A subjective touch to presence: Haptic performance, emotions and subjective significance

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Abstract

The haptic system informs us about the characteristics of external objects leading to object recognition. Subjective Significance is the way one perceives stimuli. It depends on the subjective emotional connotation a person has to a certain stimulus. The same stimulus may carry differential subjective significance value to different persons, in different contexts. Subjective significance is the individual importance that the stimulus carries. An example of subjectively significant stimuli, used in this study, is names of important persons in the subject's life, whom the subject may like (positive subjective significance) or don't like (negative subjective significance). We combined haptic stimuli with subjectively significant stimuli, to study the effect of subjective significance on haptic and attention processing. A cued attention task consists of a cue, which provides information on the following target that is in most cases, but not always, is accurate. Cue validity effects have been described in the visual and auditory modalities, but not in the haptic modality. This study will report two experiments. In the first experiment, subjectively significant stimuli were administered immediately prior to a unidirectional haptic stimuli. In the second experiment haptic cues and haptic targets were administered, and in between subjects listened to subjectively significant stimuli. Subjective affective valence of verbal stimuli was assessed by a validated questionnaire before the experiment. Response time was measured in order to identify the effect of subjective affective valence on response time to haptic stimuli..

Keywords

Haptics, cued attention, emotions, response time.

1. Introduction

Emotionally significant distracters are known to have an effect on target stimuli processing. Distinct effects have been described for negative vs. positive loaded stimuli, with shorter reaction times to negative compared to positive stimuli, and stronger brain response to negative compared to positive stimuli [2, 3].

Subjective significance (emotional loading) is correlated with the emotional connotations one has to a certain stimulus.

First names were chosen as subjectively significant stimuli [1]. The subjective significance of first names is determined by the social relationships with people that carry the names used. Therefore, the subjective significance of first names is easily controlled. Subjective significance evaluation was done by a validated questionnaire, assessing the emotional significance of people relevant to the subject. [1, 2]. The questionnaire included 46 yes\no and rating questions. A neural effect of subjective emotional valence (positive – negative) has been found by Ofek and Pratt, with stronger and earlier brain response to negative subjectively significant stimuli, when compared to positive subjectively significant stimuli [7].

The haptic system informs us about the characteristics of external objects leading to object recognition. It is involved in striking, stroking and in painful experience. Haptics is central in controlling motor acts through the body and limbs. Haptic perception seems to be based on elementary haptic patterns that convey a meaning - a haptic language. Haptic language consists of particular haptic patterns that have a particular meaning, across subjects and across contexts (situations), i.e. haptic interpretation seems valid and consistent.

A cued attention task consists of a cue, which provides information on the following target that is in most cases, but not always, accurate. Cue validity effects have been described using behavioral as well as ERP measures in the visual and auditory modalities, but not in the haptic modality. Cue validity effects were at first behaviorally described by Posner [4] in 1980, in the visual modality. Cued attention effects were described also in the auditory modality, using ERP [5, 6]. The neural effect of subjectively significant verbal distracters administered in a cued attention task has been described by Ofek [2].

The present study had two goals. The first was to characterize the effect of subjective significance on haptic processing. The second was to find and describe haptic cued attention and its interaction with subjective significance. We study here haptic cued attention, in order to examine if it is possible to reproduce, in the haptic modality, cue validity effects (shorter RT to validly cued targets) similar to those that have been reported for the auditory and visual modalities.

2. Methods

Subjects: 10 healthy subjects participated in this study. The subjects' first language was Hebrew. The subjects suffered from no known neurological disorders.

'Name' stimuli: The subjective significance of names was assessed for each subject, using a 46 questions validated questionnaire. The questionnaire was validated both internally, using alpha coherence and factor analysis, and externally, using PAT (peripheral arterial tonometry) as a sympathetic measure (Ofek and Pratt, submitted). 4 names were selected for each subject: one positive name, one negative name, and 2 neutral names. Names were recorded, digitized and saved on the computer as audio files. The protocol includes 2 experiments.

Haptic stimuli: The haptic stimuli were drags by a robotic phantom arm, to the left or to the right. Stimuli were presented by a PHANTOM. The room was dark, so that no visual information was available to the subjects. We developed a system to measure the forces applied by the subjects on the PHANTOM. and the forces applied on to the subject's hand in distinct directions. The subject holds the PHANTOM stylus in his right hand (all the subjects were right handed). The PHANTOM exerted forces on the holding hand - simple drags, to the left or to the right. In the first experiment, subjects had to press a button on the robotic phantom arm as soon as a haptic stimulus was presented. In the second experiment, the subjects had to discriminate the right from left haptic targets, and to press one of two buttons respectively on the phantom arm.

Experimental protocol: In the first experiment, haptic stimuli were administered through a PHANTOM stylus to one direction only (left or right, in separate sessions). Before 80% of the haptic stimuli, a name auditory stimulus was administered (0.7 seconds before the haptic stimulus). Before 20% percents of the haptic stimuli, no name was administered. The effect of the subjective affective valence of the name was assessed on the response time to haptic targets. In the second experiment, both left and right stimuli were included. Each rehearsal included a haptic cue, which directed the attention to the direction of the subsequent haptic target. In most cases, the cue was accurate. In 80% of the rehearsals, one of the four names was pronounced by the system. Timing of the 'name' cue was between the haptic attentional cue and the target (0.7 seconds before the haptic target). Response time was measured in order to find the effect of cue validity and subjective significance of the names distracters on processing.

