Co-funded by
the European Union

RETORE
REMEMBER TO REMEMBER

REMEMBER TO REMEMBER:

The international experience of prospective memory training (between theory and practice)

Benešová, T., Rošíková, T., Appeltauer, J. Nilius, P., Kytnarová, L., Škobrtal, P., De Nys, G., Sasanguie, D.,Jopek-Bizoń M., Kochanowska E., Mika D., Wojciechowska J., Zawada E., Jóelsdóttir, S.S.E., Einarsdóttir, Ó.R., Harðardóttir,K.

Published:
VSB - Technical University of Ostrava
Ostrava I 2024

VSB - Technical University of Ostrava
Ostrava
2024

Published:
VSB - Technical University of Ostrava
Ostrava
2024

REMEMBER TO REMEMBER

The international experience of prospective memory training (between theory and practice)

Benešová, T., Rošíková, T., Appeltauer, J. Nilius, P., Kytnarová, L., Škobrtal, P., De Nys, G., Sasanguie, D.,Jopek-Bizoń M., Kochanowska E., Mika D., Wojciechowska J., Zawada E., Jóelsdóttir, S.S.E., Einarsdóttir, Ó.R., Harðardóttir, K.

REMEMBER TO REMEMBER

Authors: Benešová, T., Rošíková, T., Appeltauer, J. Nilius, P., Kytnarová, L., Škobrtal, P., De Nys, G., Sasanguie, D.,Jopek-Bizoń M., Kochanowska E., Mika D., Wojciechowska J., Zawada E., Jóelsdóttir, S.S.E., Einarsdóttir, Ó.R., Harðardóttir, K.

Proofreading: Tereza Rošíková

Ostrava, 2024, 1st Edition

Published: VSB – Technical University of Ostrava

Printed: VSB – Technical University of Ostrava

Not for sale

ISBN 978-80-248-4781-8

ISBN 978-80-248-4782-5 (on-line)

DOI 10.31490/9788024847825

Contents:

Editorial

Memory research and training is a frequent and popular topic in psychological research and practice. Yet the topic of prospective memory, i.e. memory for the future, is not well known in professional or lay discourse.

Prospective memory is a type of memory used in many situations, and it forms a prerequisite for effective functioning in everyday life. Prospective memory, as the ability to remember what we intend to do in the future and later recall our intention at the right time, also plays a very important role in school success. Additionally, deficits in prospective memory are associated with a range of psychological difficulties, be it various cognitive impairments, neurodevelopmental disorders etc.

The international project Remember To Remember (2021-1-CZ01-KA220-SCH-000032703) involved teams from VSB-Technical University Ostrava, University of Iceland, Hogeschool GENT and Akademia techniczno-humanistyczna in Bielsko-bialej. The project focused specifically on training prospective memory in adolescents with learning difficulties and/or neurodevelopmental disorders. In the publication *REMEMBER TO REMEMBER: The international experience of prospective memory training (between theory and practice)*, a theoretical perspective on the topic of prospective memory training is offered and combined with practical findings from training conducted in the Czech Republic, Iceland, Belgium and Poland. Prospective memory falls among very important cognitive functions, therefore, training it throughout the whole life is of the highest importance.

For the Remember To Remember team,

Tereza Benešová, VSB - Technical University of Ostrava

I. Prospective Memory, Executive Functions and Metacognition

Relationships between prospective memory and metacognition and specifics for people with ASD

Tereza Benešová

Abstract

The concepts of metacognition and prospective memory are closely related to the social dimension of cognition. It is assumed that prospective memory processes are partly under metacognitive control and that people have certain metacognitive awareness and expectations about their prospective memory abilities in different task contexts. Clinical populations often fail on prospective memory tasks due to limited cognitive resources caused by a specific neurocognitive pathology. Present chapter examines other factors potentially playing a role in prospective memory deficits, such as motivation and/or metacognitive awareness of one's own limitations and capabilities whilst focusing on Autism Spectrum Disorder (ASD). ASD is a neurodevelopmental disorder where impairments in self-regulation, executive functions, and metacognition often affect prospective memory performance. Training that integrates executive function and metacognitive components may improve prospective memory in individuals with ASD, emphasizing the importance of individualized, adaptive strategies for successful memory performance.

1. The context of social learning theory

The concepts of metacognition and prospective memory are part of the interest of cognitive psychology, but they are also closely related to the social dimension of cognition. The fact that human thinking is influenced by social interactions is highlighted by social psychology through, among other things, Social Cognitive Theory (SCT), which focuses on individual learning and the relationship between personal factors, environmental influences and their reciprocal interaction.

A more systematically sophisticated theory of social learning[1] was developed by Albert Bandura and Richard Walters, who also opened a topic of cognitive processing of social experiences and the question of how the imitation process takes place and how it affects behaviour and personality development.

[1]The mechanisms of social learning are described by several theories, ranging from the neo behaviourist theories of Miller and Dollard (1941) explaining social learning through imitation of human behaviour, to the more sophisticated **social learning theory** (by Albert Bandura and Richard Walters), which was published in the early 1960s and is still one of the most influential theories of social learning today (Vyrost et al., 2019).

The basis of Bandura's (1986) SCT is the triadic reciprocal model, which consists of three basic factors: environment, person, and behaviour. These three factors interact to influence motivation, activity, and behaviour. Furthermore, according to Bandura's theory, learning by imitation includes four components, namely: attention, retention, reproduction and reinforcement.

Bandura pays attention to the component of reinforcement, when he talks about primary reinforcement (the individual observes and imitates the model's behaviour), vicarious reinforcement (anticipation of reward), self-enhancement (motivation by one's own norms, ideas, independent of the reaction of others). According to Bandura, the essence of creating new responses based on observing how someone else behaves is made possible by a person's cognitive abilities. Stimuli are transformed into mental images, i.e., using symbolic cognitive abilities, new behaviours can be created. Bandura uses the term reciprocal determinism to express the interaction between humans and their environment (Vyrost et al., 2019). To further define the concept of metacognition, one of the key concepts of social learning theory is the notion of self-regulation or self-regulation, which according to the social cognitive approach involves the interaction of knowledge about the internal and external context, aiming to move from control from the "outside" to self-direction, where the individual becomes an active actor in his or her own learning process, both in terms of activity and motivation, as well as metacognition (Škoda & Doulík, 2011). However, for the concepts of metacognition and self-regulation, many authors question their interrelationship of superiority or inferiority (Říčan & Chytrý, 2016).

2. The concept of metacognition

The concept of metacognition is encountered in developmental and cognitive psychology as well as in theories of learning (Otani & Widner, 2005; Mahdavi, 2014). According to cognitive psychologists, metacognition is considered an important component of intelligent behaviour, which also helps individuals to learn effectively (Flavell, 1979; Krykorková, 2010). In literature, we can also encounter the concept of metamemory (Schneider, 2015), i.e., knowledge about memory and memory processes. However, metacognition is a broader term, expressing more comprehensively the knowledge of cognition, monitoring and management of cognitive activities.

Bandura (1986) depicts a blurring of the distinction between cognition and metacognition when we use more general rules or strategies. However, the process of metacognition requires a process of regulation and self-reflection in addition to cognitive appraisal. At the same time, it is a conscious process, accessible to our awareness (Bannert & Mengelkamp, 2008).

Research on metacognition in developmental psychology focuses more on the differences between individual and group aspects of metacognitive knowledge, skills, and strategies. In contrast, cognitive psychology focuses more on the memory processes accompanying metacognitive monitoring and control (Lokajickova, 2015). In the field of learning, the topics of learning dispositions, self-regulation of learning and self-reflection are of particular interest.

What is essential from the perspective of the Remember To Remember project is that metacognition is formed gradually and can be improved, and that it is dependent on knowledge and experience (Lokajíčková, 2015). Metacognitive competencies begin to develop in children around the age of 5-7 (Veenman et al., 2006) and increase during the higher school-age years. At the same time, research suggests that the level of metacognitive competence can also be developed in adults.

2.1 Components of metacognition

Flavell's model of cognitive monitoring distinguishes four classes: 1st metacognitive knowledge, 2nd metacognitive experiences, 3rd goals or tasks, and 4th actions or strategies (1979).

Two basic properties of metacognition, following Flavell's model, were named by Kluwe (1982) as follows: the thinking subject has knowledge of his own thinking and of the thinking of others (i.e., declarative knowledge); the thinking subject can monitor and regulate the course of his own thinking (procedural knowledge). The structure of the metacognitive process has been the focus of many authors, with most authors emphasizing the interplay between the knowledge component and the monitoring and regulation component. Krykorková and Chvál (2001) define metacognition as an intersection of three concepts, namely metacognitive knowledge, within which the selection and direction of solutions takes place, metacognitive monitoring and metacognitive regulation.

Based on her analysis of approaches to structuring metacognition, Lokajíčková (2015) identifies overarching higher-level units, namely metacognitive knowledge and experience, metacognitive beliefs, and metacognitive monitoring, control and regulation (i.e., metacognitive processes).

However, while metacognitive knowledge implies domain-specific development, the process of metacognitive management is more general in nature, focusing on reviewing problem-solving outcomes and planning next steps. In relation to our proposed procedure for training prospective memory, we consider it important to also mention a more detailed breakdown of the metacognitive management

process as described, for example, by Veenman et al. (2006). The first step is planning, a process that precedes each cognitive operation and involves activating knowledge, choosing an appropriate strategy as well as selecting goals, reflecting on the sequence of steps, and creating a timetable for action.

The next step is monitoring, where the individual tests whether he or she has understood the task, chosen appropriate strategies to perform the task, and redefined the choice of strategies if necessary. This is an active control over one's own cognitive processes necessary for coping with task situations and Lokajíčková (2015), with support from the literature, states that this is the most complex and longest developing metacognitive competence, which can be improved during adulthood.

The third step is evaluation, i.e. control of the process of task performance and its result. Based on the evaluation, the individual also reflects on his/her further learning and cognition. The bridge between metacognitive knowledge and metacognitive control is provided by metacognitive theories, which are a kind of framework for our beliefs about our own knowledge. Metacognitive theories are formed over a lifetime based on the layers of our metacognitive experiences. Yet we can trace certain milestones developmentally, which we have also considered in designing appropriate prospective memory training. Improvements in planning occur during adolescence hand in hand with the development of abstract thinking and the ability to operate with concepts (Říčan & Pešout, 2013).

Metacognitive strategies are formed not only based on declarative knowledge from the contents of long-term memory, but also based on implicit processes in response to certain stimuli. Both processes can occur simultaneously and can include four categories of learning strategies, such as purely cognitive strategies, metacognitive strategies (planning, goal setting, monitoring, regulation), self-knowledge strategies (knowledge of one's own learning style, self-efficacy) and motivational strategies (orientation to extrinsic motivation, orientation to intrinsic motivation, personal interest in the learning, perceived value of the learning, causal attribution).

Brown et al. (1983) list among the prerequisites for effective metacognitive strategy use the availability of an adequate number of both domain-specific and general strategies. Self-knowledge, self-reflection, and general knowledge of the world are also essential components of effective strategy use.

3. The importance of prospective memory

Memory processes play an important role not only in recalling past events and experiences but are also essential in planning what we want to do in the future. Key to these processes is what is known as prospective memory, the ability to remember what we intend to do in the future and later recall our intention at the right time.

The main difference between these two types of memory is how the information or intention is equipped. In the case of retrospective memory, someone asks us directly about a piece of information and we know what to recall at that moment. In the case of prospective memory, the recall of the information is not externally given, but we ourselves must remember the intention. Thus, we ourselves must remember to remember (remember to remember).

The manifestations of prospective memory impairment may vary because all memory tasks that are associated with frontal lobe function depend on spontaneous formation of an effective strategy. Prospective memory problems account for more than half of our everyday memory problems.

However, prospective memory processes can be trained quite effectively, primarily in two ways. In the first way, training strategies to improve prospective memory performance is essential. The second way works with training the basic cognitive processes (working memory, executive functions, and others) that underlie more complex cognitive processes such as planning.

In the case of planning training sessions in the international Remember To Remember project, we have adopted a combination of both approaches, which studies have shown to be more effective (Hering et al, 2014). Prospective memory training often takes place through hands-on practice of various prospective tasks. Participants in prospective memory training are given various prospective tasks during joint sessions, but also through homework.

When creating the prospective tasks in the Remember To Remember project, the emphasis was on their relation to the everyday life of older school-age children (dealing with situations at school or in leisure time). There is a basic process for prospective tasks consisting of four stages: 1) creating and encoding an intention; 2) postponing the intention while dealing with another (ongoing) task (OT); 3) inhibiting and switching from OT to resuming the intention at an appropriate/planned time in the future; 4) and finally executing the intention.

In the literature, prospective memory is differentiated into two types according to the cues used in equipping. The first type is event-based prospective memory, and the second type is time-based prospective memory.

The principle of prospective event-based memory is to recall to perform an intention when a certain stimulus is present to recall it, or a situation occurs to elicit the intended task or activity (McDaniel & Einstein, 2000).

Time-based prospective memory means that a prospective task is performed at a predetermined time or after a specified period. One's actions are then not controlled by any external cues, but only by internal time monitoring.

4. The relationship between metacognition and prospective memory

The metacognitive processes described in the previous text are closely related to prospective memory. It is assumed that prospective memory processes are partly under metacognitive control (Kuhlmann, 2019) and that people have certain metacognitive awareness and expectations about their prospective memory abilities in different task contexts.

At the same time, cognitive processes serving each phase are needed in all tasks, namely episodic memory processes, which are needed to encode and retrieve the intention, executive control, which is needed to monitor the environment and then inhibit and switch from the ongoing task to the prospective task execution (Kliegel et al., 2002). Recently, theory of mind has also been considered in relation to prospective memory (Altgassen et al, 2012) and or episodic future thinking, which is considered important for projecting oneself into the future to imagine and perform different prospective memory tasks.

The involvement of basic cognitive resources such as episodic retrospective memory and executive function varies across the stages of the prospective memory process. In considering the distribution of the different functions, we draw on a process model of prospective memory that divides the prospective remembering process into several phases (Kliegel et al, 2002; McDaniel & Einstein, 2007): intention formation, which involves forming a plan and storing the intention in long-term memory (which, however, is usually filled with ongoing activity that does not allow rehearsal of the intended task in working memory); intention initiation, the point at which execution of the intention is initiated; and

intention execution, when the intended action is carried out in accordance with the previously formed plan. The same process model is also reflected in the parameters for the prospective task.

Parameters of a prospective memory task (McDaniel & Einstein, 2007):

- Implementation of the plan is not imminent.
- The prospective memory task is embedded in an ongoing activity.
- The window for initiating an intent is limited.
- The time scale for the implementation of the project is limited.
- The intention (intent) must be present.

The neurological basis of prospective memory processes implies a division into prospective and retrospective components of task processing. Regarding the retrospective component, the involvement of the medial temporal lobe is significant, playing a role in both prospective memory tasks and episodic memory tasks (Palmer & McDonald, 2000). Areas of the medial temporal lobe are activated by the execution of deferred intentions. In contrast, the processes underlying the prospective component are more strongly dependent on the functional integrity of the prefrontal cortex (Burgess et al., 2003).

What is essential for considering the possibilities of prospective memory training is to also consider the role of other factors such as metacognition and motivation. The general assumption that the clinical population fails on prospective memory tasks due to limited available cognitive resources caused by specific neurocognitive pathology neglects other factors such as motivation and/or metacognitive awareness of one's own limitations and capabilities. Kliegel et al. (2011) provide a specific example where a person may redefine more difficult tasks, such as time-based tasks, into simpler event-based tasks. For example, instead of trying to remember a specific time of task completion, it is easier to associate it with an event or select a compensatory tool for reminders (e.g., an alarm clock, reminders on a phone, etc.). Kliegel et al. (2011) point out that while such compensatory mechanisms are largely avoided in typical laboratory tasks, they do occur in everyday life and can enable performance improvement on prospective tasks even in the clinical population. Both motivation (the degree of motivation prior to important intentions) and metacognitive beliefs (e.g., knowledge of one's own strategies) play an important role and can lead people to strategically focus their available resources on task-relevant aspects. This is relevant in prospective memory because it is a dual-task situation that requires the allocation of attentional resources between the prospective and ongoing task, and metacognition and

motivation are involved in the execution of the process as much as the individual executive functions (see Figure 1. Revised Phase Model of Prospective Memory).

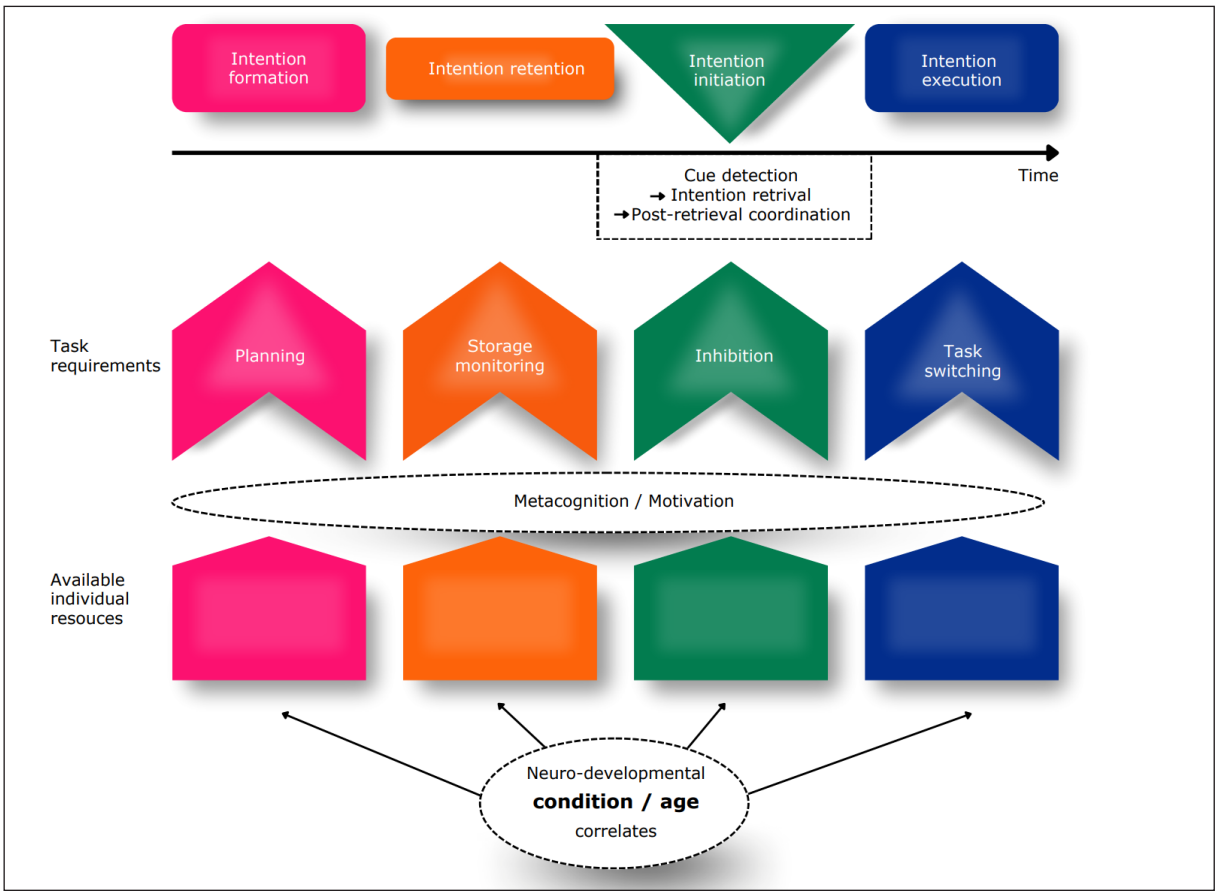


Figure 1. Revised Phase Model of Prospective Memory (Kliegel, et al., 2011, p. 2167), modified

5. Specifics of prospective memory (and metacognition) in Autism Spectrum Disorders

Autism Spectrum Disorder (ASD) is a disorder with specific impairments in neurocognitive mechanisms that interfere with the process of self-awareness. People with ASD have difficulty reflecting on their mental states, their intentions, or predicting their own actions, as well as predicting the intentions of others (Mitsea et al., 2022; Lombardo et al, 2007). The ASD perspective emphasizes impairment in the interpersonal domain, however, the disorder also has a significant impact on the intrapersonal self-referential domain, resulting in poorly developed self-management skills, such as problems with planning, control, and self-regulation (Xin et al., 2017). Problems in the domain of self-regulation are mainly manifested by inability to adapt, impulsivity, inadequate reactions, and disorganization. Difficulties in switching between mental representations of a single object in response to changing contextual factors, lower ability to discriminate and record the occurrence of target behaviours and to

evaluate performance against a predetermined goal, and the ability to evaluate performance and self-evaluate performance occur (Mitsea et al., 2022).

Autism spectrum disorders are generally characterised by impaired social communication, restricted interests and activities, and atypical reactivity to sensory stimuli, and the clinical picture and cognitive abilities can be highly variable. Despite this diversity, for most people with autism spectrum disorder (even those with average or above-average cognitive abilities), everyday life presents many difficulties (whether in self-care, household care or employment). Children with autism spectrum disorder often struggle in school due to problems with planning, coordination, and organization, and these difficulties are related to deficits in prospective memory (Altgassen et al., 2006).

Despite the importance of prospective memory for everyday functioning in autism spectrum disorders, there is little research on this topic. Studies looking at performance in prospective memory in individuals with autism spectrum disorder point to problems with tasks with increasing difficulty in the prospective component and a greater requirement for strategic monitoring (Mitsea et al., 2022). At the same time, the prospective component is supported by attention-demanding processes that are closely linked to executive functions that are important for monitoring, inhibition, and to switch to prospective intention at the appropriate time (Marsh et al., 2002).

6. Conclusion

In conclusion, tasks with high demands on attentional control resources, inhibition and cognitive flexibility place higher demands on individuals with autism spectrum disorder. At the same time, the question is what role motivation and metacognitive components play in the successful mastery of prospective tasks. If we consider the different phases of the prospective task and the presumed deficits of persons with autism in executive functions, episodic thinking about the future, as well as motivation and metacognition, we might expect reduced performance in prospective intention formation, intention maintenance, intention initiation, and intention execution.

Therefore, in prospective memory training with a focus on individuals with neurodevelopmental disorders, it is appropriate to focus not only on the area of executive function training, but also to consider the training of the individual components of metacognition as defined by Drigas & Mitsea (2020):

1. Meta-thinking/meta-learning: knowledge of one's own cognitive mechanisms, ability to learn how to learn

2. (Self-)evaluation and awareness of your strengths and weaknesses

3. (Self)observation in real time, ability to introspect

4. Self-regulation

5. Adaptation to the requirements of specific situations, needs and goals.

6. The ability to recognize not only in oneself but also in others the mental states of others, their intentions and beliefs.

7. Discrimination, i.e. the ability to filter, determine and strategically choose what is relevant and what is not in a given situation in terms of actions and behaviour.

References:

Altgassen, M., Vetter, N. C., Phillips, L. H., Akgün, C., & Kliegel, M. (2014). Theory of mind and switching predict prospective memory performance in adolescents. *Journal of experimental child psychology, 127*, 163-175.

Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*. Upper Saddle River, NJ: Prentice Hall.

Bannert, M., & Mengelkamp, Ch. (2008). Assessment of metacognition skills by means of instruction to think aloud and reflex when prompted. Does the verbalisation method affect learning? *Metacognition and Learning, 3*, 39-58.

Brown, A. L., Bransford, J. D., Ferrara, R., & Campione, J. (1983). Learning, remembering and understanding. In J. H. Flavell, & E. M. Markman (Eds.), Handbook of child psychology: Vol. 3. Cognitive development (4th ed., pp. 77-166). New York: Wiley.

Burgess, P. W., Scott, S. K., & Frith, C. D. (2003). The role of the rostral frontal cortex (area 10) in prospective memory: a lateral versus medial dissociation. *Neuropsychologia*, *41*(8), 906-918.

Drigas, A., & Mitsea, E. (2020). A metacognition based 8 pillars mindfulness model and training strategies. *Int. J. Recent Contributions Eng. Sci. IT*, *8*(4), 4-17.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. American Psychologist, 34(10), 906-911

Flores, P. A. (2018). Examining Bandura's Social Cognitive Theory Relative To An Application Within Business Skills Standards (Doctoral dissertation, University of West Florida).

Hering, A., Rendell, P. G., Rose, N. S., Schnitzspahn, K. M., & Kliegel, M. (2014). Prospective memory training in older adults and its relevance for successful aging. *Psychological research*, *78*, 892-904.

Kliegel, M., Martin, M., McDaniel, M. A., & Einstein, G. O. (2002). Complex prospective memory and executive control of working memory: A process model. *Psychological Test and Assessment Modeling, 44*(2), 303.

Kliegel, M., Altgassen, M., Hering, A., & Rose, N. S. (2011). A process-model based approach to prospective memory impairment in Parkinson's disease. *Neuropsychologia*, *49*(8), 2166-2177.

Kluwe, R. H. (1982). Cognitive knowledge and executive control: Metacognition. In *Animal Mind-Human Mind: Report of the Dahlem Workshop on Animal Mind-Human Mind, Berlin 1981, March 22-27* (pp. 201-224). Berlin, Heidelberg: Springer Berlin Heidelberg.

Krykorková, H. (2010). Self-regulation and metacognition in the context of school learning psychology. In K. Hrbáčková et al. (Eds.), Cognitive and noncognitive determinants of students' learning autoregulation development (27-44). Brno: Paido.

Krykorková, H., & Chvál, M. (2001). Developing metacognition - a path to more valuable knowledge. *Pedagogy, 51*(2), 185-196.

Kuhlmann, B. G. (2019). Metacognition of prospective memory: Will I remember to remember? *Prospective memory*, 60-77.

Lai, R. E. (2011). Metacognition: A literature review [on-line]. Retrieved from: www.pearsonassessments.com

Lokajíčková, V. (2015). Opportunities to develop learning competence in geography education (Doctoral dissertation, Masaryk University, Brno, Czech Republic) [online]. Retrieved from: http://is.muni.cz/th/237142/pedf_d/.

Lombardo, M. V., Barnes, J. L., Wheelwright, S. J., & Baron-Cohen, S. (2007). self-referential cognition and empathy in autism. *Plos one*, *2*(9), e883.

Mahdavi, M. (2014). An overview: metacognition in education. *International Journal of Multidisciplinary and current research*, *2*(6), 529-535.

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. Applied Cognitive Psychology: The Official *Journal of the Society for Applied Research in Memory and Cognition, 14*(7), S127-S144.

Marsh, R. L., Hicks, J. L., & Watson, V. (2002). The dynamics of intention retrieval and coordination of action in event-based prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *28*(4), 652.

Mitsea, E., Drigas, A., & Skianis, C. (2022). Metacognition in autism spectrum disorder: digital technologies in metacognitive skills training. *Technium Soc. Sci. J.*, *31*, 153.

Otani, H., & Widner, R. L. (2005). Metacognition: New Issues and Approaches Guest Editors' Introduction. *The journal of general psychology*, *132*(4), 329-334.

Palmer, H. M., & McDonald, S. (2000). The role of frontal and temporal lobe processes in prospective remembering. *Brain and Cognition*, *44*(1), 103-107.

Schneider, W. (2015). The development of metamemory. *Memory development from early childhood through emerging adulthood*, 255-308.

Škoda, J., & Doulík, P. (2011). *Psychodidactics: methods for effective and meaningful learning and teaching*. Grada.

Říčan, J., & Chytrý, V. (2016). *Metacognition and metacognitive strategies as theoretical and research constructs and their use in modern pedagogical practice*. Hněvín.

Říčan, J., & Pešout, O. (2013). *Learners' use of metacognitive strategies in the context of self-regulated learning*. NPP Purkyně University in Ústí nad Labem.

Výrost, J., Slaměník, I., & Sollárová, E. (2019). *Social psychology: theory, methods, applications*. Grada Publishing as.

Veenman, M. V., Van Hout-Wolters, B. H., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition Learning, 1*(1), 3-14.

Xin, J. F., Sheppard, M. E., & Brown, M. (2017). Brief report: Using iPads for self-monitoring of students with autism. *Journal of Autism and Developmental Disorders*, *47*, 1559-1567.

Tereza Benešová is a doctoral student at the Department of Psychology, Charles University in Prague.

Contact:

Tereza Benešová, PhD.
VŠB - Technická univerzita Ostrava
17. listopadu 2172/15, 708 00 Ostrava Poruba
Email: tereza.benesova@vsb.cz

Faculty of Arts, Charles University
Department of Psychology
Celetná 20, 116 42, Praha 1

Cognitive rehabilitation using ProxyQB

Petr Nilius

Abstract

Traumatic brain injury (TBI) and stroke represent significant global health challenges, leading to long-term disability and substantial societal and economic burdens. Cognitive rehabilitation (CR) is a critical component of neurorehabilitation for brain injury patients, aiming to restore or compensate for cognitive deficits. This process involves a range of evidence-based interventions tailored to individual patient needs. However, despite advancements in neuropsychology and brain plasticity, key challenges remain, including delays in treatment initiation, lack of standardization, and limited access to specialized care. Additionally, cognitive rehabilitation for children with neurodevelopmental disorders, including those with Autism spectrum disorder and ADHD, has shown promising results, particularly with the integration of virtual reality and strategic training methods. A promising solution to these challenges is the Neurorehabilitation box and its electronic counterpart, ProxyQB, a cognitive neurorehabilitation tool designed to facilitate cognitive and motor rehabilitation.

1. Introduction to cognitive rehabilitation

Brain injury, particularly traumatic brain injury (TBI) and stroke, is a major health, medical and societal challenge worldwide. In the European Union alone, estimated 57,000 deaths and 1.5 million hospital admissions are attributed to TBI each year. Life expectancy after TBI is estimated to range from less than 40% to more than 85% of that of the general population, depending on the severity of the injury and the degree of disability (Majdan et al., 2017). Due to long-term nature of disability after TBI and its unstable nature (e.g., about 1 in 3 patients experiences a decline in previously achieved levels of functioning within 10 years of injury), TBI is considered a chronic condition (Centres for Disease Control and Prevention, 2022). As life expectancy has increased in high-income countries, TBI due to falls has become more common. Epidemiological studies suggest that approximately 43% of these patients experience disability for six months or longer, characterised by functional limitations, activity limiting post-injury symptoms, cognitive complaints and/or mental health problems. Nearly a quarter of moderate-to-severe TBI patients do not return to work in the year following their injury.

With regards to stroke, there has been a reduction in the proportion of the European population experiencing a stroke over the past two decades when accounting for age. However, the number of

strokes is set to increase as a consequence of the growing proportion of the European population aged 70 and above. The projections indicate that between 2015 and 2035, there will be a 34% increase in the total number of stroke events in the EU. This will result in an increase from 613,148 in 2015 to 819,771 in 2035 (see Figure 1).

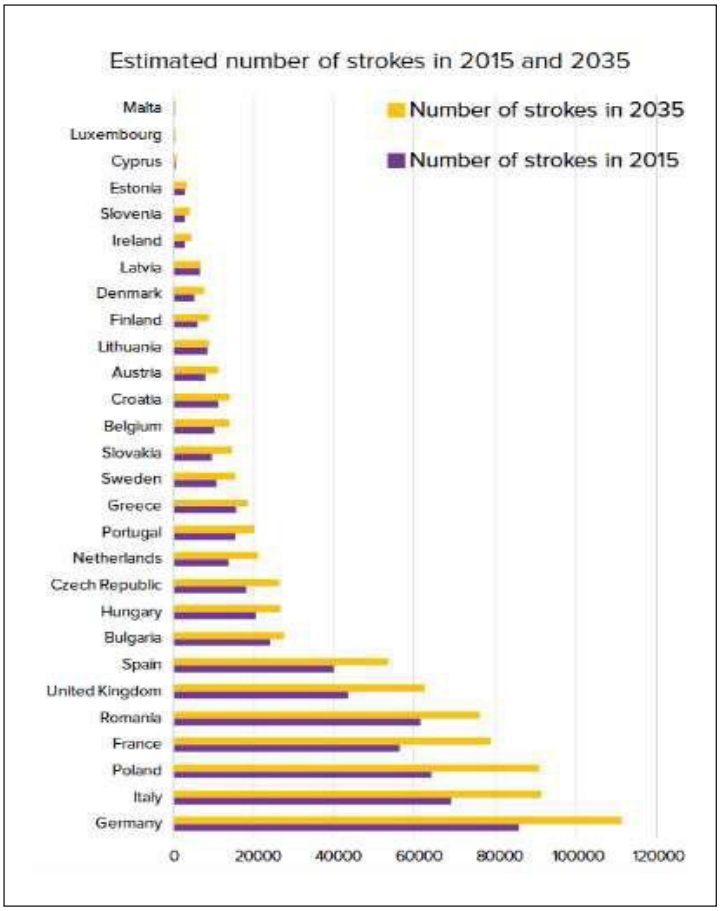


Figure 1. Stroke Alliance for Europe (SAFE). (2017). The burden of stroke in Europe: Report. King's College London. Retrieved from https://strokeeurope.eu

Presently, mortality rates associated with stroke vary considerably across different countries, with figures ranging from 30 to 170 per 100,000 of the population. Thanks to high quality and more expedient treatment, the number of deaths from stroke has decreased, however, there are more survivors living with the associated consequences. In addition to the economic impact of stroke, stroke survivors frequently cope with a wide range of adverse physical and mental consequences. These can have a significant impact on patients and their loved ones, often with long-term consequences. Common impacts include mobility, vision, speech, depression, memory, personality changes, and fatigue. The total economic cost of stroke in Europe (including healthcare and non-healthcare costs) was estimated to 45 billion euros in 2015, and it is projected to rise considerably (Stroke Alliance for Europe, 2017).

