Validation of a multisensory workstation in non-human and human primates by measuring facilitatory effects during a visuo-auditory task

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Introduction:

The perception of our environment especially of every type of stimulation depends on the ability to assimilate simultaneously several information coming from different sources, perceived by different sensorial modalities; to integrate them and finally to generate an appropriated behaviour. This ability is named multisensorial integration and it allows improvement of perceptive threshold (decrease of reaction times or less errors).

Data in non-human primates (Cappe et al, unpublished data) have shown that near threshold conditions the cross-modal condition has a facilitatory effect on reaction times and stimulus detection.

The aim of this study is to transpose a self-running protocol developed for primates to humans in order to validate it by characterizing the known facilitatory effects induced by a combination of two sensory modalities (here visual and auditory cues) very close to the theshold.

Methods:

First protocol

Subject: N=2 (H1 and H2)

Stimulus:
Acoustic: Noise bursts, 250 msec duration

Visual: Grey flash (20 cm^2) of 250 msec. on a black background with a green target (8 mm^2). Luminance was varied to determine the threshold.

Tests performed in an audiometric room in diffuse-field (with loudspeakers) condition.

Thresholds: Obtained before multisensorial session recordings

Second protocol

Subject: N=2 (H3 and H4)

Stimulus:
Acoustic: Pure tone bursts, 250 msec duration

Visual: Green flash (20 cm^2) of 250 msec. on green background with a black target (8mm circle). Hue was varied to determine the threshold.

Tests performed in an audiometric room in diffuse-field (with loudspeakers) condition.

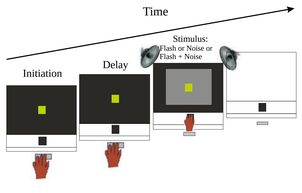
Thresholds: Obtained before and during multisensorial session recordings

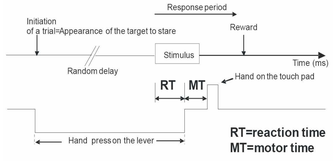
For both protocols the movements of subject's head were restricted by using a modified chin-rest. Furthermore the gaze was locked and in addition the eye position was controlled using an ISCAN eye-tracking system.

Procedure

Psychophysical method based on automated behavioral procedure with positive reinforcement

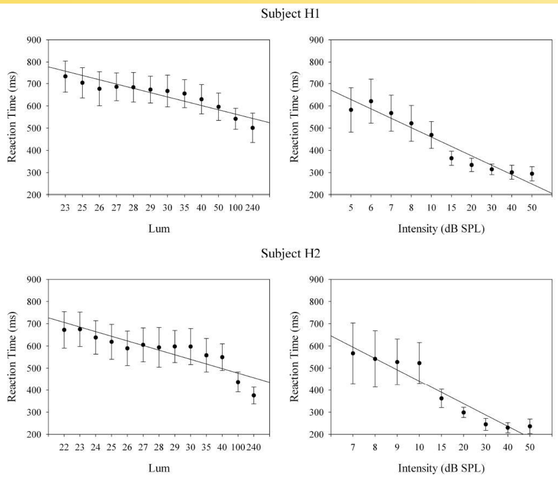
Controlling system designed with MATLAB and Tucker Davis Technologies



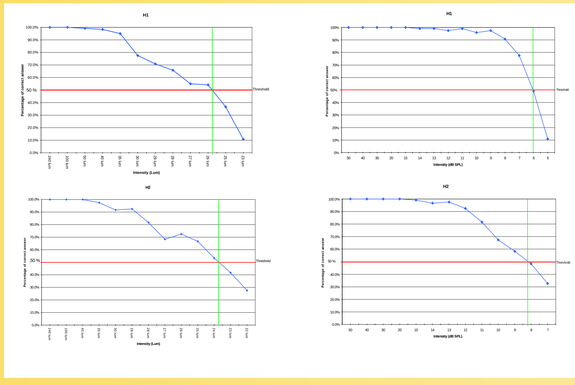


Results

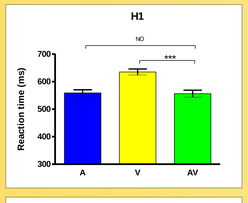
First Protocol



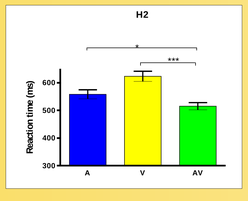
The reaction time decreases when the intensity increases



For the first protocol, the auditory and visual thresholds are evaluated before the cross-modal sessions. 6 sessions were used to obtain an average threshold for auditory and visual stimuli at different intensities.

