Integration Time For Detecting Transient Changes In The Direction Of Moving Stimuli Changes With Signal Intensity

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353.4

Introduction

The human visual system can detect transient changes in the direction of moving stimuli. Psychophysical thresholds for detecting these changes have been already measured. However, when two changes in the direction of a moving stimulus occur very close in time, the resolution of the human visual system to separate them has not been well documented.
The goal of this study is to determine such ***integration time thresholds*** (ITT) in human subjects as well as the influence of stimulus related variables (i.e direction change intensity) on this measurement.

Question

What is the ITT of the human visual system for detecting abrupt changes in the direction of a moving random dot pattern?

Method

Setup:
- Light controlled environment
- Chinrest
- Computer monitor 1152x870@75Hz

Stimuli:
Were random dot patterns presented behind a virtual aperture of 7 degrees diameter. The size of the dots was 0.1 degree and the dots' densities was 5 dots/degree^2. The dots' speed was 16 degrees/second.

Subjects:
2 naive and 2 trained subjects (1 female and 3 males) with ages ranging from 20 to 35 years participated in the experiments. All the subjects had normal or corrected vision.

Task:
Two moving RDP were presented sequentially, each one with a duration of ~500ms and separated by an interval of 266ms. One RDP (the standard) always contained one change in direction. The other RDP (the test) could contained one or two changes. The task for the subjects was to determine which of the two patterns contained two changes.
Within one experimental block the intensity of the direction change was constant but the interval between the two changes in the test pattern was varied (0-106ms). Different blocks with change intensities from 20 to 90 degrees were run in each subject.

Data Analysis:
The proportion of correct responses (correct detections) were plotted as a function of the time interval duration between the two changes (see figure 3). Weibull functions were fitted through the data points. The ITT was defined as the time interval duration at which the subjects detected the two changes in 75% of the cases.

