Psychology & Neuroscience

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Online First Publication, May 23, 2016. http://dx.doi.org/10.1037/pne0000052

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1983-3288/16/$12.00 http://dx.doi.org/10.1037/pne0000052

Is "Self-Consciousness" Equivalent to "Executive Function"?

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Consciousness can be understood as being aware of oneself and one's own conditions. The cognitive neuroscience concept of "executive function" usually includes the ability to control attention, mental flexibility, awareness, goal-directed behaviors, and the ability to anticipate the consequences of one's own behavior. Executive function is directly associated with prefrontal cortex activity. Two types of executive function that are associated with 2 different subtypes of prefrontal pathology can be distinguished: (a) "metacognitive executive function" (dorsolateral prefrontal cortex), including self-awareness, the temporality of behavior, metacognition, working memory, abstraction, problem solving, and similar complex intellectual processes, and (b) "emotional/motivational executive function" (orbitofrontal and medial frontal lobe), which is related to the ability to coordinate cognition and motivation, including the ability to control emotions and behavior. Self-consciousness represents a major element of metacognitive executive function and is directly related to activity of the left dorsolateral prefrontal cortex.

Keywords: self-consciousness, executive functions, prefrontal cortex, metacognition

"Consciousness" is a complex concept that is not easily defined. The term *consciousness* is derived from the Latin word *conscientia*: *con* (with) and *scire* (to know). Etymologically, *consciousness* means "to have knowledge." Currently, different definitions of *consciousness* can be found. For example, the Merriam-Webster Dictionary (n.d.) defines *consciousness* as "the quality or state of being aware especially of something within oneself." In his book, *Psychology of Consciousness*, Farthing (1992) included in the definition of consciousness the following: sentience, awareness, subjectivity, the ability to experience or to feel, wakefulness, having a sense of selfhood, and the executive control system of the mind. Notably, both "awareness" and "the executive control system of the mind" (i.e., metacognition) are included in this definition of consciousness. The *Stanford Encyclopedia of Philosophy* (n.d.) emphasizes that an animal, person, or other cognitive system may be regarded as conscious in a number of different ways: *sentience* (capable of sensing and responding to the world), *wakefulness* (awake and alert), *self-consciousness* (creatures that are not only aware but also aware that they are aware), *what it is like* (a being is conscious just if there is "something that it is like" to be that creature), *subject of conscious states* (having a conscious mental state), and *transitive consciousness* (a distinction between transitive and intransitive notions of consciousness can be established, and the former involves some object at which consciousness is directed).

In neurology, the term *consciousness* is used in two different ways: (a) alert, to be awakened (e.g., the definition of "Syncope and collapse" in the World Health Organization, 2004, clinical modification states that it represents a disorder that is characterized by the spontaneous loss of consciousness that is caused by an insufficient blood supply to the brain) and (b) equivalent to "to be oriented" or "to be aware" (e.g., the definition of partial complex seizure states includes disturbed awareness; Berg et al., 2010). This dual use of the term *consciousness* emphasizes the difficulty obtaining a unified,

The author is grateful to Adriana Ardila for editorial support.

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clear, and completely acceptable definition of consciousness.

For simplicity, the present article refers to self-consciousness. Self-consciousness is understood as being aware of oneself and one's own conditions. The general concept of consciousness will not be analyzed in this paper; only the question of self-consciousness will be discussed.

Executive function is also difficult to define. Similar to consciousness, it represents an umbrella term that includes diverse abilities (i.e., functions). *Executive function* is a relatively new term in the neuroscientific lexicon. Luria (1973, 1980) is considered the direct antecessor of the concept of executive function. He proposed that the frontal lobe plays an executive role in cognition and behavior, but he did not use the word *executive* in a systematic way. The term *executive functioning* (or executive function or executive functions) was introduced by Lezak (1983). She referred to *executive functioning* to discriminate cognitive functions from the "how" or "whether" of human behavior. Baddeley (1986) referred to disturbances in executive function and coined the term *dysexecutive syndrome*.

The definition of executive function usually includes the concept of controlling attention, mental flexibility, goal-directed behavior, and the ability to anticipate the consequences of one's own behavior (Denckla, 1996; Goldberg, 2001; Stuss & Knight, 2013). The concept of self-awareness and the idea that the frontal lobes serve as a manager and programmer of human psychological processes (*metacognition*) are also included in this definition (Anderson, Bechara, Damasio, Tranel, & Damasio, 1999; Moll, Zahn, de Oliveira-Souza, Krueger, & Grafman, 2005; Stuss, 2011).

