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Research Article

The Development of Executive Functions among Children with Autism Spectrum Disorder

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ABSTRACT

Autism spectrum disorder (ASD) is a complex neurodevelopmental disorder with long-lasting neurocognitive dysfunctions in addition to impaired socio-communication and restricted, repetitive and stereotypical patterns of behavior, interests, and activities (APA 2013). Long-term follow-up studies show that the developmental outcomes of autistic individuals are highly variable, even for individuals at the more intellectually able end of the autism spectrum. While some individuals go on to live independently and obtain qualifications, the majority fail to achieve independence, to attain full-time employment, or to enjoy friendships.

The concept of 'executive function' refers to the higher order control processes necessary to guide behaviour in a constantly changing environment. The concept includes abilities such as planning, working memory, mental flexibility, response initiation, response inhibition, impulse control and monitoring of action.

The aim of this study was to elaborate an individualized intervention program for children with ASD to develop the executive functions (working memory, selective attention, planning, organizing and inhibition of response). Measures of EF were administered to a sample of 5 pre-schoolers (1 girl and 4 boys with 6–7 years old).

The results show that, the individualized intervention program in this study has a semnificative influence to develop the executive functions [$H_{(2)}$=10,61; p<0,01 (p=0,005) for working memory; $H_{(2)}$=11,05; p<0,01 (p=0,004) for attention; $H_{(2)}$=11,88; p<0,01 (p=0,003) for planification; $H_{(2)}$= 10,9; p<0,01 (p=0,004) for organization and $H_{(2)}$=10,4; p<0,01 (p=0,005) for inhibition of response].

Keywords: Children with autism spectrum disorder; Executive functions; Individualized intervention program

INTRODUCTION

Anxiety Autism spectrum disorder is a complex neurodevelopmental disorder with long-lasting neurocognitive dysfunctions in addition to impaired socio-communication and restricted, repetitive and stereotypical patterns of behavior, interests and activities [1].

The term executive functions refer to a set of higher cognitive processes, mainly regulated by frontal lobes, which operate in daily complex situations and unusual contexts [2,3]. Executive functions include: planning skills, working memory, cognitive flexibility, response inhibition, impulse control and action monitoring [3-9]. However, a number of neuroimaging studies have shown that executive functions are correlated with neural activities in different regions of frontal lobes and other circuits involving posterior cortical, subcortical and thalamic areas [10-12].

Bernstein & Waber from the point of view of developmental sciences, define executive functions as an area of general resources that can be implemented immediately, according to the specific task and/or environmental requirements [13]. Using these functions the person succeeds in achieving his goals, facing challenges, organizing and planning his activities, sustaining his attention, persevering in completing a task and monitoring his thoughts and emotions [14].

In regards to the classification of executive function subcomponents, several models have been proposed. For example, factorial analysis done by Miyake identified three main factors which are somewhat related, yet can still be partially separated [15]:

1. *Shifting* implies the ability to engage and disengage attention from different tasks sets.

2. *Updating* is related to working memory and requires monitoring and coding information as well as replacing old, irrelevant information by newly relevant and useful ones.

3. *Inhibition* involves predominantly or automatically retaining

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responses when it's necessary and is considered a key component in planning skills.

An update of the model proposed by Miyake and collaborators was made by Fisk and Sharp where they identified the same three factors and an additional factor called Access that refers to the process involved in verbal fluency tasks which is believed to mediate access to long-term memory representations [15,16].

Also, Diamond proposes a three-factor model of executive functions that includes [7]:

a) Inhibition of the Dominant Response

This includes, inhibitory control which represents the ability to control one's attention, behaviors, thoughts and emotions in order to overcome the internal predispositions and instead do what's more appropriate or needed, inhibitory control of attention (interference control at the level of perception) enables us to selectively attend tasks, focusing on what we choose and suppressing attention to other stimuli and self-control, which is the ability to regulate one's emotions and behavior in the face of temptations and impulses [17,18].

b) Working Memory

Working memory is very important in everyday life, being essential in situations where we are faced with activities that involve cognitive efforts. Working memory involves retaining information and working with it [19,20].

There is a significant difference between long-term memory (working memory) and short-term memory; these categories are distinguished by verbal and visuospatial content. Therefore, long-term memory represents the ability to store mental contents that encode real-world entities and short-term memory involves only the simple storage of content [21].

c) Cognitive Flexibility

Cognitive flexibility represents our ability to adapt to changes in the environment [22,23]. One aspect of cognitive flexibility is being able to change spatial perspectives (for example: 'What would this object look like if I viewed it from a different direction') or interpersonally (for example: 'Let me see if I can see this from your point of view!').

