Opinion Article

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Areas of the Brain that Process Visual Information about Ballet Dancers' Bodies

Sergei Kruk*

Department of Communication Studies, Riga Stradins University, Riga, Latvia

***Corresponding author:** Sergei Kruk, Department of Communication Studies, Riga Stradins University, Riga, Latvia, E-mail: sergei.kruk@gmail.com

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About the Study

Classical ballet is perhaps the most elitist art. To appreciate performances, spectators must know positions, poses and movements; to understand the narrative, they must know the libretto. Adhering to the same opinion, it was a rare guest in the theatre until suddenly the dancers found a key to my autonomic nervous system. Tears, increased heart and breath rate, piloerection, sweating and vasoconstriction were the signs that communicated the story danced without words. Since then, have become a devoted ballet lover. The experience with the neuroscience of vision from the semiotic point of view; in this article, summarise the argument describing the neural mechanism in more detail [1].

The brain mobilises two distinct pathways to process visual input. The ventral pathway, in conjunction with information from visual and semantic memory, secures the recognition and identification of visually perceived objects and analyses their form. The dorsal pathway localises objects in space and processes motion signals; it operates without the intervention of visual awareness [2]. The Extrastriate Body Area (EBA) and the Fusiform Body Area (FBA) belonging to the dorsal pathway process whole bodies and body parts [3,4]. The EBA is connected to higher cortical areas during different cognitive tasks, specifically the ventral Premotor Cortex (vPMC), which houses the representation of complete body postures. The EBA is not sensitive to expressed emotion [5]. Two pathways allow for the recognition of ballet postures and movements that are already known to the spectator; emotions are not involved at this stage. Cultural competence is needed to recognise the single elements of body movement and their sequences in the continuous flow of movement and to evaluate technical precision. Since spatial properties of objects are processed without visual awareness, spectators should make special efforts to consider dynamic features of the movement as signs worth interpreting.

The ventral and dorsal pathways provide sufficient information when ballet is conceived as a combination of invariant elements. However, often choreography does not explicate the transition between elements and the required muscular effort (e.g., fast/slow, tensely/relaxed). Dancers can vary motricity and this body work informs about their inner states which include attitude to the role, partners and/or spectators. This information is processed by a neural network known as the social brain or the third visual pathway. It enables recognition of faces and bodily expressions of other persons and evaluation of their beliefs, desires, intentions, goals, experiences, sensations and emotions [6-8]. Two complementarity theories explain the work of the social brain [9-11]. The theory of theory suggests that we apply naïve psychological knowledge to infer the mental states of others from their behaviour and the environment; the simulation theory contends that we simulate their mental states internally.

The Superior Temporal Sulcus (STS) and the Temporoparietal Junction (TPJ) analyse the visible actions of others. The posterior part of STS detects and interprets motricity relevant for social information processing. The left posterior STS reacts to discrete emotion categories or body movements associated with emotions [12]. The posterior TPJ compares the received input with the relevant models of previous experience stored in explicit memory; further, this information guides visual exploration of and interaction with the surrounding social environment [13]. The posterior TPJ is identified as part of the theory of theory network. In this network, the Temporal Poles (TP), associated with memory processes, give the semantic context to the elaborated visual *stimuli*; the medial Prefrontal Cortex (mPFC) analyses the visual *stimuli* and produces explicit representations of one's own and others' mental states [11-13].

Simulation theory explains the emotional perception of others. The STS relates to the amygdala [14] that assigns somatic marks to events important for the organism [15], thus forming implicit emotional memory [16]. The amygdala compares the characteristics of a new event with the experience. Having detected a similar emotional component, it activates the hypothalamus, which regulates the autonomic nervous system. The changing condition of the body ('goose bumps' mentioned by art lovers is not a metaphor) is a signal to the cortical areas to pay more attention to the external stimulus [17]. Interoception is underpinned by the insular cortex, which represents the internal states of the body as affective feelings. The Anterior part of the Insular Cortex (AIC) integrates interoceptive information with an interpretation of the current situation, creating a subjective experience of the emotional state. An important fact explaining the difference of perception of theatrical performance is that the AIC is activated when one is observing close others, but not public figures like ballet dancers [18].

The spectator's increased attention to details and ballet addiction (buying an expensive ticket to see Swan Lake over and

over again requires strong motivation) can be explained by the involvement of the Anterior Cingulate Cortex (ACC) responsible for motivation and action. The AIC is activated in conjunction with ACC [19]. The ACC monitors personal, environmental and interpersonal information and allocates attention to the most prominent features. The neural circuit consisting of AIC and ACC is likely to interface the connection between emotion, motivation and action. A special kind of cells, von economo neurones, present in the AIC and ACC ensure fast connections within other regions of the brain enabling rapid intuitive assessments of complex situations [20,21]. Emotional stimulus activates declarative explicit and non-declarative implicit or habit memories, making them available to working memory [16,22]. Emotional reactions provide a summary of experience with a situation that we perceive as a 'gut' feeling [23]. The Ventromedial Prefrontal Cortex (vmPFC) integrates affective and cognitive information that allows self-other distinction and perspective taking [11,24]. Simulating the affective states of others, we mimic their mental states, the simulation theory contends. If the process yields a mental state as an output, we attribute it to the other [25]. The phenomenon is known as empathy: An observer shares the emotion or intention of another person and thereby understands person inner state [26].

Different appreciation of ballet depends on whether we approach the performance as a representation of a choreographer's composition or as a presentation of the personalities who live and work on the scene. In the former case, we need cultural competence; in the latter case, we can rely on our everyday experience of social interactions. Perceiving dancers as significant others, our brain consumes more energy to process the information communicated by the bodies. But bodily experience promotes intersubjective knowledge [27] and this is what balletomanes especially appreciate.

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