Experimental design

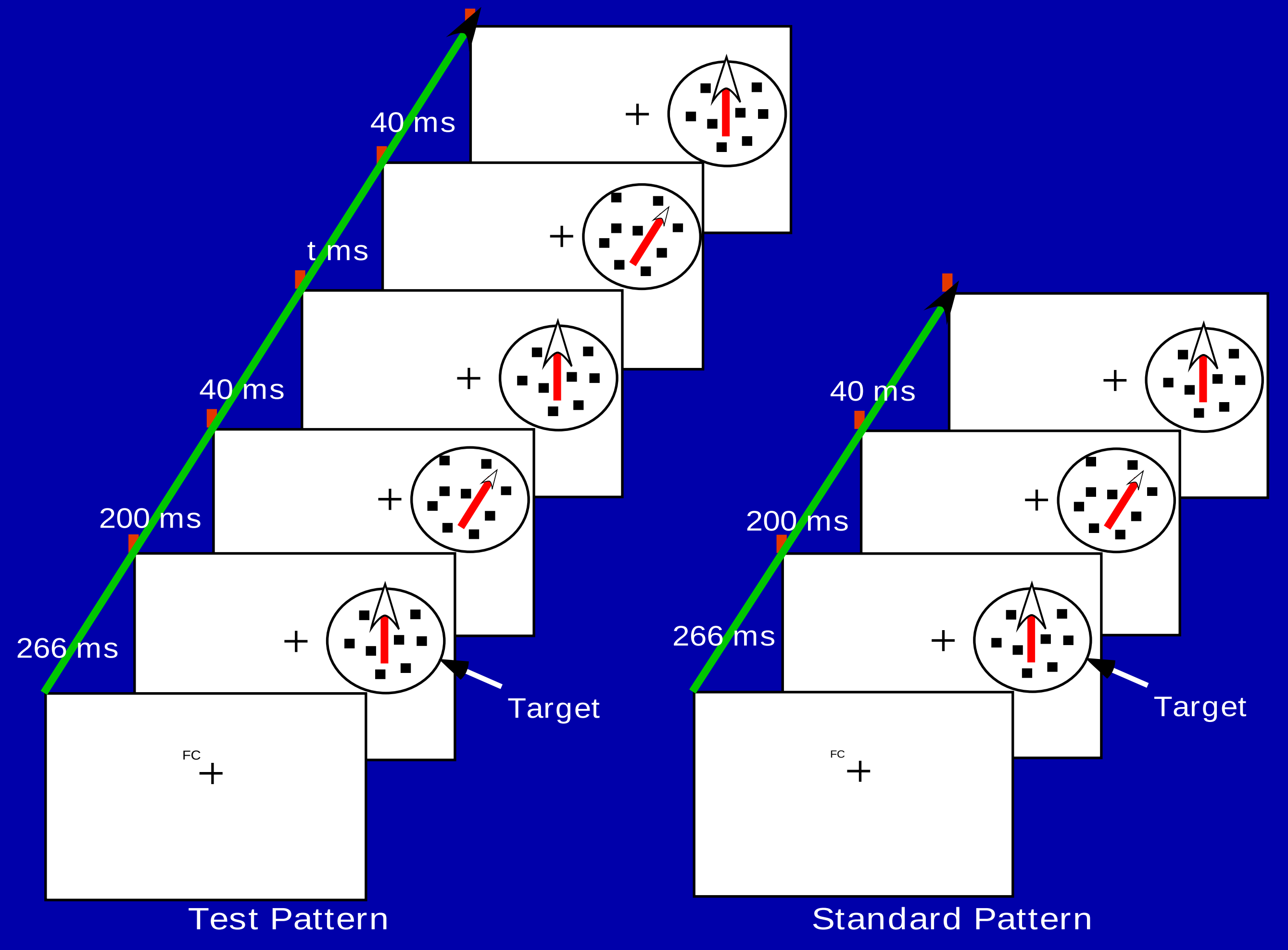

Figure 1: Trial example.
t is variable of interest and t = [0 - 106] ms

Results

Psychometric function for detecting a direction change in a RDP

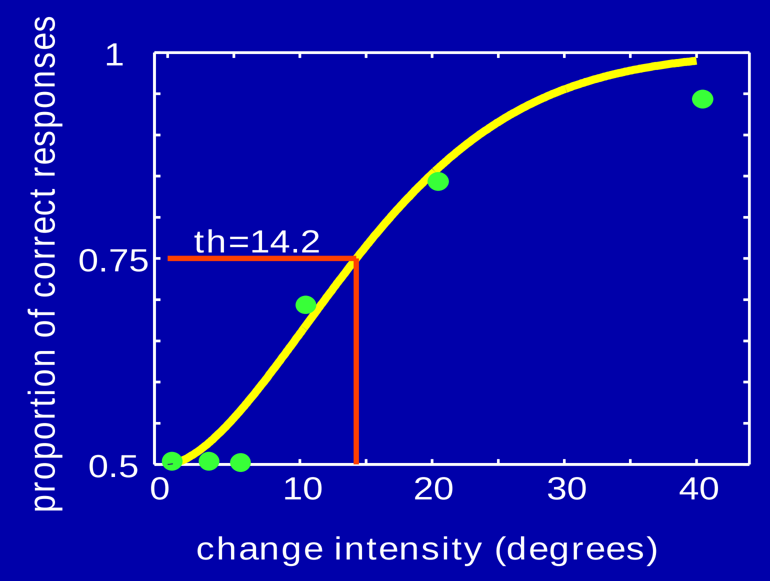

Figure 2: Example of a psychometric curve from one subject for detecting a direction change in a RDP. The abscissa displays the change intensity in degrees and the ordinate the percentage of correct responses. All the subjects were previously tested with this experiment and their thresholds determined.

