an older population.

A comparison study was conducted between young- (18 to 25 years old) and older- (55 to 75 years old) adult computer users, using the C2 Tactor. This study used similar parameters established by Hoggan and Brewster [8] and Brown et al. [3] that used modulated sinusoidal waveforms. These parameters had recognition rates of 61% [8] and 80% [3] in a young population under the age of 40 years old.

2 Methodology

A total of 40 participants, 20 males and 20 females participated in this study. The participants belonged to one of two groups: young group (18-25) years of age and older group (55-75) years of age. There were 9 males and 11 females in the young group and 11 males and 9 females in the older group. The age of the young group was (M=22.8, SD=2.197), while the older group was (M=63.2, SD=6.725).

Participants were screened through a questionnaire to determine age and dominant hand. In addition, there were several exclusion criteria based on factors which affect vibrotactile sensation. These included: recent use of vibrating equipment, medications, and any relevant medical history. This study used the C2 Tactor vibrotactile device. The input signal to the C2 Tactor was generated by an Intel High Definition Audio sound card on a Windows based personal computer. A Crown D-75 linear amplifier was used to drive the output. The experimental interface and data collection was done on a Windows based personal computer. The signals were analyzed using a Tektronix TDS 310 oscilloscope to verify the generated parameters and output levels.

The experimental interfaces were GUI Java programs to generate the tactons, capture user responses, and write to a sequential file.

3 Experimental Protocol and Parameters

Three separate tactons consisting of three, two-second intervals of 1000 ms sinusoidal wave burst of 250 Hz, a sinusoidal wave burst of 250 Hz modulated by a sinusoidal wave of 30 Hz, and a sinusoidal wave burst of 250 Hz modulated by a sinusoidal wave of 70 Hz were generated. The modulated sinusoidal wave parameters of stimuli were similar to those used by Hoggan and Brewster [8]. The modulated sinusoidal waves were generated using Daqarta software and were produced by multiplying the base sinusoidal waveform of 250 Hz with the modulating waveform.

The baseline output amplitude for experiment 2 was determined based on an exaggerated value of threshold detection, which was done on the experimenter (49 years of age) to ensure that stimulus was felt by both experimental groups, this output was ~500 mVpp.

The chosen location for the C2 vibrotactile device was on the non-hairy portion of the volar forearm of the non-dominant hand, 5 cm from the wrist, and it was attached via a loose fitting Velcro strap. The Velcro strap was placed on the end of the wire and not the C2 Tactor itself, thus only the mass of the C2 Tactor rests on the subject's skin. This ensures uniformity of pressure for all participants as well as avoids any damping effect that woul d occur if additional pressure is applied to the C2 Tactor itself. The subject used the dominant hand to manipulate the mouse and to make selections on the experimental interface. In addition, to provide audible masking, the participants were required to wear headphones; pink noise was generated to ensure that no sound, which may have emanated from the C2 Tactor, was heard.

An initial orientation and training period was conducted, before each experiment. During this training, the participants familiarized themselves with the interface and the vibration stimuli. These are a sinusoidal wave of 250 Hz that represents an incoming "voicemail", a sinusoidal wave of 250 Hz modulated by a sinusoidal wave of 30 Hz that represents an incoming "text message", and a sinusoidal wave of 250 Hz modulated by a sinusoidal wave of 70 Hz that represents an incoming "email". When the test subject felt they could effectively discriminate each tacton the experiment began. A maximum of 30 minutes was allowed for training.

The computer testing interface presented the test subject with one of three random generated tacton cues. The subject was asked to respond which message they were receiving by selecting the appropriate response on the computer-testing interface. Test subjects were allowed only one attempt to identify a particular tacton and were asked to identify a total of 30 random generated tactons, 10 of each type.

4 Results

The level of significance for statistical tests was set at 5% ($\alpha = 0.05$). qqnorm analysis showed all data collected had normal to near normal distribution. Fisher's exact test was performed to determine if there are nonrandom associations between the test results of the two groups.

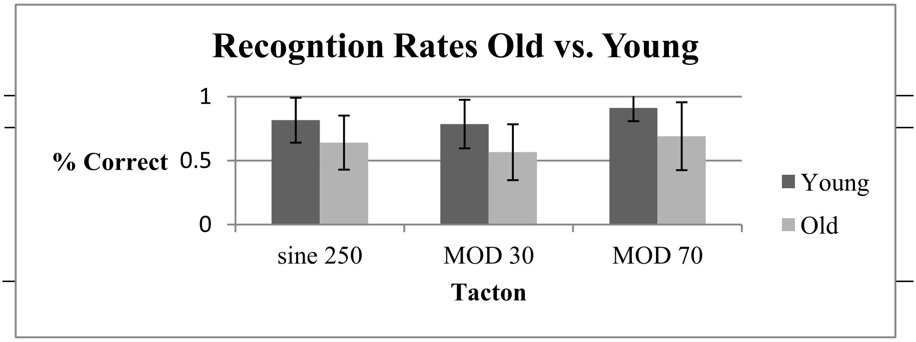

Fig. 1. Tacton recognition rates of both groups

Each waveform recognition rate was analyzed and the results are shown in table1 and figure1.

Table 1. Recognition rate results of both groups

Recognition rates		
P<=.001	**Young**	**Old**
Sinusoidal 250 Hz	**M=82%, SD=.1756**	**M=64%, SD=.2113**
MOD 30	**M=79%, SD=.1899**	**M=57%, SD=.2183**
MOD 70	**M=91%, SD=.1021**	**M=69%, SD=.2654**
Overall	**M=83%, SD=.1668**	**M=63%, SD=.2346**

5 Conclusion and Future Work

This study shows that the overall recognition rates of the younger group were consistent with those findings by

Brown et al. [3], which showed an overall recognition rate of 80%. This study confirms the findings of Brown et al. [3] that modulated waveforms with a base of 250 Hz, can serve as an effective tacton parameter in young populations. In addition, it shows that recognition rates of the same parameters are significantly lower in older adults over the age of 55 years old. The study shows that there is a statistical significance between increasing age and decreasing tacton recognition rate.

Studies have shown that persons over the age of 55 years old have significantly higher detection threshold of sinusoidal waveforms at the upper frequency range than younger groups [9]. It is also known that Pacinian receptors degrade the most with age; these receptors respond to higher frequencies, as the ones used in this study. The differences in tacton recognition rates may be a function of decreased detection thresholds at these upper frequencies.

There are also indications that non-Pacinian receptors degrade less with aging than Pacinian receptors [7], [6]. Therefore frequencies associated with these non-Pacinian receptors, those below 40 Hz may be better suited to produce more equitable results in tacton recognition and discrimination between the two groups. Furthermore, modulated waveforms may not be suitable in achieving more parity between the two groups, particularly at lower frequencies where they may be less flexible to generate and may have less effectiveness.

More studies are needed to see how effective tactons can be at this lower frequency range (10-40 Hz). If these studies show more equitable results, then tacton designers might focus on developing parameters which are most effect at these lower frequencies, and even though they are not at the optimal frequency for detection in younger groups, they may serve as a more universal parameter for detection and recognition across all age groups.

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