THE EFFECTS OF TASK DIFFICULTY ON THE MISMATCH NEGATIVITY (MMN) DURING INTER-MODAL SELECTIVE ATTENTION.

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INTRODUCTION

- The extent to which the processes indexed by the MMN are independent of attention remains unclear. Initial studies indicated that the amplitude of the MMN was unaffected by whether the subject was attending to or ignoring the eliciting auditory stimuli [1]. More recently, studies have reported that the MMN elicited by small deviants is enhanced in amplitude with auditory attention [2,3,4,5,6].

- The extent of engagement in (or attention to) a diversion task might also be expected to modulate the MMN. Capacity models define attention as the process of allocating resources to various inputs [7]. These attentional resources are limited. Hence, when a diversion task is particularly demanding, fewer attentional resources may be available for the processing the task-irrelevant auditory stimuli. Some studies comparing the MMN elicited during a diversion task that required the subjects' attention to be strongly focused (e.g. dichotic listening task) to one that did not make such strong attentional demands (e.g. reading) have reported significant MMN differences with the nature of the diversion task [2,4]. This effect may however be attributed to N2b overlap. Other studies have not found significant diversion task effects on the MMN [8,9].

- Varying the demands of a visual discrimination task may also differentially engage attentional resources. In most such studies, visual processing load has not affected the amplitude of the MMN [3,10,11,12]. This could be because the difficult tasks employed have not been arduous enough, leaving resources available to process the auditory stimuli. Few studies have actually recorded ERPs to the visual stimuli to verify the extent to which attention varies as a function of task difficulty.

- The purpose of Part 1 of the present study was to examine the modulation of the MMN with visual task difficulty. The ease of the visual target detection (easy or difficult) was manipulated to enhance or diminish the subject's ability to switch attention to the auditory channel. Both visual and auditory ERPs were recorded in order to provide ERP measures of attentional engagement.

- Part 2 addressed the possibility that subjects can switch to the auditory channel while successfully detecting visual targets in both Easy and Difficult conditions. Subjects were asked to divide their attention between the visual and auditory streams and signal both visual and auditory deviants.

PART 1

METHOD

SUBJECTS:

- Twelve (6 women) between 17 and 27 years.

STIMULI:

- Mixed sequences of equiprobable auditory and visual stimuli were presented with a random ISI ranging between 250 and 350 ms.
- Auditory: The standard stimulus was an 80 dB SPL 1000 Hz tone pip having a total duration of 50 ms and a 0.85 probability of occurrence. A frequency deviant (1050 Hz), and an intensity deviant (70 dB SPL) were presented at random in the same auditory condition, each with a probability of 0.075.
- Visual: The standard (p=0.925) and target (p=0.075) visual stimuli are illustrated in F1. The visual stimuli had a total duration of 50 ms. In different conditions, the deviant stimulus was either easy or a difficult to detect.

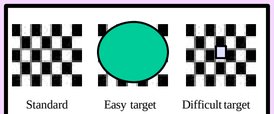
PROCEDURE:

- Subjects were asked to button press upon detection of the visual target and ignore the auditory stimuli. A total of 2000 trials were presented per experimental block. Three blocks of stimuli were presented for each task difficulty. The presentation of the conditions alternated between easy and difficult tasks and was counterbalanced across participants.

EEG RECORDING:

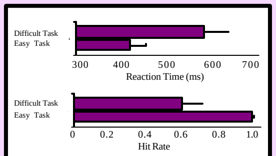
- EEG activity was recorded from 8 channels (Fz, Cz, Pz, Oz, F3, F4, M1, M2). The nose served as a reference. Horizontal and vertical EOG were also recorded.

F1. VISUAL STIMULI



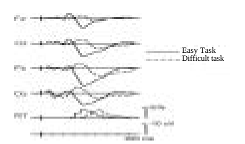
In the Difficult condition, the contrast of the center blue check was adjusted for each subject to obtain a hit rate between 0.5 and 0.7.

F2. TARGET DETECTION



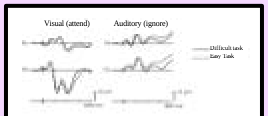
Easy and Difficulty conditions significantly differed in terms of Reaction Time and Hit Rate, ps<.0001.

F3. VISUAL TARGET ERPS



Easy and Difficult conditions significantly differed in terms of P3 (amplitude and latency) and N2 (latency), ps<.0001.

F4. STANDARD ERPS

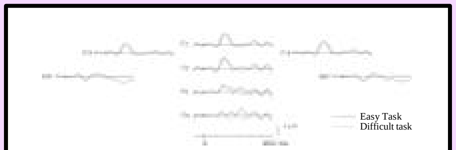


Visual and Auditory standard ERPs did not significantly differ between conditions until 200 ms following stimulus onset, ps<.03.

F5. FREQUENCY MMN

There were no differences in the MMN elicited by frequency deviants between Easy and Difficult conditions at frontal and mastoid sites.

