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Facilitatory effects during a visuo-auditory task in a multisensory workstation in non-human and human primates

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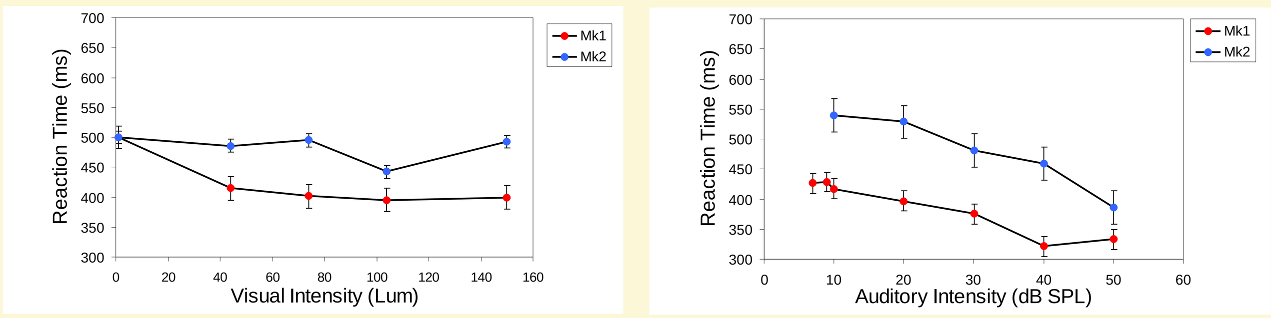
Introduction:

The perception of the external world and the adaptation to our environment depend on the abitility to assimilate simultaneously several information coming from multiple sources, processed by different sensory modalities, to integrate them and finally to generate an appropriate behaviour. This ability corresponds to mechanisms of multisensory and sensorimotor integration which, when improved, lead to a decrease of perceptive threshold and reaction time.

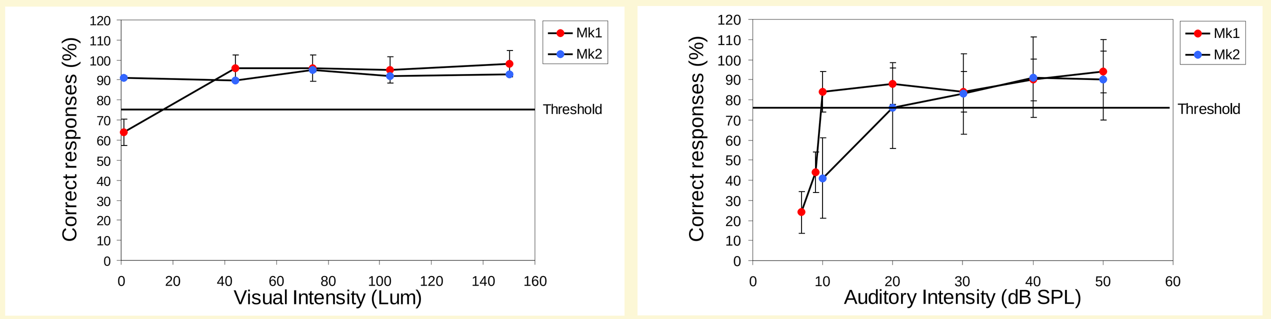
Data in non-human primates (Cappe et al., unpublished data) have revealed that near threshold conditions the cross-modal condition has a facilitatory effect on reaction times and stimulus detection (see "background").

The aim of this study is to transpose a self-running protocol developed for monkeys 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) near their threshold.