Complex neurorehabilitation plays a crucial role in the first six treatment months. To achieve the optimal outcome, comprehensive neurorehabilitation requires the integration of diverse techniques, methodologies, and technological solutions, which concurrently address motor functions and cognitive (brain) functions. It is a long-term process that centers around the efficacy of early, concentrated, and repetitive interventions tailored to the patient's specific needs and limitations. Each deficit, including motor or cognitive decline, requires a specific intervention to enhance the quality of life in the longer term. However, such comprehensive neurorehabilitation is not yet a standard feature of the European health system. A significant number of brain injury survivors are required to wait an extended period of time before an assessment of their rehabilitation needs is conducted and therapy is initiated (Stroke Alliance for Europe, 2017).

1.1 Cognitive rehabilitation

Cognitive rehabilitation constitutes an integral and inextricable component of a multifaceted neurorehabilitation strategy. It encompasses a multitude of evidence-based interventions devised to enhance cognitive performance in individuals with brain injuries or other forms of cognitive impairment. The objective is to reinstate optimal functioning or to compensate cognitive deficiencies. The specific interventions are based on neuropsychological principles and are also closely associated with other neurological disciplines and approaches.

Over the past decade, there has been a notable increase in knowledge regarding the effects and mechanisms of neurocognitive rehabilitation and brain plasticity. This is evidenced by the findings of neuropsychological testing and imaging methods, including functional magnetic resonance imaging (fMRI), brain mapping, single-photon emission computed tomography (SPECT), and others. The current state of knowledge provides a technical solution for IT machine learning tasks in collaboration with neuropsychology and the science of brain neuroplasticity. A multidisciplinary approach is essential for effective treatment of all disorders affecting the brain.

1.2 Challenges in cognitive rehabilitation

Despite the current state of knowledge describing numerous positive outcomes and best practice recommendations, there are significant methodological and technical challenges that must be overcome in order to deliver effective interventions and solutions. The key challenges that need to be addressed include ensuring early, continuous, long-term, standardised, and personalised cognitive rehabilitation;

the lack of cognitive rehabilitation devices for early neurorehabilitation stages combining psychomotor functions and cognitive tasks; disrupted access to neuro specialists after medical discharge; poor psychometric quality in studies without consistent measures for cognitive rehabilitation; and the absence of a widespread monitoring system at the EU level. These barriers highlighted the need for innovative solutions in neurorehabilitation practices.

1.3 Cognitive neurorehabilitation in children

Evidence shows that children and adolescents with neurodevelopmental disorders would benefit considerably from cognitive rehabilitation. A review of the literature by de Vries et al. 2021 reveals that contemporary approaches, including virtual reality, have yielded encouraging outcomes, particularly in the case of children with Autism Spectrum Disorders. A systematic review of 17 studies demonstrated that the utilisation of virtual technologies resulted in notable enhancements in task learning, attention and daily living skills. An alternative approach, procedural training, has the potential to enhance executive function; however, its capacity to facilitate broader cognitive and everyday domain transfer is limited. In contrast, the combination of strategy training with extensive practice has been demonstrated to be a more effective approach, particularly in the context of ADHD and specific learning disabilities (de Vries et al., 2021).

A study by Rodríguez-Prieto (2024) examining children from low-income families with neurodevelopmental disorders confirmed that targeted interventions, such as cognitive stimulation programmes, improve social cognition in particular, which may be crucial for children from socioeconomically disadvantaged backgrounds. Other research considers the heterogeneity of cognitive profiles within neurodevelopmental disorders and recommends transdiagnostic approaches that could enhance both diagnosis and treatment (Al-Saoud et al., 2024).

In summary, the efficacy of cognitive rehabilitation is contingent upon the type of intervention, intensity of training, and specific needs of patients. Future research should encompass long-term impacts and broader utilisation of technology with an emphasis on accessibility.

2. A potential solution towards more effective rehabilitation: neurorehabilitation box

The Neurorehabilitation box by Yakna is a comprehensive tool designed for the purposes of cognitive and motor rehabilitation. The device comprises of six magnetic cubes with interchangeable tiles, thereby

facilitating diverse customisation of therapeutic exercises. The tiles display a variety of symbols, including colours, numbers, animals, and more, facilitating activities that enhance attention, memory, speech, and emotional understanding. The kit is lightweight, durable, and straightforward to sanitise, thus suitable for deployment in clinical or home settings. It facilitates the implementation of early, long-term, and personalised neurorehabilitation in collaboration with trained personnel.

The original concept was derived from a prototype comprising of six cubes stored in a suitcase, namely the Neurorehabilitační kufřík (Figure 2.). It is possible to envisage a scenario in which the aforementioned solution is employed in conjunction with procedures designed for use with patients in acute phases of treatment or those suffering from severe cognitive impairments combined with motor difficulties.

Figure 2. The Neurorehabilitation box

In order to optimise the rehabilitation process and ensure a consistent approach to administration while meeting the demand for personalisation, an electronic solution, ProxyQB, was developed.

2.1 ProxyQB

The ProxyQB is a comprehensive biomedical instrument designed for cognitive rehabilitation of patients with acquired brain injury and subsequent brain dysfunction, from the early stages of treatment up to the point of returning to normal function.

The instrument is a telemedicine-based portal comprising of three key components:

a) Biomedical hardware, namely a set of variable cubes,

b) Neurorehabilitation software, and

c) Scientifically verified cognitive rehabilitation tasks (see Figure 3).

The portal solution comprises of three main components: a server, a web application, and a mobile application. The server is responsible for collecting and evaluating patient data, implementing adaptability and decision algorithms, and providing support to professionals managing the rehabilitation process. The mobile component of the software and web application serves as the interface between the user (patient) and the server component of the system.

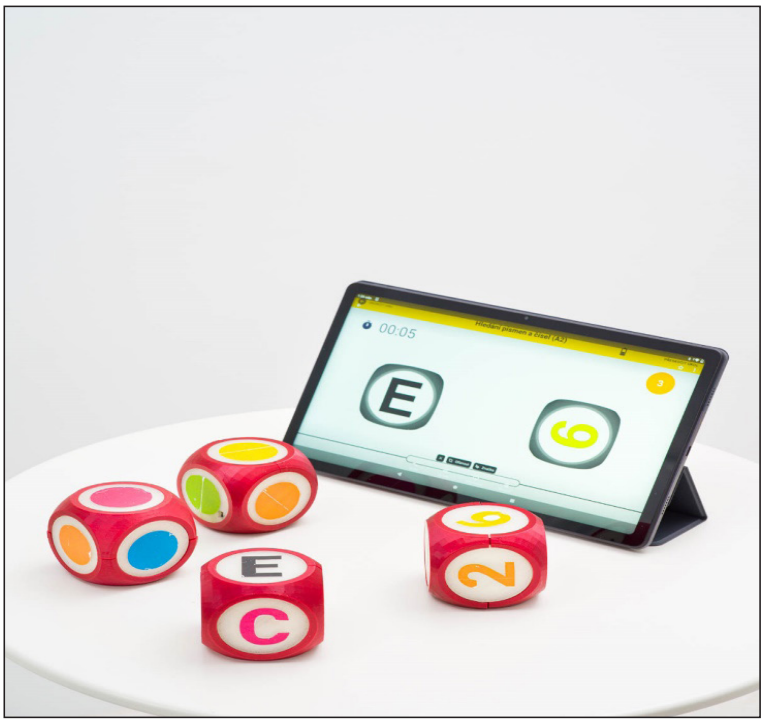


Figure 3. ProxyQB set

The games have been designed in accordance with the current state of neuropsychological knowledge and are subject to continuous validation and confirmation through statistical analysis, with the objective of ensuring their reliability.

The hardware solution comprises of neurorehabilitation cubes (1–6) with sides that display a variety of stimuli, including images, numerals, text, shapes, and colours. These cubes can be combined with a pad for personalised cognitive stimulation. Each cube contains sensors to detect movement and connect wirelessly to smart devices like smartphones or tablets. The system employs a gyroscope and accelerometer to track progress in neuromotor connections and assess the patient's rehabilitation, adjusting the treatment accordingly. Wireless connectivity ensures ease of handling, while real-time biofeedback renders the therapy engaging without compromising effectiveness.

This portable system, which is particularly useful in the early stages of treatment, allows patients to continue cognitive rehabilitation at home, thereby maintaining consistency. Patients receive a personal ID for long-term rehabilitation. Telemedicine elements ensure ongoing cooperation between the neuropsychologist/therapist and the patient. Furthermore, it offers access to big data on neuroplasticity functions and additional scientific exploration in neurorehabilitation.

The analysis of interactions between data subsets, feature subsets and machine learning algorithms facilitate the development of a more sophisticated individualisation process. The definition of classification and machine data sorting enables an effective neurorehabilitation process from the early stages of treatment, which is reflected in the patient's current health status.

Various cognitive rehabilitation systems are affected by a number of fundamental methodological issues, including psychometric reliability, the validity of the submitted exercises, and poorly focused rehabilitation interventions related to cognitive decline (Chandler et al., 2016). These issues are addressed by the PROXYQB system. These limitations are incorporated in the development of PROXYQB. The rehabilitation tasks and games are constructed within the context of neuropsychological models and validated to enhance the validity and reliability of neurorehabilitation tasks. Each rehabilitation game is assigned a difficulty rating on a video scale, ranging from simple tasks suited to the early stages of treatment to complex cognitive problems applicable to the later stages.

Due to the electronic connection, all data are collected, processed, and analysed, providing long-term feedback for patients and medical experts overseeing the cognitive rehabilitation treatment process.

3. PROXYQB and Executive Functions

Executive functions are associated with the frontal lobes and include such abilities as initiation, planning, task perseverance, the ability to stop or finish a task, mental flexibility, and inhibition. The intact functioning of executive functions is a prerequisite for the acquisition and performance of a wide range of practical skills and abilities. A deficit in executive functions has a significant impact on the ability to perform daily activities, affecting both patients and caregivers. Damage to the frontal lobes can result in a lack of self-control, mood swings and other cognitive impairments (Otero et al., 2013). A review of the literature on cognitive rehabilitation reveals that executive functions are almost always involved, to varying degrees, in the rehabilitation process (Katz & Maeir, 2011).

In the context of cognitive rehabilitation (CR), interventions may be directed towards the executive functions as a whole or towards specific domains. The principal objective of CR is to enhance awareness of cognitive deficiencies and compensate for them through various means. These include educational resources, psychodiagnostic instruments, video recordings, group activities, feedback, experimental scenarios, individual psychotherapy, and cognitive rehabilitation strategies tailored to address specific concerns.

A review of the literature suggests two approaches to executive function rehabilitation: a) improving activities of daily living (ADL) in real-world settings, and b) focused cognitive training in controlled environments. Further strategies can be classified into three categories: (a) environmental manipulation, (b) training compensatory strategies, and (c) direct interventions. Environmental manipulation addresses external factors, such as the reduction of distractions, the simplification of tasks, or the organisation of time. Compensatory techniques assist patients in approaching tasks in alternative ways, thereby minimising cognitive deficits. Direct interventions involve structured cognitive training and repetition (Randolph & Chaytor, 2022).

3.1 Effectiveness of ProxyQB

The work of Fichtnerova (2022) examined the relationship between cognitive domains and ProxyQB tasks in preschoolers (N=55, age 5 – 7.11). There is a significant correlation between selective attention, including graphomotor speed, fonological and visuospatial memory, and abstract (fluid) intelligence. All of these cognitive domains are associated with maturing executive functioning in the preschool years.

These results suggest that ProxyQB effectively supports the targeted development of these cognitive domains.

In Sýkora's study (2022), Heading in Soccer as a Potential Risk of Neuropsychological Impairment in Young Soccer Players, young athletes aged 11–15 were observed. Of these, 30 actively played soccer, and 30 participated in sports that did not involve a risk of minor brain injuries. The study found no significant differences between the groups in neuropsychological tests or ProxyQB tasks. However, a significant correlation between ProxyQB tasks and neuropsychological tests was demonstrated in attention, speed of information processing, visual perception, and visual working memory.

3.2 ReToRe project and ProxyQB

The ReToRe project aimed at developing a toolkit used for improving prospective memory and metacognition in adolescents. In the project, ProxyQB cubes were used as a tool that monitored participants' progress. For that reason, 6 games were programmed. The games incorporated exercises that were specifically tailored to target a diverse range of cognitive domains, specifically:

- **phonological attention** (*Phonological attention (A2) – ReToRe*)

The subject is required to identify two colours in response to verbal instructions provided on a tablet device. One colour is displayed on electronic cube 1, and the other is displayed on electronic cube 2. The tablet will only provide the names of the colours once. The objective of this task is to rehabilitate the phonological component of working memory and auditory attention.

- **vizuo-short term memory** *(Memory STM vizuo (B2) – ReToRe*)

In this task, an image of a letter and a number is displayed on the tablet for a period of three seconds, during which the respondent is required to commit the information to memory. Once the three-second interval has elapsed, the image is no longer visible, and the respondent must identify the individual symbols on the corresponding cubes. This task was perceived as the most challenging by respondents, as they frequently failed to recall one of the two symbols. The complexity of the task is further compounded by the fact that the symbols on the cubes are presented in different colours. This task is based on the principles of the Stroop test and aims to train the visuospatial component of working memory and spatial attention.

- **psychomotor abilities** (*Psychomotor colors (A2) – ReToRe, Figure 4*)

In this task, the respondent is required to hold coloured cubes in their hands throughout the entire task and must refrain from placing them on the surface. At the bottom of the tablet screen, a three-dimensional model of the cubes is presented, rotating in a manner consistent with the cubes held by the respondent. The respondent is tasked with ensuring that the colour displayed on the three-dimensional model aligns with the colour presented at the top of the tablet screen. This task is designed to facilitate the rehabilitation of psychomotor functions and enhance focused attention.

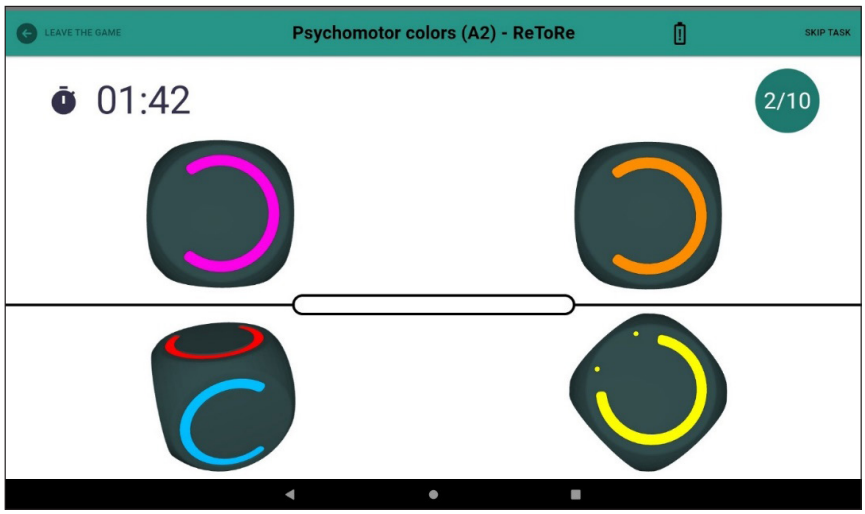


Figure 4. Psychomotor colours task

- **psychomotor abilities and executive functions** *(Roll the cubes symbols (C2-A) – ReToRe*)

In this task, the objective for the respondent is to rotate the cube to the indicated position on the tablet. The task is complicated by the fact that the subject must find a way to balance the over-rotated axes of the cube while filtering out the different colours and symbols. This task is sensitive to both the ability to react effectively to the situation and the organisation of a motor task.

- **executive functions** (*Attention speed (B4) – ReToRe)*

This task requires the identification of a number, letter, and colours presented on a digital tablet. The objective is to locate the corresponding symbols and colours on the designated cubes. The aim is to complete the task in the most efficient manner feasible. While the working memory component is a component of the task, the primary focus of the rehabilitation process lies in divided attention and planning abilities.

- **emotion recognition** (*Emotion_movie_text – ReToRe*)

In this task, the respondent is required to identify an emotion from a video of a person's face and then match it with the corresponding emotion label. Both stimuli are presented on a tablet. The respondent selects the correct emoticon by locating the same colour on the cube as the emoticon. This task is designed to assess social-emotional competence in the context of emotion recall.

3.3 The principal findings from PROXYQB data

Concurrently, the most robust correlation is observed (N=143 children, age 11 – 15 years) between visual working memory and processing speed, indicating that enhanced visual information retention in the short term is associated with superior attention focus. Additionally, positive correlations between emotion recognition and psychomotor responses are also noteworthy.

The strongest positive correlation is observed between the Attention speed (B4) - ReToRe and Phonological attention (A2) - ReToRe variables, with a correlation coefficient of 0. 97. This indicates that improvement in one of these tests is frequently associated with improvement in the other test. A negative correlation was not identified as the strongest correlation due to the fact that all correlations were positive.

The correlation between the Attention speed (B4) - ReToRe and Phonological attention (A2) - ReToRe tests is notably strong, indicating that these tests assess similar cognitive abilities or that improvement in one test is often related to improvement in the other.

The correlation between Roll the cubes symbols (C2-A) - ReToRe and the other tests is the lowest, indicating that this test may measure different abilities or that improvement in this test is not as closely related to improvement in the other tests.

While there was a notable enhancement in the Attention Speed and Emotion Recognition and Roll the Cubes Symbols (C2-A) tasks, it is regrettable that neither demonstrated a statistically significant improvement ($p < 0.05$) nor exhibited a robust effect size (Cohen's $d > 0.8$). This indicates that, while some tasks exhibited improvement, this improvement did not meet the criteria for statistical significance or sufficient robustness.

3.4 The future direction of ProxyQB

The future direction of ProxyQB is to develop personalised therapeutic approaches that are tailored to the individual needs of each patient. This will be achieved by pursuing the current directions and research paths of ProxyQB, which are as follows: specific requirements based on diagnosis, for example, the application to patients with neurodegenerative diseases, children with neurodevelopmental disorders, etc. Validation research on new methods and technologies is currently being conducted to ensure their efficacy and safety. This includes clinical trials and long-term follow-up of patients. ProxyQB is being introduced into clinical practice, including training of staff and integration of these approaches into existing rehabilitation programmes.

References

Al-Saoud, S., Nichols, E. S., Brossard-Racine, M., Wild, C. J., Norton, L., & Duerden, E. G. (2024). A transdiagnostic examination of cognitive heterogeneity in children and adolescents with neurodevelopmental disorders. *Child Neuropsychology, 30*(3).

Centers for Disease Control and Prevention. (2022). *Moderate to Severe Traumatic Brain Injury is a Lifelong Condition.* Retrieved from https://www.cdc.gov/traumaticbraininjury/pdf/moderate_to_severe_tbi_lifelong-a.pdf

Chandler, M. J., Parks, A. C., Marsiske, M., Rotblatt, L. J., & Smith, G. E. (2016). Everyday impact of cognitive interventions in mild cognitive impairment: a systematic review and meta-analysis. Neuropsychology review, 26, 225-251. Stroke Alliance for Europe (SAFE). (2017). *The burden of stroke in Europe: Report*. King's College London. Retrieved from https://strokeeurope.eu

de Vries, M., Kenworthy, L., Dovis, S., & Geurts, H. M. (2021). Cognitive training in children with neurodevelopmental conditions. In M. de Vries, L. Kenworthy, S. Dovis, & H. M. Geurts (Eds.), *Handbook of cognitive rehabilitation* (pp. 24–34). Springer.

de Vries, M., Prins, P. J. M., Schmand, B. A., & Geurts, H. M. (2021). Cognitive rehabilitation in children and adolescents with neurodevelopmental disorders: A systematic review of virtual reality interventions. *Journal of Neurodevelopmental Disorders, 13*(1), Article 22.

Fichtnerová, R. (2022). *Rozvoj kognitivních funkcí u dětí předškolního věku* [Bakalářská práce, Ostravská univerzita, Filozofická fakulta]. Theses.cz. Retrieved from: https://theses.cz/id/v3z0wo/

Katz, N., & Maeir, A. (2011). Higher-level cognitive functions enabling participation: Awareness and executive functions. In N. Katz (Ed.), *Cognition, occupation, and participation across the life span: Neuroscience, neurorehabilitation, and models of intervention in occupational therapy* (3rd ed., pp. 13–40). American Occupational Therapy Association.

Majdan, M., Plancikova, D., Maas, A., Polinder, S., Feigin, V., Theadom, A., et al. (2017). Years of life lost due to traumatic brain injury in Europe: A cross-sectional analysis of 16 countries. *PLOS Medicine, 14*(7), e1002331.

Otero, T. M., & Barker, L. A. (2013). The frontal lobes and executive functioning. In T. M. Otero & L. A. Barker (Eds.), *Handbook of Executive Functioning* (pp. 29-44). Springer.

Randolph, J. J., & Chaytor, N. S. (2022). Promoting the executive functions: Core foundations, assessment considerations, and practical applications. In J. J. Randolph & N. S. Chaytor (Eds.), *Positive Neuropsychology* (pp. 187-221). Springer.

Rodríguez-Prieto, P., Giral-Oliveros, N. A., Simpson, I. C., & Ibáñez-Alfonso, J. A. (2024). Cognitive stimulation in socioeconomically disadvantaged children with neurodevelopmental disorders: A case series. *Frontiers in Psychology, 15.*

Shahmoradi, L., & Rezayi, S. (2022). Cognitive rehabilitation in people with autism spectrum disorder: A systematic review of emerging virtual reality-based approaches. *Journal of Neuroengineering and Rehabilitation, 19*(1).

SÝKORA, Mikuláš. *Heading in soccer as a potential risk of neuropsychological impairment in young soccer players*. Ostrava, 2022. Bakalářská práce (Bc.). Ostravská univerzita. Filozofická fakulta.

Contact:

Petr Nilius, Clinical Psychology Outpatient Clinic, petr.nilius@amkp.cz

Cognitive remediation in children with ADHD

Pavel Škobrtal

Abstract

Cognitive remediation is a behavioural therapy aimed at improving cognitive function in individuals with neurological and psychiatric disorders such as ADHD. The method seeks to compensate for cognitive deficits through training of impaired functions and development of new strategies, thereby promoting the effectiveness of pharmacotherapy and psychotherapy and improving patient prognosis. Interventions for ADHD are based on two processes: restoration of neural networks and metacognitive training. Research shows that cognitive remediation, particularly targeting inhibition and working memory, can improve concentration and reduce impulsivity. Intensive training also brings improvements in untrained areas through the process of generalization, while metacognitive programs develop self-control and cognitive self-regulation. Although computer-based cognitive training programs show promising results, the question of the long-term effectiveness of these approaches and optimal application remains open.

1. Introduction to cognitive remediation

Cognitive remediation is a behavioral treatment targeting individuals with cognitive impairments that impede their daily functioning (Medalia, Herlands, Saperstein, & Revheim, 2017). The method is based on the recognition that cognition encompasses a set of abilities necessary to process, interpret, and respond to information an individual receives from the environment. Cognitive remediation focuses on the so-called cognitive functions such as attention, memory, abstract thinking, and spatial imagination. It plays a large role in improving these basic cognitive skills that support patients‘ effective functioning in their daily life (Podd, 2012). Cognitive remediation allows for improvement in cognitive deficits either by improving impaired functions or by developing new cognitive strategies designed to compensate for cognitive deficits. The approach combines a number of procedures based on the use of different training and learning techniques (Medalia, Herlands, Saperstein, & Revheim, 2017).

Cognitive remediation is characterized by an individualized approach. The intervention is tailored to address specific cognitive problems based on the individual’s self-selected rehabilitation goals. Because individuals are more likely to achieve goals that are consistent with their personal aspirations (Anthony et al., 2002), a collaborative approach with the client is preferred in cognitive remediation.

This approach involves assessing the person's existing skills and intact abilities as they relate to their goals, planning strategies to improve them, and implementing interventions to develop the necessary skills. In essence, cognitive remediation reflects the general principles of rehabilitation and emphasizes collaboration and empowerment of the individual. The process involves a thorough assessment of the person's skills, planning interventions in line with the person's goals, and actively working to improve skills and support. This collaborative approach respects the unique needs and aspirations of each individual, thereby promoting a sense of autonomy and self-determination during rehabilitation (Medalia, Herlands, Saperstein, & Revheim, 2017).

The goal of cognitive remediation is to improve cognitive abilities, either by training impaired functions or by enabling patients to learn strategies to make the best use of their residual abilities (Wykes, Reeder, 2006). Cognitive remediation can alleviate impairments in attention, memory and executive functions, as well as impairments in social cognition. This alleviation is reflected not only in the neuropsychological examination, but above all in the improvement of patients' daily functioning. The goal of remediation is precisely the reduction of disability through the reduction of cognitive deficits (Medalia, Herlands, Saperstein, & Revheim, 2017). The advantage of cognitive remediation is that it puts the patient, not the disease, at the centre of care. It is an important agent involved in the individual's recovery (Amering, Schmolke, 2009). Cognitive impairments are not readily amenable to other treatments, and for this reason rehabilitation techniques developed to improve an individual's cognitive performance are becoming increasingly important. Cognitive remediation is in no way intended to replace pharmacological treatment or psychotherapy, which are designed to treat the symptoms of the disease. However, its use is necessary to enhance their effect. Cognitive remediation, as mentioned above, is as much based on training impaired functions as it is on developing retained abilities through compensatory mechanisms (Demily and Franck, 2008).

1.1 Brain training, cognitive remediation and psychoeducation

Cognitive remediation can be seen as one method of brain training. While brain training in a broad sense is intended for the general (intact) population, cognitive remediation is a subcategory of brain training intended primarily for therapeutic use (Medalia, Herlands, Saperstein, & Revheim, 2017). Brain training software intended for the general public has an entertaining non-medical goal. It is intended for people who do not suffer from a mental or neurological disorder. Cognitive remediation, on the other hand, was developed specifically for treating patients and is performed by a therapist. Patients are not left to their own devices when cognitive remediation is performed. Instead, they are constantly supported

and mini-monitored by the therapist, which allows for more effective learning. The aim is to provide the patient with the means to apply what they learn during treatment to real-life situations through a process of generalisation. Cognitive remediation is based on scientifically validated procedures adapted to specific psychological or neurological disorders (Franck et al., 2023). In contrast, brain training methods designed for the general public are not sufficiently tailored to specific cognitive disorders.

The effects of cognitive remediation are based on the improvement of cognitive performance through specific action on information processing processes. These effects can be distinguished from those of medication and psychotherapy: medication acts on neurochemical dysfunction, whereas psychotherapy focuses on the patient's thought processes (Podd, 2012). In practice, it is advisable to combine these different therapeutic methods to achieve a significant improvement in cognitive function, which is not possible in a patient who is not stable. Either the deficit functions are trained directly (stimulation approach) or the preserved functions are developed to compensate for the deficits (compensatory approach) (Podd, 2012). Cognitive remediation improves the patient's ability to cope with everyday life by enabling them to deal more effectively with situations that are initially too complex for them.

Cognitive remediation is one of the tools used to promote the psychosocial rehabilitation of patients through very specific measures. In psychiatry, its action is complemented by other measures such as social skills training (enabling patients to learn to cope better with certain practical situations involving interaction with other people) and psychoeducation (which improves understanding of the illness and promotes adherence to treatment, particularly through related therapeutic education). Cognitive remediation does not directly affect mental contents, conscious or unconscious, but basic information processing processes, whereas psychotherapy has to do with these contents and social skills training focuses on modifying the conceptualization of social situations in order to improve patients' performance in interaction situations (Franck et al., 2008).

Psychoeducation enables patients to better understand and live with their illness and its symptoms (Franck et al., 2008). It also increases patients' awareness of the risk of relapse and the need to prevent it. Thus, it plays a positive role in medication adherence. Social skills training is indicated for some patients suffering from psychiatric disorders. Psychoeducation, social skills training and cognitive remediation play a central role in the rehabilitation process for patients suffering from chronic psychiatric disorders. However, as remediation prioritises investment in social skills training and psychotherapy, it seems that this tool should be introduced upfront so that patients can fully benefit from this care. Psychoeducation, on the other hand, can be introduced prior to or concurrently with it, as it encourages patients to invest

in cognitive remediation. Thus, cognitive remediation is likely to be introduced early in the treatment of chronic psychiatric disorders, and quickly after the crisis has resolved (Franck et al., 2008). For patients with progressive onset of illness, cognitive remediation should also be introduced as early as possible to prevent cognitive deterioration (Franck et al., 2008).

In summary, unlike traditional education, which focuses on domain-specific knowledge, cognitive remediation focuses on strengthening basic cognitive skills. Its goal is not to teach a person to read or write. Instead, its main goal is to enable an individual to develop the basic cognitive skills that are important for coping with various aspects of his or her life (Wykes, Reeder, 2006). Cognitive remediation thus goes beyond conventional education, aiming to facilitate an individual's independent living by targeting specific deficit areas of his or her cognition. For example, it can help to improve attention, enabling the person to focus more effectively on tasks related to education, work, or social interactions. As a skills training intervention in rehabilitation, cognitive remediation goes hand in hand with other interventions and emphasizes cognitive skills and their support to increase the individual's overall success and satisfaction in educational, occupational, and social settings (Wykes, Reeder, 200).

2. ADHD – diagnosis, treatment, interventions

2.1 Characteristics of ADHD

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterised by persistent symptoms of inattention, hyperactivity and impulsivity. ADHD is associated with two main groups of deficits. The first group is attention deficits that significantly affect learning processes. Most children with ADHD face serious difficulties in school, including low performance compared to healthy children and lower grades (DuPaul, Langberg, 2014). The low performance can lead to children with ADHD failing in school or being placed in special classes, and in some cases failing to complete secondary education or obtain a tertiary education (Loe, Feldman, 2007). As shown in a study by Barkley and colleagues (2002), disruption in academic skills in children with ADHD begins before entering first grade.

The second group of deficits is poor motor control and impulsivity, which is often associated with emotional disturbance. These symptoms lead to problems in the child's social and especially peer relationships. Other associated deficits include executive functions, intellectual deficits, specific learning disabilities and positive illusory bias (positive self-concept) (Hoza et al., 2004).

Children with ADHD often show specific deficits in attention, working memory and executive functions. These deficits affect not only their academic performance but also their daily life and social interactions. Children with ADHD often experience difficulties in cognitive function, particularly in the ability to sustain attention, control impulsive behaviour and use working memory effectively. However, more than 50% of children with ADHD do not exhibit severe impairments in any specific cognitive task, suggesting that cognitive deficits are not a universal feature of all individuals with ADHD (Nigg, 2005). Studies to date have not identified any specific cognitive deficit as a direct cause of ADHD. Yet, certain cognitive difficulties, such as impaired working memory and executive function, are often associated with ADHD symptoms and can lead to additional problems in speech and motor skills. One of the key features of ADHD is also abnormal sensitivity to rewards and an increased aversion to delay gratification (Sonuga-Barke et al., 2008). Children with ADHD have difficulty motivating and performing well unless they are immediately rewarded. This deficit in motivation has been linked to disturbances in dopamine pathways in the brain, an area involved in reward and motivation control (Volkow et al., 2009). Children with ADHD also often have abnormal levels of arousal, which can be either too high or, more commonly, too low. Hyperactivity and impulsivity may be the child's attempt to maintain an optimal level of arousal through excessive self-stimulation (Zentall, 1985).

