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In 1997, Pokorny & Smith developed a psychophysical method to preferentially stimulate either the parvocellular (P) or the magnocellular (M) pathways. This method provides a powerful tool to study potential visual impairments of visual pathways. Their stimuli were based on the luminance contrast gain differences between the two pathways and the mode of presentation of stimuli changes depending on the channel, M or P, to preferentially stimulate. This rules out controversial results found when P and M are stimulated following their color and/or spatial-temporal sensitivities. In this study, we tested whether normal ageing has an effect on M and P pathways. We used the described method to measure contrast thresholds in two populations differing in age (27 vs 60 year old).

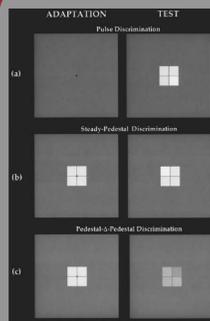
Behavioral experiment

Observers : we studied 2 groups of observers: a group of young observers and a group with older people.

Young adults: 16 observers aged 20 to 33 years (mean 27 year old).

Old adults: 20 observers aged 50 to 64 years (mean 56.5 ± 4.27 year old). All observers had a normal or corrected to normal vision with a visual acuity measured using the Monoyer Test at least 8/10 or (0.10 logMar) for both eyes. We also ensured that the color vision of each observer was normal using the Farnsworth Munsell 100 hue (FM 100 hue) test. All observers were naïve to the purpose and the design of the experiment.

Method



Extracted from Pokorny et al., 1997
(a) Parvo (Pulsed)
(b) Magno-Parvo (Steady)
(c) Magno (Delta)

The stimuli were generated using the VSG 2.5 card (CRS research system) and the Matlab 6 software. The stimuli were presented on a CRT color monitor 21" viewed binocularly at 1 m in a darkened room (resolution: 640 x 479 ; refresh rate : 60 Hz). The phosphor output was measured as a function of wavelength at the maximum light level for each phosphor with a eyeone greta MacBeth. The luminance levels was measured for the four different channels: the red, the green, the blue and the gray .

The test stimulus was a 4.6° square array of four 2.2° squares. The surround was 25° x 18.9° and filled the separations between the squares. The luminance of the surround was kept at 11.25 cd/m² throughout the experiment.

The retinal illuminance of the four-square array varied from 6.62 cd/m² to 19.10 cd/m², giving a series of contrasts. Stimuli are presented with a square function in time.

The observer's task was to discriminate (decide/answer) which square of the four-square differed from the other three. The observer first adapted for 2 min to a uniform display of 11.25 cd/m².

Observers used a response box (CB6 / CRS research system), with four buttons, to indicate which one of the four square was different from the others. Observers had to give an answer even to guess if he did not know the answer, otherwise the next trial did not appear. No feedback was given.

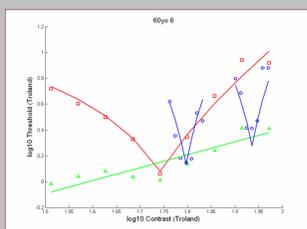
fMRI experiment

Observers: only one group of young adults participate in the fMRI experiment.

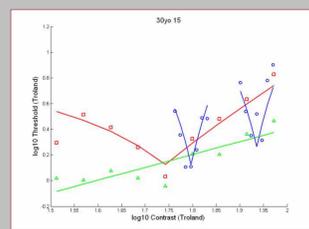
Young adults: 10 observers aged 22 to 32 year old. They all had a normal or corrected to normal vision with a visual acuity measured using the Monoyer Test at least 8/10 or (0.10 logMar) for both eyes. We also ensured that the color vision of each observer was normal using the Farnsworth Munsell 100 hue (FM 100 hue) test.