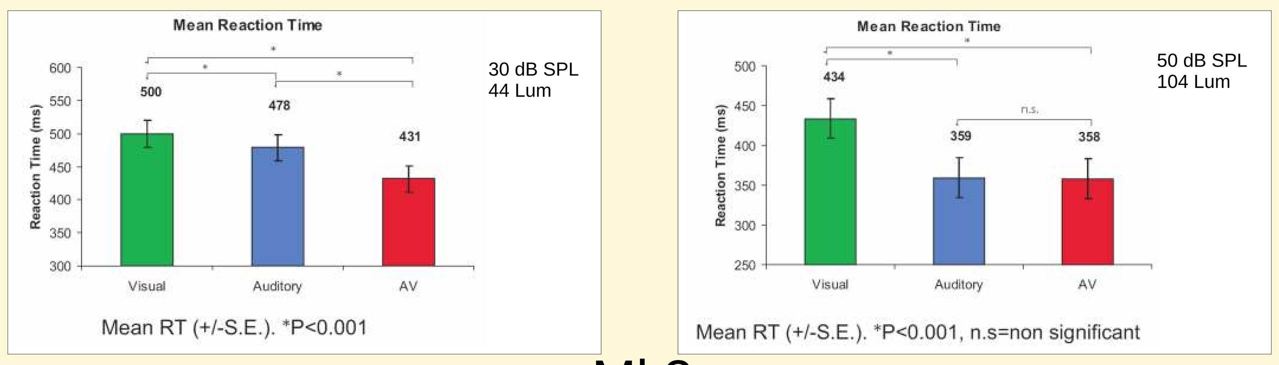
Background



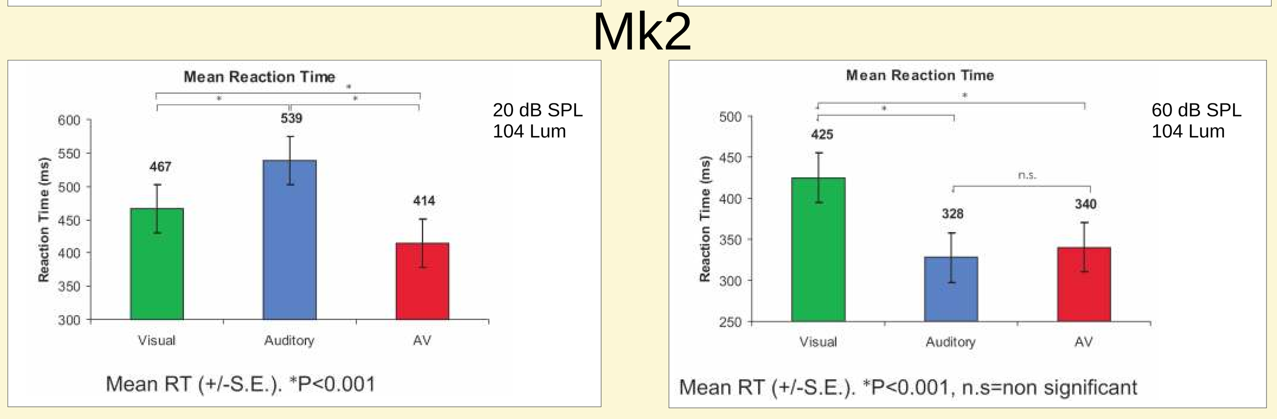
The reaction time decreased when the intensity increased



For this protocol, the auditory and visual thresholds were evaluated before the cross-modal sessions. Several sessions were used to obtain an average threshold for auditory and visual stimuli.



Mk2



Facilitatory effect on reaction time was present close to threshold but not at high intensity. Comparable data were obtained in Mk1.

Procedure

Psychophysical method based on automated behavioral procedure with positive reinforcement

Controlling system designed with MATLAB and Tucker Davis Technologies

First Protocol: (same as in monkeys)

Subject: N=2 human subjects (H1, 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: Determined once before the multisensory session recordings

Second Protocol:

Subject: N=2 human subjects (H3, H4)

Stimulus:

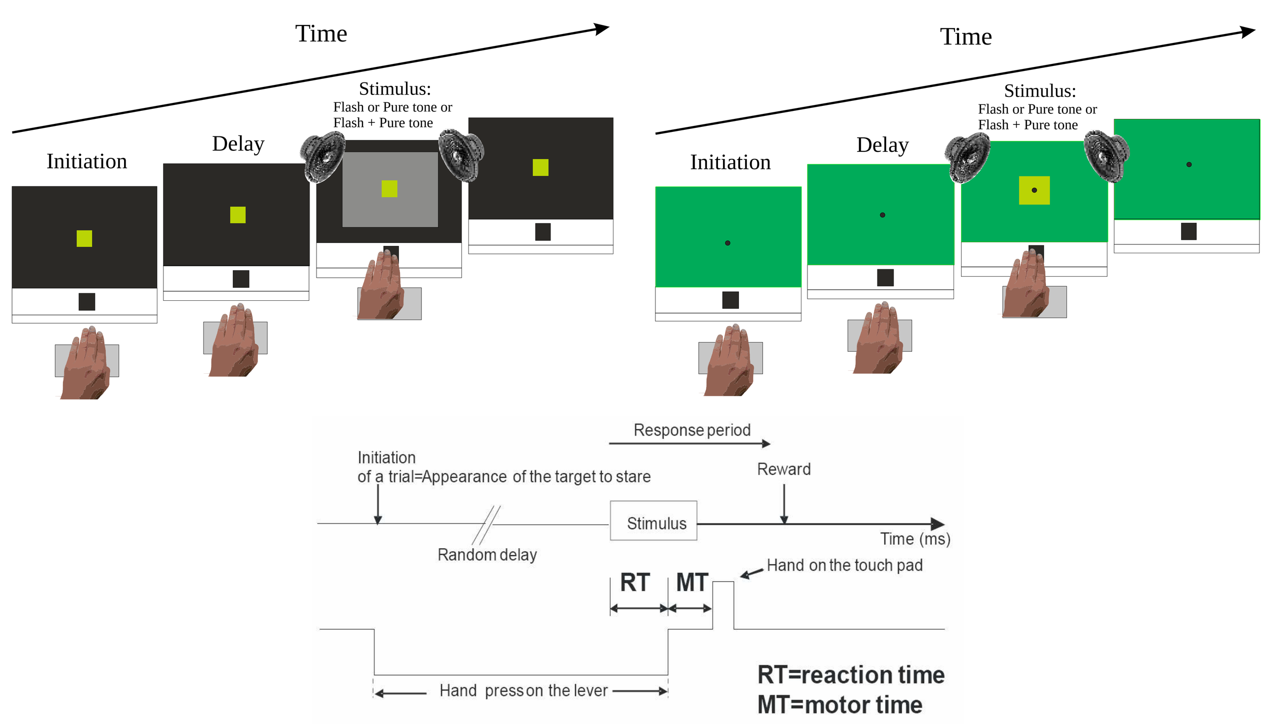
Acoustic: Pure tone bursts (1000 Hz), 250 msec duration

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.

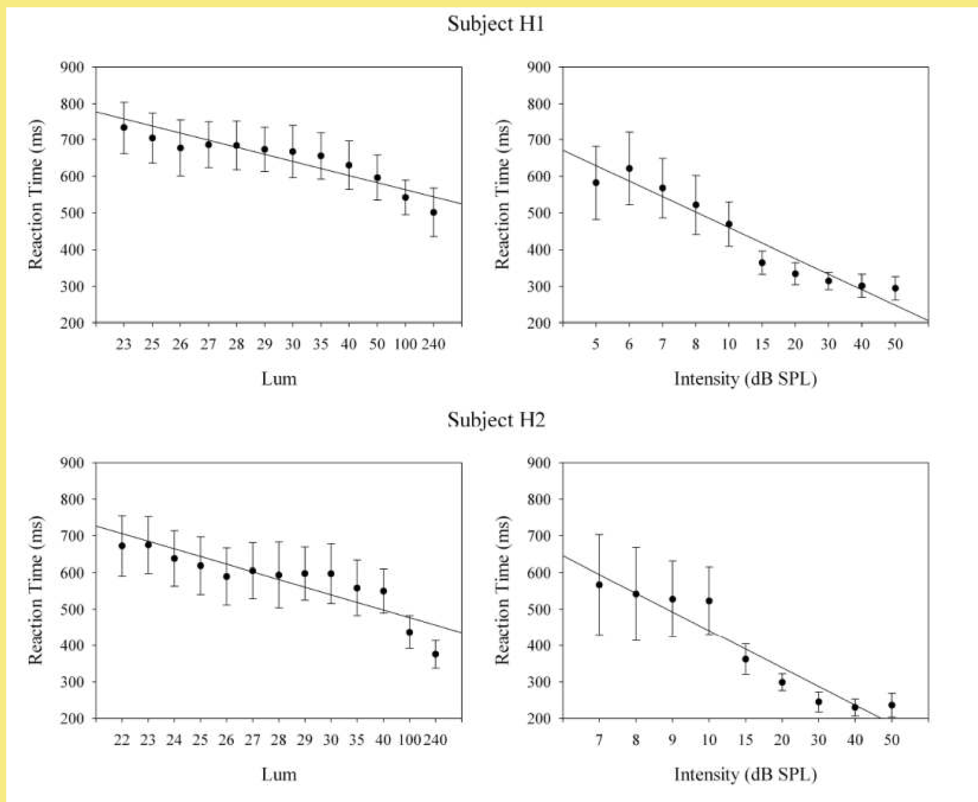
Tests performed in an audiometric room in diffuse-field (with loudspeakers) condition.

