

SHORT REPORT

Time resolution for visual information processing in Parkinson's disease

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Abstract

It has been suggested that a deficit in timing could be the cause of the sensory disturbances reported for Parkinson's disease. To test this hypothesis the temporal discrimination thresholds in four visual tasks were used to study 45 healthy young people, 14 healthy elderly people, and 17 patients with Parkinson's disease. In these tasks, subjects watched a computer controlled light emitting diode display and pushed a button when the visual event previously specified by the researcher was perceived. The time between successive images required to discriminate a visual detail was accurately quantified. In two of the four tasks, the time for visual processing of image sequences was longer in the elderly group than in the young group. No significant differences were found between patients with Parkinson's disease and their age matched controls for any of the four tasks. Present data show normal temporal discrimination and no slowing in the initial steps of visual processing in Parkinson's disease.

(*J Neurol Neurosurg Psychiatry* 1998;65:921-923)

Keywords: Parkinson's disease; timing; visual disturbances

In addition to motor disorder, sensory disturbances have been found in an appreciable percentage of patients with Parkinson's disease.¹⁻⁵ Because studies in humans^{6,7} and animals⁸⁻¹² have reported that dopamine is involved in timing, it has been suggested that an abnormal temporal discrimination could be among the causes for visual symptoms.¹³⁻¹⁵ Thus it was reported that both the minimum time interval required for paired stimuli to be felt as separate in time¹³ and the time needed to identify images¹⁵ are increased in Parkinson's disease. Recently we developed a procedure to quantify the time needed to perceive simple stimuli during different visual tasks.¹⁶ Here we used four of these tests to study the time resolution of the visual system in Parkinson's disease. Data obtained in patients with Parkinson's disease were compared with those found in young subjects and age matched elderly controls.

Material and methods

SUBJECTS

Data were obtained from a group of 45 healthy young adults (18 men and 27 women aged 27.1 (SD 1.3) years), 14 healthy elderly adults (five men and nine women aged 67.1 (SD 4.2) years), and 17 patients with Parkinson's disease (six men and 11 women aged 67.3 (SD 3.8) years). The duration of the disease was between 4 and 14 years (mean 7.7 (SD 0.8) years). All control subjects were in good health as determined by an interview, personal history questionnaire, and neurological evaluation. Patients with a history of mental confusion, history of visual disorders (cataract, retinopathy), or medication which might result in visual dysfunction were previously excluded. Levodopa was withdrawn at least 24 hours before visual testing.

The degree of parkinsonian motor disability was evaluated by a neurologist and a physician for neurorehabilitation at the University Hospital of the Canary Islands. The neurological evaluation included the unified Parkinson's disease rating scale (UPDRS), version 3.0. The bradykinesia was computed as the sum of the values for movements of the fingers, hands, arms, and legs in both body sides. To normalise from 0 to 4 the sum was divided by eight. The rigidity or tremor was computed as the sum of values in all of the four limbs divided by four. The daily living activity disabilities (DLAD) were computed as the sum of items 5 to 17 of UPDRS or using the Hoehn and Yahr or Schwab and England scales.^{17,18}

EXPERIMENTAL PROCEDURE

Subjects were tested individually in a series of four experiments performed on consecutive days between 10 00 and 12 00 am. Each day, and after 20 minutes of adaptation to darkness, subjects were tested for 10 minutes. The techniques used to quantify the time resolution of the visual system was essentially the same as those described in a previous paper.¹⁶ Briefly, subjects watched a light emitting diode display (window subtending 5.6x1.4°) controlled with a computer and responding to a push button when the event required by the researcher was detected. The minimal time necessary to detect a specific characteristic of one of the image sequences shown on figure 1 was defined as

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Received 12 March 1997 and in final form 11 June 1998
Accepted 15 June 1998

J Neurol Neurosurg Psychiatry: first published as 10.1136/jnnp.65.6.921 on 1 December 1998. Downloaded from <http://jnnp.bmj.com/> on November 26, 2022 by guest. Protected by copyright.