Another aspect of cognitive flexibility involves changing how we think about something (thinking outside the box).

Instead, Dawson and Guare argue that these executive functions help us in two ways [14]:

I. The first one involves using skills that allow us to select and achieve goals and to develop effective problem solving strategies. This category includes:

• Planning: the ability to organize an action plan to complete tasks or to achieve goals. Also involves the ability of a person to make decisions about important or unimportant aspects that should be focused on.

• Organization: the ability to use systems and materials to stay on top of a task.

• Time management: the ability of a person to estimate how long it takes to complete a task and to allocate enough time to complete it in order to respect a deadline.

• Working memory: the ability to retain as much information as possible; ability that embodies a person's capacity to use previously learned information or previous experiences and to implement them in his present or future projects.

• Metacognition: represents the ability that helps you observe your way of solving a problem; includes self-monitoring and self-evaluation skills.

II. The second one involves the skills that help us to create a perspective on our objectives, to develop an action plan to achieve them and to synthesize the resources we need to achieve them. However, in order to achieve our goals we also need skills that guide our behavior; these skills are:

• Response inhibition: represents our capacity to think about the consequences of our actions before acting.

• Emotional control (self-regulation of affect): the ability to manage our emotions for achieving our goals, completing our tasks or directing and controlling our behavior.

• Sustained attention: the ability to pay attention to a task as needed despite boredom or fatigue.

• Task initiation: the ability to start a task and to finish it without procrastinating.

• Flexibility: the ability to adapt to changing environments.

• Goal directed persistence: the ability or the desire to achieve the proposed goal without being influenced by various external variables.

Together, these skills allow us to make plans, keep track of time and finish work on time, evaluate our ideas, cope with distracters, ask for help when needed, take turns in games and conversations and stop ourselves from overreacting to minor situations. In addition, executive functions help us to focus on multiple streams of information, check for errors, make decisions and revise our plans [24]. Moreover, use of these skills allows pupils to participate successfully at school and manage their own behavior and is crucial in developing and maintaining social interactions.

Difficulties experienced at executive functions level were consistently demonstrated in school-age children, adolescents and adults diagnosed with autism spectrum disorder, as well as relatives of individuals with ASD [9,25-27]. Furthermore, problems in specific components of executive functions have been shown to distinguish autism from other neurodevelopmental disorders such as attention deficit/hyperactivity disorder (ADHD) [28].

Semrud-Clikeman and collaborators conducted a study comparing children with ASD to children with ADHD-AD (attention deficit subtype) and ADHD-H (hyperactivity subtype) on behavioral regulation [29]. The results showed that children with autism reported more severe behavior regulation difficulties than both ADHD subgroups. Gioia showed that children with ASD are more severely impaired in cognitive flexibility compared to children with ADHD, the attention deficit subtype [30].

Hovik conducted a study with the purpose of identifying the difficulties that children with ASD, Tourette syndrome and ADHD face at the level of executive functions [31]. The results highlighted that children with Tourette's syndrome had difficulties in emotional regulation, those with ASD encountered difficulties related to cognitive and behavioral flexibility and children with ADHD-attention deficit subtype had problems in planning and

organization and those with hyperactivity subtype had problems with inhibitory control.

Miranda and her colleagues realized a study whose purpose was the analysis of two fundamental socio-cognitive skills (ToM and emotion recognition) among children with ASD, ADHD and those with typical development matched on age, IQ and semantic knowledge [32]. The results showed that children with ASD and ADHD have difficulty in recognizing emotions and attribution of mental states such as feelings, beliefs, desires and intentions.

Some researchers found correlations between executive functions and: social skills and daily adaptive behaviour [14,33-35].

To sum up, the role of early development of executive functions among children with autism spectrum disorder is:

Firstly, executive functions are closely related to another aspect of neurocognitive development known to develop atypically in autism; theory of mind (ToM: Mental State Awareness).

Secondly, early development of executive functions is beneficial both in preparing children to enter the school environment and in helping them achieve academic success in reading and mathematics [36-40]. The transition from home to school environment is based on mastery of basic executive function skills, to include: remembering and following instructions, completing tasks independently and smoothly transitioning between tasks and inhibiting inappropriate behaviors.