Another one of the most significant problems for children with ADHD is a deficit in self-regulation. Self-regulation involves the ability to use thought and language to control one's own behavior. However, children with ADHD have impaired self-regulation, which leads to impulsivity, inability to maintain attention on a task, and emotional dysregulation (Martel, 2009). Children with ADHD tend to prefer immediate rewards and have difficulty waiting for longer-term benefits. This tendency toward impulsive behavior and immediate rewards leads to problems in school, where prolonged concentration and patience are often required. Theories of ADHD emphasise the interplay between cognitive processes, arousal, reward and motivation. Children with ADHD have difficulty regulating their behaviour, which is reflected in many symptoms of inattention, hyperactivity and impulsivity. Although theories regarding abnormal levels of arousal have gained some empirical support, they are not seen as a complete model that accounts for the full range of problems in children with ADHD (Antrop et al., 2000).

In summary, quantitative studies support a model of ADHD that consists of two distinguishable dimensions: inattention and hyperactivity-impulsivity (Burns et al., 2014). These dimensions are often viewed as the core characteristics of ADHD, but their interrelationships and implications for child development are complex and varied. Studies conducted on large cohorts confirm that the dimensions of inattention and hyperactivity-impulsivity are well documented across different ages, ethnicities, and

cultural groups worldwide (Toplak et al., 2012). These two dimensions are highly correlated with each other, and they predict different behavioural and cognitive impairments along the child's developmental trajectory (Kuntsi et al., 2013). For example, symptoms of inattention tend to lead to academic problems and peer neglect, while symptoms of hyperactivity-impulsivity often lead to aggressive behaviour and peer rejection. This difference in manifestations suggests that ADHD is not simply a one-dimensional disorder but consists of a complex combination of different processes. Inattention is often related to cognitive deficits that affect a child's ability to concentrate and complete tasks. On the other hand, hyperactivity and impulsivity may be more closely associated with problems in emotion and behaviour regulation. Nigg et al. (2006) point out that trying to define ADHD using only these two dimensions leads to an overly simplistic understanding of the disorder as each dimension involves many different processes, and attention and impulse control are developmentally closely linked.

2.2 Diagnosis of ADHD

ADHD is diagnosed primarily on the basis of characteristic behaviour, which can vary considerably from child to child. Therefore, the diagnosis is often made on the basis of a multidisciplinary approach. Although the neurobiological and cognitive mechanisms associated with ADHD are well known, specific biological correlates of the disorder have not yet been identified. Thus, the process of a diagnosis remains essentially clinical (Vantalon, 2005).

Diagnosis of ADHD varies across the diagnostic systems. The American DSM-5 classification offers a more subtle view of ADHD that allows for the different manifestations of the disorder to be taken into account. The DSM-5 defines three clinical subtypes of ADHD: the combined type, the predominantly absent-minded type and the predominantly hyperactive-impulsive type. This classification allows for better recognition of the different manifestations of ADHD in individual children and provides a more detailed framework for making a diagnosis. In contrast, the ICD-10, the international classification used in Europe, is coarser and based on a narrower definition of 'hyperkinetic disorder'. This requires the simultaneous presence of symptoms of inattention, impulsivity and hyperactivity, which leads to the capture of only the grosser pathology (Polanczyk et al., 2010). However, both systems agree on the main diagnostic criteria, which include the following: (1) symptoms must persist for more than six months; (2) symptoms occur more frequently and with greater severity than in other children of the same age and gender; (3) symptoms occur in two or more settings (e.g. (4) symptoms interfere with the child's social, academic, or occupational functioning; (5) symptoms cannot be better explained by another mental disorder, such as an anxiety disorder (Polanczyk et al., 2010). The average age of a diagnosis of ADHD is 7

years, but the first symptoms can often be observed as early as in a kindergarten (Roberts et al., 2014). However, at this early age, it is not always easy to distinguish between problems associated with so-called 'at-risk temperament' and a true ADHD disorder. Problems associated with inattention are often less noticeable and can be diagnosed later, particularly with regard to their persistence and impact on learning (Fourneret et al., 2000). In contrast, hyperactivity and impulsivity are noticeable in early childhood, allowing for their early identification. It is important to emphasize that the persistence of these symptoms and their impact on a child's social and academic development is a key factor in making a diagnosis. The pathological nature of ADHD is reflected not only in the persistence of difficulties, but also in how significantly these difficulties interfere with the child's social dynamics and ability to function in different environments.

Although children with ADHD often have average or above-average intelligence, their difficulties are not due to a lack of ability, but rather to the application of that ability in everyday life (Barkley, 2006). On IQ tests, children with ADHD score on average 5 to 9 points lower than a control group of children without the disorder and their own siblings (McConaughey et al., 2009). This decline in scores is due in part to deficits in working memory and other executive functions that are part of IQ tests. Further, inattention during testing reduces overall scores by an average of 2 to 5 points (Jepsen, Fagerlund, & Mortensen, 2009). However, this difference in IQ does not reflect the actual intelligence of children with ADHD, but rather their inability to effectively use their abilities to solve tasks requiring sustained concentration and organization. Children with ADHD often have difficulty maintaining attention and motivation during cognitive tests, which affects their performance. Despite these challenges, many children with ADHD have the ability to perform at high levels when provided with conditions that take into account their specific needs and limitations.

Lastly, another factor that is important to consider when making a diagnosis is that developmental delays, which are often subtle, may overlap with other neurodevelopmental disorders such as Autism Spectrum Disorders and Specific Learning Disabilities. This makes diagnosis complex and requires a multidisciplinary approach.

2.3 Treatment and interventions of ADHD

Although there is no known cure for ADHD, there are a number of treatments available that can help manage the symptoms and secondary problems associated with the disorder (Antshel & Barkley, 2008). The primary recommended treatment approach for ADHD is a combination of stimulant

medication, parent education, and behavioral educational interventions (Kaiser & Pfiffner, 2011). The multidisciplinary approach has been shown to be effective in reducing ADHD symptoms in controlled clinical trials (Smith & Shapiro, 2014). Medication, particularly stimulants such as methylphenidate, has a critical role in improving attention and reducing hyperactivity. The effectiveness of treatment is maximized when combined with behavioural interventions that include skill training, behaviour management, and education of parents to be better able to manage the challenges their children face.

Interventions should be tailored to the specific needs of each child. Cognitive remediation includes a variety of therapeutic methods that focus on improving attention, impulse control, and motor skills. It is important that therapeutic approaches include not only behavioral therapies and pharmacological treatments, but also school-based support and family involvement. Family therapy and school-based interventions can contribute significantly to better integration of children with ADHD into the regular school environment and improve their overall functioning. An effective approach to ADHD therapy requires a combination of different methods and close collaboration between professionals, the school and the family.

In addition to the approaches mentioned above, other treatment approaches such as family counselling, support groups and traditional social skills training are also used, but there is considerably less evidence for their effectiveness (Mikami, 2014). In particular, individual counselling may play a role in addressing a child's specific problems such as emotional difficulties or self-esteem issues, but it is not yet clearly established whether it has a significant impact on ADHD symptoms per se.

In recent years, alternative approaches such as neurofeedback or biofeedback, which focus on training brain waves and their effect on behaviour, have also emerged. Although there are studies that report moderate beneficial effects of neurofeedback (Gevensleben et al., 2014), evidence for its long-term effectiveness is still limited and requires further research. Another method is the use of complementary and alternative biomedical treatments, such as special diets or vitamin and mineral supplementation, including omega-3 fatty acids (Hurt & Arnold, 2014). Although some studies suggest potential benefits of these approaches (Stevenson et al., 2014), their effectiveness is still debated and there are no consistent conclusions.

3. Remediation of ADHD-related issues

Children with ADHD face many challenges that affect their daily life, education and social relationships. To help these children overcome these difficulties, various remedial programmes have been developed to improve their cognitive abilities and promote their social adaptation. The cognitive remediation tools currently used in ADHD can be categorized according to the processes targeted: attentional functions, inhibitory processes, executive functions, working memory, and finally, strengthening of behavioural self-regulation strategies. These programmes are based on an in-depth neuropsychological analysis of the difficulties of children with ADHD, which allows the implementation of compensatory strategies that minimise the negative impact of the disorder.

Remedial programs for children with ADHD aim to improve their cognitive abilities and social adaptation. This can be achieved through an in-depth analysis of the neuropsychological deficits of these children, allowing the introduction of compensatory strategies that help the child to cope better with everyday life and the school environment. The promotion of the child's inner resources and the development of self-esteem are also key to his or her successful integration into society. Enhancing a sense of self-control is essential not only for improving school performance but also for interpersonal relationships (Miller and Hinshaw, 2010). Longitudinal studies show that executive functions play a significant role in the school success and social functioning of adolescents with ADHD (Hahn-Markowitz, 2011).

The quality of the environment in which the child lives and learns, along with available external support, also plays a critical role. Based on the analysis of the former factors, a specific intervention plan can be developed reflecting the child's needs while maximizing their potential for success.

3.1 Approaches to remediation in ADHD

The remedial techniques used in interventions for children with ADHD are based on two main models of information processing: bottom-up and top-down approaches. *The bottom-up approach*, also known as the bottom-up information processing model, focuses on restoring and reorganizing the underlying neural networks through targeted interventions. This approach is based on the Hebbian model of learning, which asserts that when two neurons are active simultaneously, their synaptic connections are strengthened. Frequent activation of these neuronal networks then increases their functional capacity, leading to better organization of brain functions (Deforge, 2011). Thus, this technique focuses on improving the functioning of basic cognitive functions, such as working memory

or attention, through repeated exercises that strengthen the connections between neurons. On the other hand, the *top-down approach* focuses on influencing lower-level functions through higher-level cognitive functions. This approach involves metacognitive interventions that focus on strengthening the child's ability to control his or her behavior. Children with ADHD often have difficulty inhibiting impulses and regulating their behavior, which negatively affects their school and social functioning. Thus, metacognitive interventions promote the internalization of behavioural control mechanisms and improve inhibitory skills (Anastopoulos, Gerrard, 2003). Children learn to become aware of their own difficulties and gradually develop strategies to overcome them.

The former techniques share restoring deficient functions by means of functional and structural reorganization (brain plasticity) of the underlying neural networks. As summarized by Deforge (2011), bottom-up remediation techniques are based on Hebb's (1949, in Nolen-Hoeksema, Fredrickson, Loftus, & Wagenaar, 2012) model of synaptic functioning, according to which repeated activation of a neuronal network increases its functional capacity and facilitates cortical reorganization. In contrast, top-down techniques aim to act on low-level functions through certain higher-level functions, again with the potential effect of cortical reorganization. These metacognitive interventions aim to internalize behavioral control mechanisms by improving and enhancing inhibitory capabilities. They also encourage the subject to become aware of their own difficulties and may be superior to some cognitive-behavioural techniques used in children with ADHD (Anastopoulos, Gerrard, 2003).

4. Cognitive remediation of ADHD-related impairments

Remediation programmes targeting children with ADHD have the potential to improve not only cognitive but also social functioning in these children. Cognitive interventions that focus on bottom-up information processing allow for targeted reorganization of neuronal networks and lead to improved brain functional capacity. Longitudinal studies confirm that the quality of school performance and social functioning in adolescents with ADHD is closely linked to their executive functioning, highlighting the importance of these cognitive remediation interventions (Hahn-Markowitz, 2011). On the other hand, metacognitive interventions based on top-down information processing play a key role in the development of self-awareness and self-control in children with ADHD. Children who are more aware of their difficulties and are better able to regulate their behaviour are more likely to achieve success in both the school environment and in personal relationships. Strengthening inhibitory skills and self-control also contributes to their better adaptation to school and social situations, which is important for their future success.

Remedial programmes must also include a comprehensive approach to care that takes into account different areas of the child's functioning. Each child with ADHD has a unique cognitive and behavioural profile that requires an individual approach to designing a remedial programme. The approach involves a careful analysis of deficits and identification of symptoms to be targeted, along with an assessment of factors that may exacerbate or ameliorate the disorder (Sturm and Leclercq, 2000). This process involves not only identifying and re-educating impaired functions, but also strengthening the preserved functions that can serve as a base for the development of other abilities. It is also important to introduce compensatory strategies, such as the use of external tools or techniques to help the child overcome their deficits. Involving the child's family is also an essential part of a successful intervention. The family plays a key role in providing support in the home environment and can help to identify environmental difficulties that may hinder progression. Close collaboration between the family and the therapist thus increases the chances of success of the remedial programme.

Cognitive remediation interventions are designed to track the progression of difficulties based on each child's specific profile (Sohlberg and Mateer, 2001). This means that interventions are not generic, but targeted and personalized to match each individual's unique deficits. For example, when treating attention deficits, some authors focus on working with different sensory modalities (Cicerone et al., 2011). This approach allows the child to better adapt to everyday situations and tasks that require sustained attention. In practice, remedial programmes consist of approximately 20 sessions lasting between 20 and 45 minutes. These sessions usually take place once a week or fortnightly (Klingberg et al., 2002). The key is for the sessions to be sufficiently regular and long-term in nature to ensure that the child has sufficient time and opportunity to develop new skills. This approach has been successfully implemented in a variety of therapeutic settings, including metacognitive groups for children with ADHD on child psychiatric wards, which have shown positive results in improving attention, planning and behavioural inhibition (Bedecarrax and Briad, 2010). The cognitive remediation methods currently used for ADHD can be categorized according to the targeted processes: attentional functions, inhibitory processes, executive functions, working memory, and finally strengthening self-regulatory behavioural strategies. These methods are based on experimentally validated theoretical models of information processing and, more broadly, on the functioning of executive or attentional skills.

Lastly, motivation of the child highly influences the success of remediation. The child must be motivated to cooperate, as remedial programmes often require long-term effort and repeated practice. The therapist plays a key role in providing feedback, correcting errors and adapting exercises to the child's current needs. In addition, it is important that programmes are structured in such a way as to

promote the transfer of the results achieved to other areas of the child's life, which is referred to as the generalisation effect.

4.1 Attention remediation

Children with ADHD often face difficulties at school and in everyday life, so it is important to look for effective intervention methods that can help them improve their performance. The results of several studies show that specially designed intervention programs can significantly improve concentration skills and reduce impulsivity in children with ADHD (Manly, 2004; O'Connell, 2006). Intervention programs aimed at improving attention and concentration in children with ADHD have shown that they can lead to significant improvements in intellectual performance. For example, studies by Manly (2004) and O'Connell (2006) have shown that after completing an intervention program, the intellectual abilities of children initially rated as borderline improved to just below normal. The improvement not only enhanced the children's ability to concentrate on tasks but also contributed to their adaptive skills and reduced impulsivity. Improvement in these skills is crucial to a child's successful functioning at school and in social situations where behavioural control and attention to long-term goals are required. The findings also highlights the need for more comprehensive intervention programs that focus on long-term maintenance of attention and self-control capacity.

O'Connell (2008) followed up his original study with research on adult patients with right hemisphere lesions and associated attention deficit disorder. The study used a technique known as Self Alert Training (SAT) to help patients recognize and respond to fluctuations in their attention using an electrodermal response. The method allows patients to become aware of when their attention is waning and then actively increase it through the presentation of an exogenous stimulus, such as an audio signal. The results of the study showed that patients in the experimental group showed an improvement in concentration. Thus, the SAT represents an effective way to train patients to be able to monitor their own attention levels and actively intervene when their concentration declines. The type of intervention may also be useful for children with ADHD who often struggle with attention fluctuations and impulsivity.

4.2 Inhibition

As previously stated, ADHD presents significant challenges for children in the areas of attention maintenance, self-control and impulse inhibition. A study by Noel et al. (2007) provided crucial insights into the best way to approach the rehabilitation of attention and inhibition, which are key to proper

executive functioning. The first approach in the Noel et al. (2007) study focused on cognitive remediation of specific deficits that were identified during neuropsychological testing. The children completed an individual program that lasted 45 minutes per week for 20 weeks. After completing the program, there was a significant improvement in the children's ability to selectively focus visual and auditory attention. These skills are essential for effective learning and coping with everyday tasks. Improvements were also observed in attention allocation and inhibition, demonstrating that cognitive remediation can lead to broad positive changes in cognitive functioning in children with ADHD.

The second part of the study by Noel et al. (2007) focused on the most important aspects of rehabilitation for overall cognitive improvement. Two different methods were tested to determine whether it was more effective to rehabilitate inhibition or attention first. Results showed that the greatest improvement occurred when inhibition was rehabilitated first. Inhibition is a process that allows a child to stop impulsive behaviour and intentionally focus on the task at hand. When inhibition was rehabilitated first, its improvement carried over to other executive functions, such as better planning and decision-making skills. Conversely, in the group where rehabilitation began with attention and inhibition was trained afterwards, deterioration in inhibition was noted during the first phase. The phenomenon might be related to the fact that training attention without sufficient inhibition leads to increased impulsivity and an inability to use attention effectively. However, during the second phase, there was an improvement in inhibitory abilities, suggesting that inhibition training was a key step towards overall cognitive improvement.

The findings of Noel et al. (2007) highlight the importance of inhibition in the cognitive rehabilitation of children with ADHD. Inhibitory skills, which include the inhibition of inappropriate responses and impulses, are an essential component of executive functions that play a key role in everyday life and learning. When inhibition is rehabilitated first, it allows the child to better control their behaviour, which in turn improves other cognitive abilities such as attention and allocation of mental resources. Thus, the study supports the idea that to effectively intervene with children with ADHD, it is essential to focus first on improving inhibitory processes.

Another one of the key findings of the study by Noel et al. (2007) is the generalization process, whereby improvements in inhibitory abilities lead to improvements in other areas of executive function. This means that interventions targeting one aspect of cognitive functioning, such as inhibition, can also have a positive impact on other cognitive processes such as planning, organisation and working memory. The generalization effect is extremely important because it shows that a comprehensive approach to

rehabilitation can help children with ADHD achieve broad and lasting improvements in their cognitive functioning.

4.3 Working memory

One of the key components of cognitive functioning that can affect attention and other executive functions is working memory. Research in recent years confirmed that intensive working memory training could be an effective means of improving not only attention but also other cognitive skills. Among the most important studies on this topic is research by Klingberg, Forsberg and Westerberg (2002), which demonstrated the positive effects of working memory training on children with ADHD. Klingberg et al. (2002) focused their study on how regular and intensive working memory training affected the abilities of children with ADHD. The children completed daily 25-minute sessions for 5 to 6 weeks during which they were exposed to tasks aimed at improving their visual-spatial and auditory-verbal working memory. Results showed significant improvements in both of these areas, which had a direct impact on their ability to concentrate and process information more effectively. Another significant benefit of the study was the finding that these positive effects persisted six months after the training.

Klingberg and colleagues (2005) showed that working memory training did not only bring improvements in areas directly related to working memory, but also had a wider impact on other untrained skills. The generalised skills included improvements in problem solving and reasoning skills and strengthening inhibitory strategies. Inhibitory strategies are crucial for children with ADHD as they enable them to better control impulsive behaviour and focus more deliberately on tasks. The generalizing effect of working memory training is crucial because it shows that cognitive training can have a multifaceted effect on a child's overall functioning. The improvements in inhibitory strategies observed in this study suggest that working memory training may help children with ADHD better regulate their behaviour, which is crucial to their success in school and in everyday life. The effectiveness of working memory training on improving attention and other executive functions has been confirmed by other research. Studies by Beck et al. (2010), Holmes et al. (2010) and Prins et al. (2011) have provided similar evidence supporting the finding that working memory training can be an effective tool when working with children with ADHD. These studies have consistently demonstrated improvements in working memory and its generalizing effect on other cognitive skills. The results suggest that regular and structured training can bring long-term positive changes to children with ADHD, allowing them to better focus and organize their thought processes.

5. Metacognitive programmes

Metacognitive programs represent an important approach in the rehabilitation of children with ADHD. They focus primarily on the development of self-control and awareness of the difficulties children face and their impact on the environment. These programmes combine specific attention rehabilitation methods with modern computer techniques to create a framework for a deeper understanding of one's own cognitive processes. One example of such an approach is the computer program Pay Attention (Tamm et al., 2010), which helps children develop the ability to better focus and control their impulses. Metacognitive programs emphasize children need to able to identify their cognitive deficits, such as attention problems, and actively seek new strategies to overcome their difficulties. The process takes the form of group workshops in which children experiment with different mental management tools, often through linguistic metaphors. These metaphors help children understand abstract concepts such as self-control and cognitive self-regulation. The goal is for children to not only become aware of their difficulties, but also to learn new, more effective ways to cope.

According to Tamm et al. (2010), enhancing a child's metacognitive potential is the key to optimizing their attentional functioning. It enables children to better manage school and extracurricular activities, which improves their overall performance and social adjustment. Metacognitive programmes are usually organised in the form of workshops. These workshops run once a week for 90 minutes and are scheduled for 12 weeks. In the first phase of the program, there is a didactic part that focuses on explaining brain functions, cognitive modules and work goals. The children thus learn about executive functions (e.g. working memory, planning), associated difficulties and available tools used to improve executive functions. Mental imagery and internal discourse techniques are also an important part of these workshops as they help children create mental representations of their executive functions. The techniques include, for example, metaphorical representations of different cognitive skills, which make it easier for children to understand abstract concepts and improve their ability to self-regulate. Using these tools, children are better able to plan and organise their tasks, which leads to improvements in their daily functioning.

An important part of metacognitive programmes is the interaction of children with their peers. Giroux et al. (2010) highlight that it is the social interaction in group workshops that is a key element of successful rehabilitation. In these groups, children can share their experiences with each other, discuss the difficulties they face, and learn new strategies from others. It also contributes to the development of their social skills, which are often impaired in children with ADHD. Equally important is the involvement

of the family in this process. Parenting programmes are aimed at helping parents understand how to support their children to automate new strategies for self-control and to support the development of their ability to concentrate. The family plays a key role in the implementation of learned skills in the child's daily life and can contribute to the long-term maintenance of acquired skills.

6. Conclusion

Today, specific therapeutic programmes are offered to children with ADHD. Results show that cognitive remediation can be a relevant part of ADHD treatment. Treatment of children with ADHD should be multimodal and integrative. A wide range of therapeutic interventions can be combined according to an individual plan, from cognitive remediation to counselling measures, including pharmacotherapy. However, medication alone is not sufficient to treat ADHD. In particular, pharmaceuticals do not address all problems and their benefits do not persist long-term after treatment. It is therefore important to combine pharmacotherapy with other forms of treatment.

Depending on the age of the child, different types of interventions are appropriate (Young, Amarshinge, 2009):

- Psychoeducational interventions and parent education programmes are recommended for preschool children.
- For school-age children, parenting groups and metacognitive interventions are appropriate.
- For school-age children and adolescents, combined approaches that include parent guidance, school-based psychoeducation, cognitive remediation, pharmacotherapy and individual or group psychotherapy are recommended.
- For adults, a combination of pharmacotherapy and cognitive behavioural therapy is appropriate.

Cognitive remediation is an approach aimed at improving and strengthening attention and executive functions that are considered dysfunctional in hyperactive or inattentive children. Despite these reasons, there are still a limited number of scientifically validated programs available for children with ADHD. Although their short- and medium-term efficacy is acknowledged, their long-term effects or their possible transfer to other areas of life have not yet been demonstrated.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders DSM-5* (5th ed.). Washington, DC: Author.

Amering, M., & Schmolke, M. (2009). *Recovery in mental health*. Oxford: Wiley-Blackwell.

Anastopoulos, A., & Gerrard, L. (2003). Facilitating Understanding and Management of Attention Deficit/Hyperactivity Disorder. In M. Reinecke, F. Dattilio, & A. Freeman (Eds.), *Cognitive Therapy with chidren and adolescents. A case book for clinical practice* (pp. 19-42) (Second ed.). New York: Guilford Press.

Antrop, I., Roeyers, H., Van Oost, P., & Buysse, A. (2000). Stimulation seeking and hyperactivity in children with ADHD. *Journal of Child Psychology and Psychiatry*, 41, 225-231.

Antshel, K. M., & Barkley, R. (2008). Psychosocial interventions in attention deficit hyperactivity disorder. *Child and Adolescent Psychiatric Clinics of North America*, 17, 421-437.

Antshel, K. M., Faraone, S. V., Maglione, K., Doyle, A., Fried, R., Seidman, L., & Biederman, J. (2008). Temporal stability of ADHD in the high-IQ population: results from the MGH longitudinal family studies of ADHD. *Journal of the American Academy of Child & Adolescent Psychiatry*, 47, 817-825.

Anthony, W. A., Cohen, M. R., Farkas, M. D., & Gagne, C. (2002). *Psychiatric Rehabilitation* (2nd ed.). Boston, MA: Boston University, Center for Psychiatric Rehabilitation.

Nolen-Hoeksema, S., Fredrickson, B. L., Loftus, G. R., Wagenaar, W. A. (2012). *The psychology of Atkinson and Hilgard*. Prague: Portal.

Barkley, R. A., Shelton, T. L., Crosswait, C., Moorehouse, M., Fletcher, K., Barrett, S., Metevia, L. (2002). Preschool children with high levels of disruptive behavior: three-year outcomes as a function of adaptive disability. *Development and Psychopathology*, 14, 45-68.

Barkley, R. A. (2006). Attention-deficit/hyperactivity disorder in adolescents. In D. A. Wolfe & E. J. Mash (Eds.), *Behavioral and emotional disorders in adolescents* (pp. 91-152). New York: Guilford Press.

Beck, S. J., Hanson, C. A., Puffenberger, S. S., Benninger, K. L., & Benninger, W. B. (2010). A controlled trial of working memory training for children and adolescents with ADHD. *Journal of Clinical Child & Adolescent Psychology*, 39, 825-836.

Burns, G. L., de Moura, M. A., Beauchaine, T. P., & McBurnett, K. (2014). Bifactor latent structure of ADHD/ODD symptoms: Predictions of dual pathway/trait impulsivity etiological models of ADHD. *Journal of Child Psychology and Psychiatry*, 55, 393-401.

Cicerone, K. D., Langenbahn, D. M., Braden, C., Malec, J. F., Kalmar, K., Fraas, M., et al. (2011). Evidence-based cognitive rehabilitation: an updated review of the literature from 2003 to 2008. *Archives of Physical Medicine and Rehabilitation*, 92, 519-530.

Deforge, H. (2011). Prise en charge des troubles attentionnels et exécutifs chez l'enfant. *La remédiation cognitive : pratiques et perspectives. Développements*, 8, 5-20.

Demily, C., & Franck, N. (2008). Cognitive remediation: a promising tool for the treatment of schizophrenia. *Expert Review of Neurotherapeutics*, 8, 1029-1036.

DuPaul, G. Educational impairments in children with ADHD. In R. A. Barkley (Ed.), *Attentiondeficit hyperactivity disorder: A handbook for diagnosis and treatment* (4th ed.) New York: Guilford Press.

Fourneret, P., Desombre, H., de Villard, R., & Revol, O. (2000). Decisional procedure in school-age children with hyperkinetic syndrome. *Archives de Pediatrie*, 7(5), 554-562.

Franck, N. et al. (2023). *Remediation cognitive*. Elsevier.

Gevensleben, H., Kleemeyer, M., Rothenberger, L. G., Studer, P., Flaig-Rohr, A., Moll, G. H., Heinrich, H. (2014). Neurofeedback in ADHD: Further pieces of the puzzle. *Brain Topography*, 27, 20-32.

Giroux, S., Parent, V., & Guay, M. (2010). La remediation cognitive et la remediation métacognitive pour les personnes ayant un TDAH: deux strategies d'interventions novatrices et pour quoi pas complémentaires? *Journal de Thérapie Comportementale et Cognitive*, 20, 87-92.

Hahn-Markowitz, J., Manor, I., & Maeir, A. (2011). Effectiveness of cognitive-functional (Cog-Fun) intervention with children with attentiondeficithyperactivitydisorder: a pilot study. *American Journal of Occupational Therapy*, 65(4), 384-392.

Holmes, J., Gathercole, S., & Dunning, D. (2010). Poor working memory: impact and interventions. *Advanced Child Developmental and Behavior*, 39, 1-43.

Hoza, B., Gerdes, A. C., Hinshaw, S. P., Arnold, L. E., Pelham, W. E., Jr., Molina, B. S., &Wigal, T. (2004). Self-perceptions of competence in children with ADHD and comparison children. *Journal of Consulting and Clinical Psychology*, 72, 382-391.

Hurt, E. A., & Arnold, L. E. (2014). Dietary management of ADHD. In R. A. Barkley (Ed.), *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment* (4th ed.). New York: Guilford Press.

Jepsen, J. R. M., Fagerlund, B., & Mortensen, E. L. (2009). Do attention deficits influence IQ assessment in children and adolescents with ADHD? *Journal of Attention Disorders*, 12, 551-562.

Kaiser, N. M., & Pfiffner, L. J. (2011). Evidence-based psychosocial treatments for childhood ADHD. *Psychiatric Annals*, 41, 9-15.

Klingberg, T., Forssberg, H., & Westerberg, H. (2002). Training of working memory in children with ADHD. *Journal of Clinical and Experimental Neuropsychology*, 24(6), 781-791.

Klingberg, T., Fernell, E., Olesen, P. J., Johnson, M., Gustafsson, P., Dahlström, K., Gillberg, C. G., Forssberg, H., & Westerberg, H. (2005). Computerized Training of Working Memory in Children With ADHD: A Randomized, Controlled Trial. *Journal of the American Academy of Child & Adolescent Psychiatry*, 44(2), 177-186.

Kuntsi, J., Pinto, R., Price, T. S., van der Meere, J. J., Frazier-Wood, A. C., & Asherson, P. (2014). The separation of ADHD inattention and hyperactivityimpulsivity symptoms: Pathways from genetic effects to cognitive impairments and symptoms. *Journal of Abnormal Child Psychology*, 42, 127-136.

Loe, I. M., & Feldman, H. M. (2007). Academic and educational outcomes of children with ADHD. *Journal of Pediatric Psychology*, 32, 643-654.

Manly, T., Davison, B., Gaynord, B., Greenfield, E., Parr, A., Ridgeway, V., et al. (2004). An eletronic knot in the handkerchief: “content free cueing” and the maintenance of attentive control. *Neuropsychological Rehabilitation*, 14(1-2), 89-116.

Martel, M. M. (2009). Research review: A new perspective on attention deficit/hyperactivity disorder: Emotion dysregulation and trait models. *Journal of Child Psychology and Psychiatry*, 50, 1042-1051.

Mash, E. J., Wolfe, D. A. (2019). *Abnormal psychology*. Boston: Cengage Learning.

McConaughey, S. H., Ivanova, M. Y., Antshel, K., & Eiraldi, R. B. (2009). Standardized observational assessment of attention deficit hyperactivity disorder combined and predominantly inattentive subtypes. I. Test Session Observations. *School Psychology Review*, 38, 45-66.

Medalia, A., Herlands, T., Saperstein, A., & Revheim, N. (2017). *Cognitive Remediation for Psychological Disorders: A therapist guide (2nd Ed)*. Oxford University Press.

Medalia, A., & Choi, J. (2009). Cognitive remediation in schizophrenia. *Neuropsychological Review*, 19, 353-364.

Mikami, A. Y. (2014). Social skills training. In R. A. Barkley (Ed.), *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment* (4th ed.). New York: Guilford Press.

Miller, M., & Hinshaw, S. P. (2010). Does childhood executive function predict adolescent functional outcomes in girls with ADHD? *Journal of Abnormal Child Psychology*, 38(3), 315-326.

Nigg, J. T. (2005). Neuropsychological theory and findings in attention-deficit/hyperactivity disorder: The state of the field and salient challenges for the coming decade. *Biological Psychiatry*, 57, 1424-1435.

Nigg, J. T. (2006). Temperament and developmental psychopathology. *Journal of Child Psychology and Psychiatry*, 47, 395-422.

Noel, M., Bastin, L., Schneider, J., & Polette, D. (2007). Rééducation neuropsychologique des troubles de l'attention et de l'inhibition chez l'enfant. *Approche Neuropsychologique des Apprentissages chez l'Enfant*, 93, 156-162.

O'Connell, R. G., Bellgrove, M. A., Dockree, P. M., & Robertson, I. H. (2006). Cognitive remediation in ADHD: effects of periodic non contingent alerts on sustained attention to response. *Neuropsychological Rehabilitation*, 16, 653-665.

O'Connell, R. G., Bellgrove, M. A., Dockree, P. M., Lau, A., Fitzgerald, M., Robertson, I. H. (2008). Self-Alert Training: volitional modulation of autonomic arousal improves sustained attention. *Neuropsychologia*, 46(5), 1379-90.

Podd, M. H. (2012). *Cognitive Remediation for Brain Injury and Neurological Illness: Real Life Changes*. Springer.

