Understanding Neural Correlates of Object Recognition

Object perception involves the recognition and understanding of objects through sensory inputs such as visual, auditory, and tactile information. This process is essential for various cognitive functions, including navigation, social interactions, problem-solving, and daily activities. The ability to perceive objects relies on the brain's capacity to integrate sensory information and form coherent representations of the environment. This thesis delves into the neural mechanisms behind object perception, focusing on how the brain learns to recognize objects and whether these abilities are innate or shaped by environmental factors.

The study leverages data from Project Prakash, an initiative aimed at restoring sight to curably blind children in India. This project offers a unique opportunity to investigate fundamental questions about brain development and visual learning. Participants in the study include healthy controls with normal vision and Project Prakash subjects who have undergone sight-restoring surgeries. The research aims to assess two critical aspects of object perception: basic structure perception, which involves perceptual grouping, and complex structure perception, which involves face recognition.

Project Prakash subjects are categorized into two groups: long-term subjects (LTS), who have had extended visual experience post-surgery, and newly-sighted subjects (NSS), who are recently operated on and are followed shortly after surgery. The study seeks to determine whether congenitally blind children, treated several years after birth, can develop object perception abilities similar to those of typically sighted children, and whether these abilities are innate or acquired through experience.

The thesis first examines how perceptual grouping abilities develop in LTS over extended periods following visual surgery. Participants who had undergone cataract surgery were exposed to images containing structured and non-structured elements and were tasked with identifying structures within them. Healthy individuals of similar age, social, and economic backgrounds were included as controls. EEG data was collected from both the cataract group and the control group, and the resulting event-related potentials (ERPs) were analysed to identify different ERP components. Findings reveal high brain activation in response to structured stimuli, indicating enhanced perceptual grouping compared to random stimuli. This suggests the acquisition of perceptual grouping skills among those who underwent surgery one to five years prior to the study.

The research also investigates the development of face perception abilities in NSS. Analysis of ERP responses from occipito-temporal electrodes in these subjects reveals an ability to discriminate faces from objects post-surgery, with this capability improving over time. Interestingly, the ERP responses of these subjects converge towards those of healthy individuals as time progresses, indicating significant enhancements in face categorization abilities after vision restoration interventions among previously visually impaired individuals. These improvements manifest in various aspects, including visual acuity, behavioural responses, and EEG patterns observed in Project Prakash subjects. These findings suggest that the development of face perception ability may be influenced by experience rather than solely relying on early visual input.

Overall, the findings indicate that object perception abilities are significantly influenced by experience and environmental factors beyond early visual exposure. This thesis highlights the importance of experience-dependent plasticity in shaping object recognition skills.