# Multisensory and motor integration in stimulus detection in monkeys

Cappe C.* (1,2), Barone P. (2) and Rouiller E.M. (1)

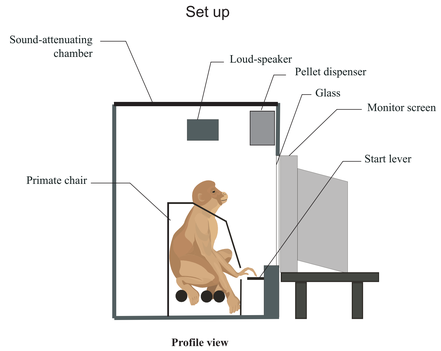
(1)Unit of physiology, Department of Medicine, University of Fribourg, Switzerland
(2)Centre de Recherche Cerveau et Cognition, CNRS/UPS UMR 5549, Faculty of Medicine Rangueil, Toulouse, France.

* E-mail : Celine.Cappe@unifr.ch

## Introduction

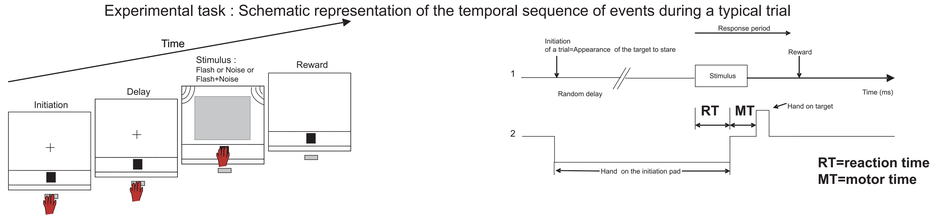
In experiments conducted in animals, the multisensory integration dealt in most cases with spatial cues, for instance the correspondence between the auditory and the visual spaces. Another line of research was more focused on the recognition of objects based on multisensory integration. For instance, in an experiment conducted on human subjects based on the identification of multi-modal (auditory-visual) versus uni-modal (auditory or visual) stimuli, it was shown that discrimination was better (less errors) and faster (shorter reaction time) for multi- than uni-modal objects (Giard and Peronnet, 1999). We present here a somewhat comparable multimodal facilitation in monkeys, although the task will consist of detection rather than recognition of auditory and/or visual stimuli.

## Methods




Two adults Macaca fascicularis were trained to perform a visuo-acoustic detection task. To initiate a trial, the monkey has to place his left hand on a starting pad, the fixation point on the monitor facing the monkey is turned on and the monkey has to fixate during the entire trial. The initiation of the trial is followed by a random delay, ranging from 500 to 6000 ms. Then, the sensory cue is presented, consisting of a unimodal visual or auditory stimulus, or a bimodal visuo-auditory stimulus corresponding to the simultaneous presentation of the two individual cues. The sequence of unimodal (auditory or visual) or bimodal trials is random. In response to each stimulus, the monkey has to touch a pad just above the starting pad. If the motor response is given within a certain time window, the animal will receive the reward (pellet) and the reaction time (RT) is measured.

Experimental task : Schematic representation of the temporal sequence of events during a typical trial




## Stimuli

The intensity of the individual auditory and visual stimuli was varied in order to establish the best conditions in which a synergistic effect is obtained.
The duration of stimuli was 250 ms.

Visual stimuli : flash on the screen in front of the animal.
We used several conditions for visual stimuli as : 17,15.2, 9.2, 6.5, 4.6 and 3.6 Lux.

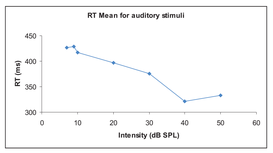
Auditory stimuli : noise burst from 2 loudspeakers on each side of the screen.
We used several conditions for auditory stimuli as : 50, 40, 30, 20, 10, 9, 7dB SPL.

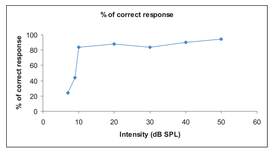
## Conclusion

At near threshold conditions of both visual and auditory stimuli, the bimodal condition has a significant facilitatory effect on reaction time and stimulus detection. Indeed, the reaction time in multisensory conditions is 12% shorter on the average than the shortest unimodal condition (auditory).
These findings confirm in monkeys the rule of the inverted effectiveness feature of multisensory integration expressed as a significant gain in stimulus detection near threshold condition which disappeared at higher intensities.
In the next step, we want to address the mechanisms of multisensory integration at the level of neuron, a dimension that cannot be assessed in human subjects.

