

VISUAL PERCEPTION: DOUBLE PULSE TEMPORAL RESOLUTION. (LACK OF CONTINGENCY UPON THE PHASE OF RESTING CARDIAC AND RESPIRATORY CYCLE)

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Abstract. Double light pulse resolution required longer inter-pulse time intervals of short duration of the pulse. The threshold of double pulse discrimination was not contingent upon the actual phase of cardiac or respiratory cycle.

INTRODUCTION

The problem of temporal factors in the subjective perception of separated pulses had been studied in many experiments, conducted either with number of pulses within the flicker train or on the basis of separate double-pulse temporal resolution (3). It is obvious that besides stimulus conditions, the differences of the criteria adopted by the subjects for making their judgements are the most responsible in similar experiments (3). The latter factor is related to a wide spectrum of uncontrolled variations not only among subjects, but also in the same subject during his/her examinations, performed at different time intervals. It seems thus appropriate to consider inner physiological variables too, as perceptual phenomena might depend on the actual state of the examined subject (2). Among them the cardiac and respiratory activities represent complex functions, reflecting to a certain degree the physiological state of the organism.

The present experiment was designed to reexamine the problem of

double pulse resolution and to look whether this type of visual perception will depend on the actual phase of cardiac and respiratory cycle.

METHODS

Apparatus

Two red-light emitting diodes (LEDs) with luminous intensity of 0.8 mcd were mounted side by side behind a plastic circle in such a way that no one could recognize, which one was on. The outer diameter of the plastic disc was 9 mm, the whole setup was mounted on a black panel measuring 120×60 mm. The whole panel itself was fixed on the wall of a sound attenuating chamber. The LEDs did not visibly illuminate the panel.

The subjects were seated directly in front of the panel, so that the LEDs were at the eye level at a distance of approximately 150 cm. Prior to the experimental session the subjects were dark adapted for 10 minutes. During dark conditions the chamber was essentially lacking in measurable illumination. The stimulation was secured by means of red LEDs that allowed precise timing (time constant 50 ns, but did not allow changes of their intensity). This mode of stimulation was without doubt in line with "pure" psychophysiological experiments of Mahneke and others (1,8). This enabled a more direct comparison.

Subjects

Sixteen subjects participated in the experiment (aged 24 - 34 years). None reported any visual defect which would interfere with his/her performance of the task.

Procedure

Subjects were run one at a time. All sequencing of stimuli, recording of response and data analysis were under the control of SM 4/20 computer (corresponding approximately to PDP 11/34). The proper experiment began after a period of relaxation, when the ECG electrodes (standard lead II configuration) were attached. The subject was instructed to view the stimulation panel in front of him/her, the chin and forehead resting on particular supports, thus minimizing head movements, and to respond by button pressing according to his/her estimate, whether one or two brief pulses were seen. The threshold measurement was performed using a staircase technique (5); the interval between both light pulses of the durations 20, 10, 5, 2 ms. respectively getting shorter till the moment when the subject was unable to see the double pulse as

such. Then the interval became gradually longer till the subject detected the double pulse etc. Intervals between both light pulses changed in linear 10 ms. steps. The threshold value has been established automatically on the basis of 20 turning points values, the duration of the threshold measurement generally not exceeding 3 minutes.

In experiments performed on eight subjects the presentation of these double pulses was either contingent upon the occurrence of R wave of the ECG or delayed with respect to the R wave occurrence for 400 ms. (4, 6). The ECG signal recorded by means of Ag/AgCl electrodes was amplified by SAN-El 1205 biological amplifier and then delivered to a Schmitt trigger, the output of which triggered a one-shot to generate a standard pulse on each odd R-wave, alternating 0 and 400 ms delays. The subjects were not aware of these different delays or even stimulus presentation contingent upon the cardiac cycle. Thirty seconds heart rate baseline was calculated prior to any threshold measurement started. There was a brief break after each measurement and then another pulse length interval was tested with a new heart rate baseline level.

In additional eight subjects the presentation of stimuli was contingent upon the breathing cycle, recorded by means of a semiconductor transducer (thermistor type PRAMET 12 NR 17). The thermistor was fixed in front of the subject's nose and the air allowed to flow freely around it. We tried to keep the subjects in a relatively quiet situation, not forcing them to breath deeply, as it should be extremely difficult to keep them under steady conditions for several minutes and to control these conditions, e.g. biochemically. Two boundary situations for pulse triggering were used when the excursions during spontaneous breathing were maximal or minimal, corresponding to expiration and inspiration. No other attempts were made, so the whole situation resembled thus the cardiac cycle part of the experiment.

The subjects were trained briefly prior to the session on the longest light pulse duration used throughout the experiment. No feedback information about the response was given.

RESULTS

The means and standard deviation of each lower and upper threshold were computed separately. Due to different absolute level values of the thresholds, no additional comparison among subjects was completed.

