Electrophysiological Insights into the Prefrontal Brain of Rats and Monkeys

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Introduction

The question of whether rats have a Prefrontal Cortex (PFC) and, if so, what the primate equivalent is has been debated for a long time. The rat medial PFC is linked to the primate Anterior Cingulate Cortex (ACC) and dorsolateral PFC, according to anatomical data. The primate and human ACC are thought to be engaged in the monitoring of activities and consequences in order to guide decisions, especially in difficult situations including cognitive conflict and mistakes. The dorsolateral PFC, on the other hand, is in charge of keeping track of and manipulating goal-related objects in memory in order to plan, solve problems, and anticipate future occurrences. Prediction is a crucial function of the human brain. Influential theoretical perspectives argue that we make predictions about upcoming sensory consequences as a result of our own activities, and that anticipating these outcomes is critical for action control. At the brain level, however, nothing is understood about how projected outcomes are recorded. We expected that brain activity representing result anticipation should occur before action is taken. Anticipation should be represented in an outcome-selective decrease in brain activity, according to computational theories on action control. The current work used scalp electroencephalography to demonstrate that brain activity reflects action-effect specific representations prior to reaction start. We used frequency entrainment to identify brain activity that was unique to various action-effects.

The social primate is highly stimulated by the motions of other conspecifics' faces and body. Single-cell studies, field potential recordings, and functional neuroimaging data show that specific visual processes exist in both human and non-human primates' Superior Temporal Sulcus (STS) that elicit selective neural responses to moving natural pictures of faces and bodies. STS systems also interpret reduced representations of biological motion, such as point lights indicating active body limb articulations and geometrical forms whose motion imitate deliberate behaviour. Facial movements, such as variations in eye gaze, which are critical for determining a person's social attentiveness, and mouth motions, which indicate future utterances, produce especially strong brain responses that distinguish across movement types.

Primates, as sociable creatures, constantly monitor one another's behaviour in order to successfully integrate into their communal living system. Successful predator avoidance requires the ability to 'read' the activities of other species in one's environment on a non-social level. Human primates' capacity to read other people's movements and actions extends beyond basic survival and effective interactions with crucial conspecifics. Without this capacity, many of our recreational and cultural endeavours would be impossible. Excellent symphony orchestras survive not just because of their outstanding musicians, but also because of their ability to read nonverbal conductor directions. Conductors clearly communicate not just how the orchestra should perform the piece of music technically, but also how the mood and emotional tone of the song should be modulated measure by measure. The silent cinema pioneers, who could entertain with their non-verbal antics, owe much of the motion picture industry's success today. To fulfill their team's aims and thwart opponents, the world's finest athletes rely on the interpretation of others' moves.

The brain underpinnings of detecting effortful vs. easy motions belonging to a certain repertoire were explored in this Electrophysiological (EEG) study (ballet). Previous research has demonstrated that seeing and imagining human acts that demand a lot of muscle work causes a rise in heart and respiratory rate. Furthermore, during the observation of effortful actions, TMS (transcranial magnetic stimulation) and EEG investigations have revealed a larger musclespecific cortical excitability and an increase in late event-related potentials. In this study, fifteen professional female ballet dancers were paired with 15 controls who had no prior experience in dance, gymnastics, or martial arts. They were given 326 short films of a male dancer doing conventional ballet moves, which might be difficult or appear to be straightforward. Furthermore, both groups showed increased Late Positivity in response to effortful stimuli, which might be due to the processing of higher amounts of visual kinematic data. Dancers engaged more frontoparietal areas, but task-related frontal and occipitotemporal visual regions were more active in controls, according to the source reconstruction swLORETA conducted on the Late Positivity component. It appears, then, that during action observation and in the absence of explicit instruction, dancers encoded effort information in a more nuanced manner. Acquired motor knowledge appears to lead to visuomotor resonance processes, which underpins improved action representation of observed motions.

Recent single-unit recording investigations in rats have found robust correlations between motor planning, movement, and reward anticipation, similar to what has been seen in the primate ACC. There's additional evidence that rats use body posture or alterations in running course as embodied techniques to partially encode information across delays, and that these are the elements monitored by medial PFC neurons. The monkey PFC may have advanced these primitive tasks by transferring them to more abstract levels of mental representation, making them less dependent on somatic or other external mnemonic signals and permitting manipulation of mental contents outside of task settings.

Recent research has found tight links between language and action-related functions, implying similar brain mechanisms. The semantics of action planning, on the other hand, are poorly understood. The current study used event-related potentials to evaluate the activation of semantic information in meaningful behaviours (ERPs). Before performing the activity, subjects planned meaningful or meaningless behaviors with items and responded with a semantic classification answer. In terms of the action's aim, the words delivered might be either congruent or incongruent. When individuals prepared significant activities, they had a greater anterior N400 for words that were incongruent to the current action objective than for words that were congruent, but no N400 impact was seen when they prepared meaningless acts. From an electrophysiological standpoint, a previous study from our research group found that viewing static images depicting dynamic/effortful actions (i.e., running, jumping) elicited a larger Late Positivity (LP) component (event-related potential, ERP) compared to static/effortless actions (i.e., reading, eating). This potential was highest over frontal and centro-parietal regions (from 350 ms beginning) and was taken as a measure of the amount of body kinematic information to be stored. The EBA, MT, STG (superior temporal gyrus), PM, M1, and IFG all showed increased activity in response to dynamic/effortful (vs. static/effortless) implicit motion in the LP time-window.

Because videos increase the existence of observable movement kinematic characteristics, video stimuli were employed instead of static frames in this work to evaluate the time course (using EEG method) and brain correlates of action perception progression. The depiction of complicated actions (ballet steps) was explored in particular by varying the motor content (effort required) of the movement as well as the viewers' visuomotor skill (ballet dancers vs. controls). We expect see a difference in ERP modulation across groups if action effort representation is anchored by visuomotor processes, because control individuals lack specialised motor skill. The need of conceptual knowledge for action becomes abundantly obvious only in the case of a neuropsychological deficiency such as ideational or conceptual apraxia, which is characterised by a loss of understanding about how to use tools and everyday household objects meaningfully. Surprisingly little is known about the mechanisms that govern the meaningful use of things, as well as the nature of the mental representations that are involved. For the most part, this is due to historical differences between studies focused only on distinct cognitive processes such as perception, language, action, and memory.

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