THE INFLUENCE OF WORKING MEMORY AND INHIBITORY CONTROL ON EDUCATIONAL CURRICULUM IN SCHOOL CHILDREN

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Abstract: In the present paper, we examine executive functions in primary school children. In particular, we focus on working memory and inhibitory control and their relevance to the design of curriculum content in the educational process. The research was conducted by administering the Behaviour Rating Inventory of Executive Function - BRIEF and the Cognitive Coping Strategies Questionnaire - CERQ in schools. We received responses from 258 primary school children, their parents and teachers. The results show us the relationships between the quality of executive functions and emotion regulation, which are essential for the successful adaptation of pupils to the educational process. We point out the need to modify educational curriculum and educational content.

Keywords: working memory, inhibitory control, educational curriculum, school age

1 Introduction

Executive functions are higher-level cognitive processes that, through their influence on lower-level processes, allow individuals to regulate their thoughts and actions during goal-directed behaviour (Friedman, Myiake, 2017). They allow us to control our behaviour and coordinate other cognitive functions, such as planning or organizing.

Executive functions and self-regulation are most often associated with students' academic performance, but to what extent is not entirely clear and proven. The relationships of associations related to self-regulation remain unexplored (Zorza et al., 2017).

As peer relationships begin to deteriorate and become unstable in early adolescence, adolescents with adequate self-regulation and empathy can rely on their ability to regulate and balance their relationships. Self-regulation develops during childhood and adolescence, and its development (as well as the development of executive functions) is influenced by life experiences (Berthelsen et. al., 2017).

It is therefore necessary to focus on strengthening individual sources of self-regulation and supporting the development of executive functions, including through curriculum content in the educational process.

1.1 Working memory and inhibitory control

In solving various difficulties, problems and cognitive operations, it is often necessary to focus attention on the necessary information. One of the executive functions that serves this purpose is the ability to monitor and update representations in working memory - working memory updating (Missier, Mäntylä, & de Bruin, 2010). We understand working memory updating as "the ability to monitor incoming information, assess its relevance to the goal, and then revise the contents of working memory so that older and outdated contents are replaced by newer, relevant ones" (Miyake et al., 2000, p. 57).

According to Morris and collective (2017), memory updating is the ability to modify current representations and schemas so that they adapt to new input. Several authors (Oberauer, Süß, Schulze, Wilhelm, & Wittmann, 2000; Lenartowicz, Escobedo-Quiroz, & Cohen, 2010) emphasise that updating working memory is a function that requires dynamic and active manipulation of content.

However, working memory is a complex and multifaceted faculty that encompasses a variety of functions (Oberauer et al., 2000). It plays a key role in storing, equipping and adapting knowledge that is essential for navigating situations, understanding instructions and making decisions when solving tasks.

The child needs to remember important information and be able to use it actively. While memorisation is quite fast, the ability to work with this knowledge and use it effectively develops much more slowly (Vágnerová, 2020).

With the help of working memory, we divide a task into smaller, manageable parts, solve one of them, memorise it and continue solving the next one at the same time. In addition, working memory also supports the understanding of language - both spoken and written. Its effective functioning is essential for successful learning, because in learning we manipulate information, plan, solve tasks step by step and link new information with that stored in long-term memory (Izdenczyová, 2017).

Pennington & Ozonoff, (1996) define working memory as the ability of the learner to store information and keep it unchanged until mental operations are performed. The working memory function is essential for effective learning because it manipulates information and organises the sequence of steps in specific tasks. It works with long-term memory and has the ability to store and process information simultaneously (Gathercole & Alloway, 2008). This means that learning success is strongly influenced by the efficiency and capacity of working memory.

As defined by Clark (cited in Friedman and Miyake, 2004), inhibition is any mechanism that dampens neural, mental or behavioural activity. However, it should be emphasised that the term inhibition is used to refer to a variety of complex processes (Miyake, et. al. 2000).

Nigg (2000) distinguishes two types of inhibition, depending on whether they are consciously controlled or occur automatically without conscious control. The author calls the former conscious inhibition of a motor or cognitive response and the latter automatic inhibition. Within conscious inhibition, he distinguishes four subtypes:

1. Interference control - this is the ability to maintain performance in the presence and action of distractors that interfere by evoking an alternative response that is inappropriate to the intended behavioural goal.
2. Cognitive inhibition - the active inhibition of mental content. It is used to suppress inappropriate or irrelevant thoughts in order to maintain attention and promote working memory activity.
3. Behavioural inhibition - the suppression of automatic responses or socially inappropriate behaviour.
4. Oculomotor inhibition - deliberate suppression of automatic reflexive movements.

According to several studies, the ability to control inhibitions contributes significantly to successful performance in a variety of tasks. According to DeBeni, Palladino, Pazzaglia and Cornoldi (1998), the ability to inhibit irrelevant information has a significant impact on working memory performance.