Thresholds: Determined daily before every multisensory session recordings

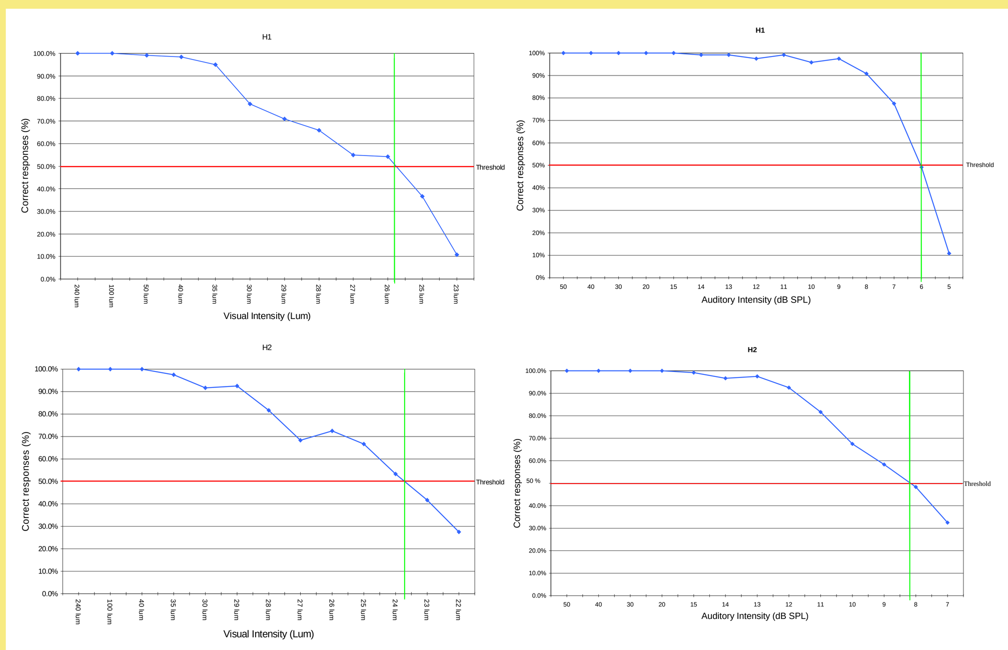
For both protocols the movements of subject's head were restricted by using a modified chin-rest. Furthermore the gaze was fixed and in addition the eye position was controlled using an ISCAN eye-tracking system.



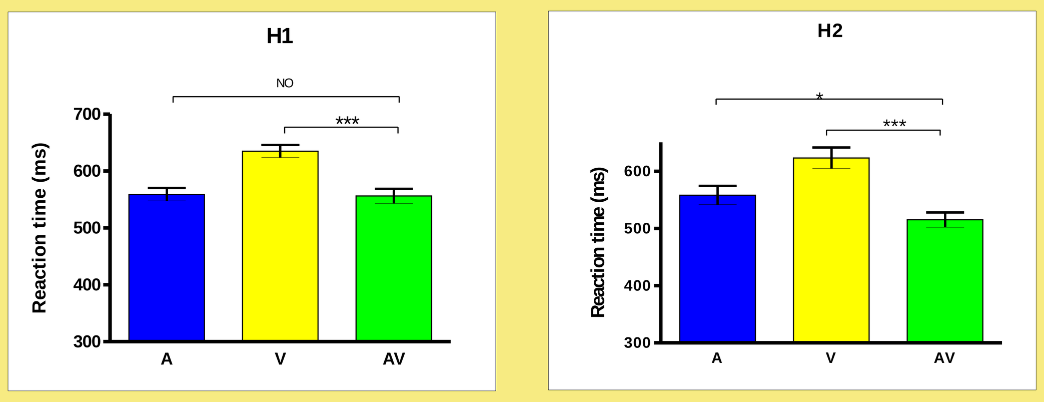
First Protocol (Human)