Polanczyk, G., Caspi, A., Houts, R., Kollins, S. H., Rohde, L. A., & Moffitt, T. E. (2010). Implications of extending the ADHD age-of-onset criterion to age 12: Results from a prospectively studied birth cohort. *Journal of the American Academy of Child & Adolescent Psychiatry*, 49, 210-216.

Prins, P., Dovis, S., Ponsioen, A., ten Brink, E., & van der Oord, S. (2011). Does computerized working memory training with game elements enhance motivation and traininnefficacy in children with ADHD? *Cyberpsychology Behavoir and Social Networking*, 14, 115-122.

Revol, O., & Fourneret, P. (2002). Diagnostic approach in hyperkinetic children. *Revue du Praticien*, 52(18), 1988-1993.

Roberts, W., Milich, R., & Barkley, R. A. (2014). Primary symptoms, subtyping, and prevalence. In R. A. Barkley (Ed.), *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment* (4th ed.). New York: Guilford Press.

Roder, V., Mueller, D. R., Mueser, K. T., & Brenner, H. D. (2006). Integrated psychological therapy (IPT) for schizophrenia: is it effective? *Schizophrenia Bulletin*, 32, S81-93.

Smith, B. H., & Shapiro, C. J. (2014). Combined treatments. In R. A. Barkley (Ed.), *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment* (4th ed.). New York: Guilford Press.

Sonuga-Barke, E. J. S., Sergeant, J. A., Nigg, J., & Willcutt, E. (2008). Executive dysfunction and delay aversion in attention deficit hyperactivity disorder: nosological and diagnostic implications. *Child and Adolescent Psychiatric Clinics of North America*, 17, 367-384.

Tamm, J. (2010). Attention Training for School-Aged Children With ADHD: Results of an Open Trial. *Journal of Attention Disorders*, 14, 86-94.

Toplak, M. E., Sorge, G. B., Flora, D. B., Chen, W., Banaschewski, T., Buitelaar, J., Faraone, S. V. (2012). The hierarchical factor model of ADHD: Invariant across age and national groupings? *Journal of Child Psychology and Psychiatry*, 53, 292-303.

Vantalon, V. (2005). *L'hyperactivité de l'enfant*. Paris: John Libbey Eurotext.

Volkow, N. D., Wang, G. J., Wang, Kollins, S. H., Wigal, T. L., Newcorn, J. H., Swanson, J. M. (2009). Evaluating the dopamine reward pathway in ADHD: Clinical implications. *JAMA: Journal of the American Medical Association*, 302, 1084-1091.

Wykes, T., & Reeder, C. (2006). *Cognitive Remediation Therapy for Schizophrenia: Theory and Practice*. Routledge.

Young, S., & Amarasinghe, J. (2010). Practitioner Review: non pharmacological treatments for ADHD: a life span approach. *Journal of Child Psychology and Psychiatry*, 51, 116–133.

Zentall, S. S. (1985). A context for hyperactivity. In K. Gadow & I. Bialer (Eds.), *Advances in learning and behavioral disabilities* (Vol. 4, pp. 273-343). Greenwich, CT: JAI Press.

Contact:

Pavel Škobrtal, University of Ostrava, pavel.skobrtal@osu.cz

Executive function and pragmatic language in children and adolescents

Lucie Kytnarová

Abstract

One of the key aspects of quality of life is communication, as communication activities enable people to maintain successful social relationships and achieve life goals. When two people communicate, they act on the basis of a stereotypical pattern of social knowledge shared between the participants in the dialogue. In order to understand the communicative intentions of a partner, one needs to recognize the stereotypical pattern of knowledge shared with a conversation partner. The pragmatic system of language is a part of a whole language system and is considered a tool that children and adults use to learn about the social world. The pragmatic system is also essential in developing and maintaining social relationships whilst engaging in culturally significant activities. The pragmatics of language then links to the expression of thoughts, ideas, wishes, and opinions in a social interaction. The location, means of communication and communication partner are also relevant factors. Current research indicates that executive functions and Theory of Mind play a significant role in the pragmatics of a language. The aim of this chapter is to understand the construct of pragmatics, to describe the relationship between executive functions and pragmatics of a language in the context of associated disorders. Impairments in executive functions and Theory of Mind cause many life-long complications not inly in the context of education, but also in terms of professional development.

1. Pragmatic linguistics

Pragmatics is a term that has been described by various fields such as philosophy, sociology or linguistics. As such, it is associated with various viewpoints and inconsistencies. The roots of the field lie in philosophy. Firstly, pragmatics has been shaped by the study of what intentions a speaker expresses, what means they use to do so, and what mechanisms enable the recipient to unravel the speaker's communicative intention (Hirsch, 2013). Secondly, each field studies pragmatics from a different viewpoint. Speech therapy studies pragmatics in relation to communication, sociology focuses on pragmatics as related to social roles, and anthropology studies pragmatics in association with specific cultures (Alduais et al., 2023). At the topic of the chapter suggests, the main interest lies in the linguistic perspective, more specifically in pragmalinguistics. Furthermore, the developmental perspective is also of interest since it concerns children development and disorders of pragmatic abilities in children (Saicová, Římalová, 2014).

Pragmalinguistics investigates how language is used in communication. Researchers focusing on pragmatics generally focus on the following areas (Saicová Římalová, 2014):

a) Principles of communication that enable communicators to understand each other.
b) Content and relational aspects of communication, politeness strategies.
c) Non-verbal communication.
d) Expression of the speaker's intention, speech acts, communicative functions.
e) Issues of persuasion, argumentation, manipulation.
f) Phenomena related to the relationship between speech and context.
g) Principles of dialogue construction.

Currently, a paradigm shift is occurring in pragmalinguistics, the so-called interactive turn. Individual utterances are beginning to be examined in a socially-interactive context, within a conversation, when participants take turns speaking rather than in isolation (Holler, 2018). Speaker alternation is universal among humans, although languages are culturally specific. Speaker alternation in both gestural and vocal modality is demonstrated across all major branches of the primate order, suggesting that it preceded language in phylogeny. However, it is not established whether this is an evolutionary analogy or homology; it would depend on whether this ability evolved independently in different primate groups (analogy) or whether all these groups inherited it from a common ancestor (homology) (Levinson, 2016). Levinson (2024) in his book „Dark Matters of Pragmatics" calls the socially interactive context 'the black hole of pragmatics'. The list of factors that influence the process of information exchange and that are relevant to understanding the conversation appears infinite as it includes the environment in which a conversation occurs, relationships between the conversation participants, current topic of conversation, any previous conversations they have had, etc. In this sense, multimodality is also discussed. Multimodality is related to the complexity of communication in social interaction and points to the complexity of achieving mutual understanding, as both speaker and listener contribute signals that are crucial to the flow of information exchange. In social interaction, multiple modalities in communication are used, for instance gestures (advising someone to go left while pointing with the left hand), as well as eye movements, blinks, facial expressions, shoulder, neck, torso movements, etc. Levinson (2024) suggests that most of the kinetic code has not yet been discovered and varies across cultures and languages. For instance, Hömke et al. (2018) investigated the length of mutual gaze and found that speakers subconsciously account for subtle differences in the length of listener blinks and produce significantly shorter responses in reaction to a long blink. The results suggest that blinking directly influences speakers' communicative behaviour in face-to-face communication and does not

merely serve a physiological function. In human interactions, bodily signals seem to fundamentally influence language processing.

The current view of pragmatics highlights the unclear basis for defining regular conversational behaviour and its variability, and thus brings more complexity in defining the Pragmatic language disorder described below. Accurate and measurable[2] pragmatic characteristics of the communication styles of the various syndromes (Autism spectrum disorder, Social pragmatic communication disorder, etc.) have not yet been established. Holler and Levinson (2019) suggest a variability in these characteristics stemming from culture and language.

2. Pragmatics from speech therapy perspective

Firstly, it is necessary to define the basic difference between the terms language and communication. Language is a set of components of a sign nature that form an organised unit / system and a set of rules that determine how to treat the units. Communication is a broader concept encompassing all forms and ways of communicating information, while language is a specific system that is one of the main tools by which people communicate. Within the structural approach, language can be conceptualized as an ordered system of sub-systems or linguistic levels (Mareš, 2014). In Czech and Slovak speech and language therapy, the traditional approach involves four linguistic planes. The pragmatic linguistic plane (pragmatics of communication, language) represents the plane of social application of communicative behaviour. Pragmatics is related to the expression of thoughts, ideas, wishes, opinions in social interaction; it includes not only what was said, but also where, how and to whom it was said, etc. Pragmatics also derives from the collective and historical experience of the group, since when two people communicate with each other, they act on the basis of a stereotyped pattern of social knowledge shared between the participants in the dialogue. In the context of communication, it is the skill of using language that involves contextual and social signals to establish contact with others (Lechta, 2003; Matthews et al., 2018).

In the Czech and Slovak literature, a list of aspects that fall under the umbrella term pragmatics of communication can be found (Bytešníková, 2007; Vitásková, Kytnarová, 2017). The aspects are:

a) Application of communication to express a specific intention, initiation (greeting, asking questions, requesting, refusing, answering, sharing information, etc.).

[2]Timing of communication role reversal, gaze length, gaze behaviour, gesticulations, body movements, etc.

b) Social behaviour - facial expression, posture, gestures, eye contact, exchange of communication roles.
c) Conversational behaviour - maintaining a topic of an ongoing conversation, reciprocity, changing a topic of the conversation, the ability to detect one's mistake in communication and its subsequent correction.
d) Communication rules and conventions - informativeness, truthfulness, relevance, clarity.
e) Receptive skills (understanding humour, sarcasm, metaphors, ambiguous meanings; also drawing inferences and developing a natural response towards the speaker's non-verbal communication).

A comprehensive view and research in speech and language therapy, specifically in the field of pragmatics, is rarely published in the Czech environment and is directed more towards the topic of Autism spectrum disorders. International approach varies significantly. The view of pragmatics is comprehensive, including recommendations for speech therapy interventions. The American Speech-Language-Hearing Association (ASHA, 2022; 2024) classifies pragmatics together with social interaction, social cognition[3] and language processing under the umbrella term of social communication.

Social communication can be defined as an interplay of social interaction, social cognition, pragmatics, and receptive and expressive language processing. Social communication is also heavily influenced by a range of cognitive functions and processes, including Theory of mind and executive functions (Wiseman-Hakes, Kakonge, & Summerby-Murray, 2018). **The term social communication is often used equivalently with the term pragmatic language ability in the literature.**

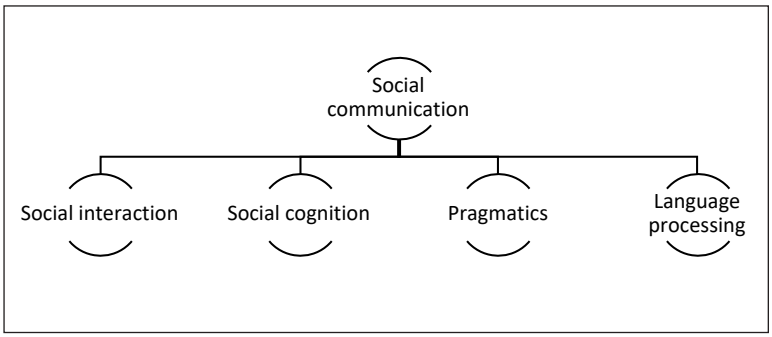


Fig. 1: Social communication model

Social interaction is a skill of effective engagement in interactions with others. The rules of social interaction can vary considerably across cultures, and variations can for instance occur in: style of speech,

[3]Understanding mental and emotional states of self and others, expected socially appropriate behaviour and consequences of inappropriate behaviour.

sex differences in communication, power relations (e.g. dominance or deference), rules of linguistic politeness, non-verbal communication (gestures, tone of voice, facial expressions, etc.) (ASHA, 2022).

Social cognition (social understanding) is generally defined as a set of processes through which information about others is integrated and used to achieve successful interactions. Social cognition involves the study of basic mental abilities that people use to understand themselves and others. It refers to a complex set of processes that enable effective responses to social interactions and dynamic social environments, such as emotion perception, Theory of Mind (ToM; mentalizing), and other processes that facilitate effective interpersonal relationships (Bodenhausen & Morales, 2012). Current studies also mention that intact ToM and executive functions (EFs), implicit and explicit memory, and joint attention are essential for understanding a partner's communicative intent (ASHA, 2022; Brizio, Gabbatore, Tirassa, & Bosco, 2015; Rowley, Rogish, Alexander, & Riggs, 2017).

Pragmatics is a field of social communication that focuses on the use of language in accordance with goals in social contexts. It is a set of rules that individuals follow when using language in conversation and other social situations. It includes both verbal and non-verbal communication. In terms of verbal communication, the rules are:

1. Speech acts, a term describing how words are used to achieve various communicative goals, such as a wish, request, command, apology, or promise. The study of speech acts helps us understand how people use language not only to transmit information but also to create and maintain social relationships (Saicová, Římalová, 2014).
2. Prosody, a term including intonation, rhythm, pauses, etc. Prosody and pragmatics are closely related as prosodic elements can significantly influence how linguistic messages are interpreted (Gussenhoven, Jacobs, 2011).
3. Grice's Theory of Maxims. The theory focuses on four basic maxims (guidelines, commands) that should be followed in cooperative communication. The theory examines whether or not the participants cooperate in communication and whether there are inconsistencies or conflicts in the communication. Violations of the cooperative principle maxims occur commonly in communication (e.g., lies, half-truths, metaphors, etc.) (Saicová, Římalová, 2014).
4. Discourse. The term is related to a message structure, including the ability to maintain a theme, an order of information, and a logical connection between sentences and ideas.

In terms of non-verbal communication, pragmatics includes gestures, postures, facial expressions, eye contact and gaze, proxemics, communication behaviour, etc.

Language processing is a translation of thoughts and feelings into the means of expressive communication (i.e. spoken, written, sign language) and the understanding and interpretation of language (ASHA, 2022).

3. Development of social communication (pragmatic language skills)

Children's pragmatic skills are developed and refined through participation in family, peer and school interactions. The interactions serve as means and motivation for an effective and strategic language use. Prucha (2011) argues that the basic form of human communication is a dialogue, therefore, a child would not acquire language without interactions involving dialogues. In order to conduct a dialogue, a child has to acquire many complex skills. The skills include the ability to take turns with other communicators at an appropriate pace and time, the ability to asses which situations require silence or a response, a skill of selecting an appropriate topic of conversation and developing it further, etc.

Gestures and vocalizations that perform pragmatic functions such as requesting, signing, protesting, and greeting belong to the earliest evidence of pragmatic development occurring at 9 to 10 months of age (Bates et al., 1975). For example, a study by Morales et al. (1998) showed that gaze-tracking skills in infants are good predictors of later language development. Pragmatic language skills acquired by the age of 1 year include a preference for looking at a human face, and listening to a human voice, finding the source of the voice, discriminating voice tone, vocalizing to gain attention, sharing attention, simple interactive games (hide-and-seek), imitating gestures, fearing strangers, expressing feelings, etc. At the age of 2, children show a number of pragmatic skills, e.g. asking questions, negotiating, discussing, protesting, adding gestures to words, showing empathy, sympathy, etc. Between the ages of 2 and 3, the ability to differentiate between one's own needs and needs of other people should emerge. By age 3, children can talk about what people think and what they know. Pouscoulous and Tomasello (2020) report that children between the ages of 2.5 and 3 years can understand simple metaphorical meaning. However, if the distance between the literal meaning and what the speaker actually intends to express increases, misunderstandings occur. The evidence suggests that the level of pragmatic language ability depends on cognitive resources and advanced Theory of Mind (ToM) skills. In preschool, the development of Theory of Mind (ToM) continues, which can be observed in the increasing ability to change a topic of conversation more frequently and the ability to formulate statements in order to discuss feelings

and emotions. Sarcasm and irony are not well understood until the age 8 years. During the school-age years, children demonstrate an increased ability to adapt their language to the conversational partner, to follow conversational rules, to use contextual cues in order to understand and produce figurative language4, and to follow standards of politeness. During adolescence and adulthood, an individual should be able to use verbal and nonverbal communication competently and flexibly, thus displaying advanced understanding and use of nonverbal behaviours. Further development includes the ability to comprehend idioms, identify subtle nuances of figurative language. The abilities are related to empathy development and to a formation of close friendships and romantic relationships (Nilsen, et al., 2021; Wiseman-Hakes, Kakonge, Summerby-Murray & Hwa-Froelich, 2023).

4. Executive functions and social communication (pragmatic language skills)

Executive functions refer to a set of mental skills necessary to regulate our behaviour. Emick and Welsh (2005) describe processes that are future- and goal-directed and include: cognitive flexibility, planning, working memory, inhibition and self-control. These processes are crucial for both effective executive functioning and appropriate pragmatic language use. From a developmental perspective, studies show that the development of executive functions in childhood is associated with the development of pragmatic language abilities. Moreover, well-developed EFs can improve pragmatic language abilities, and vice versa. EFs play an important role in social cognition, which is essential for pragmatic language abilities in return. For example, the ability to understand the perspective of others and to adapt communication to context requires both executive control and pragmatic understanding (Schuh, 2012; Bishop, Norbury, & Norbury, 2005; Bishop, Norbury, & Norbury, 2022). The ability to inhibit inappropriate responses and to control one's own behaviour is important for appropriate pragmatic language use in a variety of social contexts. To effectively account for the perspective of a conversational partner, one needs to inhibit their own perspective. Inhibition has also been associated with better lexical and syntactic abilities in children and young adults (Khanna & Boland, 2010). Cognitive flexibility allows an individual to adapt their language to different social situations, it enables appropriate modification of communicative utterances, and it is substantial when introducing new information and/or correcting misunderstandings. Cognitive flexibility appears to play a crucial role in understanding the secondary meaning of a word or sentence as difficulties with cognitive flexibility do not allow a person to switch between literal and nonliteral meanings. Functional working memory supports the ability to maintain a context of a conversation and to respond appropriately. It positively predicts the ability to understand

[4]Refers to forms of communication where the intended meaning differs from the literal or dictionary meaning of the words used (metaphors, idioms, irony, etc.).

spoken sentences in children and the ability to produce sentences in young adults (Slevc, 2011). Increasing demands on working memory in pragmatic tasks has been found to lead to less proficient communication (e.g., less regard is given to the conversational partner). Preschool and school children with developed working memory produce more successful messages (Nilsen et al., 2021)

Interestingly, in children aged 3-5 years, EFs appear to play a greater role in pragmatic language skills, such as supporting the production of fluent and clear utterances, than general intelligence (Blain-Brière et al., 2014).

Investigating deficits in EFs, they are often associated with difficulties in pragmatic language skills. Neurodevelopment disorders such as Attention Deficit Hyperactivity Disorder (ADHD) (e.g., Bruce et al., 2006; Parks, et al, 2023), Autism Spectrum Disorder (ASD, e.g. Norbury, 2014), Developmental Language Disorder (Bishop, Norbury, 2022), Down's syndrome (Kristensen et al., 2022), schizophrenia (Bambini et al., 2016) or traumatic brain injury (Arcara et al., 2019) and others provide evidence for the important role of executive function in social communication. Bambini, Looy et al. (2021) state that deficits in working memory and attention are the underlying pathomechanisms that lead to pragmatic deficits. Specifically, story comprehension and humour comprehension seem to primarily use working memory, whereas figurative language relies on working memory and, to some extent, on cognitive flexibility. Difficulties with cognitive flexibility do not allow a person to move from one meaning (literal) to another (non-literal). Conversely, inhibition has not been shown to be a strong predictor of pragmatics. Working memory allows for simultaneous consideration of multiple pieces of information needed for social communication. Working memory is also required for other executive aspects such as cognitive flexibility and inhibition. Hyter (2017) argues that pragmatics has an interdependent relationship with EFs (especially inhibition and cognitive flexibility) and social cognition (especially ToM). Working memory is seen as a connective tissue that allows all these aspects to work together in the service of social communication. Models of this type are mostly based on clinical populations where problems in pragmatic language abilities have been shown to involve both EFs and ToM abilities.

5. Social communication disorders (pragmatic language skills)

The American Speech-Language-Hearing Association (ASHA, 2022a) defines a language disorder as a disruption in the understanding and/or use of spoken, written, and/or other character systems. The disorder may involve (1) a language form (phonology, morphology, syntax), (2) language content (semantics), and/or (3) the **use of language in communication (pragmatics)** in any combination.

The interest in pragmatics, in its relationship with social communication, and in ways to effectively assess and develop pragmatic language abilities through therapy has increased with the inclusion of Social (Pragmatic) Communication Disorder (SPCD[5]) in the DSM-5 (2013). In the International Classification of Diseases ICD-11, this disorder is classified as "Developmental language disorder with impairment of mainly pragmatic language" (ICD 11, 2024).

Deficits in social communication (pragmatic language skills) are generally found in a wide range of disorders such as Developmental Intellectual Disability, Developmental Language Disorder, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD), Fragile X syndrome, Down's syndrome, traumatic brain injury, etc. (Hyter, 2017). Children with ASD in particular have difficulties with pragmatic language skills of a severe degree. The consequences of impaired pragmatic language negatively are decreased effectiveness of communication, impaired social relationships and, in adult individuals, professional performance (Vitásková, Kytnarová, 2017; Červenková, 2022).

5.1 Social Pragmatic Communication Disorder (SPCD)

Social Pragmatic Disorder is a separate diagnosis that is defined as a communication disorder with primary deficits in the social use of verbal and nonverbal communication. Primary difficulties may manifest in **social interaction, social cognition, pragmatics, language processing**, or in any combination of the above. The main criterion for this diagnosis should be a long-standing and marked difficulty in pragmatic language abilities that is not due to some other associated impairment. The deficit limit effective communication, participation in social life, social relationships and/or career success and performance. The onset of these symptoms occurs in early childhood (Baird, Norbury, 2016). The DSM-5 included the diagnosis of SPCD due to a change in the criteria for diagnosing ASD. According to the new criteria, some children will no longer meet the criteria for the diagnosis, but will still require appropriate care (Huerta et al., 2012).

The main symptoms of SPCD include impairment in the social use of verbal and non-verbal communication (Ketelaars et al., 2017). The impairment refers to difficulties in the use of language and gestures in social interactions where the impairment lies in an appropriate use of these tools in different social situations. For example, verbal communication involves not only speaking, but also using the correct tone, volume and pace appropriate for as situation. As such, a person with SPCD may speak too loudly in a quiet environment or use a formal tone in an informal conversation. Svindt (2019) states that these children

[5]Social Pragmatic Communication Disorder

often respond inadequately to questions, adding that another typical feature is that they are more comfortable talking to adults because adults are more tolerant of their issues and understand them better. Conversation with adults enables children with SPCD to use more formal communication style or vocabulary and use phrases that are typical of older people. Furthermore, children with SPCD usually share very little information, making it difficult for the listener to understand what has happened since there is a limited amount of information necessary for understanding the whole story. In terms of non-verbal communication, an individual with SPCD may not maintain eye contact when speaking or may have issues with understand the meaning of certain facial expressions or gestures. They may not be aware of personal space and thus may stand too close to someone, which can then lead to awkward or misunderstood social interactions (Alduais et al., 2023).

Červenková (2022) emphasises that a child with SPCD will have difficulties in making and maintaining friendships, difficulties in developing academic skills and in work performance in general. This diagnosis cannot be given to children whose speech development is not yet complete, so it is usually not given until the age of five. These difficulties may primarily manifest themselves only when dealing with more complex and challenging communication situations, and may not be detectable in routine and simple communicative exchanges. This can effectively mask the presence of the disorder, which can lead to delays in the recognition and diagnosis of social pragmatic communication disorder.

5.1.1. Impairment of pragmatic language skills in Autism Spectrum Disorders

SPCD and Autism Spectrum Disorders are difficult to differentiate from one another. Common citation of these terms is also frequent (see Figure 1), suggesting a shared focus in the research community. It also reflects an ongoing debate focusing on the overlap and differences between these conditions, which should lead to improved diagnostic and therapeutic strategies (Alduais et al., 2023).

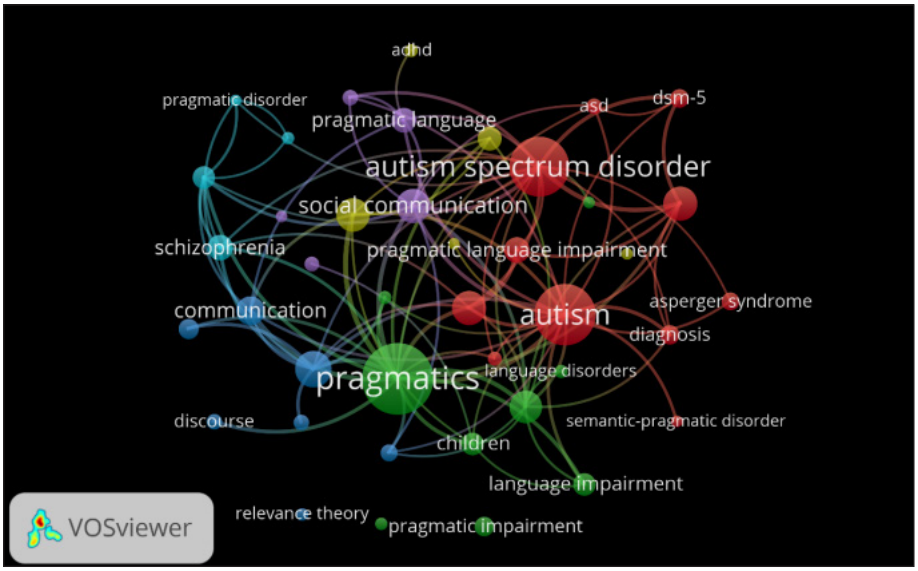


Figure 1 Key concepts of SPCD and ASD (Alduais et al., 2023, p. 21)

The difficulty in differentiating Social Pragmatic Communication Disorder from Autism Spectrum Disorder can play a significant role. Specifically when people with mild forms of ASD receive a diagnosis of SPCD and thus do not receive adequate therapy.

Conclusion

The chapter brings a more comprehensive view of pragmatics in the context of social communication to the Czech environment. To avoid confusion, the basic concepts of pragmatic linguistics have been defined, and the developmental aspect of pragmatic language abilities are also included. The interrelationship with executive function disorders was described and the process of a diagnosis of Social Pragmatic Communication Disorder was examined. Finally, the link to Autism Spectrum Disorders was also presented. The chapter aims to contribute to a basic understanding of Social Communication Disorder symptoms in relation to executive functions, and emphasises the early development of SPCD in childhood which, if left unnoticed, can then have many negative consequences on the quality of life in general.

References

Adams, C. (2002). practitioner review: the assessment of language pragmatics. *Journal of Child Psychology and Psychiatry, 43, 973-987.*

Alduais, A., Alfadda, H., Allegretta, S., Trivkovic, T. (2023). Pragmatic Language Impairment: A Scientometric Review, Applied Sciences, 13, 16.

Arcara, G., Tonini, E., Muriago, G., Mondin, E., Sgarabottolo, E., Bertagnoni, G., Semenza, C., Bambini, V. (2019). Pragmatics and figurative language in individuals with traumatic brain injury. fine-grained assessment and relevance-theoretic considerations. Aphasiology, 1-30.

ASHA (2024). American speech-language-hearing association Social Communication [online]., Available from: https://www.asha.org/public/speech/development/Pragmatics/

ASHA (2022). American speech-language-hearing association, Social Communication Disorder [online]. 2018 Available from: https://www.asha.org/PRPSpecificTopic.aspx?folderid=8589934980§ion=Overview

ASHA (2022a). Definitions of communication disorders and variations. Available from www.asha.org/policy.

Bambini, V., Van Looy, L., Demiddele, K., & Schaeken, W. (2014). The contribution of executive functions to communicative-pragmatic skills: Insights from aging and different types of pragmatic inference. *Journal of Pragmatics, 63,* 35-51.

Bambini, V., Arcara, G., Bechi, M., Buonocore, M., Cavallaro, R., & Bosia, M. (2016). The communicative impairment as a core feature of schizophrenia: frequency of pragmatic deficits, cognitive substrates, and relation with quality of life. *Compr. Psychiatr.*

Bambini, Valentina & Looy, Lotte & Demiddele, Kevin & Schaeken, Walter. (2021). What is the contribution of executive functions to communicative-pragmatic skills? Insights from aging and different types of pragmatic inference. *Cognitive Processing.*

Bates, E., Camaioni, L., & Volterra, V. (1975). The acquisition of performatives prior to speech. *Merrill-Palmer Quarterly of Behavior and Development, 21*(3), 205–226.

Baird, G., & Norbury, C. F. (2016). Social (pragmatic) communication disorders and autism spectrum disorder. *Archives of disease in childhood, 101*(8), 745–751.

Bishop, D. V. M. and Norbury, C. F. (2002). Exploring the borderlands of autistic disorder and specific language impairment: a study using standardised diagnostic instruments. *Journal of Child Psychology and Psychiatry,* 43(7), 917-929.

Bishop, D. V. M., & Norbury, C. F. (2022). Developmental language disorder. *Nature Reviews Disease Primers,* 8(1), 1-20.

Blain-Brière, B., Bouchard, C., & Bigras, N. (2014). The role of executive functions in the pragmatic skills of children age 4-5. *Frontiers in Psychology,* 5, 240.

Bodenhausen, G. & Morales, J. (2012). Social Cognition and Perception. *Handbook of Psychology.* Wiley.

Brizio, A., Gabbatore, I., Tirassa, M., & Bosco, F. M. (2015). "No more a child, not yet an adult": studying social cognition in adolescence. *Frontiers in Psychology,* 6.

Bruce B., Thernlund G., & Nettelbladt U. (2006). ADHD and language impairment: a study of the parent questionnaire FTF (Five to Fifteen). *Eur. Child Adoles. Psychiatry,* 15, 52-60.

Bytešníková, I. (2007). Rozvoj komunikačních kompetencí u dětí předškolního věku. Brno: MU.

Červenková, B. (2022). Social pragmatic communication disorder. Letters of Clinical Speech Therapy, 2.

Emick, J., & Welsh, M. (2005). Association between formal operational thought and executive function as measured by the Tower of Hanoi-Revised. *Learning and Individual Differences, 15*(3), 177–188.

DSM-V (2022). Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision (DSM-5-TR™). American Psychiatric Association.

Gloria, R. Sinbandhit, A., Stuart, A. et al, (2018). Neuropsychological and social cognitive function in young people at genetic risk of bipolar disorder, *Bipolar Disorder Vulnerability,* Academic Press, pp. 157-193.

Gussenhoven, C., Jacobs, H. (Eds.) (2011). *The Oxford handbook of language prosody.* Oxford University Press.

Hirschová, M. (2013): Pragmatics in Czech. 2nd ed. 2nd edition: 2.

Hömke, P., Holler, J., Levinson, S., C. (2018) Eye blinks are perceived as communicative signals in human face-to-face interaction. *PLoS ONE,* 13(12): e0208030.

Holler, J., Kendrick, K.H. & Levinson, S.C. (2018). Processing language in face-to-face conversation: Questions with gestures get faster responses. *Psychon Bull Rev* 25, 1900-1908.

Holler, J., Levinson, S. C. (2019). Multimodal Language Processing in Human Communication, *Trends in Cognitive Sciences.*

Huerta, M., Bishop, S. L., Duncan, A., Hus, V., Lord, C. (2012). Application of DSM-5 criteria for autism spectrum disorder to three samples of children with DSM-IV diagnoses of pervasive developmental disorders. *The American journal of psychiatry,* 169(10), 1056-1064.

Hwa-Froelich, D. A. (2023) Social communication development. In *Social Communication Development and Disorders.*

Hyter, Y., D (2017). Pragmatic assessment and intervention in children. In: Cummings, L. (ed) *Research in clinical pragmatics,* 493- 526. Springer.

ICD-11 (2022). International Classification of Diseases. 11th Revision (ICD 11). The global standard for diagnostic health information. Version: 02/2022. Chapter 06 Mental, behavioural or neurodevelopmental disorders. Geneva: WHO.

Ketelaars, M., P., Embrechts, M., T., J., A. (2017). Pragmatic Language Impairment. In *Perspectives in Pragmatics, Philosophy & Psychology*; Cummings, L., Ed.; Springer, Switzerland, 11, 29-57.

Khanna, M. M., & Boland, J. E. (2010). Children's use of language context in lexical ambiguity resolution. *The Quarterly Journal of Experimental Psychology, 63*(1), 160–193

Kristensen, K., Lorenz, K. M., Zhou, X., Piro-Gambetti, B., Hartley, S. L., Godar, S. P., Diel, S., Neubauer, E., & Litovsky, R. Y. (2022). Language and executive functioning in young adults with Down syndrome. *Journal of intellectual disability research : JIDR, 66*(1-2), 151-161.