Example of ITT determination for one subject

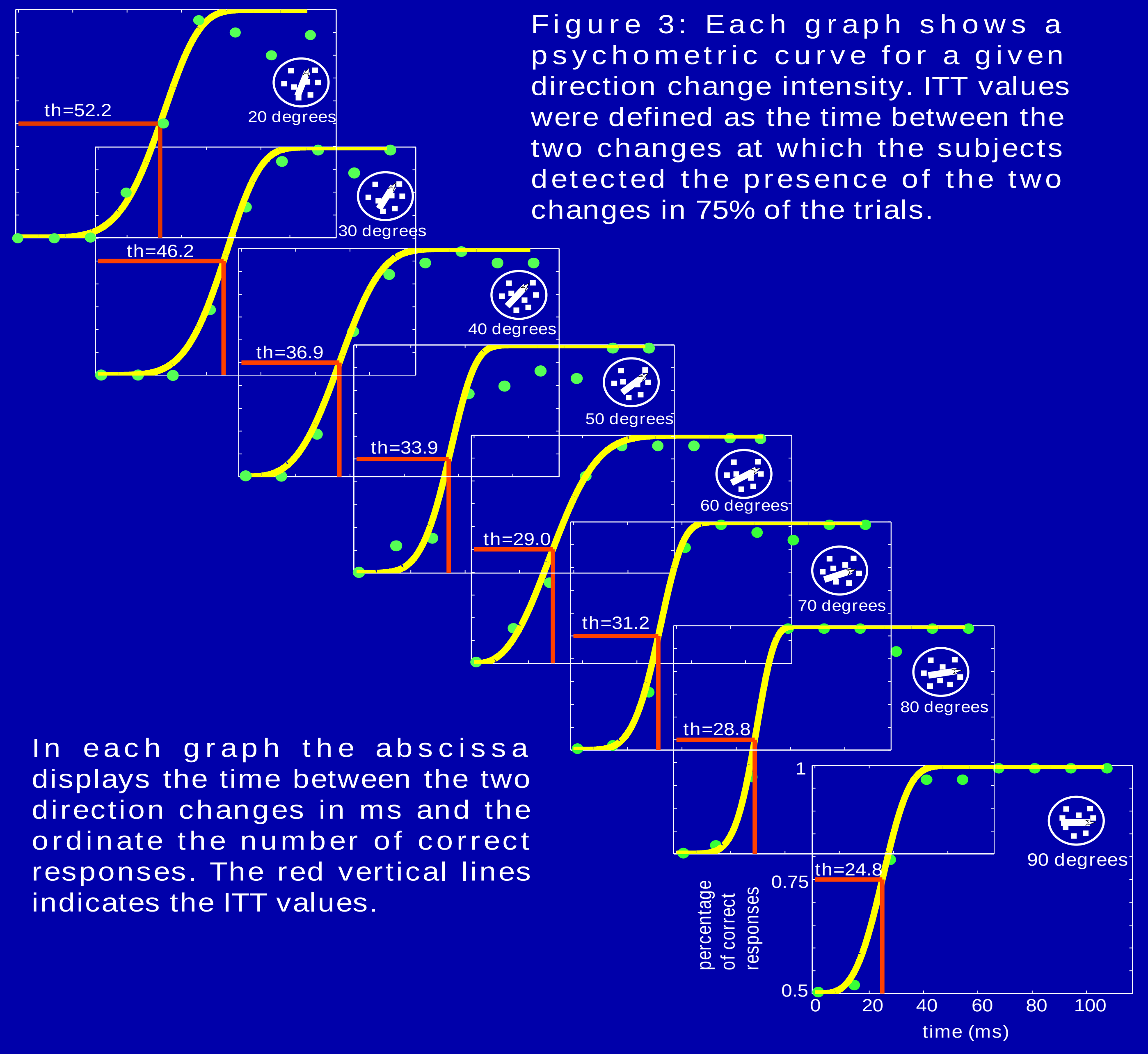

Figure 3: Each graph shows a psychometric curve for a given direction change intensity. ITT values were defined as the time between the two changes at which the subjects detected the presence of the two changes in 75% of the trials.

In each graph the abscissa displays the time between the two direction changes in ms and the ordinate the number of correct responses. The red vertical lines indicates the ITT values.

ITT as a function of stimulus change intensity

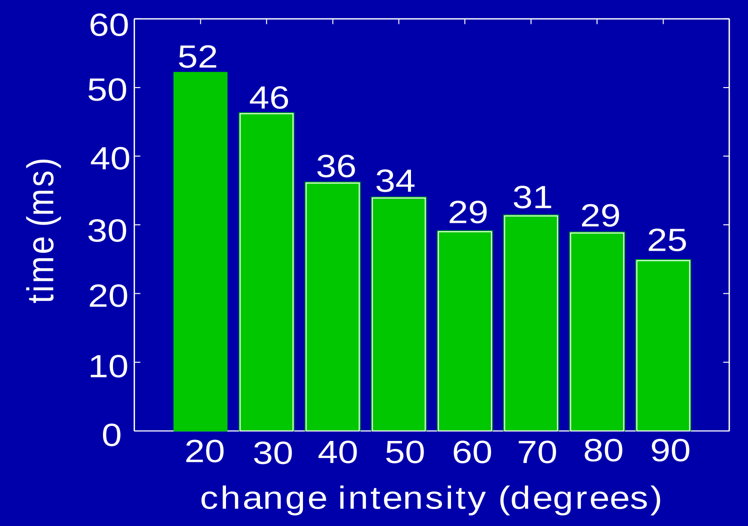

Figure 4: ITT values decrease as a function of signal change intensity. Observe that the intensity of the change was always higher than the detection threshold for one direction change (see figure 2).