In addition, McNab et al. (2008) found that some functional areas involved in inhibitory control are also activated during working memory engagement. Inhibitory control, like the ability to update working memory, is another executive function that contributes to reading comprehension (Gernsbacher, 1993).

An important part of the executive system in the developmental process is the regulation of attention. Its regulation and maintenance "interacts with memory processes to form the cognitive structures necessary for executive control and behavioural control" (Akyurek, 2018).

1.2 A developmental perspective on working memory and inhibitory control

Working memory begins to form at an early age and develops during the preschool years as part of a child's overall cognitive development. It is closely linked to the development of attention, reasoning and language skills. It plays an important role in the understanding of spoken language. It is necessary for successful socialisation - children with a well-developed working memory find it easier to remember rules and are better at activities that require them to be followed (Cowan, 2016; Garon et al., 2008).

Wagner (2020) states that working memory capacity is limited in pre-schoolers, with younger children having difficulty linking and effectively using more knowledge. Both executive functions, working memory and inhibitory control, depend on brain capacity that is still limited at this age. Therefore, increased demands on one of these functions may negatively affect the use of the other (Diamond, 2013).

According to Zelazo and Carlson (2012), behavioural research has shown that the development of rule use follows a predictable pattern: children first acquire the ability to follow one rule, and then learn to switch flexibly between two rules, and finally are able to switch flexibly between two incompatible pairs of rules.

When a child has to remember a larger amount of information, a more complex rule or a rule change, the capacity of their working memory can significantly affect their performance. Processing information more efficiently also improves retention. Since it is not just a matter of mechanically retaining knowledge, but also of understanding it, the child's level of thinking also plays a very important role.

Accelerated processing of information also contributes to the development of working memory, which reduces the likelihood of forgetting information between the processing and storage phases (Vágnerová, 2020).

Working memory and inhibitory control support self-regulatory mechanisms. Hofmann, Schmeichel, and Baddeley (2012) argue that self-regulation is a fundamental aspect of human behaviour.

2 Research part

2.1 Objective and methods of research

The main aim of the research study was to investigate how memory and inhibitory control influence the structure of educational content and to make recommendations for teachers in the development of educational curricular content.

The selection of respondents for our research was oriented towards a group of school-aged students; the age range of the respondents was between 11 and 13 years (M = 12.65; SD = 0.78). 258 respondents from primary schools in Slovakia took part in the study. The administration took place in the school.

We used the Behaviour Rating Inventory of Executive Function (BRIEF), a questionnaire for parents and teachers of school-aged children that allows the assessment and rating of children's executive functions in the home and school environment. The method is used to assess children between the ages of 5 and 18. Each version of the questionnaire, for both parents and teachers, contains 86 items in eight scales that assess different aspects of executive functioning: inhibition, shifting of attention, emotional control, and initiative, working memory, planning and organisation, organisation of tools, behavioural control.

The second was the CERQ multidimensional questionnaire (Garnefski et al., 2001), which consists of 36 items that examine an individual's general cognitive style and nine emotion regulation strategies after experiencing a stressful situation. Four questionnaire items assess each strategy, with five strategies falling under the category of adaptation: acceptance, positive reappraisal, planning, positive refocusing, putting things in perspective; other regulation strategies assessed in the questionnaire: self-blame, rumination, catastrophizing, blaming others. The respondent answers on a five-point Likert scale. The questionnaire is designed to identify cognitive emotion regulation strategies (or cognitive coping strategies) that someone uses after experiencing negative events or situations.

The results of the questionnaires were analysed using the SPSS statistical programme. The distribution of the data according to the Kolmogorov-Smirnov test met the normality criterion.

2.2 Research results

From our comparisons, we can confirm that the individual relationships between the variables studied are complementary. In the following, we mainly present the results that showed significant co-relations and relationships.

The higher the children's initiative, the more independent they are in solving problems, the higher and richer the level of working memory (M = 1.85; SD = 0.42). There is a positive correlation at the 0.05 level, suggesting that in this case there is less need for adult supervision, and the children in our sample are also more likely to remember information in the longer term (p = 0.020, r = 0.205*). This is also related to the completion of homework, which they do not forget and complete without help from parents or teachers.

It is also worth noting the positive correlation with planning/organising (M = 1.78; SD = 0.37), which gains significantly in structure and precision when children's working memory is accurate and unproblematic (p = .000, r = .305**) when working memory is effective. These two factors influence each other, and if an individual is able to organise their activities without confusion and chaos, if they can navigate the schedule and timetable of activities, then their working memory is likely to be working at an appropriate level. Adequate time management also contributes to this, which motivates respondents to perform better.

Working memory is also positively correlated with shifting attention (M = 1.84; SD = 0.39), which is an important part of executive functioning. If respondents in our sample are working effectively with their working memory, it is possible that this is reflected in attention shifting and its effectiveness (p = .000, r = .310**).

