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The role of Executive Functions in people with Autism Spectrum Disorder

Il ruolo delle Funzioni Esecutive in persone con Disturbo dello Spettro Autistico

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Abstract

Executive functions involve a set of complex cognitive abilities that have the task of programming and controlling other cognitive functions and modifying them according to circumstances in order to achieve a goal. They thus regulate cognitive processes, behaviour, and the management of emotions. It is now known that all mechanisms managed by executive functions are affected in numerous neurodevelopmental disorders, including Autism Spectrum Disorder. In fact, it presents a variable symptomatology, affecting various cognitive, behavioural, motor and sensory aspects. The aim of this work was to delve into the subject of executive functions, and above all to analyse and explain the close link between executive functions and Autism Spectrum Disorder. Based on previous studies, this work shows a clear link between them. In particular, it appears that Autism Spectrum Disorder presents moderate deficits in all sub-domains of Executive Functions, and in particular visuospatial and inhibition-related Working Memory, and interference control. However, the literature still shows conflicting results, and further studies are needed to thoroughly evaluate the different subdomains of Executive Functions and the different forms of Autism Spectrum Disorder.

Keywords: Autistic Spectrum Disorder; Executive Functions

Sintesi

Le funzioni esecutive riguardano un insieme di abilità cognitive complesse il cui compito è quello di programmare e controllare altre funzioni cognitive e modificarle in base alle circostanze, al fine di raggiungere uno scopo. Esse regolano i processi cognitivi, il comportamento, e la gestione delle emozioni. È ormai noto che i meccanismi gestiti dalle funzioni esecutive, sono coinvolte nei disturbi del Neurosviluppo, tra cui il Disturbo dello Spettro Autistico. Infatti esso presenta una sintomatologia che riguarda diversi aspetti cognitivi, comportamentali, motori e sensoriali. L'obiettivo di questo lavoro è stato quello di approfondire l'argomento delle funzioni esecutive, e soprattutto quello di analizzare lo stretto legame che intercorre tra Funzioni Esecutive e Disturbo dello Spettro Autistico. Sulla base di studi precedenti, questo lavora evidenza un chiaro legame tra di essi. In particolare, il Disturbo dello Spettro Autistico presenta dei deficit moderati in tutti i sottodomini delle Funzioni Esecutive, ed in particolare della Memoria di Lavoro Visuo-Spaziale e quella legata al Controllo delle Interferenze. Tuttavia la letteratura mostra ancora risultati contrastanti, e necessita di ulteriori approfondimenti che vadano ad indagare i diversi sottodomini delle funzioni esecutive e le diverse forme di Disturbo dello Spettro Autistico.

Parole chiave: Disturbo dello Spettro Autistico; funzioni esecutive.

1. Introduction

Autism Spectrum Disorder (ASD) include a group of neurodevelopmental disorders, (American Psychiatric Association, 2013), including Autism, Asperger's syndrome (AS) and pervasive developmental disorder not otherwise specified (PDD-NOS) (Sharma, Gonda, & Tarazi, 2018). They were introduced in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) and are characterised by a range of deficits in communication, social skills, learning and executive functions. Although the causes of these disorders are still unknown, it has been shown that the incidence of ASD is linked to an environmental component (Sealey et al., 2016), such as exposure of the foetus to certain psychotropic drugs or insecticides or premature births, and to a genetic component. Indeed, it was shown by Folstein and Rutter, and subsequently confirmed by Bailey et al. (1995), that monozygotic twins were more likely to share the diagnosis than dizygotic twins, suggesting a genetic influence (Folstein & Rutter, 1977).

ASD is among the most common of the neurodevelopmental disorders, with a current rate hovering around a range of 30-60 cases per 10000 (Williams, Higgins, & Brayne, 2006), an incidence that seems to have increased in recent years, and which also seems to vary according to geographical location (Chiarotti & Venerosi, 2020). It is important to emphasise that the variability in the incidence of ASD depends on numerous factors. Among them, for example, an improvement in the ability to recognise the disease and the coexistence of clinical symptoms due to neurodevelopmental disorders differing from ASD (Mannion & Leader, 2013; Matson & Nebel-Schwalm, 2007).

