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Supplemental Information

Altered Visual Plasticity in Morbidly Obese Subjects

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Transparent Methods

Subjects

A group of 53 adult volunteers (15 males, age: mean ± SD = 35±12 years, range from 18 to 55 years), participated in the study. All subjects had normal or corrected-to-normal visual acuity. For each subject, body weight and height were measured in order to compute the Body Mass Index (BMI). The average (mean±SD) BMI was 34±11 (range: from 18.75 to 53.5). Subjects data are reported in Table 1. All obese subjects (BMI>30) underwent a full metabolic assessment and only subjects with normal glucose tolerance were included in the study. Morbidly obese subjects (BMI>40) also underwent a battery of cognitive tests (Mini Mental State Examination and Montreal Cognitive Assessment), all subjects showed cognitive performances in the normal range. Subjects with psychiatric disorders, neurodegenerative diseases, epilepsy, depression treatment, steroids treatment, traumatic brain injury over the preceding six months, liver function enzymes higher more than two times the upper limit, heart failure (NYHA III-IV), type 1 diabetes and women who were pregnant or breastfeeding were excluded from the study.

Ethics Statement

All subjects gave informed consent to participate to the study, which adhered to the tenets of the Declaration of Helsinki and was approved by the local ethical committee [Comitato Etico Pediatrico Regionale—Azienda Ospedaliero-Universitaria Meyer—Firenze (FI)], under the protocol "Plasticità del sistema visivo" (3/2011).

Apparatus and stimuli

The experiment took place in a dark and quiet room at the Unit of Metabolic Diseases and Diabetes of the clinical hospital of Pisa (Azienda Ospedaliero-Universitaria Pisana).

Visual stimuli were generated by the VSG 2/5 stimulus generator (CRS, Cambridge Research Systems), housed in Laptop (Dell) controlled by Matlab programs. Visual stimuli were two sinusoidal gratings, oriented either 45° clockwise or counterclockwise (size: 2σ = 2°, spatial frequency: 2 cpd), presented on a uniform background (luminance: 9cd/m2 CIE x=.311, y=.341) in central vision with a central black fixation point and a common squared frame to facilitate dichoptic fusion. Visual stimuli were displayed on a 17-inch CRT monitor (FD Trinitron CRT multiscan G200) monitor, driven at a resolution of 1024x600 pixels, with a refresh rate of 120 Hz. Observers viewed the display at a distance of 57 cm through CRS Ferro-Magnetic shutter goggles that occluded alternately one of the two eyes each frame. Responses were recorded through the computer keyboard.

Procedures

Monocular Deprivation

Monocular deprivation was performed using an eye-patch of a translucent plastic material that allowed light to reach the retina (luminance attenuation 0.07 logUnits) but completely prevented pattern vision, as assessed by the Fourier transform of a natural world image seen through the eye-patch. The dominant eye (the eye showing longer perceptual predominance in binocular rivalry and/or the fixation eye at the Porta test) was patched for two hours. During the 2h of monocular occlusion patients were free to perform normal activities (walking, reading, using a computer).

Binocular Rivalry

Each binocular rivalry experimental block lasted 125 seconds. After an acoustic signal (beep), the binocular rivalry stimuli appeared. Subjects reported their perception (clockwise, counterclockwise or mixed) by continuously pressing with the right hand one of three keys (left, right and down arrows) of the computer keyboard. At each experimental block, the orientation associated to each eye was randomly varied so that neither subject nor experimenter knew which stimulus was associated with which eye until the end of the session, when it was verified visually. Two binocular rivalry experimental blocks were acquired before short-term monocular deprivation and four blocks after eye-patch removal.

Analyses

The Body Mass Index (BMI) was computed for each subject using the following (standard) equation:

$$\frac{\text{Weight(Kg)}}{\text{Height(m)}^2}$$

Eq.1

The perceptual reports recorded through the computer keyboard were analyzed using Matlab. Mean phase durations for the two orientations and for mixed percepts (the average perceptual duration of each rivalrous stimulus) as well as the total time (T) spent by the observer perceiving the stimulus presented to either eye (deprived and non-deprived) and the total time of mixed percepts were computed. Proportion of mixed percept is the total time of mixed percept normalized by total trial time (T).

To quantify sensory eye dominance, we obtained an index of ocular dominance, ranging from 0 (complete dominance of the non-deprived eye) to 1 (complete dominance of the deprived eye), according to the following equation:

$$\frac{T_{Dep}}{T_{Dep} + T_{NonDep}}$$

Eq.2

The effect of monocular deprivation was computed as the difference between the sensory eye dominance index measured after and before the 2h of monocular deprivation. This measure was not affected by the variation in proportion of the mixed percept.

Statistics

Statistical analyses were performed using SPSS-2.0 and Matlab software. Subjects were divided into three groups according to their BMI: group 1 (N=20) included healthy-weight (N=17, BMI range from 18.5 to 25) and overweight subjects (N=3, BMI range from 25.1 to 30), group 2 (N=16) included class I (BMI range from 30.1 to 35) and class II (BMI range from 35.1: to 40) obese subjects (moderate and severe obesity) and group 3 (N=17) included class III (BMI > 40.1) obese subjects (morbid obesity). The effect of monocular deprivation and the proportion of mixed percepts were then compared across groups using a univariate ANOVA. Post-hoc tests were performed by using independent-samples t-tests, the obtained p-value was corrected for multiple comparisons using the Bonferroni method. All t-tests were two-tailed and α value was fixed at 0.05.

The sample size was determined based on previous studies measuring the effect of short-term monocular deprivation on ocular dominance in adult humans (Binda and Lunghi, 2017; Lunghi et al., 2015a, 2013, 2011). These studies showed that a sample size between 10 and 20 provides enough power to reveal the effect of short-term monocular deprivation.

Correlations were computed using the Pearson's correlation coefficient (r), statistical significance assessed using a permutation test. The obtained p-value was corrected for multiple comparisons using the Bonferroni method. In order to assess the robustness of the correlation, we also computed the Bayes Factor (BF): conventionally, a BF lower than 0.3 indicates evidence in favor of the null hypothesis (no correlation), whereas a BF larger than 3 indicates evidence in favor of the alternative hypothesis and therefore a robust correlation between the two variables tested.