The reaction time decreased when the intensity increased



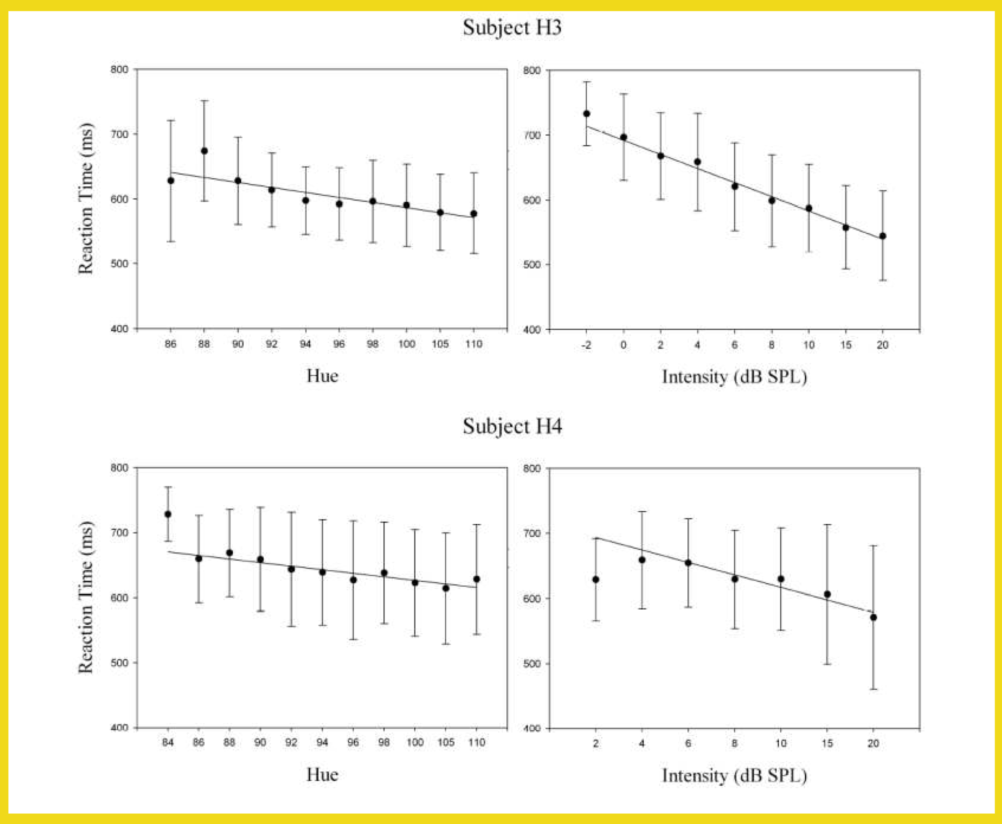
For the first protocol, the auditory and visual thresholds were evaluated once before the cross-modal sessions. 6 sessions were used to obtain an average threshold for auditory and visual stimuli.