Ardila (2008, 2013) proposed that executive function can be separated into two major subgroups:

1. *Metacognitive executive functions* include the ability to anticipate the consequences of behavior, self-awareness, the temporality of behavior (i.e., understanding and using time concepts), controlling cognition (metacognition), working memory, abstraction, problem solving, and similar complex intellectual processes.
2. *Emotional/motivational executive functions* are responsible for coordinating cognition and motivation. This means the ability to fulfill basic impulses using socially appropriate strategies. The ability to control emotions and behavior is included in this definition. In this case, what is most important does not necessarily refer to the best conceptual and intellectual result but instead refers to what is in accordance with personal impulses (Bechara & Martin, 2004; Fuster, 2001).

The idea that executive function has two fundamental types has indeed been proposed by different authors. For example, a distinction has been suggested between the so-called "cool" cognitive aspects of executive function (corresponding to metacognitive executive functions that are mostly associated with dorsolateral areas of the prefrontal cortex) and the so-called hot affective aspects of executive function (i.e., emotional/motivational executive functions that are more directly related to the ventral and medial regions of the prefrontal cortex; Zelazo & Muller, 2002). This hot/cool classification has also been used to account for the development of executive function in children (Hongwanishkul, Happaney, Lee, & Zelazo, 2005; Zelazo & Carlson, 2012) and executive function disturbances in children with attention-deficit/hyperactivity disorder (Skogli, Egeland, Andersen, Hovi, & Øie, 2014). Additionally, cool (metacognitive) executive functions are significantly correlated with an individual's general intellectual ability (intelligence), whereas hot (emotional/motivational) executive functions are not related to general intellectual functioning (e.g., verbal mental age and performance mental age). In other words, unlike hot executive functions (i.e., emotional/motivational executive functions), cool (metacognitive) executive functions are involved in controlling cognition, self-awareness, the temporality of behavior, and similar intellectual processes. Stuss (2011) referred to two major anatomical/functional systems: a ventral-medial/orbital system for emotional and behavioral regulation and a frontopolar system for integrative—even metacognitive—functions. These two systems clearly correspond to the emotional/motivational and metacognitive executive function distinction that was proposed by Ardila (2008).

Neurological Bases of Metacognitive Executive Functions and Self-Consciousness

The prefrontal cortex has been directly related to executive function and cognitive control (e.g., Fuster, 2001; Goldberg, 2001). The prefrontal cortex is usually parcellated into dorsolateral, orbitofrontal, and medial cortices (Miller, 2000; Miller & Cummings, 2007). The dorsolateral prefrontal cortex is more directly related to cognitive control and metacognition (Miller, 2000). The orbitofrontal and medial prefrontal cortices are more related to emotional control, the coordination of emotion and cognition, and the expression and control of emotional behaviors (Kringelbach, 2005; Miller, Freedman, & Wallis, 2002). Thus, two major prefrontal areas ("systems") that are associated with two clinical syndromes can be distinguished:

Dorsolateral Syndrome

Cummings (1993) suggested that the prefrontal dorsolateral circuit is the most important for executive function. Deficits that are associated with this syndrome include an inability to organize a behavioral response to novel or complex stimuli, an inability to follow temporal sequences, an inability to anticipate the consequences of behavior, an inability to shift cognitive sets, and an inability to organize information to meet changing environmental demands. The dorsolateral prefrontal cortex has been shown to participate in planning, abstraction, problem solving, and working memory. Luria (1980) directly related the left dorsolateral prefrontal cortex to self-consciousness.

Functional MRI revealed dorsolateral prefrontal activation in such tasks as the Tower of Hanoi (Fincham, Carter, van Veen, Stenger, & Anderson, 2002), Controlled Word Association Test (letter fluency; Baldo, Schwartz, Wilkins, & Dronkers, 2006), working memory (Yoon, Hoffman, & D'Esposito, 2007), and Wisconsin Card Sorting Test (Lie, Specht, Marshall, & Fink, 2006). According to Fuster (1997, 2002), the most general executive function of the lateral prefrontal cortex is the temporal organization of goal-directed actions in the domains of behavior, cognition, and language. Furthermore, the dorsolateral prefrontal cortex appears to play a central role in global aspects of general intelligence (Barbey, Colom, & Grafman, 2013).

