Chapter 20

Motion Perception in Healthy Humans and Cognitive Disorders

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ABSTRACT

To elucidate how the dorsal visual pathway is functionally altered in mild cognitive impairment (MCI) and Alzheimer’s disease (AD) patients, first, the neural basis of motion perception in healthy young adults was examined by using visual event-related potentials (ERPs) and functional magnetic resonance imaging (fMRI) with coherent motion stimuli such as radial optic flow (OF) and horizontal motion (HO). Nonspecific, motion-related N170 from V5/MT and OF-specific P200 with an inferior parietal lobule (IPL) origin were obtained in ERPs. fMRI revealed the close relationship between IPL activity and OF stimuli. Next, coherent motion perception was assessed by the psychophysical thresholds for patients with AD and MCI, as well as ERPs for MCI patients. MCI patients manifested a selective elevation of the OF threshold, while AD patients exhibited higher psychophysical thresholds for both OF and HO. In ERPs, the P200 latency for OF (but not the N170 latency for OF and HO) was significantly prolonged in MCI patients. These findings indicate that patients with AD and MCI have impaired coherent motion processing due to higher levels of the dorsal pathway. In particular, OF processing related to the IPL is selectively impaired in patients with MCI. Therefore, a combined approach with psychophysics and ERPs using coherent motion (particularly OF) can be useful to discriminate MCI and AD patients from older but healthy adults.

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INTRODUCTION

The Parallel Visual Pathways in Humans

Two major parallel visual pathways exist in humans, namely the parvocellular (P) and magnocellular (M) pathways (Livingstone, & Hubel, 1988; Tobimatsu, & Celesia, 2006). Both systems begin in the retina and project to the primary visual cortex (V1) via the lateral geniculate nucleus. From V1, the P-pathway projects to the ventral stream, which includes V4 and the inferior temporal cortex. This system is responsible for processing form and color because it can detect stimuli with high spatial frequency and color (Livingstone & Hubel, 1988; Tobimatsu, & Celesia, 2006). Conversely, after V1, the M-pathway projects to the dorsal stream, which includes V3a, V5/MT, MST, V6 and the posterior parietal lobule. This system plays an important role in detecting motion as it responds to high temporal stimuli (Livingstone, & Hubel, 1988; Tobimatsu, & Celesia, 2006). Recently, the dorsal stream was shown to be divided into two functional streams in primates: the dorso-dorsal (d-d) and ventro-dorsal (v-d) streams (Rizzolatti, & Matelli, 2003). The former consists of V6 and the superior parietal lobule (SPL), whereas the latter is formed by V5/MT and the inferior parietal lobule (IPL).

Motion Perception in Humans

Motion information is mainly processed by the dorsal stream (Livingstone, & Hubel, 1988; Tobimatsu, & Celesia, 2006). It is well-known that the higher level dorsal stream, including V5/MT, integrates local motion signals from V1 into global motion (Snowden, Treue, Erickson, & Andersen, 1991) (Figure 2). Therefore, coherent motion stimuli have been widely used to investigate global motion processing in psychophysical, electrophysiological and neuroimaging studies (Newsome, & Paré, 1988; Niedeggen, & Wist, 1999; Morrone et al., 2000). There are several types of global motion, including radial optic flow (OF) and horizontal motion (HO; Figure 3). In particular, radial OF, the visual motion seen during observer self-movement, is important for...