Thirdly, it is well known that the prefrontal cortex mediates executive functions, showing a prolonged development trajectory: it begins to develop very early in life, has a boost during the preschool period and continues to develop well into adolescence [41]. The extended postnatal developmental of prefrontal cortical networks becomes very sensitive to exogenous influences. Some studies have reported direct evidence of the malleability of executive function skills. Thus, training preschoolers' executive function skills leads to substantial improvements in their ability to self-regulate their behavior among children with different disorders and typical populations [42,43].

RESEARCH METHODOLOGY

The aim of this research is to develop a personalized intervention program for children diagnosed with autism spectrum disorder based on the development of executive functions (working memory, selective attention, planning, organizing and response inhibition), focused on the following objectives:

• Establishing the level of development of executive functions of children with ASD included in this study;

• Implementation of an intervention program for the development of executive functions for children with ASD;

• Establishing the degree of efficiency of the program implemented by periodically evaluating children's performance in terms of developing executive functions.

The hypothesis of this research is the following: the POWER intervention program will have a high impact on the development of executive functions (working memory, selective attention, planning, organizing and response inhibition) among children with ASD.

PARTICIPANTS

The participants are five children diagnosed with autism spectrum disorder, aged between 6 years and 4 months-7 years and 7 months (Avg=6 years and 9 months), children from Autism Baia Mare Association, Sighetu-Marmaiei subsidiary, Romania. From the five children included in the study, 4 are boys and 1 is a girl.

MEASURES

NEPSY (A Developmental NEuroPSYchological Assesment, Korkman, Kirk & Kemp, 1998).

The NEPSY is a complex tool for assesing the neuropsychological development of preschool and school-age children (3-12 years) [44].

The neurocognitive functions evaluated by this tool are the following:

- Sensorimotor functions
- Visuospatial processing
- Executive functions
- Language
- Memory and learning

This tool contains 27 neuropsychological tests which provide details about performance in each area of development and factors that may contribute to a particular primary or secondary deficit; these tests are being divided into the following two age groups:

a) **For ages 3-4:** Visual Attention, Design Copying, Body part naming, Block Construction, Verbal Fluency, Narrative Memory, Phonological Processing, Imitating hand positions, Visuomotor Precision, Comprehension of Instructions, Manual Motor Sequences, Oromotor Sequences, Statue and Sentence Repetition.

b) **For ages 5-12:** Auditory Attention and Response Set, Visual Attention, Fingertip Tapping, Comprehension of Instructions, Block Construction, Design Copying, Finger Discrimination, Design Fluency, Verbal Fluency, Route Finding, Knock and Tap, Imitating Hand Positions, Comprehension of Instructions, Sentence Repetition, Memory of faces, Narrative Memory, Speeded Naming, Statue, Visuomotor Precision, Word List, Interference, Oromotor Sequence, Phonological Process, Manual Motor Sequences, Tower, Arrows, Memory of Names, List Memory, Word List Interference.

This battery of tests cand be used by clinical psychologists and school psychologists and the average time of application is 90 minutes.

The areas, respectively the deficiencies on which NEPSY has been validated are: juvenile neuronal ceroid lipofuscinosis, fetal alcohol exposure, very low birth weight and asphyxia, congenital spastic hemiplegia, ADHD, ASD, Asperger Syndrome and learning disorders, language disorder and attention problems [44-50].

DESIGN

For testing the hypothesis of this research, we used a longitudinal study because the research was extended over a period of seven months. In order to test the efficiency of the personalized intervention program, the study had an experimental design based on case studies. The dependent variables of this research are the executive functions (measured with NEPSY), while the personalized intervention program represents the independent variable. In the pre-test phase we focused on evaluating and identifying the level of executive functions of the participants included in this study

in order to gather information and obtain the reference data. In the intermediate period we focused on evaluating the progress of children regarding the development of executive functions, this took place three months after the activities of the proposed intervention program. The post-test phase took place in the following week after we finished the program consisting in the reapplication of the same investigative tool.

PROCEDURE

To begin with, the mothers of the participants in this study were given an informed consent where they were provided with information related to the purpose of the child's participation in this research and were assured of confidentiality of the data. The personalized intervention program was extended over a period of seven months; the meetings were scheduled once per week for 60 minutes for each therapy session. The activities of the intervention program were carried out using the following methods: linkage, verbal/ physical prompting, ludo therapy, etc.

RESULTS

To evaluate the effectiveness of the proposed intervention program based on the development of executive functions (working memory, selective attention, planning, organizing and response inhibition) among children with ASD we used the nonparametric Kruskal-Wallis H test.