Autism spectrum disorder consists of a multitude of symptoms, with a high variability between individuals. Since early years of life, difficulties in learning, social relationships (Voss et al., 2019), communication (Filipek, 1999), verbal and non-verbal language (Gladfelter & VanZuiden, 2020), and movement coordination are evident (Sharma, Gonda, & Tarazi, 2018). In addition, sensory impairments, represented by responses to reduced or intensified stimuli, are often observed (Oldehinkel et al., 2019).

Moreover, several studies investigated the association between Autism Spectrum Disorder and executive functioning (EF) (Barendse et al., 2013; Leung, Vogan, Powell, Anagnostou, & Taylor, 2016). EF enables the planning and execution of behaviours in order to achieve a goal, and modify them when necessary, and also regulate the management of emotions, functions that are impaired in people with ASD (Henry & Bettenay, 2010).

The purpose of this study is to provide a comprehensive definition of the concept of executive functions, and to highlight the main findings investigating the relationship between autism spectrum disorder and executive functions.

2. Executive Functions

Executive functions are a complex of cognitive abilities that regulate and control other cognitive functions and behaviour. The term was first used by Lezac in 1982, who used it to refer to "the cognitive abilities that make an individual capable of independent, purposeful, and adaptive behaviour" (Lezak, 1982). Baddeley (1990; 1992), on the other hand, defined it as a complex of mechanisms that allows optimising performance in situations that require the simultaneous activation of different cognitive processes. Subsequently, Knight and Stuss (2002) as “the processes required to enact goal-directed behaviour”. Although there is a difference between the various definitions mentioned

above, it is evident that all authors share the idea that EF are cognitive functions that are responsible for planning and executing determined behaviours, and for adapting them according to contextual situations. Scientific interest in FE functions has grown considerably in recent years, as it is still a poorly known field. It has been shown that EF begin to develop in the earliest years of life (pre-school age) and reach high levels during adolescence (Anderson, Anderson, Northam, Jacobs, & Mikiewicz, 2002; Zelazo et al., 2003). It has recently emerged that there is a correlation between the development of executive functions in childhood and adolescence and an increase in white matter volume (Paus, 2005), and that their development is associated with the maturation of the pre-frontal cortex, which appears to be their anatomical substrate.

2.1. Executive Functions Classification

Originally, EF were described as a single mechanism managing different cognitive functions, nevertheless, it was demonstrated, through research, that unitary models were too simplistic to explain complex executive processes. Pennington and Ozonoff (1996) subdivided EF into several subdomains, including planning, working memory/updating, problem-solving, self-control, mental flexibility, generativity/fluency and inhibition of prepotent responses. However, these sub-domains are to be understood as interconnected skills that occur simultaneously during goal-directed mental processes. Currently, the most accredited theoretical model is the model of Miyake et al. (2000), who focused on three main aspects. The first is Working Memory, i.e. the ability to retain information in memory and manipulate it for short periods of time. The second is 'shifting', the ability to modify one's behaviour in relation to a change in environmental demands, considering different perspectives and priorities. The last is inhibition, the ability to deliberately ignore distracting stimuli, i.e. irrelevant information, while maintaining purpose. In addition to the cognitive processes mentioned above, the executive domain is also concerned with the mechanisms that regulate behaviour, emotions and motivation. In this regard, Zelazo and Müller, formulated a distinction between 'hot' executive functions, relating to affective aspects, associated with the prefrontal cortex, and 'cold' executive functions, associated with the dorsolateral cortex (Metcalfe & Mischel, 1999; Zelazo et al., 2003). Although the division between hot EF and cold EF is still unclear and has not been studied extensively, it appears that EF deficits have been implicated in a wide variety of disorders, including Autism. Indeed, Zelezo and Müller support the idea that, while autism mainly involves a deficit of hot executive functions with consequent impairment of cold EF, Attention Deficit Hyperactivity Disorder (ADHD) might instead involve a deficit of cold EF (Zelazo et al., 2003).