We believe that school-age children who can remember both information and activities to be carried out over a longer period can shift their attention more easily from one activity to another without the need for external cues to shift their attention. They are more likely to shift attention away from negative emotions and situations, and are less likely to be distracted by changes in plans or different factors during the lesson.

Another variable was inhibitory control, which is the respondent's ability to control their attention, behaviour, thoughts and emotions. It involves suppressing internal predispositions and choosing what is more appropriate or necessary (Diamond, 2013).

The significant relationship between the two variables was perspective taking, which influences students' inhibition (M = 1.72; SD = 0.38). A positive correlation was found at the 0.05 level, indicating that the more respondents think prospectively and positively about challenging situations, the more we can observe an increase in the frequency of behavioural inhibition of individuals (p = .018, r = .210*). In this case, respondents are able to control their behaviour and adapt it to the situation they find themselves in. When individuals are able to view the situation with detachment and perceive it as something that can be overcome, their behaviour is under their own control.

However, behavioural inhibition also shows a negative relationship with suppression (M = 4.28; SD = 1.56) at the 0.01 level, as indicated by the associations confirmed so far (p=.009,

r=-.279**). In this significant correlation, we can observe a phenomenon that suggests that the sample of respondents who use a suppression strategy in problem solving are likely to have lower levels of inhibition and behavioural control. Intractability, impulsivity and lack of control tend to increase with increased use of the suppression strategy, which is also reflected in our sample. Respondents try to suppress and not express their emotions; this strategy may induce the opposite behaviour, which is likely to manifest itself later in specific situations.

Based on the following correlation, which examines the relationship between inhibition and blaming others (M = 3.14; SD = 0.82), we can hypothesise at the 0.01 level that as the score on the variable blaming others increases, so does the difficulty with inhibition and behavioural control (p=.007, r=.274**). Respondents who cannot take responsibility for their actions and blame all their problems and their consequences on other people are also more likely to engage in impulsive and uncontrollable behaviour.

3 Discussion

An important formative factor of executive function is working memory, which plays an important role in our paper. Hofmann, Schmeichel, and Baddeley (2012) support the idea that working memory, as a 'cold' executive function, controls and regulates emotions, which is one reason why it is essential to work with and develop it.

They argue that working memory is also a kind of drive for goal achievement, which our research has shown to be true, supported by correlations with organisation and planning. When working memory is at a higher level, it can lead to mobilisation and the setting of achievable goals.

If people are still thinking about the situations they have experienced and are unable to get away from them and change their way of thinking, this will be reflected in the way they organise the tools they need to carry out tasks and everyday situations. It increases forgetfulness, lack of independence and impatience, and affects other executive functions such as planning, organising, working memory or shifting attention.

Our research does not allow us to assess whether good school performance is a consequence of good executive functioning. The behaviour regulation index, which consists of emotional control, inhibition as well as attention shifting, is inseparable with the metacognition index.

The activity of the behavioral regulation index and metacognition is reflected in the performance of common everyday situations, planning the day, overall functioning as well as in academic activities and in the decision-making process (Miller & Byrnes, 2001).

If the respondent has, problems with inhibition and control of emotions, their decision-making abilities are limited and their decisions are mostly ineffective. If their emotional regulation and behavioral regulation index are normal, the achievement of goals in life and the development and activity of executive functions are higher (Vancu, Jonášová, 2024).

4 Recommendations and conclusion

From our comparisons, we can confirm that working memory is "an active memory system responsible for the temporary storage and concurrent processing of information" (Bayliss et al., 2005, p. 580). It integrates the products of other cognitive processes and is involved in a range of complex mental activities.

One of the aims of this approach is precisely to ensure that learning does not overload the child's working memory, otherwise it will be ineffective (Kester, Paas, & van Merriënboer, 2010).

Students with poor working memory often get 'lost' when solving more tasks that are complex, need to repeat instructions more often, skip steps in problem solving, and are often unable to complete given tasks (Alloway et al., 2005). There is widespread consensus that a poorly functioning working memory system has a devastating effect on the functioning of higher mental processes in reading, arithmetic or the organisation of intentional behaviour in general (McDonald & Day, 2010).

Working memory is arguably a prerequisite for effective learning, as the learning process requires the manipulation of information, planning and a series of problem-solving steps, interaction with long-term memory, and simultaneous memorization and processing of information (Gathercole & Alloway, 2008).

Working memory is not significantly more involved in already routine activities. All this implies that teachers should try to optimize the demands on working memory, especially in the initial stages of learning. The content of the classroom is full of information that is new to the pupils.

The limitations of working memory apply particularly to this information, and for this reason, the structure of this learning content needs to be carefully considered, particularly for pupils. The implications of these claims are elaborated further within the educational theory of cognitive load (Paas, van Gog, & Sweller, 2010).

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