

University of Groningen

Temporal acuity in foveal vision

Oostenbrug, Melle Wytze Marten

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version

Publisher's PDF, also known as Version of record

Publication date:

1975

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Oostenbrug, M. W. M. (1975). *Temporal acuity in foveal vision*. s.n.

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

INTRODUCTION AND SUMMARY

The human brain is able to detect and discriminate short intervals of time, as they appear between events in the outside world that are perceived through any of the sensory systems. Such an ability, attributed to a perceptive mechanism, is thought to be localized in a functional entity of the central nervous system that is responsible for the associated conscious sensation. This thesis presents some experimental results of a study of this mechanism of temporal acuity, performed with stimulation via the visual system.

In practice two general approaches exist as distinguished by their experimental methods, the psychophysical one and the electrophysiological one. Restricting ourselves to human, in the psychophysical approach, other parts of the same brain are instructed to evaluate the produced information and report the evoked sensation, thus introducing problems of observer bias. Also, questions of physiological realization and connectivity are left open. When electrophysiological methods are applied, this pitfall of observer bias is replaced by problems of relevance and identification. For electrical recordings from single nerve cells to be relevant outside the limited interest of neuronal input-output relations, they are not only to be identified with some perceptive function but also their relative contribution to the information processing should be appreciated. It appears to us, as neither method really is the better one, that both lines of research should continually be confronted with each other to yield useful insight in the functioning of the mechanism under study. The limitations of both methods may thus be compensated for.

There exist methods in psychophysics for handling problems of observer bias, some of them are connected to the application of Signal Detection Theory. In this theory, which rather is a general model of analysis, it basically is assumed that two (or more) signals embedded in noise are to be discriminated by outweighing their respective probabilities to exceed certain criterion levels. The observer bias thus is authorized as a criterion level handled by the observer, which is then accessible to measurement. This enables one

to define bias-free measures of detectability of the form of a signal-to-noise ratio, called the detection index.

The mechanism for the perception of short time intervals in general can be stimulated through any of the sensory modalities, e.g. visual, aural or tactile, or even mixed combinations. As the mechanism uses information transmitted from the sensory input through the peripheral pathways to a rather centrally located part of the brain, its performance is limited by the characteristics of those pathways. Conversely, acuity measurements may allow conclusions to be drawn about those characteristics. In this thesis the acuity mechanism has been studied with psychophysical methods and visual stimulation. The results of this study are presented in the form of three companion papers (Parts I, II and III).

In the experiments, the stimulus time interval was demarcated by two short pulses of light of small diameter flashed one after the other. They were projected near the centre of the visual field in different eyes on either side of the fixation point. A few selected values of the stimulus time interval were presented many times in random order, each to be judged by the observer, in order to calculate the probability distributions of observer's responses for the different stimulus values. The analysis then yields a value of the temporal acuity that in fact is operationally defined as the inverse time interval between pulses resulting in a detection index of unity with respect to simultaneous pulses. Under different conditions observers are well able to discriminate intervals of 15 to 100 ms, corresponding to acuity values of 0.06 to 0.01 ms⁻¹.

Part I treats the experimental set-up and the methods of analysis, together with a short review of Signal Detection Theory. Some experiments are described that demonstrate the applicability of this theory, and establish that the internal noise is normally (gaussian) distributed. Other experiments are dedicated to effects of temporal integration in relation to Bloch's Law, and effects of the relative position in the visual field of the pulses of light constituting the stimulus. No difference is found between projection of pulses to either eye or to one eye (dichoptic or monoptic), indicating that the mechanism receives binocularly integrated information. Already existing evidence that the acuity mechanism is confined to the dominant hemisphere is confirmed. A curious deterioration of acuity values is found for pulses projected to the outer (temporal) retinal halves with respect to the inner (nasal) ones, though remaining still within the foveal

area.

Part II is devoted to the influence on the temporal acuity of changes in luminance of the pulses of light as well as changes in adaptation level controlled by a steady background field. This allows the discussion of transfer characteristics of peripheral visual pathways. It was found that spatial and temporal summation of the pulse energy occurs up to at least 1° of visual angle (foveally) and 32 ms duration. Within these integration bounds relative differences in pulse energy are likely to arrive with a strongly reduced magnitude (by a factor of the order of 0.2) at the acuity mechanism's input. Differences in adaptation have very little, if any, influence on the measured acuity. Comparison with available electrophysiological data suggests that the acuity mechanism acquires its information mainly through so-called transient neural channels.

In Part III a model for a time interval processor is developed based on the interaction of two signals consisting of a random series of nerve action potentials. Such a signal in general may be accurately described by a stochastic point process of (to a large extent) independent events in time. A two-input system is constructed where events in one channel are able to delete events in the other channel with a chance decreasing with the time passed between their occurrences. The non-deleted events are accumulated in a "leaky" counter that loses its content randomly at a rate proportional to its momentary content. The processor then delivers a stochastic signal suitable for analysis in detection theoretical terms. Mathematical formulations are given in an Appendix. The model displays the general characteristics of the experimental data, and suggests by its numerical values that at least a few neural channels should converge at either input.