Orbitofrontal and Medial Frontal Syndrome

Pathology of the orbitofrontal cortex has been associated with behavioral disinhibition, inappropriate behaviors, changes in personality (i.e., behavioral style), irritability, emotional instability, distractibility, and disregard for important events (Stuss & Knight, 2013). The orbitofrontal cortex appears to be linked predominantly with limbic (emotional brain) and basal forebrain sites. Additionally, damage to the medial frontal lobe causes apathy or abulia (i.e., a severe form of apathy). Acute bilateral lesions of the medial frontal area can cause akinetic mutism, in which the individual is awake and self-aware but does not initiate behavior (Ross & Stewart, 1981). According to Fuster (1997, 2002), the ventromedial areas of the prefrontal cortex are involved in the expression and control of emotional and instinctual behaviors. However, these patients do not present disturbances in abstraction or any difficulty in card sorting tasks (e.g., the Wisconsin Card Sorting Test; Laiacona et al., 1989).

The ventromedial areas of the prefrontal cortex are involved in the expression and control of emotional behaviors (Fuster, 2001, 2002). This function is related to the so-called inhibitory control of behavior (Miller & Wang, 2006). Clinical evidence (Luria, 1969; Stuss & Knight, 2013) and experimental research (Leung & Cai, 2007; Medalla, Lera, Feinberg, & Barbas, 2007) suggest that the neural substrates for this inhibitory function reside mainly in the medial and orbital portions of the prefrontal cortex. Fuster (2002) stated, "The apparent physiological objective of inhibitory influences from orbitomedial cortex is the suppression of internal and external inputs that can interfere with whatever structure of behavior, speech, or cognition is about to be undertaken or currently underway" (p. 382).

Autonoetic Consciousness

The concept of autonoetic consciousness has become important in contemporary interpretations of consciousness (Baddeley, Eysenck, & Anderson, 2009). It refers to the ability to men-

tally use temporality and analyze one's own thoughts and subjective experiences. It is involved in the development of self-identity and closely related to episodic memory. In a series of papers that analyzed the frontal lobes and executive function, Stuss and colleagues advanced a neuropsychological interpretation of autonoetic consciousness (Stuss, 1991, 2011; Stuss & Alexander, 2000; Stuss, Gallup, & Alexander, 2001; Stuss & Knight, 2013; Stuss & Levine, 2001; Stuss, Picton, & Alexander, 2001; Wheeler, Stuss, & Tulving, 1997). These authors proposed that the frontal poles, particularly in the right hemisphere, are involved in more recently evolved aspects of human nature, including autonoetic consciousness and self-awareness. According to (Stuss, 2011; Wheeler, Stuss, & Tulving, 1997) autonoetic consciousness is involved in most complex abilities, including the ability to perform mental time travel in a personal, subjective way. This ability is regarded as a hallmark of retrieval from episodic memory. He further introduced a distinction between consciousness and awareness. (Stuss, 2011; Wheeler, Stuss, & Tulving, 1997) proposed that consciousness is the general ability that an individual has for particular kinds of mental representations and subjective experiences, whereas awareness can be understood as a specific manifestation of consciousness.

The concept of autonoetic consciousness that was developed in the area of psychology and applied to neuropsychology, especially by (Stuss, 2011; Wheeler, Stuss, & Tulving, 1997) is consequently very close to the idea of self-consciousness. It includes two key elements: self-awareness and temporality. Notably, the word *noetic* is something that refers to the intellect or mind (Oxford English Dictionary, n.d.). *Autonoetic* means "self-mind" or simply self-awareness.

Disturbances in Self-Consciousness Associated With Brain Pathology

As mentioned in preceding text, two different types of disturbances in consciousness are usually distinguished in clinical neurology (Aminoff, Greenberg, & Simon, 2015; Bernat, 2006; Goetz, 2007): disturbances in arousal and the level of activation, ranging from a minimal attention disorder to coma and disturbances in self-awareness and orientation, as observed in states of confusion, delirium, and dementia. Disturbances in arousal and activation are associated with brainstem and orbitofrontal pathology, whereas disturbances in self-awareness and orientation (especially temporal orientation) are observed in cases of dorsolateral prefrontal damage. In the latter case, a disorder in self-consciousness can be assumed.

However, if a different definition of consciousness is used, then disturbances in consciousness would be associated with a different type of brain pathology. For example, if consciousness means not only to be alert but also to remember ongoing events (as assumed in the definition of partial complex seizures that is generally used by the International League Against Epilepsy; Fisher et al., 2005), then the temporal lobe should also be included as a neurological substrate of consciousness.

Conclusion

Self-consciousness can be understood as the awareness of oneself and one's own conditions. This concept represents a major element of metacognitive executive function and is directly related to activity of the dorsolateral prefrontal cortex.

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Received February 18, 2016
Revision received April 21, 2016
Accepted April 23, 2016 ■