As no significant changes were observed between the thresholds under the above mentioned conditions, the corresponding data groups were pooled together. These new grand averages served as a basis for final

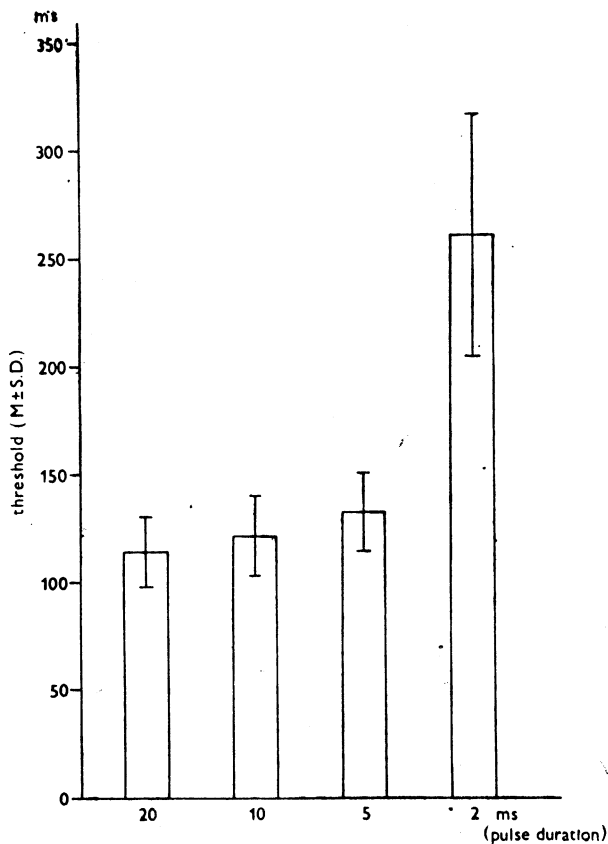


Fig. 1. Means and standard deviations of threshold values over all subjects displayed separately for four pulse durations (2, 5, 10 and 20 ms).

comparisons. Their values are presented in Fig. 1. These results show a pulse duration effect $F(2/15) = 2.475$, $p < 0.05$, with significant differences for subjects, too. The compressed array of significance among different groups of pulses (at least at 5% level) is presented in Fig. 2. Consistent difference exist between the first three light pulse durations (20, 10 and 5 ms) and the shortest one (2 ms), this difference being expressed in all subjects. Thus the double light pulse resolution requires a longer interpulse time in case the light pulses are short.

As regards the possible contingency of threshold estimates upon the phase of cardiac and respiratory cycle, no such effect was observed. However, evaluating heart rate in the former experiments, we did find in one third of them an acceleration of the heart rate which did not influence the threshold.

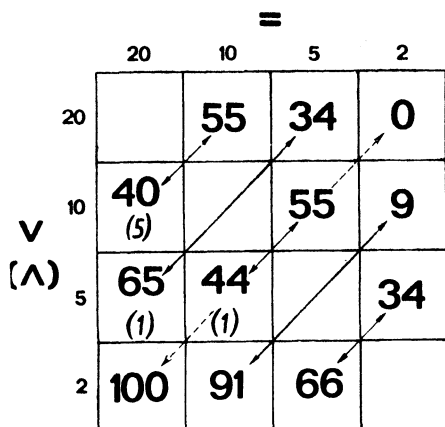


Fig. 2. Significance of mutual differences among four pulse durations during threshold estimations. The values in the body are expressed in %. The sign "(v)" indicates the trend of the given significance (at least at 5% level). As an example: 100 indicates that all trials between 20 and 2 ms were significantly different etc.

DISCUSSION

We have confirmed the finding that at sufficiently short duration of a pair of light pulses, their distance in time has to be longer for differentiating them as two separate ones (8). The neural mechanisms underlying this phenomena remain unclear. It is plausible to assume that a separate trace of the first pulse in the pair has to be maintained somehow in the brain till the onset of the second pulse, from which it has to be differentiated. Thus, paradoxically enough, the time required for storing the short lasting pulse is much longer than that for the long lasting ones, although the former ones are apparently "weaker" and one might hypothesize therefore that their trace should be "weaker" as well. A possibility to be considered is that some sort of amplification of those "weak" traces developing gradually in time is necessary for performing the neural processes aiming of the separation of the two pulses. One has to take into consideration that our experimental situation was different from the technical point of view from earlier reports, as we used LEDs for stimulus presentation and their usage did not prevent us from the "brightness problem", despite the fact that always two pulses were used. We had no possibility of direct energy measurement, unfortunately.

The minimal time necessary for subjective separation of double pulses was in our situation somewhat shorter than reported e.g. by Boyton (3) for a different paradigm situation (7), levelling around 25 ms. The above studies were concerned mostly with temporal threshold estimations around or slightly above the intensity threshold. Our study limited itself only to the duration of stimuli presentation, believing that their intensity remained the same even during the very brief stimuli conditions with no luminance of the background at all.

As for the contingency of the threshold established for the perception of double brief visual pulse stimuli upon cardiovascular and respiratory cycle is concerned, our results were negative. We did find, however, in other experiments (6) that out of target incidence in a simple one-dimensional visuo-motor tracking task does depend on the actual phase of the cardiac cycle. This and similar results might reflect the circumstance that spontaneous firing of a considerable amount of reticular neurons is clearly related to the phase of cardiac cycle, which might course phasic shifts of vigilance. It seems probable that the hypothetical modulatory effect of those vigilance oscillations is not uniform, it might influence various processes differently or not act upon them at all concerning the changes in heart rate, we have to bear in mind that the heart rate varies in a relatively wide range of behavioral states and situations and the law of initial values has to be considered too. It is not possible to expect a high acceleratory response, when already the pre-trial heart rate levels are high.

Contrary to the generally accepted procedure of testing the effect of learned speeding and/or slowing of the heart rate on perception we rather looked upon the problem, how the heart activity per se could be influenced by increasing the difficulty of the cognitive task. The answer, however, is not unequivocal, as the expected increase in the heart rate was observed in 30% only. No phasic dependence of temporal differentiation between pairs of light pulses could be found in any of the heart rate levels recorded.

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