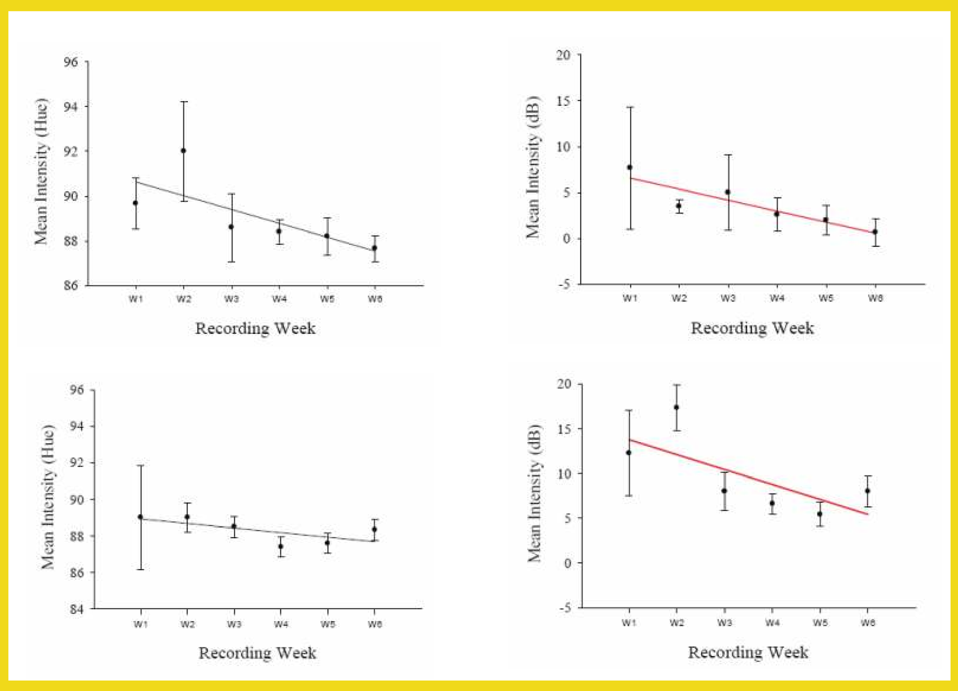
In subject H1, the reaction time was longer for visual than for auditory or visuo-acoustic stimuli. The difference between the reaction time for auditory and for visuo-acoustic stimuli was not significant.

In subject H2, the results showed a clear facilitatory effect. The reaction time was shorter for visuo-acoustic than for both other stimuli.

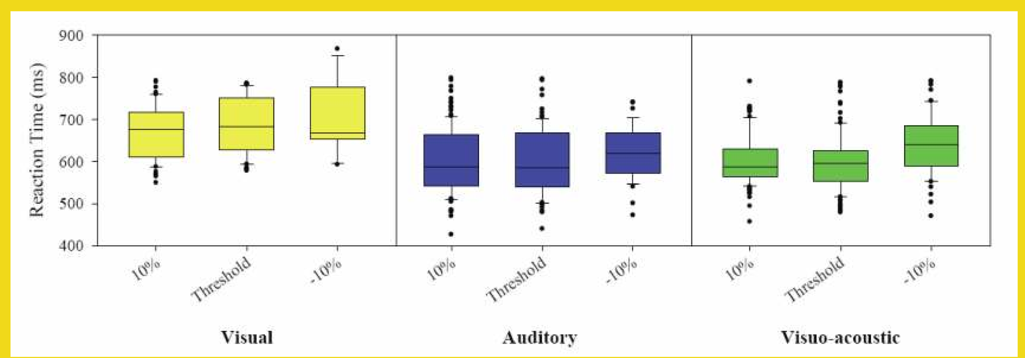
Second Protocol (Human)



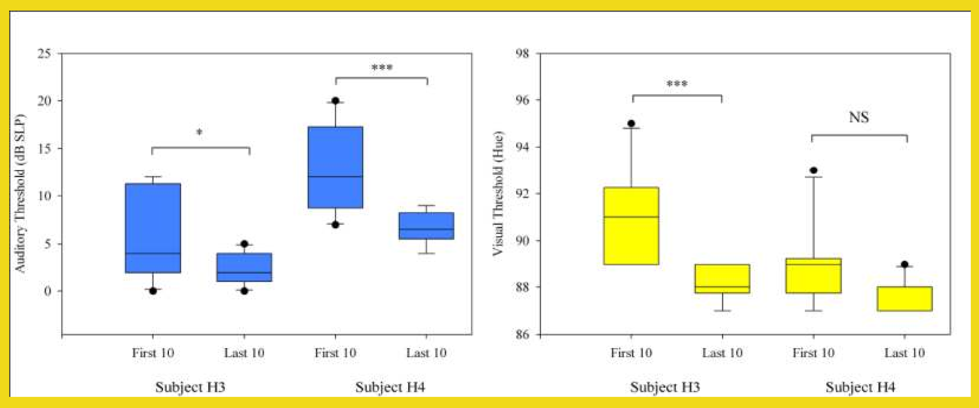
The reaction time decreased when the intensity increased