Analyzing the results from Table 1, we can see that the working memory was best improved (M=13), followed by planning (M=12,9), attention and organizing (M=12,6) and finally response inhibition (M=12,2).

After calculating the Kruskal-Wallis H test we obtained: $H_{(2)}$=10,61; p<0,01 (p=0,005) for working memory; $H_{(2)}$=11,05; p<0,01 (p=0,004) for attention; $H_{(2)}$=11,88; p<0,01 (p=0,003) for planning; $H_{(2)}$=10,9; p<0,01 (p=0,004) for organizing and $H_{(2)}$=10,4; p<0,01 (p=0,005) for response inhibition. This shows that there are significant differences regarding the development of executive functions depending on the three experimental phases (pre-test, intermediate and post-test). Thus, our hypothesis for this research was confirmed (Table 2) [51-57].

Table 1: The rank averages of the variables obtained in the three experimental conditions.

	Etapa experimentala	N	Media rangurilor
Working Memory	Pre-test phase	5	4.00
	Intermediate phase	5	7.00
	Post-test phase	5	13.00
Attention	Pre-test phase	5	3.40
	Intermediate phase	5	8.00
	Post-test phase	5	12,60
Planification	pre-test phase	5	3.40
	Intermediate phase	5	7.70
	Post-test phase	5	12.90
Organization	Pre-test phase	5	3.40
	Intermediate phase	5	8.00
	Post-test phase	5	12.60
Response Inhibition	Pre-test phase	5	3.20
	Intermediate phase	5	8.60
	Post-test phase	5	12.20

Table 2: Description of the obtained results of the measured variables under the three experimental conditions.

	Working memory	Attention	Planification	Planification	Response Inhibition
Response Inhibition	10.61	11.05	11.88	10.9	10.42
df	2	2	2	2	2
Asymp. Sig.	0.005	0.004	0.003	0.004	0.005
Asymp. Sig.					

CONCLUSION

Autism is a pervasive developmental disorder characterized by deficits in social interaction, communication and repetitive and stereotyped patterns of behaviors. In autistic spectrum disorders one can distinguish the absence of eye-to-eye gaze, stereotype play, the absence of expressive and receptive language, the presence of non-verbal communication, refusal to enter in unknown spaces, inability to relate (the absence of empathy). All these are manifestations of the expressive and receptive language development being affected, as well as affections in social skills development with the inability to have emotional reciprocity or attachment as well as the presence of repetitive and stereotyped pattern of behavior and interests

A core area of development that underlies the most important behavior from childhood and which is seen throughout their lifespan is executive functions. These executive functions include a series of interdependent processes, but in some ways independent processes involved in planning, regulation and goal orientation towards activities as well as in the emergent development of academic skills.

Studies showed that poor executive functions are associated with cognitive deficits, poor socio-emotional adjustment, a lack of concentration, a lack of understanding cause and effect, an inability to understand mental states and/or impulsivity.

The present research aimed to implement a personalized intervention program applied to five children diagnosed with ASD with the role of helping them develop executive functions (working memory, selective attention, planning, organizing and response inhibition) for the development of a high level of independence. For this propose the procedure was based on dynamic-formative psych diagnostic which was carried out in three phases: the initial evaluation (pre-test), the training (application and implementation of the elaborated intervention program) and the progress evaluation (post-test) conducted through a longitudinal study over a period of seven months.

After the application of the individualized intervention program, progress was made in the area of executive functions, especially in the development of the following functions: working memory, ability to concentrate, response inhibition, increased perseverance in achieving goals, organizing and cognitive flexibility.

One of the limitations of this study could be the small sample of participants; therefore, it can't represent a high degree of accuracy in generalizing the obtained results. The second could be the selection of executive functions that have been used in our research; some executive functions such as cognitive flexibility and metacognition have not been investigated through structured tasks. The third limit of the study is the period of the intervention program; the activities unfolded only for a period of seven months

thus we cannot say that the proposed intervention program has a high level of efficiency regarding the development of executive functions among children with ASD.

A future research direction would be the introduction of activities based on developing meditation techniques of the mindfulness kind, into the intervention program. The mindfulness-type meditative practices can be beneficial both physically and mentally.

Furthermore, some research suggests that applying these meditative practices can lead to better attention regulation, emotional regulation and stimulating executive functions (metacognition, focus capacity).

Another future research direction would be to investigate a mediation relationship between executive functions - pragmatic abilities and abilities of the field of theory of mind (ToM) - social skills. Thus, according to this model, pragmatic abilities and the theory of mind abilities will mediate the relationship between executive functions and the development of social skills.

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