Lechta, V. (2003). Diagnosis of impaired communication skills. Prague: Portal.

Levinson, S. C. (2016). Turn-taking in Human Communication - Origins and Implications for Language Processing, *Trends in Cognitive Sciences*, 20, 1, 6-14.

Levinson, S. C. (2024). The Dark Matter of Pragmatics: Known Unknowns. Cambridge: Cambridge University Press.

Mareš, P. (2014). Introduction to Linguistics and Linguistic Bohemistics, Prague: Karolinum.

Matthews, D., Biney, H., & Abbot-Smith, K. (2018). Individual differences in children's pragmatic ability: A review of associations with formal language, social cognition, and executive functions. *Language Learning and Development, 14*(3), 186-223.

Morales, M., Mundy, P. Rojas, J. (1998). Following the direction of gaze and language development in 6-month-olds, *Infant Behavior and Development*, 21 (2), 373-377.

Nilsen, E. S., Silva, J., McAuley, T., & Floto, S. (2021). Executive functioning moderates associations between shyness and pragmatic abilities. *Social Development, 30*(2), 554-574.

Norbury, C. F. (2014). practitioner review: social (pragmatic) communication disorder conceptualization, evidence and clinical implications. *Journal of Child Psychology and Psychiatry*, 55(3), 204-216.

Parks, K. Hannah, K. E., Moreau, Ch., Brainin, N., Joanisse, L., Joanisse, M. (2023). Language abilities in children and adolescents with DLD and ADHD: A scoping review, *Journal of Communication Disorders*, 106, 106381.

Pouscoulous, P., & Tomasello, M. (2020). *The development of pragmatic language: The case of metaphor. Journal of Child Language Research*, 47(4), 723-742.

Prucha, J. (2011). *Dětská řeč a komunikace*. Praha: Grada.

Rowley, D. A., Rogish, M., Alexander, T., & Riggs, K. J. (2017). Cognitive correlates of pragmatic language comprehension in adult traumatic brain injury: A systematic review and meta-analyses. Brain Injury, 31(12), 1564-1574.

Saicová Římalová, L. (2014). Pragmatics: a study guide. Prague: Karolinum.

Schuh J. M. (2012). Pragmatic Language Abilities: Working Memory Influences on Mutual Information. *Doctoral Dissertations*, University of Connecticut.

Slevc, L. R. (2011). Saying what's on your mind: Working memory effects on sentence production. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37*(6), 1503–1514.

Svindt, V. A társas pragmatikai kommunikációs zavar: terminológiai kérdések, tüneti diagnosztikai módszerek és problémák. Magyar Pszichológiai Szemle [online]. 2019, 74(2), pp. 215-231 [cited 2020-06-02]. DOI: 10.1556/0016.2019. 74. 2. 6. ISSN 0025-0279.

Vitásková, K.; Kytnarová, L. (2017). Pragmatic language level in persons with autism spectrum disorders: assessment of pragmatic language level in persons with autism spectrum disorders from the perspective of a speech therapist. Olomouc: Palacký University.

Wiseman-Hakes, C., Kakonge, L., Summerby-Murray, S. (2018). Language, Cognitive-Communication and Social Communication. In. *Cognitive Rehabilitation for Pediatric Neurological Disorders*, 122-153.

Contact:

Lucie Kytnarová, University of Ostrava, lucie.kytnarova@osu.cz

The role and development of executive functions in ASD adolescents

Tereza Rošíková, Jan Appeltauer

Abstract

DSM-V defines Autism spectrum disorder (ASD) as a neurodevelopmental disorder with persistent deficits in social communication and restricted and repetitive behaviour across multiple contexts. Present article focuses on the development and neural underpinnings of three major components of executive functions in ASD adolescents, since adolescence is associated with higher demands on both executive and social functioning. Working memory, inhibition and set shifting were investigated both from neurological and developmental perspective. Alterations in development during adolescence were identified and associated with corresponding neural areas. Working memory reaches its peak in adolescence followed by delays not observed in a typically developing population. In contrast, overall development of inhibition appears to be delayed in the ASD population. In terms of cognitive flexibility, despite its improvement in adolescence, impairment appears to persist into adulthood. Nevertheless, the complexity of both ASD and executive functioning requires more research.

1. Executive functions

Executive functions (EFs) are currently thought of as an umbrella term for higher-order cognitive abilities including various cognitive processes such as divided attention, working memory, cognitive flexibility, inhibition, planning etc., also called metacognitive processes (Anderson, 2002; Goldstein & Naglieri, 2014; Prochazka & Orel, 2021). Anderson (2002) developed a complex model of executive functions. The model organised EFs into four domains: cognitive flexibility, attentional control, goal setting and information processing (Figure 1) and included both simple and more complex processes that are dependent on each other and often interlinked, thus suggesting functional relationships among the components of EF. Many more models of EFs have also been developed (e.g. Banich's Cascade of control model, Duncan's model, Central executive model, Norman and Shallice's Supervisory Attentional System model, and the hot and cold executive function model (Hunter & Sparrow, 2012; Prochazka & Orel, 2021).

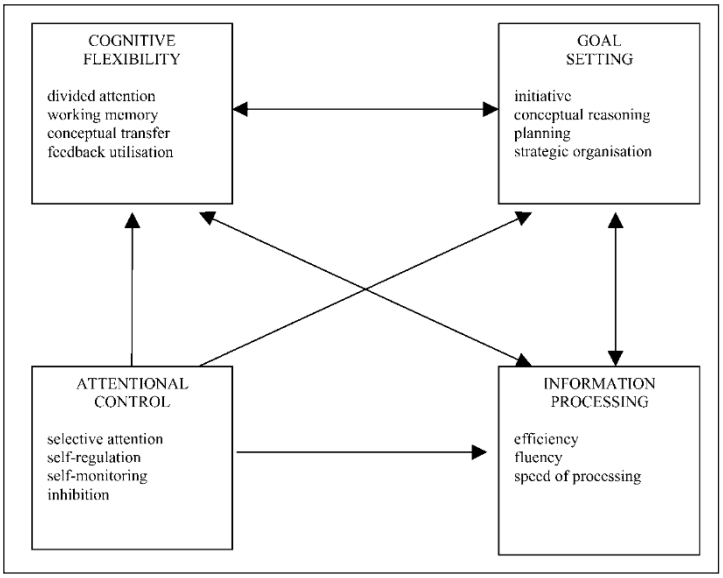


Figure 1. A model of executive functions (Anderson, 2002).

Despite the lack of consensus on the definition of EF, both observational and behavioural studies agree on EFs having the main role in directing and harmonising other cognitive functions which underlie goal-directed behaviour (Hunter & Sparrow, 2012; Goldstein & Naglieri, 2014; Prochazka & Orel, 2021; Vagnerova, 2020). EFs also play a significant role in the human adaptability to novel situations (Diamond, 2013). A development of executive functions is a long-term process beginning in infancy and continuing to adulthood with developmental spurts also occurring (Best & Miller, 2010). Development of EFs is intricately linked to neural processes such as neural differentiation, synaptic pruning, and myelination.

1.1 Development and neural basis of EFs

In terms of neural correlates of EFs, research stemming mainly from investigations of frontal lobe dysfunction in both children and adults supports theories that executive functions reside in regions of the prefrontal cortex that are connected to other brain structures, e.g. basal ganglia, brainstem, thalamus, hypothalamus, limbic system, reticular formation, cerebellum etc. (Blumenfeld, 2002; Hunter & Sparrow, 2012; Prochazka & Orel, 2021; Stuss, 2011; Vagnerova, 2020). The prefrontal cortex is the largest region of the frontal lobes, which is also superior to all areas of the brain. It is composed of association cells that are connected to all cortical areas in addition to the upper parts of the brainstem and the thalamus (Blumenfeld, 2002; Prochazka & Orel, 2021). Through these connections, the prefrontal cortex establishes feedback connections with components of the reticular formation and areas of the neocortex, specifically the temporal, occipital, and parietal regions (Prochazka & Orel, 2021). Figure 2 depicts an overlap between areas responsible for working memory (updating), set-shifting and inhibition

and the interconnections produced by a Neurosynth meta-analysis of functional neuroimaging studies focusing on the location of executive functions in the brain (Uddin, 2021).

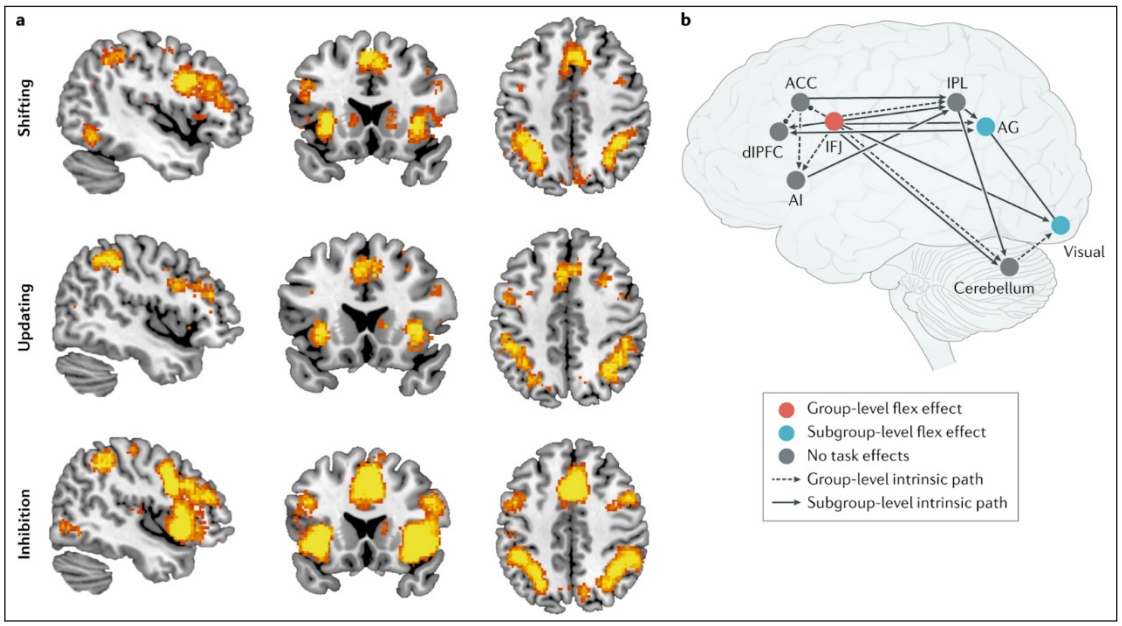


Figure 2. Functional overlap between areas lateral frontoparietal and midcingulo-insular brain regions including the inferior frontal junction, anterior cingulate cortex, angular gurus, anterior insula, dorsolateral prefrontal cortex, inferior parietal lobule (Uddin, 2021).

Since the extent of this chapter only allows to focus on purely the foundational components of EFs (e.g. Diamond, 2013; Koziol & Lutz, 2013; Friedman and Robbins, 2022), neural correlates specific to these components shall be explored.

1.1.1. Working memory

Working memory (WM) is defined as an ability to hold in mind certain information (visual and auditory) and manipulate it for a brief period without any outside aids (e.g. Best & Miller, 2010). It is proposed to consist of three components: phonological loop, visuospatial sketchpad, and the central executive (Baddeley, 1996, 2000, 2012). The main area considered to be associated with working memory is the dorsolateral prefrontal cortex (dlPFC), and together with the posterior perinatal cortex it forms the central executive network, whose task is to guide and harmonise attention, working memory and reasoning during demanding cognitive processes (Diamond, 2013; Vagnerova, 2020). Maturation of the dlPFC plays a vital role in the development of attention, working memory and other executive functions (Vagnerova, 2020; Zelazo & Müller, 2002). Development of working memory is reliant on the complexity of tasks an individual faces (Conklin et al., 2007). As such, working memory begins to develop at an early age of approximately 4 years and continues its development until teenage years (approx. 14 years).

Neuroimaging studies provide more evidence to support the course of WM development by showing increased myelination within the fronto-parietal network as an individual ages (Best & Miller, 2010).

1.1.2. Inhibition

First signs of inhibition occur in infancy when a child is able to delay obtaining a treat (approximate age between 3 and 4 years). As stated above, the development of each EF component is connected to the development of other components. As such, inhibition is also related to the development of WM. Investigations of inhibition development through various neuropsychological tasks such as the Statue in the NEPSY or the Go/No task propose significant development of the ability between ages 6 - 10 years and at the age of 12 years with most significant changes occurring up to the age of 21 years. An EEG study by Jonkman (2006) reported gradual yet slow specialisation of the frontal regions of the brain starting as early as at the age of 4 months. Functional imaging studies further report increases and decreases of activation during inhibition tasks until approx. 12 years (Johnstone et al., 2007). Studies investigating inhibition development in children and adolescents support the Interactive Specialisation theory by Johnson (2000, 2011).

1.1.3. Cognitive flexibility (set-shifting)

Ionescu (2012) defines cognitive flexibility as an ability to shift one's attention between various tasks and stimuli. For functional set-shifting, inhibition and working memory are required as the ability to shift attention is dependent on successfully inhibiting unnecessary stimuli and maintaining and updating information needed for cognitive flexibility. Cognitive flexibility improves as situational demands increase. The first signs of set-shifting development appear between the ages of 8 - 10 years when a developmental spurt occurs, and continues through adolescence to adulthood (Crone, 2008). The spurt-like development of cognitive flexibility correlates with fMRI studies. Rubia et al. (2006) shows maturation in the inferior frontal, parietal, and anterior cingulate regions, however, the study also reported a decrease in dlPFC activity during adolescence. A proposed explanation for the lower activity in dlPFC considers the dlPFC to provide compensatory mechanisms and once other regions of the brain have matured sufficiently, it is no longer required as much.

1.2 Executive function impairments

Diamond (2012) presents a summary of different areas of life in which executive functions play a significant role (Figure 3). The areas include quality of mental and physical health, school and job performance, quality of life and public safety.

Aspects of life	The ways in which EFs are relevant to that aspect of life	References
Mental health	EFs are impaired in many mental disorders, including:	
	- Addictions	Baler & Volkow 2006
	- Attention deficit hyperactivity (ADHD)	Diamond 2005, Lui & Tannock 2007
	- Conduct disorder	Fairchild et al. 2009
	- Depression	Taylor-Tavares et al. 2007
	- Obsessive compulsive disorder (OCD)	Penadés et al. 2007
	- Schizophrenia	Barch 2005
Physical health	Poorer EFs are associated with obesity, overeating, substance abuse, and poor treatment adherence	Crescioni et al. 2011, Miller et al. 2011, Riggs et al. 2010
Quality of life	People with better EFs enjoy a better quality of life	Brown & Landgraf 2010, Davis et al. 2010
School readiness	EFs are more important for school readiness than are IQ or entry-level reading or math	Blair & Razza 2007, Morrison et al. 2010
School success	EFs predict both math and reading competence throughout the school years	Borella et al. 2010, Duncan et al. 2007, Gathercole et al. 2004
Job success	Poor EFs lead to poor productivity and difficulty finding and keeping a job	Bailey 2007
Marital harmony	A partner with poor EFs can be more difficult to get along with, less dependable, and/or more likely to act on impulse	Eakin et al. 2004
Public safety	Poor EFs lead to social problems (including crime, reckless behavior, violence, and emotional outbursts)	Broidy et al. 2003, Denson et al. 2011

Figure 3. Relevance of executive functions to various aspects of life (Diamond, 2012).

Neurodevelopmental disorders such as Attention Deficit Hyperactivity Disorder, learning disorders, behaviour disorders (e.g. Conduct Disorder) or Autism Spectrum Disorder (ASD) are merely examples of the importance of EFs in human lives. In this chapter, executive (dys)functions in ASD will be explored more closely.

2. Autism Spectrum Disorder

The Diagnostic and Statistical Manual of Mental Disorders (DSM-V, 2013) defines Autism Spectrum Disorder (ASD) as a 'neurodevelopmental disorder with persistent deficits in social communication and social interaction across multiple contexts, and restricted, repetitive patterns of behaviour, interests, or activities'. These deficits can for instance be observed in reciprocal interactions, abnormalities in

eye contact, limited or absent body language, stereotyped movements, abnormally high interests in unusual topics (e.g. transport schedule, information technologies), hypo- or hyper-sensitivity to sounds, materials, foods etc. Furthermore, deficits in executive functioning are also associated with ASD (Wang et al., 2017). According to the World Health Organisation (WHO), Autism Spectrum Disorder occurs in 1 out of 100 individuals, however, more recent studies (e.g. Maenner et al., 2023) suggest 1 in 36 children obtain the diagnosis with a higher percentage of males than females.

In terms of neurological development, various neural abnormalities, both structural and functional, have been identified. Generally, studies report an increase in cortical volume and thickness alongside altered synaptic connectivity in cortical and subcortical regions (Demetriou et al., 2018). In terms of size, larger volumes of areas such as the orbitofrontal region, medial prefrontal and cingulate cortex, inferior temporal gyrus, and basal ganglia have been identified in ASD individuals when compared to the neurotypical population (Dougherty et al., 2016). These areas affected by asymmetric brain matter growth are thought to be responsible for deficits in social behaviour, speech, and emotion processing (Dennis & Thompson, 2013; Vagnerova, 2023).

Regarding altered functional connectivity in the ASD brain, the most common theory suggests decreased connectivity between distant brain regions as opposed to increased connectivity between regions closer to each other (Belmonte et al., 2004). However, a review by Mohammad-Rezazadeh et al. (2016) suggested methodological factors of research studies focusing on altered connectivity in ASD might have caused different findings rather than reporting a presence of actual neurological changes. Furthermore, Vasa, Mostofsky and Ewen (2016) challenged past research of altered connectivity in ASD by proposing a need for not only descriptive models but rather exploratory models of connectivity in ASD, and also for cooperative or competitive studies, and for using a broader range of methods for investigations. Although there are many theories of what causes ASD-specific issues and ASD is indeed considered a disorder of connectivity, full understanding of the disorder has not been achieved yet. Some suggest executive dysfunctions could stand behind the social deficits in ASD, for instance repetitive behaviour links to cognitive flexibility problems, thus forming the Executive dysfunction theory (e.g. Hill, 2004). The Executive dysfunction theory has been very influential in terms of the perception of the disorder (Yeung, Bai and Mak, 2024).

2.1 Executive (dys)functions in ASD

Executive functions and their role in ASD symptomatology is quite a recent topic. ASD is a very heterogeneous disorder, therefore difficult to examine (Happé & Frith, 2020). A meta-analysis by Demetriou et al. (2018) depicts executive dysfunctions in ASD that are present across development (Fig. 4).

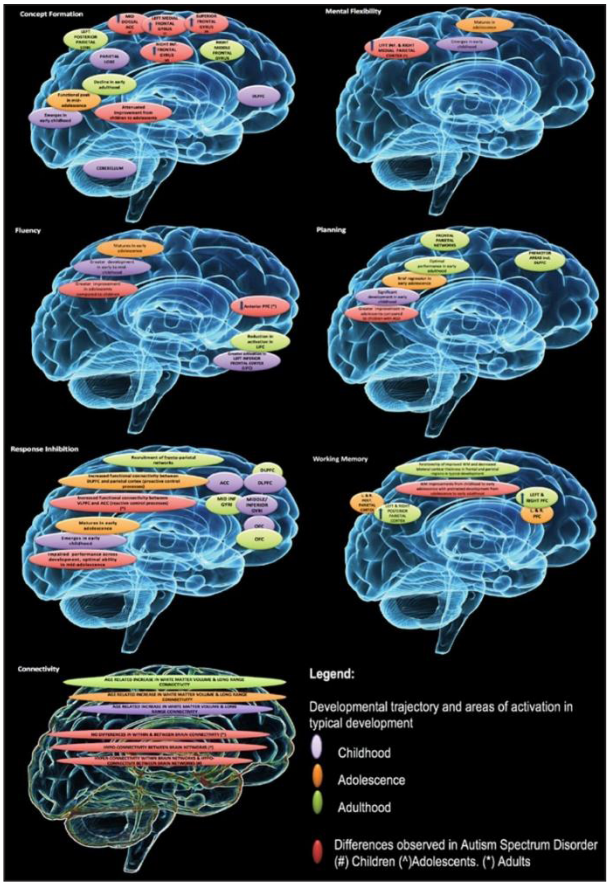


Figure 4. Changes in EFs throughout development (Demetriou et al., 2018).

Furthermore, a systematic review by Yeung, Bai, and Mak (2024) showed impairments of EFs in ASD adolescents, however, no difference was identified in terms of age-related changes of EFs components.

EFs changes throughout development are mirrored by neurological changes in brain function, structure, and connectivity. Indeed, in ASD, alterations in neural development reflect executive dysfunctions and impairments specific to EFs in ASD adolescents (Barendse et al., 2013; Demetriou et al., 2018; Luna et al., 2007; O'Hearn et al., 2008; Vara et al., 2014; Zhang et al., 2020). Unfortunately, with a limited presence of review articles focused on EFs in ASD, research focusing on individual executive (dys)functions is

more common. As stated above, due to the scope of the chapter, focus is put only on the three primary executive functions – working memory, inhibition, and set shifting.

2.1.1. Working memory (WM)

Scientific evidence shows impairments of working memory (WM), more specifically in the visual and spatial components of working memory in ASD (Chen et al., 2016; Luna et al., 2007). While the impairment can be seen through the whole development of autistic individuals, improvements in the capacity of WM have also been identified (Barendse et al., 2013; Demetriou et al., 2018; Luna et al., 2007; O'Hearn et al., 2008). Some studies suggested ASD adolescents perform better on WM tasks than children with ASD, but worse than their typically developed peers (Barendse et al., 2013; Chen et al., 2016; Luna et al., 2007; O'Hearn et al., 2008). However, Demetriou et al. (2018) demonstrated that adolescents with ASD can perform similarly to their typically developing peers. Explanations for contrasting findings might be found in the analysis of developmental changes concerning working memory.

In typically developing adolescent participants of the study aged 12 - 18 years, visual WM performance was low, therefore the difference between the level of visual WM performance in ASD adolescents and TD adolescents was not as pronounced as in other development stages (Demetriou et al., 2018). Consequently, the study showed ASD individuals made more errors on more complex spatial WM tasks than TD respondents when processing complex information was necessary (Barendse et al., 2013; Chen et al., 2016). The errors included shorter ability to remember information after delay, impaired ability to preserve an image in memory, difficulty in maintaining and retrieving internal representations (Barendse et al., 2013; Chen et al., 2016; Luna et al., 2007).

Complexity of tasks appears to be the main factor influencing performance of ASD adolescents in WM tasks (Chen et al., 2016). When comparing adults with ASD, their level of WM correlates with the level of WM in ASD adolescents. In contrast, typically developing adults' WM continues to improve during development (Barendse et al., 2013; Demetriou et al., 2018; Luna et al., 2007). In other words, in the ASD population, visual WM seems to peak in adolescence followed by subsequent delay and limited development compared to typically developing individuals of the same age (Demetriou et al., 2018; Luna et al., 2007).

2.1.2. Inhibition

Impairment of inhibition is often reported in ASD population, specifically the ability to inhibit prepotent motor responses throughout development (Demetriou et al., 2018; Luna et al., 2007). Studies focused on autistic adolescents show some level of improvement during development when compared to their younger peers (Demetriou et al., 2018; Luna et al., 2007; O'Hearn et al., 2008). Furthermore, in other tests (e.g. Stroop test) that enable the use of verbal or other compensatory strategies, ASD adolescents show similar levels of performance (O'Hearn et al., 2008). However, in tests measuring inhibition of motor responses, ASD adolescents perform worse than their TD peers (Luna et al., 2007; Padmanabhan et al., 2015). While maturation and improvement of inhibition generally occurs during typical development, ASD adolescents do not display the same trajectory of improvement as their typical peers (Demetriou et al., 2018; Luna et al., 2007; O'Hearn et al., 2008). In summary, in ASD population, development of inhibition from childhood to adolescence is delayed and appears to stop developing completely in adult ASD (Demetriou et al., 2018; Luna et al., 2007; O'Hearn et al., 2008; Padmanabhan et al., 2015; Vara et al., 2014).

2.1.3. Cognitive flexibility

Cognitive flexibility development is strongly linked to the development of inhibition and working memory. Refinement of these components together allows individuals to maintain multiple rules in their minds whilst simultaneously following only the rule that is currently needed and suppress the others that are no longer required (Garon et al., 2008; Vagnerova, 2020). Since inhibition and WM are impaired in ASD, cognitive flexibility is also affected (Demetriou et al., 2018; Kimhi et al., 2014; Uddin, 2021). When compared to younger peers, cognitive flexibility impairment seems to decrease (Chen et al., 2016; Demetriou et al., 2018; Uddin, 2021). While we can see improvement of cognitive flexibility in ASD adolescents, there still is noticeable impairment when compared to their TD counterparts (Demetriou et al., 2018; Kimhi et al., 2014; Uddin, 2021). The impairment seems to persist into adulthood (Demetriou et al., 2018).

3. Final remarks

ASD is a neurodevelopmental disorder associated with impaired social and executive functioning. Along with deficits in the presented executive function components, impairments in planning, speed processing, and global EFs have been identified in ASD population (e.g. Demetriou et al., 2018; Yeung,

Bai &Mak, 2024). Moreover, ASD is a complex disorder with complex neural underpinnings. As such, when considering the role of executive dysfunctions in the profile of the disorder, there are many factors that need to be accounted for with research approaches being of them. Indeed, development of EFs is usually investigated from the perspective of each individual component (Lee et al., 2013; Shing et al., 2010). However, it is important to consider that executive function models which divide EF into subtypes stem mainly from scientific literature focused on adults. A few have argued that these models are therefore not applicable to children, however, others provided evidence that adult models can be applied to children as well (McKenna et al., 2017).

Another issue in this line of research could be structured, lab-based tasks that do not necessarily reflect complex life situations (Burgess et al., 2006). Indeed, a study by Kenny, Remington & Pellicano (2024) focused on impairments in EFs as described by autistic individuals themselves and found that theoretical knowledge and models do not directly fit with deficits subjectively experienced by ASD individuals. Tamm et al. (2024) provided more support by experimenting with real-life measures such as the Weekly Calendar Planning Activity (WCPA). In addition, the authors suggested the WCPA could be used for cognitive neurorehabilitation/remediation of executive deficits associated with ASD. Pasqualotto et al. (2021) provided more evidence supporting the usefulness of EFs training.

Lastly, ASD is a disorder of social functioning. Therefore, investigating the link between social and executive functioning and subsequently applying findings into integrative approach towards ASD and cognitive rehabilitation could ameliorate not only the understanding of the disorder and neural functions, but more importantly help population with ASD with improvements of their daily functioning (Leung et al., 2016; Hajri et al., 2022).

References

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5th. edition).

Anderson, P. (2002). Assessment and development of executive function (EF) during childhood. *Child neuropsychology*, *8*(2), 71-82.

Baddeley, A. (2000). The episodic buffer: a new component of working memory? *Trends in cognitive sciences*, *4*(11), 417-423.

Baddeley, A. (2012). Working memory: Theories, models, and controversies. *Annual review of psychology*, *63*(1), 1-29.

Baddeley, A. D., & Della Sala, S. (1996). Working memory and executive control. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, *351*(1346), 1397-1404.

Barendse, E. M., Hendriks, M. P., Jansen, J. F., Backes, W. H., Hofman, P. A., Thoonen, G., ... & Aldenkamp, A. P. (2013). Working memory deficits in high-functioning adolescents with autism spectrum disorders: neuropsychological and neuroimaging correlates. *Journal of neurodevelopmental disorders*, *5*, 1-11.

Belmonte MK, Cook EH, Anderson GM, Greenough WT, Beckel-Mitchener A. Autism as a disorder of neural information processing: Directions for research and targets for therapy. Mol Psychiatry. 2004;9(7):646–663.

Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child development*, *81*(6), 1641-1660.

Blumenfeld, H. (2002). Neuroanatomy through clinical cases.

Burgess, P. W., Alderman, N., Forbes, C., Costello, A., LAURE, M. C., Dawson, D. R., ... & Channon, S. (2006). The case for the development and use of "ecologically valid" measures of executive function in experimental and clinical neuropsychology. *Journal of the international neuropsychological society*, *12*(2), 194-209.

Chen, S. F., Chien, Y. L., Wu, C. T., Shang, C. Y., Wu, Y. Y., & Gau, S. S. (2016). Deficits in executive functions among youths with autism spectrum disorders: an age-stratified analysis. *Psychological medicine*, *46*(8), 1625-1638.

Conklin, H. M., Luciana, M., Hooper, C. J., & Yarger, R. S. (2007). Working memory performance in typically developing children and adolescents: Behavioral evidence of protracted frontal lobe development. *Developmental neuropsychology*, *31*(1), 103-128.

Courchesne, E. (2002). Abnormal early brain development in autism. *Molecular psychiatry*, *7*(2), S21-S23.

Crone, E. A., Bullens, L., Van der Plas, E. A. A., Kijkuit, E. J., & Zelazo, P. D. (2008). Developmental changes and individual differences in risk and perspective taking in adolescence. *Development and psychopathology*, *20*(4), 1213-1229.

Demetriou, E. A., Lampit, A., Quintana, D. S., Naismith, S. L., Song, Y. J., Pye, J. E., ... & Guastella, A. J. (2018). Autism spectrum disorders: a meta-analysis of executive function. *Molecular psychiatry*, *23*(5), 1198-1204.

Dennis, E. L., & Thompson, P. M. (2013). Typical and atypical brain development: a review of neuroimaging studies. *Dialogues in clinical neuroscience*, *15*(3), 359-384.

Diamond, A. (2013). Executive functions. *Annual review of psychology*, *64*(1), 135-168.

Dougherty, C. C., Evans, D. W., Myers, S. M., Moore, G. J., & Michael, A. M. (2016). A comparison of structural brain imaging findings in autism spectrum disorder and attention-deficit hyperactivity disorder. *Neuropsychology review*, *26*, 25-43.

Friedman, N. P., & Robbins, T. W. (2022). The role of prefrontal cortex in cognitive control and executive function. *Neuropsychopharmacology*, *47*(1), 72-89.

Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: a review using an integrative framework. *Psychological bulletin*, *134*(1), 31.

Goldstein, S., & Naglieri, J. A. (2014). *Executive functioning*.

Hajri, M., Abbes, Z., Yahia, H. B., Jelili, S., Halayem, S., Mrabet, A., & Bouden, A. (2022). Cognitive deficits in children with autism spectrum disorders: Toward an integrative approach combining social and non-social cognition. *Frontiers in Psychiatry*, *13*, 917121.

Happé, F., & Frith, U. (2020). Annual Research Review: Looking back to look forward–changes in the concept of autism and implications for future research. *Journal of Child Psychology and Psychiatry*, *61*(3), 218-232.

Hill, E. L. (2004). Executive dysfunction in autism. *Trends in cognitive sciences*, *8*(1), 26-32.

Hunter, S. J., & Sparrow, E. P. (Eds.). (2012). *Executive function and dysfunction: Identification, assessment, and treatment*. Cambridge University Press.

Ionescu, T. (2012). Exploring the nature of cognitive flexibility. *New ideas in psychology*, *30*(2), 190-200.

Johnson, M. H. (2000). Functional brain development in infants: Elements of an interactive specialization framework. *Child development*, *71*(1), 75-81.

Johnson, M. H. (2011). Interactive specialization: a domain-general framework for human functional brain development? *Developmental cognitive neuroscience*, *1*(1), 7-21.

Johnstone, S. J., Dimoska, A., Smith, J. L., Barry, R. J., Pleffer, C. B., Chiswick, D., & Clarke, A. R. (2007). The development of stop-signal and Go/Nogo response inhibition in children aged 7–12 years: performance and event-related potential indices. *International Journal of Psychophysiology*, *63*(1), 25-38.

Jonkman, L. M. (2006). The development of preparation, conflict monitoring and inhibition from early childhood to young adulthood; a Go/Nogo ERP study. *Brain research*, *1097*(1), 181-193.

Kenny, L., Remington, A., & Pellicano, E. (2024). Everyday executive function issues from the perspectives of Autistic adolescents and their parents: Theoretical and empirical implications. *Autism*, 13623613231224093.

Kimhi, Y., Shoam-Kugelmas, D., Agam Ben-Artzi, G., Ben-Moshe, I., & Bauminger-Zviely, N. (2014). Theory of mind and executive function in preschoolers with typical development versus intellectually able preschoolers with autism spectrum disorder. *Journal of autism and developmental disorders*, *44*, 2341-2354.

Kortz, M. W., & Lillehei, K. O. (2021). Insular cortex.