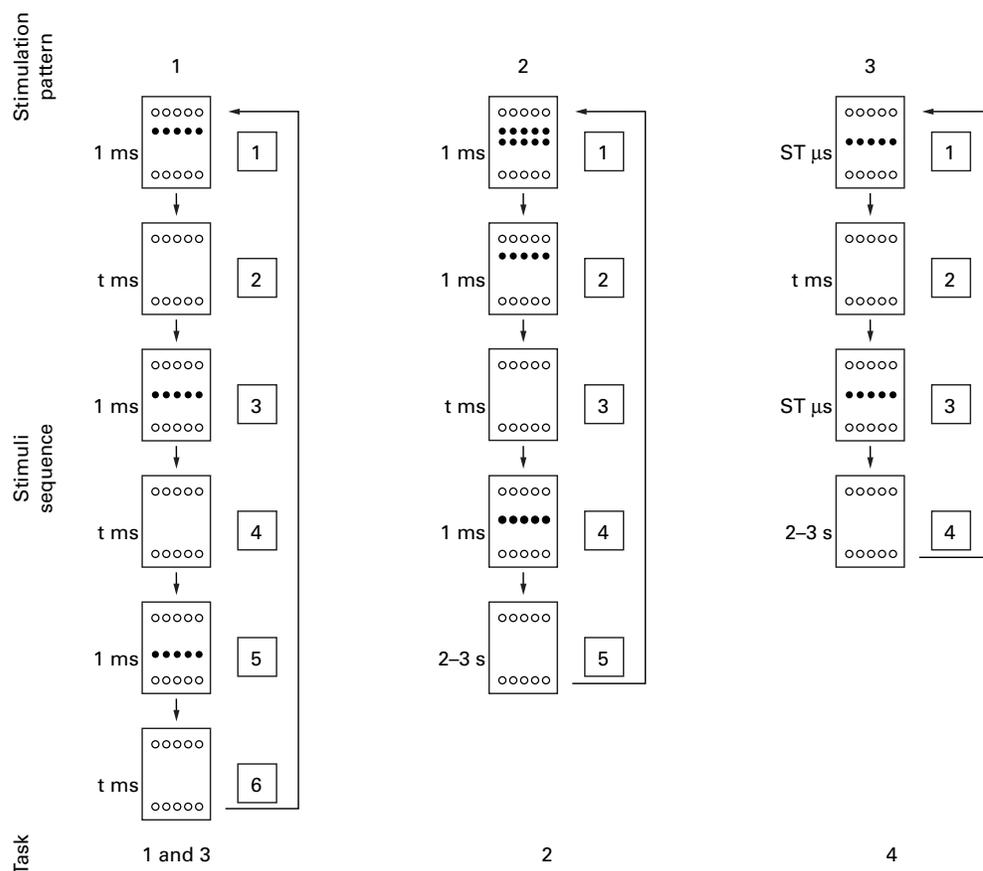


Figure 1 Stimuli sequences for the three stimulation patterns (top) and four visual tasks (bottom) used. “*t*” is the duration of experimental variables (ms). “*ST*” is the duration of a subthreshold stimulus duration (μ s).

detecting time threshold (DTT). For each task, the experimental variable is marked by *t*.

The stimulation pattern n1 was: (1) dotted line 3 switched on for 1 ms; (2) all lines switched off for a variable time *t*; (3) line 4 switched on for 1 ms; (4) all lines switched off for time *t*; (5) dotted line 5 switched on for 1 ms; (6) all lines switched off during time *t*. Two different tasks were performed with this stimulation pattern. With task n1 consecutive switching on and off was detected as a flickering (transitory switched off) of any of the lines that constitute the stimulus. With the task n3 consecutive switching on and off of lines 3, 4, and 5 was perceived as three individual dotted lines that are one by one discriminated with a periodical sequence. There is no perception that two lines have been switched on at the same time.

The stimulation pattern n2 was: (1) dotted lines 3 and 4 switched on for 1 ms; (2) line 3 switched on and line 4 switched off for 1 ms; (3) all lines switched off during a variable time *t*; (4) line 4 switched on for 1 ms; (5) all lines switched off during an interval the duration of which was randomly generated between 2 and 3 seconds. The task performed with this stimulation pattern was to detect any difference between lines 3 and 4 (task 2). Thus each line was switched on and off twice, the first one (line 2) with an interstimulus interval=0 and the other with a variable interstimulus interval (*t*). For low *t* values the successive stimuli were

fused (a temporal window) and both lines appear to be identical.

The stimulation pattern n3 was: (1) dotted line 4 switched on during a subthreshold time (*ST*); (2) all lines switched off for a variable time (*t*); (3) line 4 switched on for *ST* ms; (4) all lines switched off for an interval the duration of which was randomly generated between 2 and 3 seconds. The detection threshold was quantified by the limits method. Initially the switch on duration of the stimuli was 1 μ s, being increased in 0.5 μ s units until detected by the subject. Then the detection threshold was verified by increasing and decreasing the stimuli duration around the threshold boundary. The *ST* was computed as a stimulus time 30% shorter than that found for the detection threshold. Unless two successive stimuli were fused, the *ST* stimulus could not be detected. Thus task 4 was used to quantify the fusion window for successive *ST* stimuli arriving at the same place on the retina.