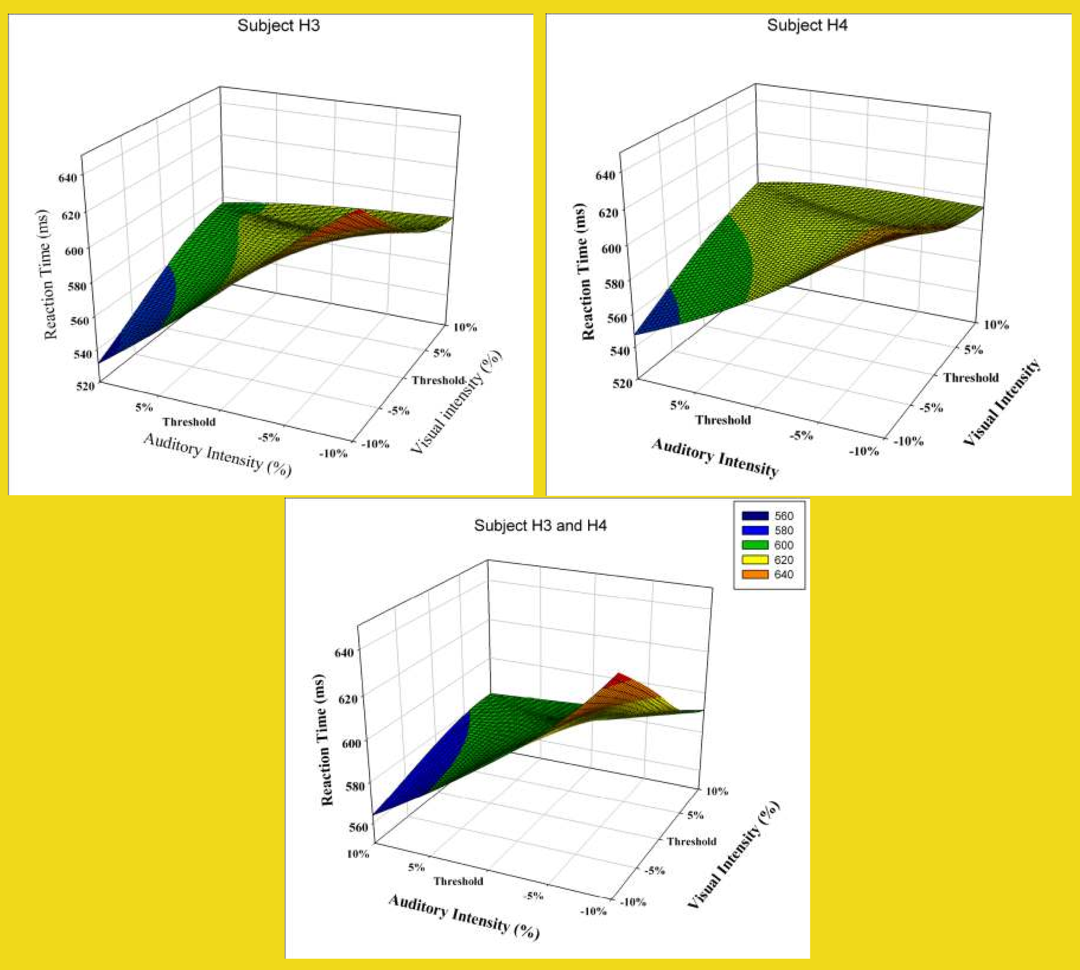
Along the sessions the auditory and visual thresholds showed a progressive decrease with time.



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



We observed 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 was significant for both subjects.



In the conditions tested here, the shortest reaction time was obtained when the auditory intensity was above the threshold and the visual intensity was below the threshold. In contrast, the highest reaction time was obtained when the intensity used was 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 a decrease of threshold with time.

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

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

4° For human, 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 was present in one subject for stimuli around threshold (--> principle of inverse effectiveness) but it was not significant for the 3 others. In contrast, the cross-modal facilitatory effect on reaction time was present in both monkeys.

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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