Koziol, L. F., & Lutz, J. T. (2013). From movement to thought: the development of executive function. *Applied Neuropsychology: Child*, *2*(2), 104-115.

Kulišťák, P. (2017). Klinická neuropsychologie v praxi. Univerzita Karlova – Nakladatelství Karolinum.

Leung, R. C., Vogan, V. M., Powell, T. L., Anagnostou, E., & Taylor, M. J. (2016). The role of executive functions in social impairment in Autism Spectrum Disorder. *Child Neuropsychology*, *22*(3), 336-344.

Luna, B., Doll, S. K., Hegedus, S. J., Minshew, N. J., & Sweeney, J. A. (2007). Maturation of executive function in autism. *Biological psychiatry*, *61*(4), 474-481.

Maenner, M. J. (2023). Prevalence and characteristics of autism spectrum disorder among children aged 8 years—Autism and Developmental Disabilities Monitoring Network, 11 sites, United States, 2020. MMWR. Surveillance Summaries, 72.

Maximo, J. O., Cadena, E. J., & Kana, R. K. (2014). The implications of brain connectivity in the neuropsychology of autism. *Neuropsychology review*, *24*, 16-31.

Mohammad-Rezazadeh, I., Frohlich, J., Loo, S. K., & Jeste, S. S. (2016). Brain connectivity in autism spectrum disorder. *Current opinion in neurology*, *29*(2), 137-147.

O'Hearn, K., Asato, M., Ordaz, S., & Luna, B. (2008). Neurodevelopment and executive function in autism. *Development and psychopathology*, *20*(4), 1103-1132.

Padmanabhan, A., Garver, K., O'Hearn, K., Nawarawong, N., Liu, R., Minshew, N., ... & Luna, B. (2015). Developmental changes in brain function underlying inhibitory control in autism spectrum disorders. *Autism Research*, *8*(2), 123-135.

Pasqualotto, A., Mazzoni, N., Bentenuto, A., Mule, A., Benso, F., & Venuti, P. (2021). Effects of cognitive training programs on executive function in children and adolescents with autism spectrum disorder: a systematic review. *Brain sciences*, *11*(10), 1280.

Prochazka, R., Orel, M. (2021). *Vývojová neuropsychologie*. Grada Publishing as.

Rubia, K., Smith, A. B., Woolley, J., Nosarti, C., Heyman, I., Taylor, E., & Brammer, M. (2006). Progressive increase of frontostriatal brain activation from childhood to adulthood during event-related tasks of cognitive control. *Human brain mapping*, *27*(12), 973-993.

Stuss, D. T. (2011). Functions of the frontal lobes: relation to executive functions. *Journal of the international neuropsychological Society*, *17*(5), 759-765.

Tamm, L., Hamik, E. M., Zoromski, A. K., & Duncan, A. (2024). Use of the Weekly Calendar Planning Activity to Assess Executive Function in Adolescents With Autism Spectrum Disorder. *The American Journal of Occupational Therapy*, *78*(1), 7801205040.

Uddin, L. Q. (2021). Brain mechanisms supporting flexible cognition and behavior in adolescents with autism spectrum disorder. *Biological Psychiatry*, *89*(2), 172-183.

Vágnerová, M. (2020). *Vývoj pozornosti a exekutivních funkcí*. Raabe.

Vágnerová, M. (2023). *Vývojová neuropsychologie*. Raabe.

Vara, A. S., Pang, E. W., Doyle-Thomas, K. A., Vidal, J., Taylor, M. J., & Anagnostou, E. (2014). Is inhibitory control a 'no-go'in adolescents with autism spectrum disorder? *Molecular Autism*, *5*, 1-10.

Vasa, R. A., Mostofsky, S. H., & Ewen, J. B. (2016). The disrupted connectivity hypothesis of autism spectrum disorders: time for the next phase in research. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, *1*(3), 245-252.

Wang, Y., Zhang, Y. B., Liu, L. L., Cui, J. F., Wang, J., Shum, D. H., ... & Chan, R. C. (2017). A meta-analysis of working memory impairments in autism spectrum disorders. *Neuropsychology review*, *27*, 46-61.

Yeung, M. K., Bai, J., & Mak, K. L. (2024). Longitudinal changes in executive function in autism spectrum disorder: A systematic review and meta-analyses. *Autism Research*.

Zelazo, P. D. (2002). Executive function in typical and atypical development. *Handbook of childhood cognitive development/Oxford: Blackwell*.

Zhang, Z., Peng, P., & Zhang, D. (2020). Executive function in high-functioning autism spectrum disorder: a meta-analysis of fMRI studies. *Journal of autism and developmental disorders*, *50*, 4022-4038.

Contact:

Tereza Rošíková, tereza.rosikova@osu.cz
Jan Appeltauer, jan.appeltauer01@upol.cz.

II. International Experience in Prospective Memory Training

Enhancing prospective memory in adolescents: The ReToRe project in Czechia

Tereza Rošíková, Tereza Benešová, Lucie Kytnarová

1. Introduction to the project

As the name Remember to Remember (ReToRe) suggests, the project focuses on the concept of prospective memory. The aim of the project is three-fold. The first part of the aim was to introduce the concept of prospective memory to adolescents and the general public. Second subsequent aim was the development of materials that would enable further advancements of prospective memory including additional development of other 'background' training materials (ongoing tasks, OT) focused on executive functions. Lastly, since metacognition plays a significant role in prospective memory, collection of qualitative information concerning metacognitive strategies used by adolescents was the last part of the project.

Scientific evidence provides support for the importance of training prospective memory especially in adolescence (e.g. Altgassen, Kretschmer, & Schnitzspahn, 2017; Bowman, Cutmore, & Shum, 2015, Schneider, 2010). In the upcoming sections, the concept of prospective memory shall be introduced. Additionally, executive functions and metacognition will be investigated since they play a significant role in the development and functioning of prospective memory. Materials developed for the purpose of the project will be introduced. Lastly, ReToRe realisation in the Czech republic will be covered.

1.1 Understanding Prospective Memory

Prospective memory (PM) is the ability to remember to perform an action at the appropriate time in the future (Rummel & Kvavilashvili, 2023). This memory type contrasts with retrospective memory, which involves recalling past events or facts. Prospective memory plays a key role in everyday activities, including remembering to attend appointments, finish assignments, or call a friend at a scheduled time (Dismukes, 2012). The manifestations of prospective memory impairment may vary because all memory tasks that are associated with frontal lobe function depend on spontaneous formation of an effective strategy (Umeda et al., 2011). Prospective memory problems account for more than half of our everyday

memory problems. In adolescence, the capacity to manage future intentions is critical for academic success, social interactions, and personal development (Guo et al., 2023).

Prospective memory in adolescence

Research highlights the critical role of prospective memory in adolescence. Adolescents are at a pivotal stage in cognitive development, during which their ability to manage future intentions is maturing. Studies have shown that prospective memory is vital for managing the demands of school, home life, and social environments (e.g. Altgassen, Kretschmer, & Schnitzspahn, 2017; Bowman, Cutmore, & Shum, 2015).

McDaniel and Einstein (2000) distinguish two types of prospective memory: event-based (remembering to perform an action when a specific cue occurs) and time-based (remembering to execute an intention at a specific time). Both types are necessary for adolescents, especially in an educational setting, where they must manage multiple assignments, deadlines, and extracurricular activities.

Research by Cheng et al. (2012) indicates that prospective memory can be trained effectively through practice and that this training has significant implications for improving self-regulation and executive functions (working memory, attention etc.). Adolescents with well-developed prospective memory abilities are better able to manage time, prioritize tasks, and switch between different activities, all of which are essential for academic success and social functioning.

When planning training sessions in the ReToRe project, a combination of both training strategies was adopted (Hering et al, 2014). Prospective memory training often took place through a hands-on practice of various prospective tasks. Participants were given various prospective tasks during group sessions, but also through homework.

When creating the prospective tasks, emphasis was placed on their connection to everyday life of older school-aged children (solving situations at school or during free time). For prospective tasks, the basic process consisted of four phases:

1. Forming and encoding an intention.
2. Postponing the intention while dealing with another (ongoing) task (OT).

3. Inhibiting and switching from the OT to resuming the intention at an appropriate/planned time in the future.
4. Intention execution.

In the context of the ReToRe project, prospective memory is a central focus because it directly influences how adolescents plan, execute, and manage tasks. The ability to remember and execute intentions at the right time underpins many academic and personal responsibilities, such as remembering to complete homework assignments, attending after-school events, or fulfilling social obligations.

1.2 Understanding executive functions

In the broadest sense, executive functions refer to those abilities that enable us to adapt flexibly to changing conditions and to move from one situation to another (Lezak, Howieson, & Loring, 2012). In a narrower sense, it is an umbrella term for abilities that include planning, problem solving, working memory, inhibition, shifting or changing settings, switching attention from one task to another, cognitive flexibility, initiating action and organizing the course of action, updating or tracking and encoding incoming relevant information and replacing irrelevant information with new, relevant information, and monitoring or continuously monitoring one's own cognitive performance (Gaál, 2011; Koukolík, 2012). The executive function training materials draw on the division of executive functions given above and the working memory model of Baddley and Hitch (1974).

Working memory refers to the brain's capacity for short-term abstraction and manipulation of information and is a fundamental neurocognitive process in various aspects of everyday functioning (Owens, Duda, 2018). Working memory lies at the boundary between executive functions and memory, and its smooth, integrative progression is essential in everyday life (Rodriguez, 2017). Baddeley and Hitch's (1974) original model divides working memory into systems that are used to store information, namely the phonological loop and the visuospatial sketchpad. The main part of this model is the central executive whose task is to coordinate the two systems mentioned above and to coordinate and access information from and to long-term memory (Czop and Heretik, 2016). In 2000, Baddeley extended the original model to include an additional component, the episodic stack The revised working memory model (Figure 1) thus provides a better basis for addressing more complex aspects of executive control in working memory (Baddeley, 2000).

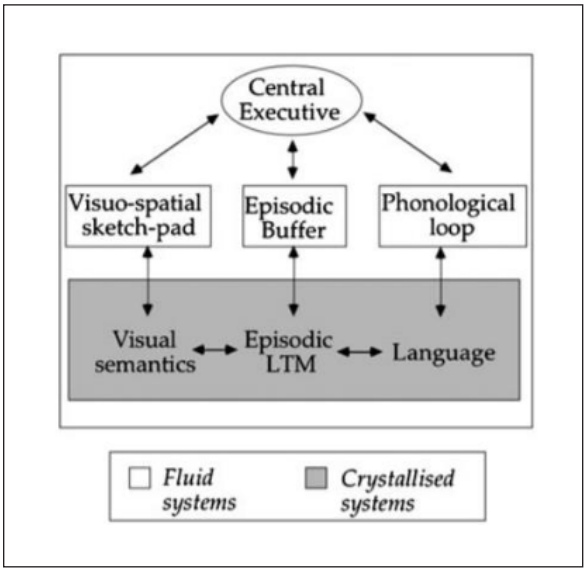


Figure 1: Baddeley's model of working memory (Baddley, 2012)

Difficulty in executive function has a significant impact on quality of life, particularly on independence (Lezak, Howieson, & Loring, 2012). In addition, Fillingham et al. (2006) also state that intact working memory and executive function reflect the ability to learn in the therapeutic process. Studies across different age categories speak in favour of significant effects of working memory training and the possibility of significant transfer to untrained tasks (Strobach, Karbach, 2021). The observed effects of working memory training could be particularly useful for individuals for whom low working memory capacity is limiting in academic performance and everyday life (Klinberg, 2010). According to Owens and Duda (2018), working memory training improves performance on working memory tasks and also increases the activity of the executive neural network for working memory. The observed effects of working memory training could be particularly useful for individuals for whom low working memory capacity is limiting in academic performance and everyday life (Klinberg, 2010). According to Owens and Duda (2018), working memory training improves performance on working memory tasks and also increases the activity of the executive neural network for working memory. These functions are also essential for functional communication, as communication is largely based on the process of initiation, problem solving, monitoring, and changing mental settings (shifting) in terms of executive function components.

Importance of executive functions in adolescence

Research consistently highlights the importance of executive functions in adolescent development. Lezak et al. (2012) emphasize that executive functions play a pivotal role in adapting flexibly to new situations

and challenges. Adolescents with impaired executive functions often experience difficulties in managing academic workloads, navigating social relationships, and making responsible decisions.

A study by Fillingham et al. (2006) found that well-developed executive functions, particularly working memory, and inhibitory control, are strongly correlated with academic performance. Similarly, Klingberg (2010) and Owens and Duda (2018) suggest that training working memory and other executive functions can have a significant impact on improving cognitive control and academic achievement.

1.3 The role of metacognition

Metacognition involves thinking about one's thinking, including the awareness and control of one's cognitive processes. Adolescents with strong metacognitive abilities are better able to reflect on their learning, identify strategies that work for them, and regulate their cognitive behaviour. As they approach more complex tasks, they can assess what strategies might be most effective and adjust their approach accordingly.

Metacognitive development in adolescence

Research has shown that metacognition develops throughout childhood and adolescence, reaching greater sophistication in the teenage years. Adolescents with well-developed metacognitive skills are more likely to employ effective learning strategies, assess their performance critically, and adjust their approaches based on reflection and feedback (Schraw & Dennison, 1994). Metacognitive awareness is linked to academic success, as adolescents who monitor their own learning and adjust their strategies tend to perform better in school and demonstrate higher levels of problem-solving ability (Veenman et al., 2006). By improving metacognitive skills, adolescents can better regulate their prospective memory and executive functions, ultimately leading to more effective decision-making, planning, and task execution. In the ReToRe project, metacognitive training materials are designed to help adolescents reflect on their thinking, evaluate their progress, and adjust their strategies as needed.

1.4 ProxyQB

The project included an additional prototype tool – a cognitive neurorehabilitation tool ProxyQB. ProxyQB consists of 4 plastic cubes virtually connected to a tablet containing a specialised software (see Figure 2). The software enables creation of tasks specialised on training of various cognitive functions

such as working memory, attention, inhibition, emotion recognition etc. For the purposes of the project, 6 tasks were created (for more detailed information see Section 2.3). The aim of using the ProxyQB prototype was primarily to track participants' progress over time, providing real-time feedback to both adolescents and researchers.

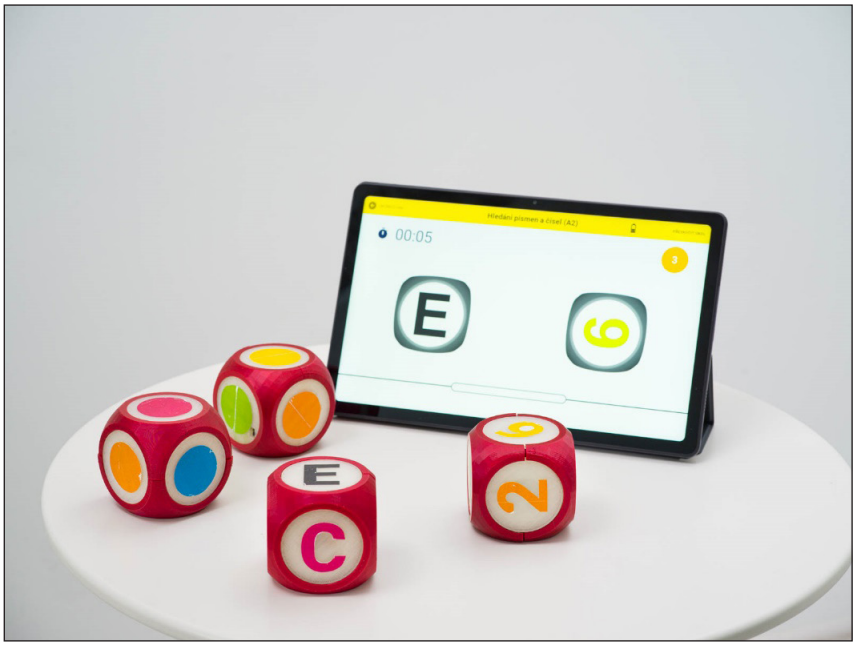


Figure 2. The ProxyQB set.

The ReToRe project integrates prospective memory, executive functions, and metacognition into a holistic training approach. Adolescents engage in tasks that require them to plan for future actions, manage cognitive resources, and reflect on their strategies. By combining these cognitive domains, the project helps adolescents develop the skills they need to navigate both present and future demands effectively. The tasks developed as part of the project shall be described in the following section.

2. Task and materials development

All the materials were created by a team of the project coordinator, psychologist, and therapist Mgr. et Mgr. Tereza Benesova, PhD., a speech therapist Mgr. Lucie Kytnarova, PhD., and a paediatric neuropsychologist Tereza Rosikova, MSc. A graphic designer was responsible for the visual side of the materials. The ProxyQB prototype was used with permission from a developer of the tool, clinical psychologist, and a therapist PhDr. Petr Nilius, PhD. Language mutations were created in cooperation with IT specialists who also provided technical support for all the participating partners.

Tasks targeting prospective memory

The ReToRe project integrates prospective memory tasks designed to engage both event-based and time-based memory. The tasks are structured to mirror real-life situations where adolescents need to remember to perform actions in the future.

An example of a prospective memory task used in the project:

Prospective Task I:

1. *Task preparation*: The administrator prepares an assignment consisting of a client sheet, map (Figure 3), playing pieces, and worksheets themed around different life scenarios such as Pharmacy, Helping a friend, and Cinema. These scenarios reflect realistic situations adolescents encounter in their everyday lives.
2. *Introduction*: The adolescent reads the assignment, and the administrator ensures that the task is clearly understood. Afterward, the administrator assigns background tasks that focus on executive functions.
3. *Task execution*: During the background tasks, the adolescent is prompted by a green circle symbol displayed on the screen. This symbol serves as a cue for the adolescent to shift their focus to the prospective memory task. The adolescent must place the figure on the map at the appropriate location and select the corresponding image from the worksheet.
4. *Return to background tasks*: After completing the prospective task, the adolescent returns to the background executive function tasks, allowing the practice of task switching and other cognitive processes.

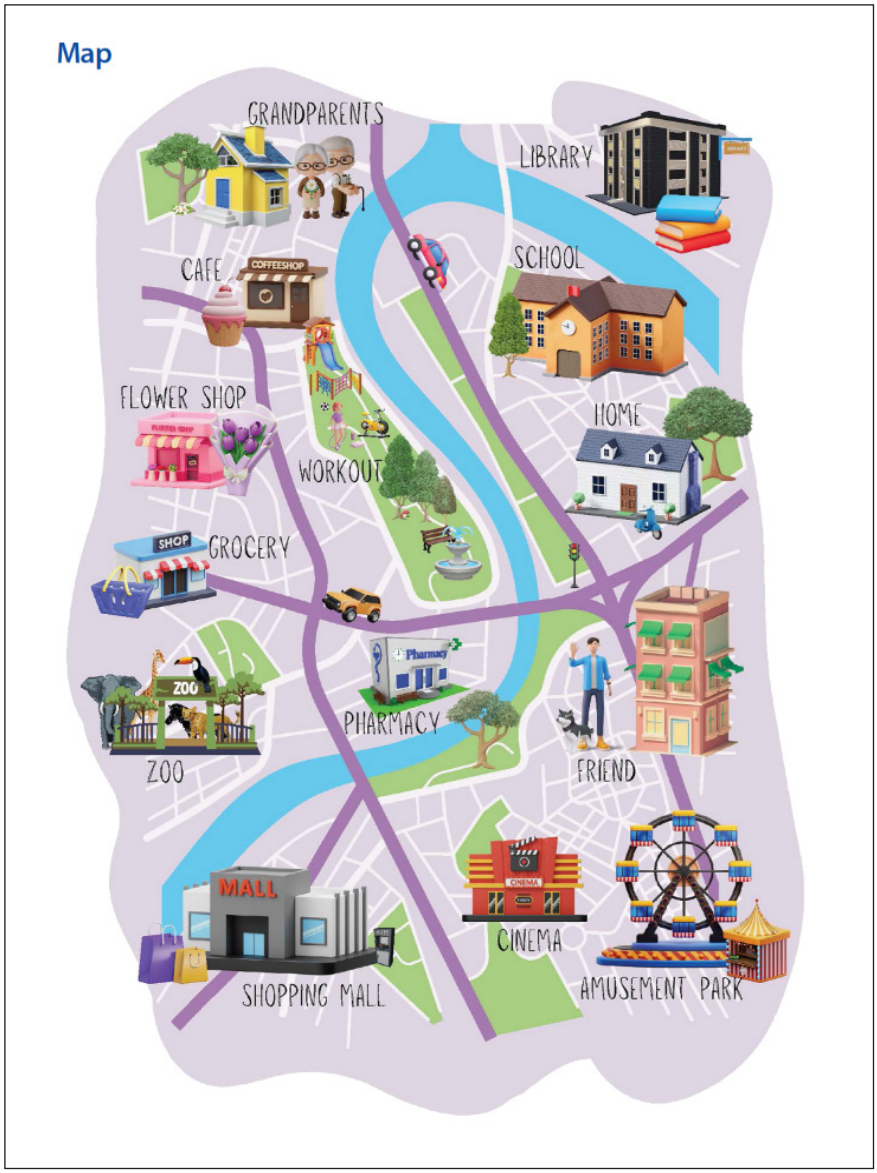


Figure 3. A map used in the PM tasks.

When constructing tasks for event – based or time-based PM, additional task parameters were followed (McDaniel and Einstein, 2007):

1. Delayed implementation of the plan.
2. The role of the PM is embedded in an ongoing activity.
3. The window for initiating an intent is limited.
4. The time scale for the implementation of the project is limited.
5. The intention (intent) must be present.

The tasks were designed to challenge both event – based and time – based prospective memory, thus helping participants develop the ability to recall intentions at the appropriate moment, whether triggered by an external event or by an internal time cue.

2.1 Tasks targeting executive functions

In the ReToRe project, executive function tasks were designed to enhance adolescents' working memory, cognitive flexibility, and inhibitory control, thereby fostering improved performance in both academic tasks and daily life activities. The individual tasks are based on the above mentioned theory and their design was further inspired by publications for training memory and cognitive functions in general, e.g. "Memory Training for the Whole Year" and "Memory Training for Every Age" by Jitka Suchá, "Cognitive Functions and their Rehabilitation in Clinical Practice I-IV" by Štěňová and Ostatníková (2011), Cognitive Training in Practice (Klucká, Volfová, 2009), worksheets and diagnostics by Bednářová (2015, 2021, 2022). Various mobile apps and computer programs for memory and working memory training served as additional inspiration. Knowledge about test tasks from diagnostic tests designed for clinical diagnosis of memory, attention and executive functions also played a role in developing the tasks (e.g., the Stroop test or the so-called n-back tests, the d2 attention test or the Trail making test). Lastly, exercises which had been developed by students Alžběta Dubská, Helena Sobieská, Amálie Jahodová, Veronika Polášková and Michaela Myslíková in diploma theses, under the guidance of Mgr. Lucie Kytnarová, Ph.D., were incorporated. For an example of a task focused on working memory, more specifically its component called phological loop, see Figure 4.

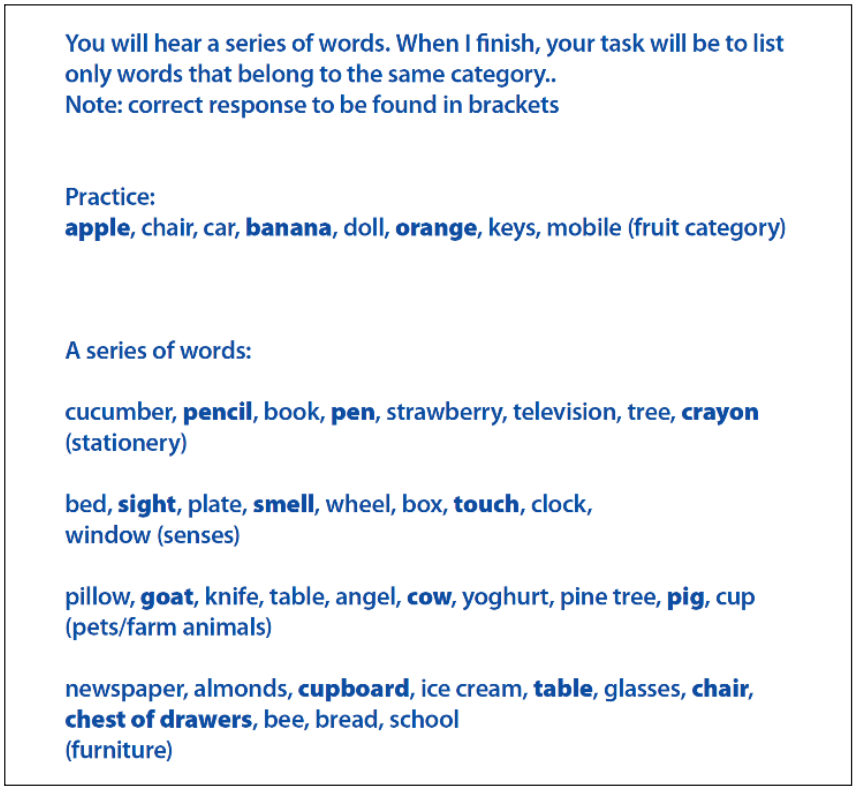


Figure 4. Example task focused on phonological loop.

2.2 ProxyQB tasks

The tasks included:

1. Phonological attention: A task where adolescents are required to identify two colours based on auditory cues. This exercise targets auditory attention and working memory, training the ability to manage and retain information for a brief period.
2. Visuo – spatial memory: Adolescents are asked to memorize a combination of letters and numbers displayed briefly on a screen, evaluating their visual working memory and spatial attention.
3. Two psychomotor tasks: These tasks engage psychomotor skills and attention. Adolescents are required to hold and manipulate physical cubes while following visual cues on a screen, training their ability to coordinate motor actions with cognitive processing.
4. Attention speed: In this task, adolescents identify and locate corresponding symbols on physical cubes after receiving a series of visual cues on a screen. This task focuses on divided attention and executive planning.
5. Emotion processing: Adolescents identify basic emotions of avatars and assign them to corresponding emotion names, such as fear, happiness etc.

3. ReToRe in the Czech republic

3.1 Descriptives of the training

Materials were originally created in Czech language, therefore, neither translation was required, nor cultural adjustments. Children aged 11 – 16 years were recruited through Junior university programme organised by the Technical university of Ostrava (VSB – TUO) and from Ambulance klinicke psychologie s.r.o (Amkp). A specialised ReToRe training called "Improve your memory for the future'' was organised in three periods: the first period ran from October 30rd 2023 to December 11th, 2023, second from March 18th, 2024, to May 6th, 2024, third November 11th, 2024, to December 16th, 2024. Training was led by the same team which designed the materials: project coordinator, psychologist, and therapist Mgr. et Mgr. Tereza Benesova, PhD., a speech therapist Mgr. Lucie Kytnarova, PhD., and a paediatric neuropsychologist Tereza Rosikova, MSc. Overall, 13 children without mental health issues participated in the programme at the university to examine training effectiveness in healthy developing adolescents. These children did not have any psychopathologies, however, specific learning deficits were present. In addition, some participants underwent the training in order to improve their learning skills. 8 other children who also participated in the programme were regular patients of Amkp s.r.o. They presented with various neurodevelopmental disorders including Autism spectrum disorder and stuttering.

3.2 Training Procedures and Implementation

The training program consisted of six 50 – minute group sessions. Seventeen of the twenty participants completed the full program; one attended only one session, another withdrew after four sessions. Technical issues with ProxyQB meant that the ProxyQB part of the training was included in the sessions only for the group of adolescents who participated in the first period of training.

Each session was organised in the same way. Before each session, the room and materials were prepared. There was no clock in the room, therefore, participants could monitor the time on the administrator's phone, with the set time serving as a cue for the prospective memory task. After participants arrived, an accepting atmosphere was created for the adolescents to feel comfortable. A topic of the session was presented with an introduction to the present executive function covered. Children were asked about real-life examples of using certain function to ensure their understanding. Subsequently, a story from the PM set of tasks was read. When waiting for cues, children participated in the OT tasks covering executive functions. After each training, participants answered questions

regarding metacognition, e.g. what strategies they used to succeed in the tasks, what they could do next time etc. (see Attachment 1). Since the training was organised as a group training, participants could benefit from the company of others and gain further inspiration in terms of other metacognitive strategies applied by their peers. At the end of each session, participants were given optional homework tasks (for examples see Attachment 2). These tasks encouraged independent prospective memory practice until the next session. Moreover, since the tasks served mainly as an inspiration and participants were asked to invent their own homework tasks, children's creativity was also encouraged.

3.3 3.3 Outcomes and limitations of the project

There were 3 subsequent parts of the project's aim:

1. Introduction of the concept of prospective memory to adolescents and general public.
2. Development of materials that would enable further advancements of prospective memory. Additional development of other 'background' training materials focused on executive functions.
3. Collection of qualitative information concerning metacognitive strategies used by adolescents.

The first part of the project's aim was fulfilled. In addition to the training, the project was introduced during Psychologicke dny in Olomouc in September 2024. A conference focused on the topics addressed by the project was organised on November 29th, 2024.

The second part of the aim was partially fulfilled. All the materials were developed to the highest standards, however, no assessment of participant's advancements was undertaken. The ProxyQB prototype did not prove as a useful tool in assessing progress due to the various technical difficulties encountered during the training sessions. In total, only the second group of adolescents during the second period of training was able to successfully complete all the 6 tasks once.

The third part, i.e., collection of qualitative information about metacognitive strategies, was successfully completed. The most commonly used strategies included:

- visualising the task scenario
- connecting real life experiences to the task scenario
- repetition of task information and demands to oneself.
- checking time for time-based tasks on one's phone.

Conclusion

The ReToRe project has provided valuable insights into the enhancement of prospective memory and executive functions in adolescents. By designing targeted tasks that engage both prospective memory and executive functions, the project has contributed to improving awareness of the concept of prospective memory, provided training opportunities for both prospective memory training but also executive function training, and added various metacognitive strategies that had proven to be essential for academic success, social adaptation, and personal development.

The scientific evidence highlights the importance of these cognitive functions in adolescence. As adolescents develop the capacity to manage future intentions and regulate their behaviour, they are better equipped to navigate the challenges of growing up. The integration of ProxyQB as a tool for data collection has unfortunately only partially allowed for real-time monitoring of progress due to the technical issues.

By focusing on prospective memory and executive functions, the ReToRe project has provided adolescents with the cognitive tools necessary to succeed academically and manage everyday challenges, thus contributing to their overall cognitive development and well-being. The significance of metacognitive strategies as part of the learning and training process was also supported.

References

Baddeley, A. (2000). The episodic buffer: a new component of working memory? *Trends in Cognitive Sciences*, 4(11), 417-423.

Baddeley, A. (2012). Working memory: Theories, models, and controversies. *Annual Review of Psychology*, 63, 1-29.

Baddeley, A., & Hitch, G. (1974). Working memory. *Psychology of Learning and Motivation*, 47-89.

Bednářová, J. (2021). *Orientation in space and time for children from 4 to 6 years old: When it was, where it happened, the bear cub wandered* (3rd ed.). Edika.

Bednářová, J., & Šmardová, V. (2015). *Diagnosis of the preschool child: What a child should know between the ages of 3 and 6* (2nd ed.). Edika.

Bednářová, J., & Šmardová, V. (2022). *Diagnosis of the preschool child 2: What a child should know at the age of 3 to 6 years*. Computer Press.

Bowman, C., Cutmore, T., & Shum, D. (2015). The development of prospective memory across adolescence: An event-related potential analysis. *Frontiers in Human Neuroscience*, 9, 362.

Cheng, Y., Wu, W., Feng, W., Wang, J., Chen, Y., Shen, Y... & Li, C. (2012). The effects of multi-domain versus single-domain cognitive training in non-demented older people: A randomized controlled trial. *BMC Medicine*, 10, 1-13.

Czop, O., & Heretik, A. (2016). Working memory and executive function: Concepts, relationships, and controversies. *Annales Psychologici*, Brno: Masaryk University, Vol. 2016, No. 2, 67-80.

Dismukes, R. K. (2012). Prospective memory in workplace and everyday situations. *Current Directions in Psychological Science*, 21(4), 215-220.

Dubská, A. (2021). *Creation of therapeutic material focused on executive function disorder from the perspective of neuronal multifunctional approach to aphasia therapy*. Olomouc: Palacký University Olomouc. Faculty of Education.

Fillingham, J. K., et al. (2006). The treatment of anomia using errorless learning. *Neuropsychological Rehabilitation*, 16(2), 129-54.