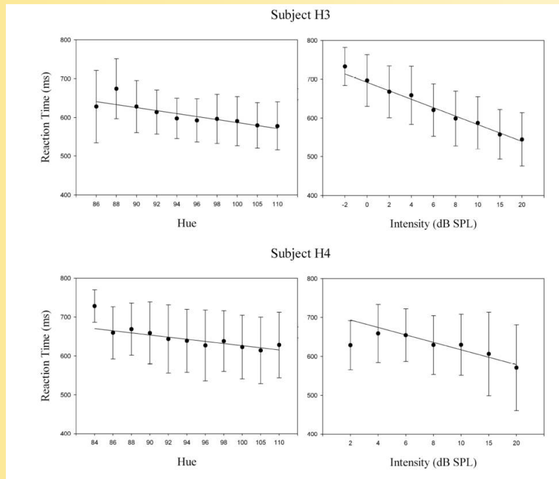


In subject H1, the reaction time is longer for visual than for auditory or visuo-acoustic stimuli. There is no significant difference between the reaction time for auditory and the reaction time for visuo-acoustic

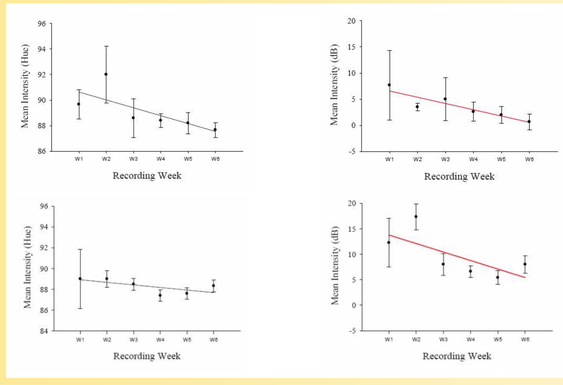


In subject H2, the results show a clear a facilitatory effect. The reaction time is longer for visual than for auditory or visuo-acoustic stimuli and the reaction time is shorter for visuo-acoustic than for both other stimuli.

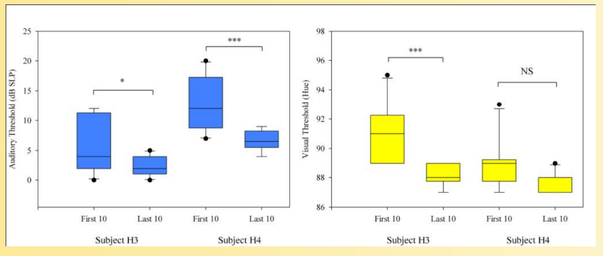
Second Protocol



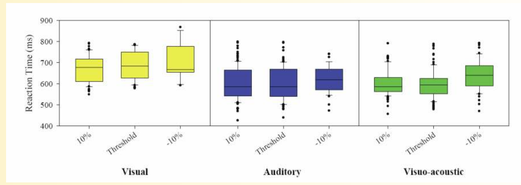
The reaction time decreases when the intensity increases



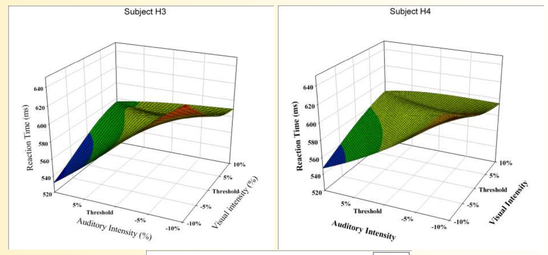
Along the sessions the auditory and visual thresholds show an evolution towards a progressive decrease.

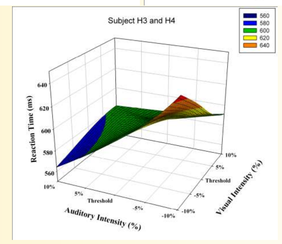


We observe a progressive decrease of the auditory and the visual thresholds from the beginning to the end of the study. For the auditory thresholds the diminution is significant for both subjects.



The reaction time is higher for visual than for auditory or visuo-acoustic stimuli. This difference is statistically significant. However this difference is not significant between the auditory and visuo-acoustic reaction time.





In the conditions tested here, the shortest reaction time is obtained when the auditory intensity is above the threshold and the visual intensity is below the threshold. In contrast, the highest reaction time is obtained when the intensity used is below the threshold (-10% for both stimuli) for both stimuli.

Conclusions:

1° The daily collection of visual and auditory thresholds are required when one wants to characterize facilitatory effect around the threshold, because there is an evolution along time.

2° The reaction times in response of both stimuli are dependent on the intensity of stimulation. The higher the intensity, the shorter the reaction time.

3° The reaction times are shorter in the protocol with noise bursts than with pure tone bursts.

4° The reaction times are longer for visual than for auditory or visuo-acoustic stimuli, independently of the intensity.

5° The cross-modal facilitatory effect on reaction time is present in one subject for stimuli around threshold (--> principle of inverse effectiveness) but is not significant for the 3 others.

Perspectives:

1° A next step is aimed at analyzing the percentage of success during the multi-sensory sessions at both absolute thresholds and sub-liminary thresholds level.

2° Future protocol will integrate larger ranges of intensities above and below the thresholds.

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