3. Results

In the present study, effect of subjective affective valence was found on response time to haptic target stimuli. Due to the separation between subjective negative to subjective positive, shorter reaction times to haptic stimuli were found following subjective negative stimuli, when compared to subjective positive stimuli ($p < 0.05$).

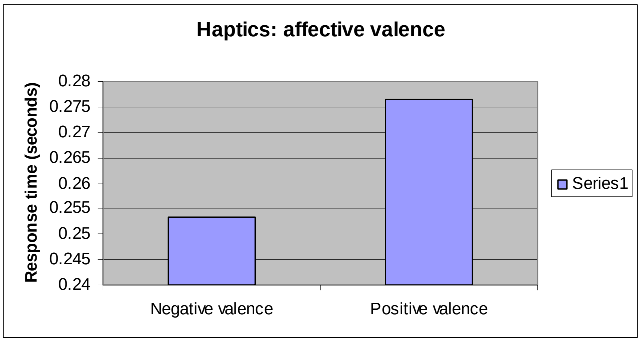

Figure 1.Effect of affective valence of the names on reaction times to haptic stimuli. Effect of cue validity was found, with shorter reaction times after valid haptic cues, when compared to invalid haptic cues.

Table 1: Summary of results

Reaction time (seconds)	Name stimulus
0.253269079	Negative valence
0.276476355	Positive valence
0.047320718	ttest Negative - positive

4. Discussion

Attention and haptic processing interacted with subjective affective significance, with a distinct difference between positive to negative subjectively significant distracters. Haptic processing seemed enhanced when preceded by negative subjectively significant stimuli.

A previous study reported the effect of subjectively significant stimuli on the on-going brain activity during a cued attention task [2]. In that previous study conducted by Ofek and Pratt [2], significant effect of subjectively significant distracters was found on brain activity in an auditory cued attention task. In that study, no separation was done between positive and negative subjectively significant distracters, and thus, no significant effect was found on response time (significant effect was found on brain activity). In the current study, we assessed the distinct effect of subjective positive vs. subjective negative cues on the behavioral response to haptic stimuli. Due to the distinction done between subjective positive to subjective negative, effect was found on the behavioral data, and the specific response defined, with shorter reaction times after subjective negative stimuli.

Ofek and Pratt [7] have shown that the latency of the brain response to negative subjectively significant stimuli is shorter than the latency of brain response to positive subjectively significant stimuli. This finding goes hand in hand with the present finding relating response time to haptic stimuli following subjectively significant stimuli.

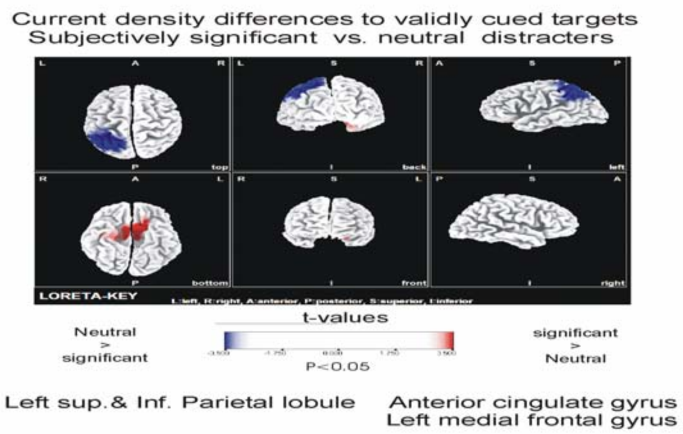

Figure 2. Picture of LORETA image. The pictures presents brain activity analyzed by LORETA (low resolution electromagnetic tomography- a system widely used for source localization. For additional details: (www.unizh.ch/keyinst/New**LORETA**/**LORETA**01.htm) in response to targets in a cued attention task following subjectively significant and neutral name distracters. The picture manifests the effect of subjectively significant names on the brain response to target stimuli. After neutral stimuli, the parietal lobule was activated. After subjectively significant stimuli, the ant. Cingulate gyrus and medial frontal gyrus were activated.

Is decreased response time related to presence? We suggest that this result suggests that emotional effects may improve the involvement and hence may improve presence.

Using the applied definition of presence, as the similarity between physiological-neurological and behavioral responses in a mediated environment to those in a physical environment, these results may suggest a way to measure presence, by testing the decrease in RT in response to subjectively emotional stimuli

In VE, negative connotation stimuli may be used as cues (unrelated to the VE, just to enhance presence), or as part of the VE (avatars with faces negative/positive subjective connotations, or using names the subjects are emotionally positive or negatively attached).

Future studies may include EEG (ERP) or fMRI to characterize better the interference of emotional input with haptic processing.

This study may lay the basics to the building of VR systems using subjectively significant cues.

References

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