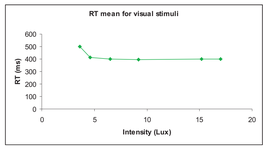
## Results

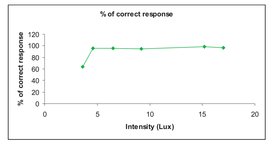
Auditory Threshold




Visual Threshold

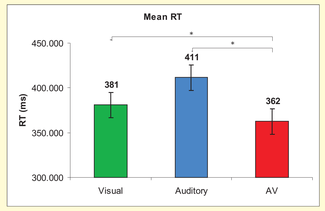


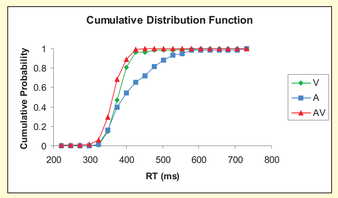

These results show that the higher the intensity is, the shorter is the reactions time and the more correct is the response. This is true for both auditory and visual stimuli.The visual threshold is near 3.6 Lux and the auditory threshold is near 10 dB SPL.

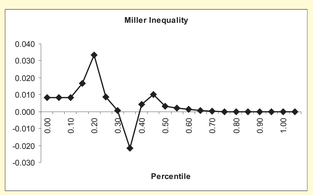
Results from three representative conditions

### Near threshold
10 dB SPL, 4.6 Lux

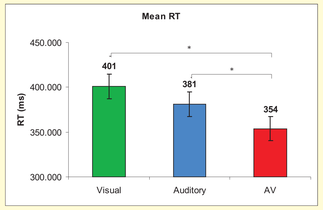



Mean RT (+/-S.E.). *P<0.001

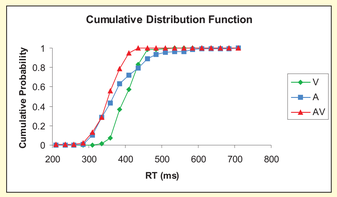


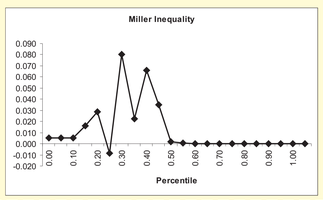




### Just above threshold
20 dB SPL, 9.2 Lux

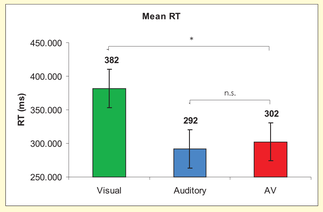



Mean RT (+/-S.E.). *P<0.001

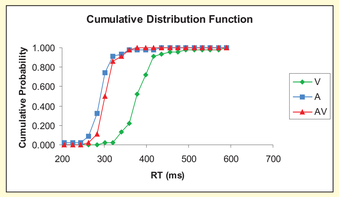


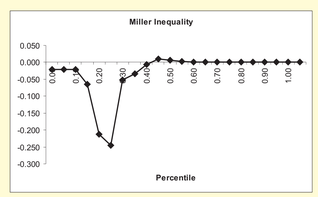




### At higher intensity
40 dB SPL, 6,5 Lux

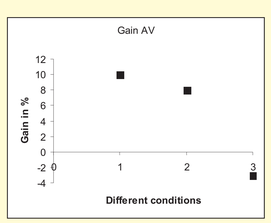



Mean RT (+/-S.E.). *P<0.001, n.s=non significant




**Miller Inequality**
We applied the race model (Miller, 1982) to analyze RTs to determine if the observed multisensory facilitation was beyond that predicted by statistical summation for the unisensory visual and auditory conditions. The race model (Miller inequality) is defined as follows : P (RTAV<T) = P (RTA<T)+P(RTV<T) where , where P(RT < T) is the cumulative probability density function (CDF) of RT.
This analysis is able to determine if the multisensory response is faster than predicted by statistical facilitation associated with redundant sensory stimuli. For example, we observed at 10dB SPL, 4.6 Lux, a violation of the race model (i.e.values are greater than zero) for the first quartile of the RTs distribution. This means a behavioral facilitation under multisensory conditions when compared to the race model prediction.




Gain =(RT(AV) - RT (A))*100/RT(A)
The different conditions are:
1. 10 dB SPL, 4.6 Lux
2. 20 dB SPL, 9.2 Lux
3. 40 dB SPL, 6.5 Lux

These results show that mean reaction time for multisensory conditions at 20 dB SPL, 9.2 Lux and 10 dB SPL, 4.6 Lux (i.e near threshold) were significantly faster than those for the corresponding unisensory conditions ; however this is not the case at 40 dB SPL, 6.5 Lux.