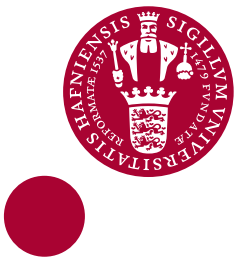

Human visual evoked potentials are potentiated by long-term visuo-gustatory conditioning

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EVENT ABSTRACT

Human Visual Evoked Potentials are Potentiated by Long-Term Visuo-Gustatory Conditioning

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Aim: The taste of food items and beverages can be recalled on the basis of their visual appearance using long-term visuo-gustatory associative memory. This raises a question concerning the processes in the human brain that take place when visual appearance (conditioned stimulus, CS) is combined with flavor (unconditioned stimulus, US). Possible learning-induced plastic changes of the CS-evoked visual potentials were investigated using high-density EEG scanning. Effects of associations with both an appetitive and an aversive flavor were examined. Methods: 12 healthy subjects participated, age 20-41, mean 29.6±6 (S.D.). 118 EEG-channels were used (ANT Neuro, Enschede, the Netherlands). Electrode cables were actively shielded and electrodes were placed according to the standard “5 % system” [1] referenced to the average potential of all electrodes. Two pairs of bipolar electrodes recorded EOGs. Sampling rate: 512 per s per channel. Before image-taste association, subjects were presented with two unfamiliar images. Visual evoked potentials (VEPs) were recorded for each of them (60 presentations of each in semi-random sequence; stimulus duration: 1 sec). In a subsequent training session, one of the images was associated with the taste of an appetitive apple juice, and the other with an aversive version of the same juice containing NaCl, glutamate and ferro-sulphate. Three presentations of each CS-US pair were given in semirandom sequence. Each of the two images was presented before the appetitive US to half of the subjects and before the aversive US to the other half. One day after training, memory of the image-taste associations was tested (100% correct answers required) and VEPs were recorded again using the same procedure as before training – in order to compare the two sets of VEPs. All epochs containing visual presentations were examined off-line and rejected if containing any type of artifact. Results: On a hedonic rating scale from -5 to +5, the appetitive juice received an average score of +3.3 ± 0.3 (S.E.M.) versus -2.9 ± 0.4 for the aversive juice. Comparisons between VEPs recorded before and after image-flavor associations revealed the following changes: 1. The average peak delay for the N2-wave of the VEPs recorded in 20 electrodes placed over posterior visual cortex areas was 168.9 ± 1.2 ms (S.E.M.) before training while after training with appetitive juice it was reduced to 153.9 ± 2.0 ms

(p<0.001) and aversive conditioning reduced it to 163.6 ± 1.7 ms (p<0.001). 2. The average potential difference between peaks of the N2 and P3 waves in the same 20 posterior electrodes was 8.3 ± 0.2 μV before training versus 10.4 ± 0.4 μV after appetitive and 10.1 ± 0.4 μV after aversive conditioning (p<0.001 for both). 3. Mean theta power in the 20 electrodes was 0.74 ± 0.04 μV2 before training versus 1.38 ± 0.11 μV2 after appetitive training and 0.99 ± 0.06 μV2 after aversive (p<0.0001 for both). (The values are group average data for trial average power calculated on the basis of Fast Fourier Transformation for the first 750 ms of VEPs). 4. Visually induced currents were examined using swLORETA [2] (7*7*7mm voxels) in 5 left and 5 right hemisphere visual regions: (1) cuneus (visual areas 1 and 2 above the calcarine fissure), (2) lingual gyrus and the medial occipital gyrus (areas 1 and 2 below the calcarine fissure), (3) the middle inferior occipital gyrus, (4) the inferior temporal gyrus posterior to 50 mm behind the anterior commissure and (5) the middle part of the inferior temporal gyrus (between 10 and 50 mm posterior to the anterior commissure). Voxel positions identified by Thalairach coordinates were allocated to regions using a stereotaxic atlas [3]. Currents were examined separately at the N2 and the P3 peaks (averaged over a period between 2 samples before to 2 samples after each peak). Before training, the average N2 peak current was 11.2±0.2 nA across all regions compared to 19.1±0.4 nA after appetitive and 20.2±0.7 nA after aversive training. For P3: 10.1±0.2 nA before conditioning, 17.5±0.3 nA after appetitive and 17.4±0.4 nA after aversive conditioning (p<0.0001 for both types of learning and for both peaks). The increases of image evoked currents were also statistically significant within each left and right hemispheric region. No significant differences were observed between the effects of appetitive and aversive conditioning for image-evoked amplitudes, theta power or regional currents. 5. A correlation was found between VEP plasticity and the hedonic ratings of the juices. Although the two juices were the same for all subjects, the hedonic scores varied between individuals from +1 to +5 for the appetitive juice and from -1 to -5 for the aversive one. When these individual ratings were plotted on an X-axis against the individual percentage increases of the N2-peak to P3-peak amplitudes on the Y-axis, a linear relationship with a positive slope was observed for appetitive conditioning (Pearson Correlation Coefficient = 0.76 (p=0.004)). After aversive conditioning, a negative linear relationship appeared (Correlation Coefficient = -0.87 (p=0.001). Conclusions: One day after either appetitive or aversive image-taste conditioning, visual CNS-processing was changed: (1) The processing speed was enhanced, (2) amplitudes of endogenous VEP waves were augmented leading to (3) enhanced visually induced power in the theta frequency band. (4) Visually evoked currents were increased in early activated cortex areas and in the ventral visual stream. (5) The hedonic ratings of the appetitive and the aversive USs performed by each subject were found to correlate with the magnitude of learning-induced VEP-plasticity observed in each subject: the stronger the subjectively perceived hedonic intensity of the US, the greater the magnitude of VEP-plasticity. The results on VEP potentiation in N2 and P3 waves of VEPs confirm previous observations on the effects

of long-term appetitive visuo-gustatory conditioning from this laboratory [4]. Short-term visual taste conditioning has previously been found to increase VEP amplitudes [5].

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