F6. INTENSITY MMN



There were no differences in the MMN elicited by intensity deviants between Easy and Difficult conditions at frontal and mastoid sites

PART 2

METHOD

SUBJECTS and STIMULI

- Same as in Part 1.

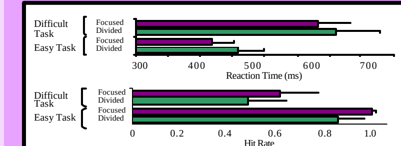
PROCEDURE:

- After completing Part 1, subjects were instructed to divide their attention between visual and auditory channels and to discriminate both visual and auditory deviants. The visual task was again easy or difficult. A total of 2000 trials were presented per block. One block of stimuli was presented for each task difficulty

RESULTS:

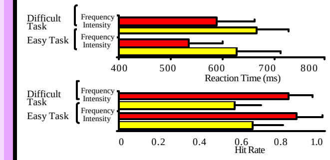
- Focused (Part 1) and Divided (Part 2) conditions are compared

F7. VISUAL TARGET DETECTION



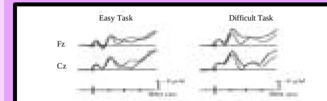
Reaction time and Hit rate were significantly affected by task difficulty and attentional focus, ps<.003. The interaction was not significant, p>.80

F8. AUDITORY TARGET DETECTION



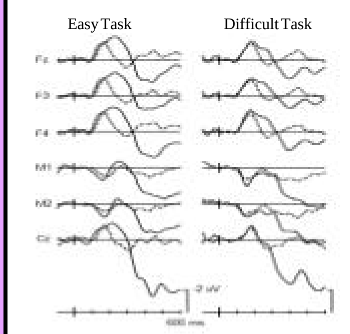
Reaction time and Hit rate were significantly affected by the type of auditory deviant, p<.0005. Reaction time and Hit rate were however not significantly affected by visual task difficulty, p>.10.

F9. AUDITORY STANDARDS



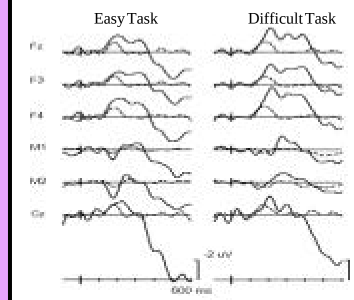
The auditory standard was significantly affected by attentional focus from 100 to 150 ms in the Difficult condition only, p<.01.

F10. FREQUENCY DIFFERENCE WAVES



The deviance-related negativity was significantly affected by attention. This enhancement however most likely reflects N2b activity. The true MMN was not affected by the direction of attention.

F11. INTENSITY DIFFERENCE WAVES



Again, the deviance-related negativity was significantly affected by attention. For the intensity deviant, the N2b peaked after the MMN. Auditory attention may therefore well have enhanced the MMN.

CONCLUSIONS

- The Easy and Difficult visual discrimination tasks successfully varied task difficulty. In the Easy task, reaction time (RT) was faster and hit rate (HR) was higher (see F2). Also, P3 and N2 peaked earlier and P3 was larger in the Easy than in the Difficult task (F3). Task difficulty did not however show an attentional effect on the visual and auditory standard waveforms prior to 200 ms (F4). Importantly, the level of difficulty of the visual discrimination task did not significantly affect the MMN to frequency (F5) and intensity (F6) deviants.

- When subjects attended to both visual and auditory channels, their visual task performance deteriorated slightly but significantly. This deterioration was however not greater during the Difficult than the Easy task (F7). Subjects also showed a good performance on the concomitant auditory detection task. This performance was not affected by visual task difficulty (F8). These results suggest that subjects could switch from the visual to the auditory channels in both Easy and Difficult tasks without incurring a large visual performance decrement.

- The deviance-related negativity was significantly larger when subjects attended to than when they ignored the auditory channel. For the frequency deviant (F10), N2b was superimposed on the MMN; hence, the larger deviance-related negativities cannot be solely attributed to MMN activity. For the intensity deviant, the N2b appears to peak later than the MMN (F11). Support for this also comes from the longer RTs for the intensity relative to the frequency deviants (F8). Auditory attention may thus have enhanced the intensity MMN.

REFERENCES

[1] Näätänen et al., Acta Psychol 1978;42:313-329. [2] Alain and Woods, Psychophysiology 1997;34:534-546. [3] Alho et al., Electroenceph Clin Neurophysiol 1992;82:356-368. [4] Näätänen et al, Psychophysiology 1993;30:436-450. [5] Trejo et al., Psychophysiology 1995;32:319-328. [6] Woldorff et al., Psychophysiology 1998;35:283-292. [7] Kahneman, Attention and effort. Englewood Cliffs, NJ: Prentice-Hall, 1973. [8] Kathmann et al., Clin Neurophysiol 1999;110:317-323. [9] Paavilainen et al., Biol Psychol 1993;37:23-41. [10] Dittmann-Balcar et al., NeuroReport 1999;10:3749-3753. [11] Harmony et al., Cogn Brain Res 2000;9:52-60. [12] Otten et al., Neuroreport 2000;11:875-880.