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# **INFLUENCE OF LOW-LEVEL STIMULUS FEATURES ON HIGH-LEVEL STIMULUS CATEGORIZATION? BEHAVIORAL AND NEURAL EVIDENCE**

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***Abstract.*** A crucial issue in the cognitive neuroscience of face perception has centered on the extraction and processing of relevant information from the visual environment. In particular, the influence of low-level stimulus features on high-level information processing remains under investigation and debate. While most previous research addresses individual roles of the spatial frequency (SF) scales (using just one SF band at a time), issues regarding the integration of these scales have remained unexplored. In order to better understand how faces are processed by the visual system, it is necessary to determine the relative contribution of low and high spatial frequency scales in the perception of faces. Using visually guided reaching as a continuous behavioral measure and magnetoencephalography, face perception and categorization was investigated in healthy adults. Results from the reaching trajectories as well as the neuroimaging study demonstrate a behavioral significance and the neural primacy for low spatial frequency information in stronger, faster and lateralized perception of faces.

***Keywords:*** face perception, spatial frequency, MEG, M170

A crucial issue in the cognitive neuroscience of face perception has centered on the extraction and processing of relevant information from the visual environment. In particular, the influence of low-level stimulus features on high-level information processing remains under investigation and debate. Early stages of visual encoding involves rapid processing of low-level stimulus properties such as luminance, contrast and spatial frequency. While most previous research addressed individual roles of the spatial frequency (SF) scales (using just one SF band at a time), issues regarding the integration of these scales and their role in higher level visual processes have remained unexplored. In order to better understand how higher-level stimuli are processed by the visual system, it is necessary to determine the relative contribution of low and high spatial frequency scales in perception of faces and other stimuli. Using visually guided reaching as a continuous behavioral measure and magnetoencephalography (MEG), we investigated the perceptual dynamics and categorization of faces and places in healthy adults.

We used reaching trajectories as our behavioral measure because this method can provide a window into the perceptual decision making process.

Tracking of hand movements can provide real-time access to fine-grained traces of the information accumulation that remain hidden in other discrete behavioral measures. In the experiments reported here, the subjects were required to initiate their hand movements before they arrive at a decision and their hand movement trajectories allow us to observe how the decision evolves. A change in the trajectory path (measured as path-offset or curvature) potentially reflects a change of mind in their decision-making process that is modulated by the amount of information available to the perceptual system.

In the first study, the experimental stimuli were LSF–HSF hybrids of superimposed male and female faces that were presented peripherally and centrally in alternate experimental blocks. Subject were required to reach out and point to a specified sex (counter-balanced across subjects) on a touch screen while their movements were recorded using a high-fidelity optotrak motion capture system. Path-offset was taken as a dependent measure in the decision making process. We calculated the deviation from a straight-line path from start to end of the movements. Curvature was defined as the ratio of this deviation to the length of the straight-line path. The mean curvature measure of the trajectories reveal that there is less effect of (interference by) LSF faces at fovea as compared to periphery while reaching to HSF targets.

Similarly, in another study using the same experimental setup, we tested if the LSF advantage is face specific or also involved in place perception. Here we used LSF-HSF hybrids of faces and places. Subjects were required to reach out and point to the targets and their movements were recorded. The trajectories revealed that LSF interference was both 95 ms earlier and stronger for faces than places and was lateralized to the left visual field.

Finally, a reaction time and a MEG study was conducted using spatially filtered images of faces and places (not hybrids). Subjects' reaction times were measured in a task requiring categorization of LSF and HSF faces and places. Reaction time measures revealed significantly faster categorization of faces driven by LSF information, while rapid categorization of places was facilitated by HSF information. The MEG study showed significantly earlier latency of the M170 component for LSF faces compared to HSF faces. Moreover, the M170 amplitude was larger for LSF faces than for LSF places, whereas the reverse pattern was evident for HSF faces and places.

Results from the reaching trajectories as well as the MEG study demonstrate a behavioral significance and the neural primacy for low spatial frequency information in stronger, faster and lateralized perception of faces. Collating together, the results suggest that spatial frequency (a low-level feature) modulates the processing of category specific information for (high-level stimuli such as) faces and places.

# **Влияние низкоуровневых признаков стимул на высокоуровневую категоризацию стимула. Поведенческие и нейрофизиологические данные**

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*Аннотация.* Центральным вопросом нейрокогнитивных исследований восприятия лиц — проблема извлечения и обработки релевантной информации из зрительно воспринимаемого окружения. В частности, до сих пор продолжается изучение и обсуждение влияния низкоуровневых признаков стимула на высокоуровневые процессы обработки информации. В данной работе, используя реакцию дотягивания под контролем зрения в качестве непрерывного поведенческого показателя, а также магнитоэнцефалографию, мы исследовали восприятие и категоризацию лиц здоровыми испытуемыми. Результаты траекторий дотягивания и данные нейровизуализации демонстрируют поведенческую значимость и нервный примат низких пространственных частот, что выражается в более чётком, быстром и латерализованном восприятии лиц.

*Ключевые слова:* восприятие лиц, пространственные частоты, магнитоэнцефалография