Gaál, L. (2011). *Executive functions - taxonomy and clinical manifestations of their disorders*. In *Case studies in clinical neuropsychology*. Prague: Karolinum.

Guo, Y., Gan, J., Wang, W., Ma, J., & Li, Y. (2023). Prosocial motivation can promote the time-based prospective memory of school-age children. *PsyCh Journal*, *12*(2), 222-229.

Hering, A., Rendell, P. G., Rose, N. S., Schnitzspahn, K. M., & Kliegel, M. (2014). Prospective memory training in older adults and its relevance for successful aging. *Psychological Research*, 78, 892-904.

Jahodová, A., & Polášková, V. (2023). *Development of cognitive functions in children with developmental language disorder in a speech therapy perspective*. Olomouc: Palacký University Olomouc. Faculty of Education.

Klinberg, T. (2010). Training and plasticity of working memory. *Trends in Cognitive Sciences*, 14(7), 317-324.

Klucká, J., & Volfová, P. (2009). *Cognitive training in practice*. Prague: Grada.

Koukolík, F. (2012). *Human brain: Functional systems, norm and disorders*. Prague.

Kytnarová, L. (2019). *Cognitive rehabilitation in persons with aphasia in a speech therapy perspective*. Olomouc: Palacký University Olomouc. Faculty of Education.

Lezak, M. D., Howieson, D. B., & Loring, D. W. (2012). *Neuropsychological Assessment* (5th ed.). New York: Oxford University Press.

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition*, 14(7), S127-S144.

Myslíková, M. (2021). *Development of therapeutic material focused on attention deficit disorder from the perspective of neuronal multifunctional approach to aphasia therapy*. Olomouc: Palacký University Olomouc. Faculty of Education.

Owens, M. M., Duda, B., Sweet, L. H., & MacKillop, J. (2018). Distinct functional and structural neural underpinnings of working memory. *NeuroImage*, 174, 463-471.

Rummel, J., & Kvavilashvili, L. (2023). Current theories of prospective memory and new directions for theory development. *Nature Reviews Psychology*, 2(1), 40-54.

Rodriguez, M. (2017). Cognitive remediation in schizophrenia. In P. Kulistak et al. (Eds.), *Neuropsychology in clinical practice* (pp. 627-651). Prague: Karolinum.

Schneider, W. (2010). Metacognition and memory development in childhood and adolescence. Metacognition, strategy use, and instruction, 54, 81.

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*, 19(4), 460-475.

Šteňová, V., & Ostatníková, D. (2011). *Cognitive functions and their rehabilitation in clinical practice I-IV.* Bratislava: Mabag.

Strobach, T., & Karbach, J. (Eds.). (2021). *Cognitive training*.

Sobieská, H. (2020). *Creating material focusing on cognitive flexibility in people with aphasia*. Olomouc: Palacký University Olomouc. Faculty of Education.

Umeda, S., Kurosaki, Y., Terasawa, Y., Kato, M., & Miyahara, Y. (2011). Deficits in prospective memory following damage to the prefrontal cortex. *Neuropsychologia*, 49(8), 2178-2184.

Veenman, M. V., Van Hout-Wolters, B. H., & Afflerbach, P. (2006). Metacognition and learning: Conceptual and methodological considerations. *Metacognition and Learning*, 1, 3-14.

Contacts:

Tereza Rošíková, University of Ostrava, tereza.rosikova@osu.cz
Tereza Benešová, VSB – Technical University of Ostrava, tereza.benesova@vsb.cz
Lucie Kytnarová, University of Ostrava, lucie.kytnarova@osu.cz

Attachments

Attachment 1: Self-evaluation

PROSPECTIVE MEMORY
SELF-EVALUATION

- What was I asked to remember?
- Was the task important to me?

PREDICTION

I expected the tasks to be

simple  difficult

I chose those aids/strategies to help me remember better: .....

.....

.....

.....

EVALUATION

Did I complete the tasks as asked? yes no

I completed the task well because .....

.....

.....

I did not complete the task well because .....

.....

.....

The aids/strategies I chose were useful  useless

.....

.....

Next time I would try to use aids/strategies such as .....

.....

.....

RETORE REMEMBER TO REMEMBER

··· 2 ···

Co-funded by the European Union

Attachment 2: Prospective memory homework tasks examples

PROSPECTIVE MEMORY TASKS
(CLIENT)

Special tasks:

1. Count out loud from 1 to 50. For each number that contains the number 3, raise your hand.
2. Draw circles. After every 5th circle, draw a line.
3. Say aloud the story of the Little Red Riding Hood. Every time you say Little Red Riding Hood, slap your thigh.
4. Play the song using the link below. Every time you hear the word „happy", jump up and down. Pharrell Williams - Happy (Video) - YouTube
5. When it starts to rain, smile at someone in the room.

During the day tasks:

1. Every time you eat breakfast, write down what you will do all day.
2. In the morning, put a piece of paper in your pocket. When you see a red car, throw the piece of paper in a bin.
3. When you go to school/for a walk and see a dog, touch your hair.
4. Every lunch break, note down the time you go for lunch on your phone.
5. Every time you sign your name, put a period after your signature.
6. Every time you come home, read one page from any book.
7. Every time you start doing your homework, use a stopwatch on your phone to see how long it takes.
8. Every time you have diner, check the time.
9. Every day at 6 pm, do a set of jumping jacks, a few squats, go for a workout, a jog…
10. Every time you go to sleep before 10 p.m., draw a line.

Social media tasks:

1. Every time you open social media on your phone (e.g. Instagram, Facebook, TikTok), have a drink.
2. Write a list of small tasks you would like to accomplish. Each time someone calls you, carry out one of the tasks.
3. Every time you text someone, eat a piece of vegetable or fruit.
4. Every time you write a message on Messenger, learn a new word in a foreign language.
5. When you like something on Instagram, lock and unlock your phone.

Remember To Remember in Belgium

Delphine Sasanguie, Griet De Nys

1. Introduction

1.1 The Remember to Remember Research Project

The Remember to Remember (ReToRe) project was a collaboration led by the Technical University of Ostrava's Project Support Centre (Czech Republic), with partnerships from the Technical University of Ostrava (Czech Republic), Haskoli Islands (Iceland), Hogeschool Gent (Belgium), and Akademia Techniczno-Humanistyczna W Bielsku-Bialej (Poland). Funded by the Erasmus+ Programme under KA201 – Strategic Partnerships for school education, this project spanned 36 months from January 2022 to December 2024.

The primary objective of Remember to Remember was to develop an innovative toolkit with various tasks aimed at enhancing 'prospective memory' and 'metacognitive skills' of children with learning disabilities and/or Autism Spectrum Disorder (ASD). The tool(kit) consists of worksheets about prospective memory, worksheets about executive functions, self-evaluations about metacognition and digital ProxyQB, and was developed by Mgr. et Mgr. Tereza Benesova, PhD., Mgr. Lucie Kytnarova, PhD., and Tereza Rosikova, MSc. As part of the project, children aged 12 – 15 years underwent 10 training sessions (1 per week). Each training session, children participated in prospective memory tasks in combination with executive functions tasks. Based on these test training experiences in all countries, the toolkit has been refined by all partners throughout the project.

Secondly, by targeting prospective memory and metacognitive skills via the toolkit, the project aimed to expand the range of possible remedial interventions available at the time for cognitive training, particularly tailored to children with ASD and learning disabilities. Part of the project was a publication of a monograph written by the collaborative team from all the cooperating countries, i.e. a specialized publication on Prospective Memory and Metacognitive / Executive functions training. This chapter is a part of the monograph, focusing on the experiences and results from the training in Belgium.

1.2 Education in Belgium

In Belgium, the education system is structured by regions, with distinct regions for the Dutch-speaking community (Flanders), the French-speaking community (Wallonia) and the German-speaking community (in the eastern part of the country). Each community manages its own educational system. In Flanders, the northern region of Belgium, the educational system is organized into several distinct stages: 1) preschool or kindergarten education (2.5 – 5 year olds), 2) primary education (6 – 12 year olds, grades 1 – 6) and 3) secondary education (12 – 18 year olds, grade 7 – 12). Tertiary education is offered at colleges and universities. Most children attend preschools or kindergartens from the age of 2.5 – 3 years, and it is obligatory from the age of 5 years (education, n.d.).

Secondary education in Flanders offers students a choice among various tracks based on their interests, abilities, and future aspirations. These tracks include general education (Algemeen Secundair Onderwijs, ASO), technical education (Technisch Secundair Onderwijs, TSO), vocational education (Beroepssecundair Onderwijs, BSO), and arts education (Kunstsecundair Onderwijs, KSO). The ASO track is academically oriented, preparing students for higher education (doorstroomfinaliteit), while TSO, BSO, and KSO offer more practical and specialized training, with options for students to enter the workforce (arbeidsgerichte finaliteit) or pursue further education (dubbele finaliteit).

Learning support centres provide additional support to schools when existing care measures are not sufficient. They help when a pupil follows an individually adapted curriculum or when a pupil follows mainstream education with intensive support. Learning support focuses on the needs of pupils as well as teachers and school teams. It also builds on school care measures which are already in place (Naar een Decreet Leersteun Voor Leerlingen met Specifieke Onderwijsbehoeften, n.d.). These centres consist of expert health care professionals (e.g. speech therapists, occupational therapists, clinical psychologists, remedial teachers...). The goal is to ensure that students with special educational needs (SEN) can participate fully in regular classroom activities while receiving additional help they need.

Supporters from learning support centres, often referred to as “ondersteuners,” play a crucial role in the system. They are specialized professionals - such as special education teachers, therapists, and psychologists - who work closely with students, teachers, and schools. Their support takes various forms, including direct assistance to students, i.e. helping them with specific learning tasks or managing behavioural challenges. They also provide indirect support by advising teachers on how to adapt their teaching methods or classroom environment to meet the needs of all students better.

Furthermore, “ondersteuners”/supporters collaborate with parents, teachers, and other professionals to develop individualized education plans (IEPs) for students with SEN. These plans outline specific goals and also strategies used to achieve the goals, ensuring that each student receives tailored support that aligns with their unique needs (*Wat? - OT Pixel*, 2023).

For the ReToRe project, we collaborated with supporters from three learning support centres. Three members of one learning support centre, here and after referred to as ‘supporters’, trained children with the ReToRe toolkit from January to May 2024. Three other supporters of three different centres trained children from November to December 2024. All the 20 trained children were diagnosed with learning disorders and/or ASD which was an inclusion requirement of the project. They needed support in areas of executive functions, prospective memory, and/or metacognition. That is, the support needs of these pupils had to include the need for the development of executive functions, prospective memory, and/or metacognition. Only in this way could the available time the supporters have with their pupils also be justified for this project. The project fits into the objectives of this organisation, provided it also meets the needs of the pupils (see the last section - Discussion).

2. Methodology

2.1 Participants

Seven trainers participated in total. Three of these trainers were affiliated with the Learning Support Centre PIXSY, an organization specializing in educational interventions targeting children with learning disabilities. Three other trainers were linked to three different supportive teams. The last participating trainer was from Hogeschool Gent. Thirteen students were trained by ‘trainers-supporters’ from one learning supportive.

20 children were trained aged 11 to 15 years (M = 12 years 5 months). Each child was diagnosed with developmental and/or learning difficulties and required special support. For more details see Table 1.

Table 1. Descriptive information about participants.

Age	Developmental and/or learning difficulties
11	Reading and spelling disorder
11	Reading and spelling disorder
11	Autism Spectrum Disorder (ASD), ADHD & Dyslexia
11	Autism Spectrum Disorder (ASD) and ADHD

Age	Developmental and/or learning difficulties
11	Spelling disorder, motor impairment, Autism Spectrum Disorder (ASD)
11	Autism Spectrum Disorder (ASD)
11	Dyslexia
11	Dyslexia
11	ADHD and Giftedness
12	Dyscalculia
13	Spina bifida type 4 (motor impairment)
13	Autism Spectrum Disorder (ASD)
13	Learning difficulties
14	Developmental dysphasia, speech, and language development disorders
15	Autism Spectrum Disorder (ASD)
15	Autism Spectrum Disorder (ASD)
15	Autism Spectrum Disorder (ASD)
15	Autism Spectrum Disorder (ASD) and ADHD

20 students who participated in the “Remember to Remember” project will have completed the full series of training sessions by December 2024. The first group of 15 children was trained from January to May 2024. The remaining 5 children were trained from November to December 2024. therefore, data from the remaining 5 children were not available at the time the chapter was created. The diverse group of respondents provided a comprehensive view of the opportunities available in working with children with learning disabilities and offered valuable insights.

2.2 Procedure: Training sessions

Fifteen children were trained individually in Belgium from January 2024 to May 2024, 5 children from November 2024 to December 2024. The training program consisted of 5 to 7 sessions per student. One session mostly lasted 50 minutes, the same time limit as a school period. Twelve of the 15 respondents who already finished the training needed 5 sessions to complete the training, while the remaining 2 respondents needed 6 sessions, and one needed 7 sessions. Each session was carefully structured, and a detailed protocol was followed to ensure consistency and to maximize the effectiveness of the interventions:

- Each session began with the trainer completing an observation document. That included asking about the child’s mood and noting it down.
- The trainer then introduced a prospective memory task (2. 3. 1 Materials Prospective Memory). The student was given a document with the task instructions, along with a drawn plan of a fictive

city and a pawn to use during the tasks. The student was given time to read and memorize the instructions before the document was removed and only the card and the pawn remained. After introducing the prospective memory task, the trainer continued with executive function worksheets (2. 3. 2 Materials Executive functions).

- At regular intervals or after a specific signal, the trainer asked the student to recall and perform the previously introduced prospective memory task. The necessary materials were then provided to the student to perform the task. Throughout the sessions, the trainer monitored the student's progress on both the background tasks and the prospective memory tasks. If the student encountered difficulties, the trainer gave partial directions to guide the child. The trainer could differentiate in their approach.
- Each prospective memory task had 3 different subtasks. The prospective memory task was finished when the 3 tasks were completed or when the 50 minute time limit expired.
- 15 minutes before the end of a session, each child completed 6 digital exercises from a pre-planned task set prepared on a tablet that was connected to ProxyQB (2. 3. 3 ProxyQB). The tasks were the same for every child in all the involved ReToRe partner countries. All answers were recorded including response time and correct answers.
- Each session ended with the respondent completing a self-assessment (2. 3. 4 Metacognition). The trainer discussed metacognitive strategies that were used during the prospective memory-games with the child, so the child could reflect on them and to recommend other strategies for next time.
- Finally, the trainer gave a short assignment for the student to work on in the following week (homework). The homework, or more little tasks to think of during the upcoming week included tasks like: 'touch your hair every time you see a dog / touch your knee when you blow your nose / write down how long you work for school every day /...'. In the following session, the trainer could ask if the child remembered to do the homework.
- All observations and notes were accurately recorded in an observation document by the trainer.

The methodical approach ensured that each training session was both consistent and adaptable to the individual needs of the participants, providing valuable data about the interventions. The combination of prospective memory tasks with executive function exercises was created in a way so that a child with learning disabilities could benefit from cognitive development.

2.3 Materials

In a chapter by Tereza Rosikova, materials created and used in this project are described. The Remember-To-Remember toolkit consists of a set of prospective tasks, a set of exercises focused on executive functions, a self-assessment tool for metacognition, and a set of a tablet and 4 plastic cubes, Proxy QB.

The ReToRe set of tasks consists of the 5 prospective memory tasks, 6 executive function tasks and ProxyQB set. The main purpose of this whole test package is to investigate 1) whether children become faster and better at exercises within the ProxyQB set as the training sessions progress, 2) to gain insight into the metacognitive strategies children use in fulfilling the prospective tasks and 3) the experience of the trainers of using the ReToRe toolkit.

3. Results

3.1 ProxyQB

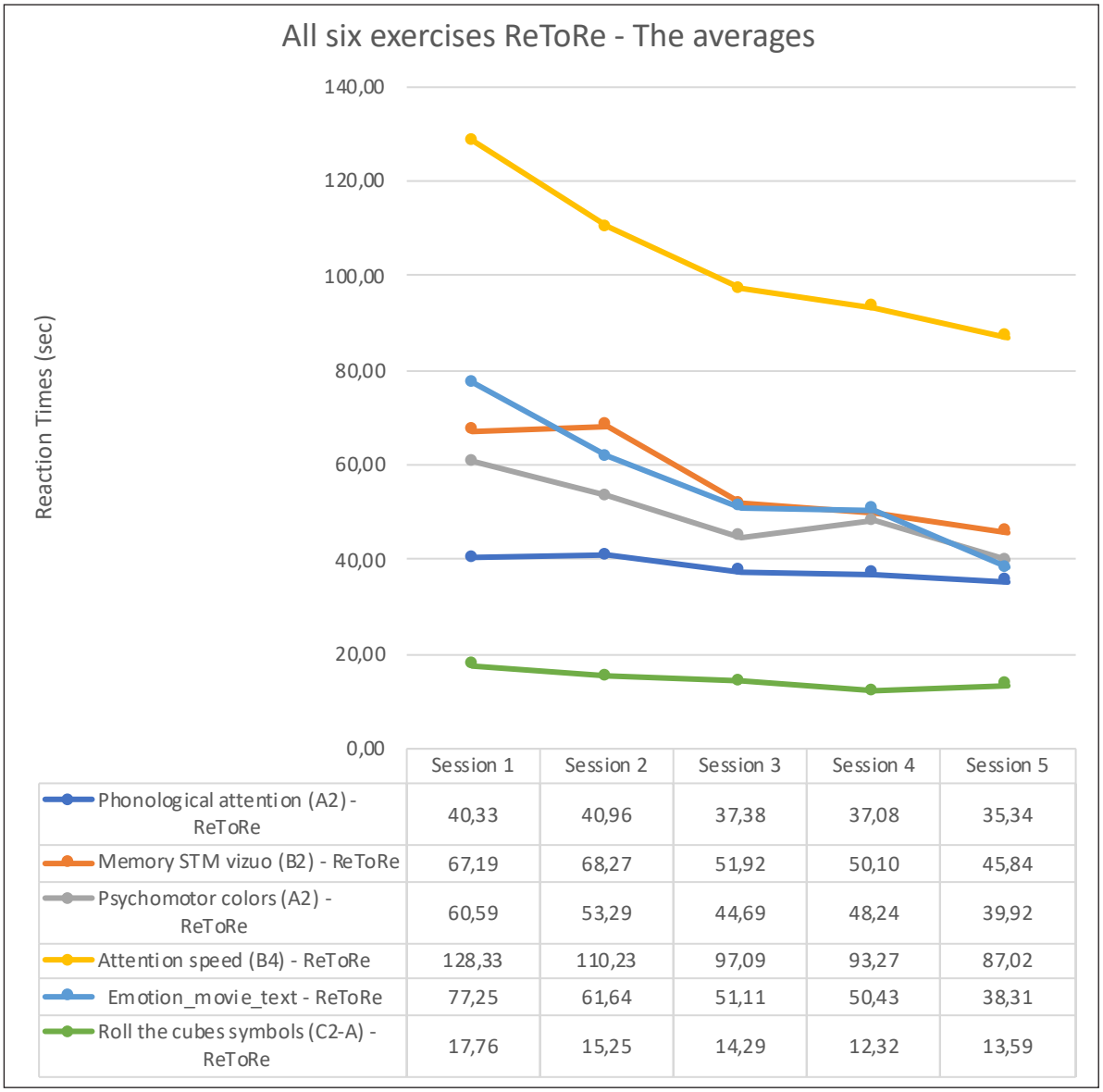
The aim was to use the ProxyQB set at the end of each session. However, since the set was a prototype, many technological problems occurred. For the set to work, a few requirements needed to be fulfilled including a good Wi-Fi connection, well-charged cubes, and a tablet. There were also issues with login into the system, orienting in the application ProxyQB and finding the right tasks. In the first month of training, it was not yet clear (or not possible) that a rehabilitation programme had to be followed, so exercises were first selected manually, and later the software itself suggested 6 exercises. Due to all the issues described above, during training, it was often impossible to fulfil all the required 6 tasks. Despite that, some questions related to the ProxyQB training were answered:

1) Do children achieve higher speed in fulfilling the tasks as training progresses?

A total of 15 children (N=15) performed 6 exercises each session, for 4 to 9 sessions each time, according to the software. If someone needed more than 5 sessions, the average of the last sessions was taken as the mean for session 5.

The software recorded the time in seconds, up to 2 decimal places. Outliers with SD=3 were not included in the results.

The graph below shows the mean time (M) needed by the 15 students (N=15) to complete the 6 exercises in 5 sessions. The time taken per exercise was measured in seconds (up to two decimal places) and is shown for five consecutive sessions. The data were analysed without outliers (SD > 3) and the mean time per sequence was calculated.



	Session 1	Session 2	Session 3	Session 4	Session 5
Phonological attention (A2) - ReToRe	40,33	40,96	37,38	37,08	35,34
Memory STM vizuo (B2) - ReToRe	67,19	68,27	51,92	50,10	45,84
Psychomotor colors (A2) - ReToRe	60,59	53,29	44,69	48,24	39,92
Attention speed (B4) - ReToRe	128,33	110,23	97,09	93,27	87,02
Emotion_movie_text - ReToRe	77,25	61,64	51,11	50,43	38,31
Roll the cubes symbols (C2-A) - ReToRe	17,76	15,25	14,29	12,32	13,59

The horizontal axis shows 5 sessions (session 1 to session 5). On occasion, session 5 is considered an average: if students needed more than 5 sessions to complete the exercises, an average of sessions 5 to 9 is taken and this value is assigned to session 5. That value is then considered to calculate the average of that range for all students for that exercise.

The y-axis (vertical axis) shows the average time (in seconds) required to complete the exercise. There were 6 exercises to complete, so 6 average times are shown per session, 1 per exercise with the ProxyQB.

For each exercise, the average for session 1 is lower than the average of session 5. In the first session, the average time was higher than in the last session. A continuous decreasing trend is the case only for exercise B4-Attention speed. In the 5 other exercises, the values fluctuate. The graph shows that the average time taken by the students to complete the exercises is shorter in the last session compared to session 1.

3.2 Metacognition

Metacognition involves planning, monitoring, and evaluating. The self-assessment document probed for the students' metacognitive skills when completing the prospective tasks. In more detail, this self-assessment document is about metacognitive evaluation. Namely, it involves adjusting and correcting the student's own cognitive activities and behaviours in response to the student's evaluation of performance during the tasks (Broadbent et al., 2021). The self-assessment tool specifically asks about students' metacognitive strategies in tackling the prospective task and not about their approach to exercises around executive functions. Out of the total of 79 separate training sessions among all the 15 respondents, a total of 32 self-evaluations was completed. The 15 respondents completed a self-assessment paper on average 2.13 times, each time at the end of a session in their training series. One student did not complete any self-assessment paper (0 out of 5, lower limit), and 1 student after each session (5 out of 5 in total, upper limit). Of the remaining 5 learners whose training is currently ongoing, no self-assessment documents were incorporated into these results.

Through this self-assessment tool, this study aims to answer the research question:

2) Which metacognitive strategies do students use during Remember-To-Remember tasks, more specifically in the Prospective memory exercises?

Answers given by the students in the self-assessment document after training were collected. The answers were gradually obtained under the guidance of the trainer and thus better described on the self-assessment document. The answers students gave are task strategies. Task strategies include strategies that helped students integrate and connect new information with previous knowledge, select appropriate information and also make connections between the information to be learned, and

apply previous knowledge to these new tasks (Broadbent, 2021). The answers were categorised into six random categories based on learning strategies:

- **Visualisation** refers to a visual representation of the info to be memorised.
- **Auditory strategy** is linked to an auditory skill used to remember the info**.**
- **Time-based strategies:** Where time measurement was needed according to learners to complete prospective tasks successfully.
- **Active learning:** When students did something with the task information.
- **Repeating:** When a student said they repeated the subject matter.
- **No strategy:**
  - if students explicitly stated they did not use a strategy or had no idea what they were required to do.
  - if students said they used their brain, without telling how or what they did.
- **Other:** Where all other answers that did not fit previous categories fall into.

Questions that were left blank (and thus not answered) were not included in the above answers.

The analysis did not show whether a certain type of answer was given by one pupil in different self-assessment papers or whether several pupils gave the same type of answers, thus suggesting a use of the same strategy. That applied to all the questions discussed in this analysis.

Below, answers to the following question(s) were organised into the following categories as based on open coding.

Questions: 'I chose to use these strategies beforehand' and 'Next time, I will try this strategy to remember even better'.

- **Visual strategies:** 10 answers referred to a visual representation of the info required to be remembered: Using the city plan (visual support) / Writing it down / Holding fingers / Tapping fingers / Using fingers / Using environment / Imagining it in my head / Visual thinking / Looking in front of me, imagining it / Visualisation.
- Examples of active learning was given 5 times:
  - Selecting info and sequencing / Reading everything correctly
  - Key words / Key words / Key words.

- Repeating: 4 times student(s) gave an answer about repeating:
  - Repeat in my head / Repeat / Repeat/ Repeat before executing.
- **Other**: 8 answers were categorised under Other: Because I understand correctly / Doing my best / Doing the right thing / Asking for help / Doing everything right / Depends on the exercise I get / Doing the same or more / Creating categories, patterns.
- **No strategies:**
  - 6 times students explicitly stated that they had no idea whether and what strategy they (would) use: No idea / I didn't really have a strategy / No strategy / I still don't know / No idea / I don't know.
  - 15 answers in the self-assessment paper were strategies about 'using their brain': Because I've been thinking / Using brain / In my head / Everything in my head / Just remembering / Learning / Thinking about the subject / Remembering (brain) / Thinking better, using head better / Using brain / Using my brain / My brain / My brain / My brain / My brain.
- **Time-based strategies:** 6 responses were given where time measurement was required: Using a timer / Alarm clock / Using an alarm clock / Timing on a mobile phone / My mobile phone / Using a clock.
- **Auditory strategies:** 5 answers were categorised as an auditory strategy when students were required to verbally produce an answer: Speaking out loud / Saying a command out loud / Out loud / Repeating it in my head or out loud / Repeating it in my head and out loud before performing.

Together, the 2 questions were answered 58 times in the 79 self-evaluations submitted. 'Use brain' is the answer most often read in the self-assessment documents. The answers to the first question were the result of 2 questions which might give a biased picture in the number of answers compared to the following questions where 1 question was asked, answered, and analysed each time.

Below, the literal answers to the question 'What helped you succeed in the exercises?' are organised. The result after open coding of the question was:

- **1 x Time-based strategy:** Mobile phone used to see the time.
- **4 x Auditory strategies:** Listened to the explanation / Listened well / Listened to what you said / Listened to the task, understood it, and knew what I had to do.
- **1 x Visual strategy:** Visualised.

- **11 x No strategy:** Just made it / Ready quickly / Thinking well / I remember it / Remembering well / Being smart / Because I think / Because I used my brain / Remembering / Because I am smart / Being able to remember a lot.
- **9 x Other:** Using tricks / Because I did it right / Because I did it well / I knew what to do / Used tricks / Good concentration / I tried my best / Because I did what I was asked to / Executed everything.

The question was answered 28 times out of 79 papers, which was less compared to the previous two questions. Answers were also more dispersed. 'Think' or 'Remember' remained the most frequently chosen answer. The other answers were more scattered.

Students' answers to the question 'What did NOT work well in the exercises?' were collected as well. The results obtained after open coding of the question were:

- **Time-based strategies**: none
- **Auditory strategy**: none
- **Visual strategy:** none
- **No strategy:** I don't know.
- **Other:**
  - **Attention:** Confused / Not paying attention.
  - **Good or wrong:** Mistaken / Wrong / Because I made mistakes / Mixed up something / Because not everything was correct.
  - **Remembering:** Forgot something / Too much to remember / Forgot.
  - Did not read assignment properly / Difficult.

The majority of answers were linked to 'did something wrong' without telling more or 'remembering' as the reason why the exercises failed.

In all the answers, students not only gave their strategies for the prospective tasks, but also for the executive functions' exercises. Answers like 'use fingers' and 'categorise' were not possible in the prospective tasks, but they were possible to use in the executive function exercises.

Trainers indicated that learners found it difficult to complete the self-assessment document without guidance. Guidance proved necessary to make learners think actively as they were often unable to reflect on their own cognitive processes. Following the finding, more support was provided by the trainers in

completing the document during later sessions. As Ku and Ho (2010) point out, “In fact, any non-real-time measurement that requires participants to recall their cognition after task completion would give an incomplete picture of the actual thinking process” (p. 254-255). This suggests that obtaining valid data on the cognitive processes during task performance would be more effective than collecting information afterwards, which was not the case in the training.

Collecting valid information before or after an exercise about a learner’s thinking process is not straightforward. For instance, it is difficult for participants to be aware of a cognitive process or how it relates to whether one manages a task well (Ku & Ho, 2010). The answer ‘I don’t know (yet)’ / ‘no idea’ was given by several students when asked what tricks or strategies they used or wanted to use when doing the prospective assignments. Unanswered questions were not included in this analysis. Trainers said that help was needed to write something down.

Metacognitive skills increase with age and develop during adolescence, partly due to growth in self-awareness (Weil et al., 2013). However, no information was collected within this study on the correlation between students’ age and the strategies they chose.

3.3 Feedback from the trainers

A total of seven trainers were involved in this study. Three trainers are still working with the materials at the time this report was written. Their experiences are not described here. Four trainers who already tested the full package, each with at least 2 students, had a generally positive experience, although they also mentioned some challenges in response to the research question:

3) What is the trainers’ experience in using the ReToRe toolkit?

The materials

The materials used during the trainings, including the folder with exercises on prospective memory and executive functions, and the digital set (ProxyQB), were considered very useful by the trainers. After some adaptations to the Flemish context, the materials were well applicable in a classroom practice. However, the Proxy-QB did brought frustration, as they often did not work properly at first and were not always easy to connect to the tablet or charge. One trainer also regretted that the ProxyQB could not be used by them in the long run (only prototypes owned by the Technical university Ostrava). The children

really liked the ProxyQB, which was an important incentive for their involvement in the exercises. The exercises on prospective memory and executive functions were perceived as clear and well-constructed, although the material needed a good translation to the Flemish context as well as having to be clarified in various assignments among the trainers for the different trainers to conduct the assignment in the same way. The possibility of some interpretation in the exercises was seen as an advantage, as it allowed trainers to tailor exercises to the students' needs.

Added value for learners

All trainers reported interesting insights into the ways their learners approached the tasks. They found that learners often managed challenges creatively, especially when they got stuck with a specific executive function. By actively questioning which strategies the learners used, the trainers noticed that some learners creatively sought detours to reach a solution. That offered them an opportunity to tailor their approach to the individual needs of the learners. In addition, the trainers were surprised to see how resourceful and motivated the learners were, especially as they were able to keep their attention throughout an hour-long session. The toolkit package provides trainers with information about the learner that they often did not gather in other ways. Thus, the toolkit provided a good addition to the other observations to get a broader picture of a child.

Added value for the trainers

The trainers themselves also learned valuable lessons. Patience often proved necessary, especially when technology did not cooperate, such as the Proxy-QB or tablets. They also developed a better understanding of executive functions and learned how those can be trained in practice during a one-to-one training. One of the trainers indicated that organising and preparing the sessions was essential for smooth running, and that good preparation in advance, such as selecting assignments for the next day, made a lot of difference. The executive functions of the trainers themselves were also challenged to ensure the training sessions ran smoothly and to keep an overview of everything that was happening during the sessions.

Deploy ability in day-to-day operations

The trainers saw many opportunities to further deploy the knowledge and materials they had worked with in the future. For instance, they thought of elaborating the exercises so that they could be used in

classes instead of just a one-to-one training. They also thought of spreading the toolkit more widely to other schools. The idea of turning the materials into a classroom game appealed to one of the trainers, as that could further increase students' engagement. Another trainer hoped it would be possible to continue using the Proxy-QB cubes in the future so that pupils' progress could be monitored. The latter was unfortunately not possible.

Meaningful elements and missed aspects

The trainers especially appreciated the opportunity to collaborate and exchange feedback with colleagues and researchers. The folder with exercises on prospective memory and executive functions was considered very useful. The support from both HOGENT and the project coordination in the Czech Republic was praised, as was the openness to feedback. One point of criticism concerned the sometimes too large space for free interpretation, which led to the need for more guidelines and clarity on how to interpret certain sessions. Time pressure was also perceived as a challenge, as the combination of multitasking and organising the sessions sometimes proved difficult.

4. Discussion

4.1 ProxyQB

The exact link between the paper game set and the digital set is not clear. To what extent did learners become faster with the ProxyQB due to more practice opportunities? The link between the speed of the ProxyQB and the paper worksheets could be made specified.