The DTT was always quantified by the limits method.¹⁹ Statistical analysis was performed with an analysis of variance (ANOVA) followed by a two way Student’s *t* test. Differences were judged to be significant at $p < 0.05$.

Results

In the 17 patients with Parkinson’s disease studied a middle degree was found for rigidity (1.14 (SD 0.18)), bradykinesia (0.87 (SD 0.13)), tremor (0.27 (SD 0.08)), DLAD (7.9

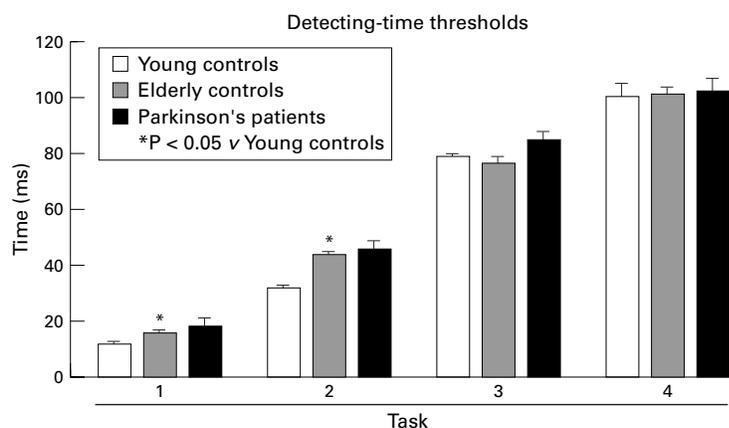


Figure 2 Detecting time thresholds for the three experimental groups in the four visual tasks.

(SD 1.49)), and Hoehn and Yahr (1.3 (SD 0.21)) or Schwab and England (81.6 (SD 3.47)%) scales.

In both task 1 (ANOVA $F=17.65$, $p<0.0001$) and task 2 (ANOVA $F=6.10$, $p<0.01$) the t value was higher in the elderly than in the young controls ($p<0.01$ task 1; $p<0.01$ task 2). No differences were found between elderly controls and patients with Parkinson's disease either in task 1 ($p=0.098$) or in task 2 ($p=0.675$). No significant differences were found between groups in task 3 (ANOVA $F=1.92$, $p=0.15$) or task 4 (ANOVA $F=1.49$, $p=2.38$).

Discussion

The main findings of the present study were (1) the time required to solve simple visual tasks increases during normal aging; (2) this increase was similar in patients with Parkinson's disease and age matched controls. These findings do not support the hypothesis that, as occurs in motor functions, Parkinson's disease induces in the visual system a perceptual slowness with a decrease in time resolution.

In addition to other visual disturbances,^{4,5} two previous studies have reported evidence suggesting an abnormal temporal discrimination in the visual system of patients with Parkinson's disease.¹³⁻¹⁵ Pillon *et al*¹⁵ found an increase in the time needed to name 12 of 15 objects the images of which were superimposed in a figure. In this test, the slowness of performance could be influenced by motor disturbances in the ocular movements required to explore the superimposed images or in the phonation movements.²⁰⁻²² Because the four tasks used here are free from the motor performance effect, present data cannot be directly compared with those obtained in this previous study. In the other study, Artieda *et al*^{13,14} found that the threshold for fusion of paired stimuli increased from around 68 ms (control) to around 85 ms (Parkinson's disease). In the present study the fusion threshold was around 30 ms (fig 2), a value similar to that previously reported in other works and that has been used to define the "cotemporal window"

for successive or the "horizon of simultaneity" for parallel visual stimuli.^{16,23,24} Perhaps differences in the experimental methodology and in the group of patients (the disability degree was low to mild in the present work and moderate to severe in most patients included in the study by Artieda *et al*) could be the basis for data disagreement.

In summary, the present data show no slowing for the first steps of visual processing in Parkinson's disease. The preservation of normal visual processing probably avoids visual disturbances in functions that, such as reading, need a fast computation of visual information. It has been reported that visual cues can be used to facilitate the starting of different motor patterns often blocked in Parkinson's disease.²⁵ Fast visual processing is probably also needed for this rehabilitation treatment.

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