3. Autistic Spectrum Disorder and Executive Functions

Per The relationship between ASD and executive functions has been analysed in several studies. There seems to be a close correlation between the symptomatology of ASD and executive functioning (Craig et al., 2016). After all, the dysexecutive syndrome presents a clinical picture characterised by cognitive deficits, behavioural, emotional and motor disorders, which are also present in ASD (Navas Collado & Muñoz García, 2004). In fact, among the various theories related to ASD symptomatology, one supports the hypothesis that the complex behavioural manifestations are a consequence of impaired executive functions (Hill, 2004).

As previously mentioned, the most widely used model for defining executive functions is that of Miyake et al. (2000), which identifies three fundamental aspects of EF: inhibition, working memory and shifting. Ongoing research investigating the efficiency of inhibitory control in people with ASD, and many of them are in agreement about the reduction of one of the two forms of inhibition, the interference control. A number of studies have investigated the efficiency of inhibitory control in people with ASD, and many of them are in agreement about the reduction of one of the two forms of inhibition, the interference control. However, Geurts and colleagues showed a greater worsening of prepotent inhibition in individuals with ASD than in healthy controls, a result in contrast to the literature (Geurts, van den Bergh, & Ruzzano, 2014). In addition, they also took into account the age of the subjects, pointing out that age moderated performance on the prepotent response inhibition task, but not on the interference control task, again in contrast to Christ and colleagues, who found an improvement in prepotent response inhibition performance with increasing age (Christ, Holt, White, & Green, 2007; Christ, Kester, Bodner, & Miles, 2011). However, these discrepancies could be due to the difference in the age of the samples, as Geurts focused on adults (Geurts, van den Bergh, & Ruzzano, 2014), whereas Christ examined a cohort of children (Christ, Kester, Bodner, & Miles, 2011).

Another widely discussed aspect of executive functions in ASD is Spatial Memory. Several studies agree that working memory is impaired in individuals with ASD. In particular, most studies have found a deficit in visuospatial memory tasks in individuals with ASD and high-functioning disorder, compared to healthy subjects with difficulties in performing tasks with higher cognitive load (e.g. dual tasks) and reduced cognitive flexibility (Frith, 2003; Klingberg et al., 2005; Van der Molen et al., 2010). However, a review that investigated the correlation between ASD and working memory found that, although ASD presents obvious communication and language difficulties, verbal working memory is not impaired, and that individuals with ASD present strategies that require verbal working memory similar to those of individuals with typical functioning (Kercood, Grskovic, Banda, & Begeske, 2014; Russell, Jarrod, & Henry, 1996; Williams, Goldstein, Carpenter, & Minshew, 2005). However, it is intuitive that the severity of the symptoms and especially the type of disorder must be taken into account (Kercood, Grskovic, Banda, & Begeske, 2014).

A further review of the literature conducted by Demetriou et al. (2018), on the other hand, showed an overall moderate impairment of executive functions in ASD.

Finally, Landa and Goldberg (2005) assessed cognitive flexibility through the ID/ED task of the CANTAB® (Fray, Robbins, & Sahakian, 1996) in persons with high-functioning autism, finding a tendency to have greater difficulty with intra-dimensional displacement and fewer errors with respect to extra-dimensional displacement.

4. Conclusions

In conclusion, the aim of the present work was to highlight the main features of executive functions with a focus on the scientific evidence that has investigated the relationship between EF and ASD. Although close links exist between the symptomatology of the disorder and the dysexecutive syndrome, conflicting hypotheses and work are still evident. In persons with autism spectrum disorder, there appears to be a moderate overall impairment of executive functions, mainly involving working memory. However, further

work is needed to thoroughly analyse the relationship between the different sub-domains of executive functions and, above all, to try to differentiate the different disorders, which present different symptoms, in order to better understand the relationship between them.

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