MR acquisition: Functional MR imaging was performed on a Bruker 3T MR imager, equipped with echo-planar (EPI) acquisition

Individual results

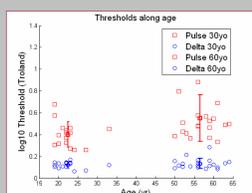


Contrast threshold for the three paradigms for a young adult

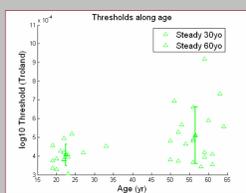


Contrast threshold for the three paradigms for an old adult

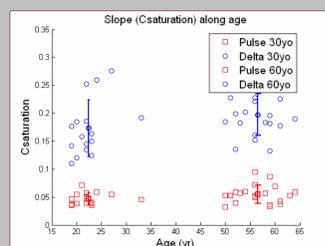
Group analysis



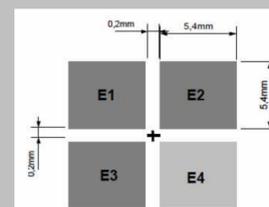
Contrast threshold for all the participants for two paradigms: pulse (Parvo) and pedestal-delta-pedestal (Magno)



Contrast threshold for all the participants for one paradigm: steady (Magno-Parvo)



As expected there is an increase of the mean threshold with aging; on the opposite there is no significant difference between the slopes obtained for the two groups of observers, and this for the three paradigms. Even if we had a look on the oldest observer, his slope did not significantly differ from the ones of young observers.



The stimuli used in the fMRI study was the same as for the behavioral experiment.

E0 : condition with contrast below the measured threshold (the target was not visible).

E1-E4 : conditions with contrast above the measured threshold.

Participant had to answer even if he did not know the answer (condition E0).



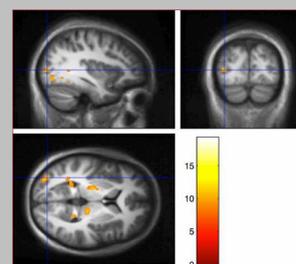
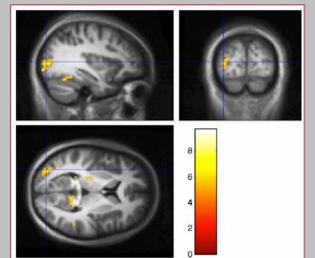
We used a mixed design : blocks (paradigm P, paradigm M, paradigm M-P) and events (E0, E1, E2, E3 and E4)

Repeated 6 times : P, M-P, M, P, M-P, M in a random order.

All observers had practice trials in the scanner before running data acquisition; these practice trials allows to measure the observer threshold for the three paradigm.

Group analysis

Magno (E0, E1, E2, E3 and E4) ; (p<.05 FWE voxel size>50) : dorsal activations



Magno vs Parvo (all events); (p<.0001 uncorrected voxel size>50) : activations in V3a and V5

We observed large variabilities between different subjects. The contrast above/below threshold was not strong enough to « be visible » in the cortical activations.

As expected, we found that both M and P contrast thresholds increase with age but we did not find any difference between the two pathways efficiency measured as the slope of contrasts vs. threshold curve. These results are in agreement with Wuergler's results (Wuergler *et al.*, 2010) but are non-consistent with Elliot's ones (Elliot *et al.*, 2010). This inconsistency may be due to (1) the lower mean age of our elderly population (60 vs 70) , (2) our use, to produce the stimuli, of a VSG card 2.5 (Cambridge Research Systems) with a more accurate control of luminance as compared to the Elliot's study.

For the fMRI experiment, we adapted the same protocol. The strength of the effect between a contrast above/below threshold is not enough to contrast the two main conditions : M and P. Our second goal was to see a ventral/dorsal activation for Parvo/Magno preferential activation. In fact, even if the M paradigm showed activations in the dorsal pathway, the P paradigm did not show any specific activation. Actually, the method uses only presentation mode for stimulating preferentially Parvo or Magno pathway. In our group analysis this does not result in differential brain activation. The only difference appears in V5 and V3A which indeed correspond at least for V5 to areas dedicated to motion (or temporal modulation of contrast).