Population data

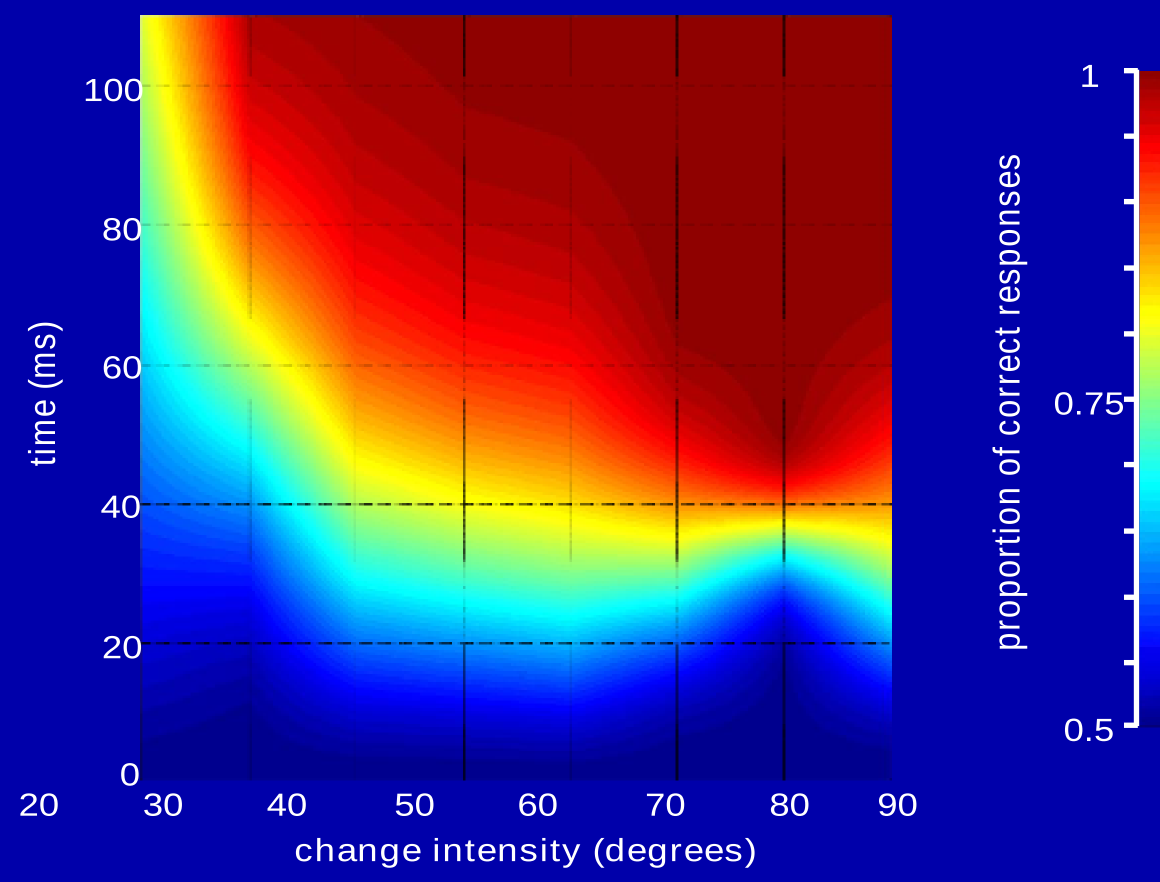

Figure 5: Population ITTs. Responses from different subjects were averaged and Weibull functions fitted through them. The abscissa displays direction change intensity in degrees and the ordinate the duration of the time interval between the two changes. The color scale symbolizes the proportion of correct detections.

Control experiment

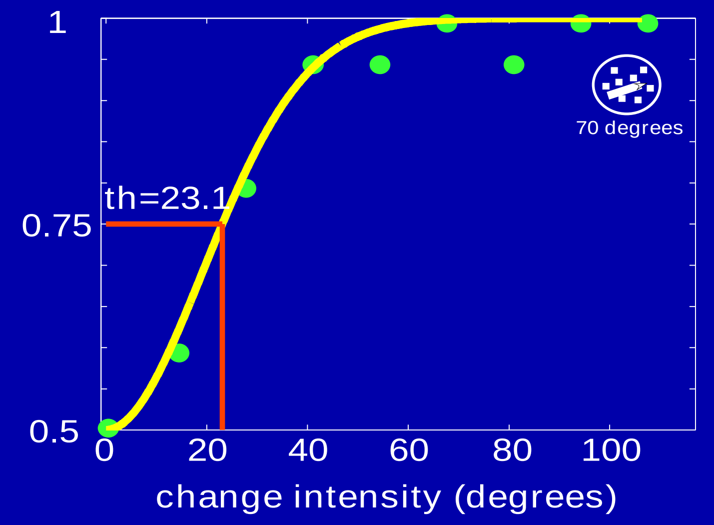

Figure 6: Psychometric curve for detecting two direction changes when the standard pattern contained one direction change but of the same duration as the two changes in the test.

Conclusions

The integration time threshold (ITT) for discriminating two changes in the direction of moving stimuli varies with the intensity of the direction change.
For low intensities (20-30 dg) the ITT was ~60-70 ms decreasing monotonically to ~30 ms for larger intensities (80-90 dg). Our results provide a measurement of the integration time for transient motion signals in the human visual system.