The data was corrected by removing outliers with SD < 3, as indicated in the methodology. The wide margin also allowed for some outliers which strongly influenced certain peaks in the graph of some students. From the experience of the trainers, the technical aspects could influence the times, which may well explain some outliers.

Due to the diverse group of children (read various learning difficulties) and the various trainers-supporters, it was not always clear what influenced the results. The reason behind certain high or low speeds could not be identified.

4.2 Metacognition

Comparing the number of answers did not lead to a clear picture, as some questions were combined. However, the type of answer pupils gave did provide some information about the chosen task strategy. Learners mainly mentioned memory as the main strategy in tackling the prospective tasks. The way answers were phrased, limited and superficial, such as 'my brain', 'because I am smart' and 'remember well' showed little conscious metacognitive insight, which the literature also confirmed (Ku et al., 2010). The extent to which those learners effectively deployed task strategies versus the awareness of those deployed metacognitive strategies was not clear from this study. Indeed, according to Ku & Ho (2010), being aware of the metacognitive strategies used is difficult and requires guidance during the metacognitive process. Trainers also indicated that the students involved needed thorough guidance to formulate an answer to the questions from the self-assessment form and students found it difficult to answer the questions. The limited number of answers and the superficiality could show that this awareness process required much more intensive guidance to move from a task strategy to metacognitive strategies.

4.3 Feedback trainers

According to the trainers, the cooperation went smoothly, both with the people from the Technical university - Czech Republic (project coordination) and the researcher from HOGENT. The material was perceived as useful. Technical problems with the ProxyQB negatively impacted efficiency. Despite the positive aspects, all trainers indicated that the project was time-intensive, both in terms of the trainings and writing down observations to process the data. However, they appreciated the support and room for feedback in the approach to the trainings and the materials, as well as the freedom in interpretation and accommodation of the materials to the needs of their learners. Nevertheless, the latter is described as a pitfall research-wise. Learners were motivated to work with the toolkit. It gave the trainer-supporter new information about the learners in terms of their attention, strategies and approaches to prospective tasks and tasks requiring executive functions.

4.4 Limitations

The ReToRe toolkit contained a range of engaging, challenging learning games that could be extended for a wider audience beyond pupils with learning difficulties and learning disabilities. It gave trainers a lot of freedom to deploy the games in a way that best suited pupils' needs. The multiplicity and

freedom also brought many opportunities for variation and interpretation. The various interrelated components were difficult to separate: the exercises requiring prospective memory, the exercises demanding executive functions, metacognitive strategies about prospective memory and the digital ProxyQB. Thus, it was not possible to disentangle metacognitive strategies about prospective tasks from the exercises focused on executive functions. The therapists' observational data contained fascinating information, although it was difficult to compare because the therapists were given broad viewpoints. Targeted therapist observation points were necessary to gather targeted information.

The package was designed for one-to-one counselling, which, in most educational settings, this was only possible in specific cases or therapeutic settings. Supporters in education need to be responsive and in tune with the student's care and support needs in their support of students. Training executive functions and prospective memory was often not yet seen as a priority for many pupils, schools, and parents, especially when compared to language and maths needs. Trainers, on the other hand, did see the added value of the package focusing on executive functions and prospective memory in students with learning disabilities, as well as in a broader student population.

Finally, it was difficult to find learners and tutors willing to participate into the project. Children with learning disabilities in education were given limited support hours, thus making it difficult to have that time taken up by a project on executive functions and prospective memory which was not among the priorities of their specific care needs and demands. Usually support in mathematics and language was often asked of support workers.

5. Conclusion

On average, students completed the ProxyQB tasks in session 5 across all six exercises compared to session 1. Evidence supporting a positive impact of the ReToRe worksheets on performance in the ProxyQB tasks was not clear. Neither was the impact of the technical problems on average speeds.

Students found it difficult or superficial to name strategies throughout the whole ReToRe toolkit task 'Using their brain' or 'Just memorise' were among the most mentioned strategies according to learners themselves for doing their assignment well. Using a time-related strategy was thought of, but hardly mentioned in response to why a task went or did not go well. What strategies exactly were used for the prospective memory tasks versus the executive function exercises was unclear. The answers to the questions in the self-assessment documents did show that guidance was necessary for students to

reflect on their thinking processes, to go from task strategies to real metacognition. Without support, students found it difficult to name their (metacognitive) strategies, which was also evident from the literature (Ku & Ho, 2010).

Trainers were positive about the ReToRe toolkit in terms of the paper version. Concerning the digital ProxyQB, learners were enthusiastic, but a lot of technical problems were experienced. For trainers, using the ReToRe toolkit required some preparation and challenged their executive functions. It was a challenge to see the training series implemented in the already existing coaching of the sought-after target group. Helpful support in both preparation and during the training sessions was appreciated. Great freedom of interpretation and approach was both a plus and a minus. The toolkit gave the trainers a different, refreshing picture of their students regarding attention, approach, and strategies.

Acknowledgements

This research was supported by HOGENT's Learning in Diversity research centre and made possible thanks to the support of Erasmus+: Project identification code: 2021-1-CZ01-KA220-SCH-000032703

The research was approved by the Ethical Committee of the Faculty of Psychology and Educational Sciences of Ghent University (2023-024).

Three trainers from supportive Centre Pixsy were involved from the beginning. They participated in fine-tuning the training materials to make everything ready for use. All materials were thoroughly explored, tried, critiqued, and adjusted, for which great thanks. We thank all the students and their supporters who participated in this project together and the parents for their trust and approval.

References

Broadbent, J., Panadero, E., Lodge, J. & Fuller-Tyszkiewicz, M. (2021). *The Self-Regulation for Learning Online (SRL-O) questionnaire manual.* Retrieved from www.srl-o.com.

Education. (n.d.). Vlaanderen. Retrieved from https://www.vlaanderen.be/en/your-future-in-flanders/education-0.

Ku, K. Y., & Ho, I. T. (2010). Metacognitive strategies that enhance critical thinking. *Metacognition and learning*, *5*, 251-267.

Naar een decreet leersteun voor leerlingen met specifieke onderwijsbehoeften. (n.d.). Retrieved from https://onderwijs.vlaanderen.be/nl/directies-administraties-en-besturen/onderwijsinhoud-en-leerlingenbegeleiding/basisonderwijs/zorgbeleid-leerlingenbegeleiding-en-clb/leerlingen-met-specifieke-onderwijsbehoeften/naar-een-decreet-leersteun-voor-leerlingen-met-specifieke-onderwijsbehoeften.

Teng, M. F., Wang, C., & Wu, J. G. (2023). Metacognitive strategies, language learning motivation, self-efficacy belief, and English achievement during remote learning: A structural equation modelling approach. *RELC Journal*, *54*(3), 648-666.

Wat? - OT Pixel. (2023, 8 September). OT Pixel. Retrieved from https://pixsy.be/pixsy/wat/.

Delphine Sasanguie is the Research Coordinator of the Research Centre for Learning in Diversity at HOGENT University of Applied Sciences and Arts.

She received a Master in Educational Sciences (Special Educational Needs) and a PhD in Cognitive Developmental Psychology. Her main research focuses on the interplay between cognitive and affective factors influencing mathematical abilities.

Contact:

Delphine Sasanguie
Research Centre for Learning in Diversity HOGENT
Valentin Vaerwyckweg 1
9000 Gent
BELGIUM
Delphine.sasanguie@hogent.be

Griet De Nys is a researcher for the Research Centre for Learning in Diversity at HOGENT University of Applied Sciences and Arts and attached as a lecturer in the teacher training department of HOGENT.

She holds a Master's degree in Pedagogical Sciences and a Bachelor in early childhood education. Her research focus is mainly on school refusal as a form of school absences in children and adolescents.

Contact:

Griet De Nys
Research Centre for Learning in Diversity HOGENT
Valentin Vaerwyckweg 1
9000 Gent
BELGIUM
Griet.DeNys@hogent.be

ReToRe in Iceland: Challenges and Opportunities in Implementing a Cognitive Training Program

Sigrún Sif Eyfeld Jóelsdóttir, Ólöf Ragna Einarsdóttir, Kristín Harðardóttir

1. Introduction

Iceland's predominantly publicly funded education system comprises four levels: pre-school (2 to 6 years), compulsory (primary and lower secondary) (6-16 years), upper secondary (16 to 19 years), and higher education (19 and up). The central government sets policy, while municipalities manage pre- schools and compulsory schools, including their development, resources, special services, and oversight. Compulsory education is mandatory for children aged six to sixteen (Government of Iceland, n.d.; Compulsory School Act, 2008).

Municipalities are responsible for the operation and funding of primary schools, overseeing all aspects from school development and resource management to special services, evaluation, and policy implementation. According to Statistics Iceland (2022), during the 2022-2023 school year, Iceland had 174 public primary schools educating approximately 47,000 students (grades 1-10, ages 6-16). In 2023, 13 private schools enrolled over 1,450 students, and three special schools served 174 students. The majority of primary school children attend public schools.

Iceland's Compulsory School Act (2008) mandates inclusive education in regular primary schools for all students, regardless of physical or mental abilities. Students with specific learning disabilities or challenges, emotional or social difficulties, or other support needs (including dyslexia and chronic illnesses or other health-related support needs) are entitled to receive appropriate specialized support.

The Icelandic research team selected participants from support education programs in the greater capital area school for several reasons. Iceland's inclusive compulsory education system provides a diverse learning environment; teachers in these programs identified suitable candidates (aged 11-15 with mild learning difficulties or requiring support) based on pre-test criteria, with parental consent secured for participation. Consequently, the Icelandic ReToRe research team did not access any students' health or diagnostic information (developmental disorders, learning disabilities, etc.), as this was unnecessary for the pre-test and protected by Icelandic privacy laws and ethical research standards.

This study focuses on the Icelandic adaptation and implementation of the ReToRe pre-test training program. A key methodological choice was employing a single trainer within a familiar school setting to maximize participant comfort and data validity while minimizing extraneous factors. This approach is consistent with ethical research principles and enhances the reliability of the findings. The study focus further highlights the importance of cultural adaptation, modifying tasks to reflect Icelandic realities and employing culturally relevant examples. The inclusive nature of the Icelandic education system significantly influenced participant selection and training, offering valuable insights into the program's successful implementation within such an environment. This monograph analyzes the training materials' effectiveness, identifying key strengths and weaknesses through qualitative data gathered during the training process. The ultimate aim is to draw practical implications for future iterations of the ReToRe materials and to contribute to the broader field of special education training, demonstrating the complexities of adapting a standardized program to a specific cultural context and offering valuable insights for improving the training materials for diverse learners.

2. Methodology

The research team translated the materials from the English version to Icelandic, which a graphic designer then formatted according to the research coordinators' templates by late March 2024. However, further adaptations were necessary to reflect Icelandic realities. For example, since Icelandic law prohibits children from collecting pharmacy prescriptions, Task 1 (Prospective Memory) was revised to replace unfamiliar product labels with more familiar ones and to focus on over-the-counter products (vitamins, cough drops etc.) instead of prescription medications.

Collaboration with local elementary school administrations proved the most effective method for recruiting participants, obtaining parental consent, and conducting testing in familiar settings. Using a single researcher, rather than training additional personnel, was a more efficient approach given the pre-testing timeframe and the complexity of ensuring high-quality training to outside professionals without pre-existing results. While a school initially agreed to participate in spring 2024, it subsequently withdrew. The school year's conclusion in spring prevented the completion of the planned pre-testing at that point.

Parental consent was obtained from seven children during the summer break from a school in a municipality in the greater capital area. That school subsequently agreed to participate, encompassing 410 students aged 6-16. Informed consent was obtained from parents via school administration during

the first week of September, with the remaining participants recruited by the second week, as per the study protocol. Data collection was completed by the end of October 2024.

2.1 Training Procedures and Implementation

The trainer working with the children was a member of the Iceland research team. This choice was made to serve multiple purposes, including maintaining consistency in the pretest timeline and ensuring uniformity across training sessions and contextual settings. Furthermore, training sessions were conducted during school hours in the children's familiar school environment, with the school's permission, providing continuity and comfort for the participants.

The training program consisted of six 40-minute sessions per child, with an additional 15 minutes allocated for recording and preparation between sessions. Seventeen of the twenty participants completed the full program; one attended a single session, another withdrew after four sessions, and one refused to continue using the ProxyQB after the fourth session. Four participants missed one week of training due to illness, extending the overall program duration by one week. Technical issues with the ProxyQB and iPad app occasionally shortened sessions; however, the trainer ensured that all available data were recorded.

Before the student entered, the trainer set up the room (see Figure 1). The phone was placed at the orange dot, with a timer counting down from 35:00 minutes. Since there was no wall clock, the student could monitor the time on the phone when set time was a cue for the prospective memory task.

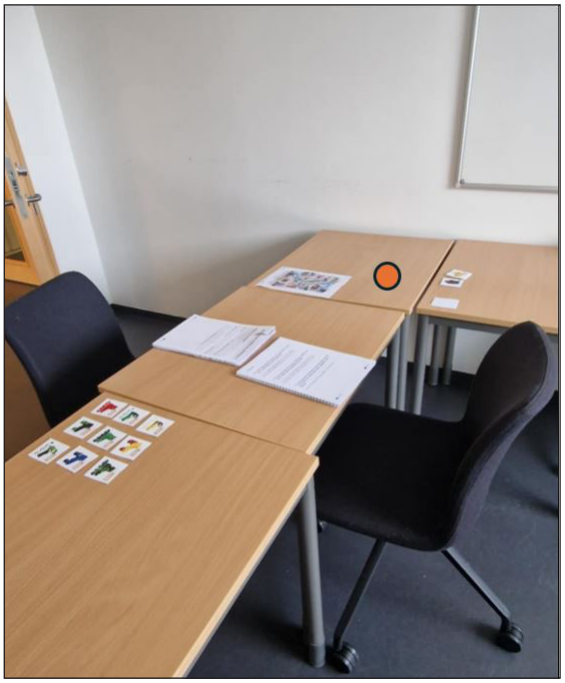


Figure 1. Training session setup and environment.

At the start of the first session, the trainer explained the session structure and thoroughly introduced the prospective memory task map and materials. Before each session started, participants were asked how they were feeling to record their mood and mental state. Table 1 details the session-by-session administration schedule.

Table 1. Organization of administration of worksheets throughout the sessions

Session	Executive functioning training worksheet	Prospective memory training worksheet
1	1–Colors	Prospective memory 1
2	2–Cancellation	Prospective memory 2
3	3–Working Memory Phonological Loop	Prospective memory 3
4	4–Working Memory Visuospatial Sketchpad	Prospective memory 4
5	5–Working Memory Episodic Buffer	Prospective memory 5
6	Worksheet 6 – Inhibition	Prospective memory 6

If students completed the assigned tasks during the session, they could use the Proxy-QB app on a tablet with four training cubes. Task performance data collected by the app was anonymized and processed by the University of Ostrava in the Czech Republic as part of the pilot study.

At the end of each session, participants received a simple, optional homework task, such as: “In the morning, put a small note in your pocket. When you see a red car, throw the note away.” These tasks encouraged independent memory practice until the next session. During follow-up discussions,

students were asked about their experiences, even if they only remembered to apply the memory rule once. Additionally, students completed a self-evaluation form with the trainer's guidance during each session to inform on metacognitive strategies if any.

2.2 Describing participants: Who the children are. Age, learning disability

Participants comprised 20 students (10 girls and 10 boys, aged 11-14) from a greater metropolitan area school, all of whom received supplemental educational support due to learning challenges. Of the 20 participants, most (15) were 11 years old, eight girls and seven boys. The remaining five participants included two 14-year-old girls, two 13-year-old boys, and one 12-year-old boy. As previously mentioned, the methodology employed by the Icelandic research team eliminated the necessity for specific diagnoses of learning disabilities, neurological disorders, or any other health conditions among the participating children.

Table 2. Participants: Age and gender

	Girl	Boy
11 years	8	7
12 years		1
13 years		2
14 years	2	
	10	10

3. Results

3.1 Prospective memory training – Observations and Adaptations

The trainer documented each prospective memory training session, noting participants' moods, tasks performed, necessary adaptations, and task difficulty. Tasks included everyday scenarios such as going to the pharmacy, helping friends, going to the movies, and shopping, as outlined in the worksheets. Notably, many participants completed all prospective memory tasks by the fifth session.

Participants showed considerable individual differences in mood during the sessions, which influenced their approach to tasks and stamina for completing assignments. Some were motivated and found tasks manageable, while others struggled or found tasks confusing, requiring additional guidance or re-explanation. Engagement and performance often aligned with the participant's initial mood.

Task difficulty varied among participants. Some managed tasks easily, while others struggled with multi-step planning, delayed recall, or linking visual prompts to tasks. Instructions were delivered step-by-step, with adjustments like simplification or cues (visual, verbal, or time-based) to aid understanding, initiation, and completion. Tasks often involved time-dependent components, requiring recall after a delay where participants frequently shared their perceptions of task difficulty.

Adaptations in trainer's instructions and application included providing instructions one at a time, using visual or verbal cues to prompt completion, and rephrasing or demonstrating tasks for clarity. Sessions ended with feedback discussions where participants reflected on challenges and successes. Positive reinforcement was regularly used to encourage and motivate them.

Many participants shared positive feedback about learning strategies for handling prospective memory tasks, though some expressed frustration with specific exercises. A common frustration among participants in prospective memory tasks centered on timing cues and recalling specific details. Some struggled to act at designated times or in response to visual cues, often needing reminders or prompts to complete tasks correctly. Tasks with multiple steps, such as those in Prospective Memory Tasks III, IV and V ("Shopping Mall" or "Grocery Shop"), highlighted difficulties in recalling specific items or following instructions accurately. While not universal, these challenges often required additional guidance or repeated instructions during timed, detail-oriented activities. The scenarios involved relatable everyday tasks such as shopping (e.g., grocery stores, malls), social interactions (e.g., helping friends or family), and contextual recall (e.g., linking images and cues to specific tasks). Motivation and mood significantly influenced performance, with positive encouragement helping participants stay engaged despite challenges. These observations underscore both the benefits and difficulties of prospective memory exercises in enhancing everyday memory skills.

Participants demonstrated diverse abilities, necessitating individualized support and adaptive teaching strategies to ensure successful completion of prospective memory tasks. The consistent presence of a single trainer likely facilitated this process by providing ongoing support and consistent instruction. Table 3 provides eight illustrative examples of common challenges, adaptations, and strategies used during prospective memory training, highlighting the individualized approach required to accommodate participant diversity.

Table 3. Examples of tasks, challenges, and observations from the trainer

	Task Example	Challenges and adaptation	Observation from trainer
Participant A	PROSPECTIVE TASK I PHARMACY – HELPING A FRIEND – CINEMA	Required instructions to be delivered one at a time, with tasks read aloud for clarity.	Found the tasks progressively more difficult, particularly in the third session. Felt the tasks were "very hard" but received reassurance from the trainer.
Participant B	PROSPECTIVE TASK III SHOPPING MALL – ZOO – COFFEESHOP AND A SWEET SHOP	Missed the cue to start the task but completed it correctly and on time with verbal prompting and a set timeframe.	Generally enthusiastic about tasks and performed them well but occasionally needed reminders for delayed tasks.
Participant C	PROSPECTIVE TASK IV GROCERY SHOP – HOME – AMUSEMENT PARK	Disliked certain other types of tasks (namely "Proxy Cubes") and expressed a strong aversion to them.	Despite general reluctance, completed the tasks correctly when guided.
Participant D	PROSPECTIVE TASK IV GROCERY SHOP – HOME – AMUSEMENT PARK	Required reminders when prompted by cues like to start the tasks and seemed distracted.	Expressed difficulty with timing but performed tasks accurately with slight delays.
Participant E	PROSPECTIVE TASK I PHARMACY – HELPING A FRIEND – CINEMA	No major challenges; completed tasks promptly upon seeing visual cues.	Enjoyed the tasks and found them straightforward.
Participant F	PROSPECTIVE TASK IV GROCERY SHOP – HOME – AMUSEMENT PARK	Missed certain steps (e.g., forgetting to pick up bread or skipping a visual prompt).	Found most tasks difficult and struggled to maintain focus, occasionally requiring additional prompts.
Participant G	PROSPECTIVE TASK I PHARMACY – HELPING A FRIEND – CINEMA	Used personal mnemonic strategies, like associating visual cues with actions (e.g., putting fingers down for cinema seating arrangements).	Enjoyed the session but noted that some tasks felt challenging.
Participant H	PROSPECTIVE TASK IV GROCERY SHOP – HOME – AMUSEMENT PARK	Required frequent guidance and reminders to complete tasks correctly.	Reported feeling tired and reluctant at times but completed tasks correctly when focused.

3.2 Executive Functioning Training: Observations and Adaptations

The observations from executive functioning training emphasize the need for personalized support, adaptable teaching methods, and active participant engagement in developing executive functioning skills. Addressing emotional and cognitive barriers facilitated significant progress, even in initially challenging tasks. Consistent support from the same trainer throughout sessions was observed to

improve participant comfort and confidence, enabling the trainer to address individual needs effectively. Adaptive training methods offered a more flexible learning environment, allowing participants to advance at their own pace. Engagement was crucial in maintaining participants' motivation and investment in their training.

Each session recorded by the trainer provided insights into the participants' performance on specific tasks, including both general performance and qualitative feedback, highlighting areas needing further attention. The training sessions revealed individual strengths and challenges, particularly in cognitive skills like memory, attention, focus, cognitive flexibility, self-regulation, and inhibition. Common challenges included difficulties with multi-step instructions or complex tasks and confusion from overlapping demands, such as remembering colors and numbers simultaneously. Fatigue and disinterest were also issues, particularly during longer or repetitive tasks.

The Executive Functioning Worksheet used in the third session, focused on the phonological loop, proved particularly challenging for many participants. This led to reduced enthusiasm and, in some cases, eventual disengagement in or after the fourth session. Notably, those who struggled the most and disengaged before completing all sessions were 11 years old, the youngest age group, highlighting the need to further adapt training materials to age and cognitive levels to address these persistent challenges, the trainer adapted the tasks by breaking them into smaller steps, providing repeated instructions, guided examples, and simplified explanations. Participants were encouraged to practice at their own pace. In contrast, other tasks in the training were completed more easily, suggesting that the worksheet itself may have flaws or that such tasks are inherently too difficult. Throughout the training period, incremental improvements in task performance were observed, supported by repeated practice, positive reinforcement, and encouragement, which helped reduce frustration and build confidence.

Participants provided feedback after each session, often highlighting specific tasks they found either challenging or enjoyable. The trainer used these discussions to offer reassurance and emphasize that encountering difficulties is a natural part of the learning process. Post-session discussions also helped identify particular areas of difficulty among participants.

Memory-based tasks, such as associating colors with numbers (e.g., Tasks 2a and 2b from the Reading and Naming Colors worksheet), were especially challenging when visual aids were removed. Multi-step tasks, like applying overstriking rules that involved combining conditions (e.g., "Strike out the letter D only when preceded by the number 3"), frequently caused confusion, particularly during task transitions.

Similarly, exercises requiring cognitive flexibility, such as switching from identifying patterns to reacting to stimuli, posed significant challenges, and often required additional guidance.

Fatigue and loss of focus were common during lengthy or repetitive exercises, with participants often disengaging toward the end of sessions. The trainer addressed this by framing tasks as practice rather than tests, offering constructive feedback, and encouraging reflection on progress. This approach boosted morale, fostered a sense of accomplishment, and maintained engagement despite challenges.

Before sessions, participants expressed a mix of emotions, including positive anticipation, fatigue, disinterest, and nervousness. Many arrived eager and excited, especially for tasks they had enjoyed previously. Participants attending training sessions immediately after sports practice or during the final hours of school often experienced fatigue, leading to reluctance or frustration with challenging or repetitive tasks. Some participants reported anxiety, especially if they had struggled in prior sessions.

To address these moods, trainers adapted by adjusting tone and pacing to match energy levels. For tired or disinterested participants, sessions began with simpler tasks to build confidence. Enthusiastic participants were encouraged to engage more actively. Open discussions about feelings also helped participants feel heard and better prepared for the session.

Some participants required only minor clarifications, while others faced significant challenges necessitating substantial adaptations. Table 4 outlines the primary adaptation strategies used by the trainer for task modifications with examples.

Table 4. Examples of adaptation and guidance strategies in the executive functioning training sessions

Simplifying Instructions	**Example 2: Participant 4 (Working memory ponological loop)** ***Challenge*** *: Distinguishing between odd and even numbers was overwhelming in the initial instructions.* ***Adaptation*** *: The trainer limited the scope by focusing on fewer numbers at a time and repeated the instructions multiple times.* ***Outcome*** *: The participant successfully completed the simplified version inspite of having lost interest before moving on to the next task.*
Repetition and Guidance	**Example 3: Participant 3 (Colours)** ***Challenge*** *: The tasks were very easy, finished to early in the session.* ***Adaptation*** *: The trainer chose the most challenging tasks in the session to work over two times.* ***Outcome*** *: The participant had executive function tasks needed throughout the session .*
Breaking Tasks Into Smaller Components	**Example 4: Participant 5 (Working memory phonological loop)** ***Challenge*** *: Rememberring actions and pairing with visual cues was too complex when presented as a whole.* ***Adaptation*** *: The trainer split the task into smaller parts, asking the participant to focus on one section at a time.* ***Outcome*** *: The participant successfully completed individual sections and gradually managed the entire sequence.*

3.3 Proxy QB User Experiences- Qualitative Findings

Participant reactions to the training with the ProxyQB varied widely across sessions and individuals. Some found the ProxyQB engaging and enjoyable, even suggesting commercial potential; others expressed significant frustration, describing them as tedious, annoying, or worse. One participant, for instance, was so frustrated they wanted to form an “anti-cube club”. Conversely, multiple participants reported significant frustration from frequent malfunctions, ranging from connectivity problems to power failures, resulting in considerable negative feedback and impacting task completion and overall training effectiveness.

Even when the cubes were functioning correctly, some tasks proved overly challenging. One participant struggled to distinguish odd and even numbers or associate colors with numbers. Another found the task of remembering actions and pairing them with visual cues overwhelmingly difficult. This suggests that inherent task complexity, irrespective of technical issues, contributed to negative experiences.

The cubes’ frequent malfunctions—including connectivity issues and power failures despite adequate charging—exacerbated negative feelings. Repeated interruptions and restarts significantly impacted enjoyment and progress. This underscores the importance of reliable technology for a positive user experience, even with well-designed tasks.

In short, the ProxyQB elicited a broad range of emotional responses, from positive enjoyment to intense dislike, stemming from both task design and significant technical issues. Positive experiences highlighting the potential appeal of the task design when functioning correctly. The consistent use of a single trainer helped maintain a reasonable level of engagement despite these challenges, though

student engagement varied greatly, ranging from enthusiastic participation to significant disinterest and frustration often linked to task difficulty and technical issues.

The inconsistent performance and negative user experiences with the ProxyQB necessitate significant improvements before future use. Addressing both the inherent complexity of some tasks and the critical need for reliable functionality is crucial to ensure a positive and effective learning experience. Although positive feedback suggests the ProxyQB task design holds much potential, if technical reliability issues are fully resolved.

3.4 Children's self-assessment

The research team omitted the self-assessment sheets from these findings because the information gathered was deemed relatively insignificant. The trainer's documentation during discussions before and after training sessions captured crucial insights into the children's experiences with the tasks, making the self-assessments redundant. Furthermore, the minimal amount of information the children provided on these sheets further diminished their relevance to the study's conclusions.

4. Feedback from the trainer

In summary, the material would benefit from clearer instructions, culturally relevant examples, accurate details, and simplified tasks tailored to participants' abilities.

Firstly, the task instructions were often unclear or confusing. For example, the Pharmacy Task included ambiguous prompts like 'green light', which required extra demonstrations from the trainer. Similarly, the Cancellation Task lacked clear guidance on sequencing from left to right, leading to mistakes.

Cultural irrelevance was another issue, with many tasks referencing unfamiliar concepts for participants, such as non-Icelandic book titles or terms like 'wolf cub' and 'lama'. This unfamiliarity could cause confusion and reduce engagement. Additionally, the material lacked cultural and visual context. In the Library Task, for instance, using unknown books made it difficult for participants to make selections. When visual aids were provided, they were often inadequate, further complicating comprehension.

There were also inconsistencies and inaccuracies within the tasks, possibly related to the translation process, whether from English to Icelandic or from Czech to English. For instance, the School Task

mistakenly mentioned an unrelated geology test, while the Supermarket Task had pricing errors and vague wording about available funds. Some tasks were overly complex, especially for younger participants. The Odd/Even Number Task (Working memory: Phonological loop) required a level of numerical understanding and listening skills that many participants did not have. Similarly, the Grocery Shop-Home-Amusement Park task (Prospective Memory Worksheet IV) included random prompts, such as the trainer saying the word 'sky' (Icelandic: himinn) aloud to remind the child to begin the next task, which was grocery shopping. However, that word was completely unrelated to grocery shopping, and the cue did create unnecessary confusion. Cognitive overload was a significant concern, as certain tasks combined multiple demands, like associating colors with numbers or striking out letters based on previous numbers. That complex structure required clear instructions and options for adaptation for both participants and trainers.

Finally, the tasks lacked flexibility, offering no alternative paths for participants with different skill levels, which forced trainers to modify tasks manually. In short, improving the training materials by providing clearer instructions, culturally relevant examples, accurate details, and simplified tasks tailored to participants' different level of abilities would greatly enhance the effectiveness of the training.

5. Critical reflection

The Icelandic implementation of the Remember-to-Remember pre-test training program revealed key factors contributing to its success and areas needing improvement. Consistent use of a single trainer in the familiar school environment proved crucial, minimizing disruptions, fostering rapport with participants, and enabling personalized adjustments based on individual needs and learning styles. That consistency resulted in improved participant engagement, reduced anxiety, and better task completion.

However, the study also identified limitations in the original training materials. Specifically, a lack of cultural relevance and ambiguous instructions in several tasks (e.g., Prospective memory tasks, Pharmacy, Library, Supermarket) caused confusion and necessitated frequent trainer intervention. Inconsistent and inaccurate details within the tasks further highlighted the need for a thorough review and revision of the material before broader implementation. Overly complex tasks and instances of cognitive overload also challenged some participants. Future iterations should simplify tasks and provide clear, step-by-step instructions to address these issues.

Despite challenges, using a single trainer in a familiar setting proved highly effective, enhancing engagement, and ensuring training completion. That approach's success underscored the importance of consistent, personalized support and the need for pre-outlined adaptive instruction.

To enhance the effectiveness of existing training materials, future studies should incorporate the following: culturally relevant task revisions; clear, step-by-step instructions; a set of simplified tasks; consistent trainers in familiar settings; and iterative improvements based on participant and trainer feedback.

The ReToRe training materials' application and pre-testing demonstrate the future potential for developing comprehensive training tools for special education teachers. Collaboration with relevant Icelandic educational institutions (e.g., the Ministry of Education, the Directorate of Education and School Services, or research institutions) is crucial. Collaboration between key institutions would ensure alignment with national standards, incorporate expert pedagogical knowledge, and promote long-term sustainability of the project. Furthermore, it would facilitate valuable feedback from educators in the field and important stakeholders, ensuring the materials align with best practices in special education and remain responsive to the evolving needs of Icelandic schools.

References

Compulsory School Act, No. 91/2008. (2008). Althingi. Retrieved from: https://www.althingi.is/lagas/nuna/2008091.html.

Government of Iceland. (n.d.). Education. Retrieved from: https://www.government.is/topics/education/.

Statistics Iceland. (2022). Students in compulsory schools 2022. Retrieved from: https://hagstofa.is/utgafur/frettasafn/menntun/nemendur-i-grunnskolum-2022/.

Contact:

Sigrún Sif Eyfeld Jóelsdóttir, University of Iceland, ssj@hi.is
Ólöf Ragna Einarsdóttir, University of Iceland, ore@hi.is
Kristín Harðardóttir, University of Iceland, krishar@hi.is

PROSPECTIVE MEMORY AND EXECUTIVE FUNCTIONS RESEARCH RESULTS IN POLAND

Jopek-Bizoń Małgorzata, Kochanowska Ewa, Mika Dagmara, Wojciechowska Justyna, Zawada Ernest

1. Introduction

Following the regulations of the generally understood education law in Poland, a student with Autism Spectrum Disorders is treated as a student with a disability. *REGULATION OF THE MINISTER OF NATIONAL EDUCATION of 9 August 2017* on *The Conditions for Organizing Education, Upbringing and Care for Disabled, Socially Maladjusted and at Risk of Social Maladjustment Children and Youth* (*Journal of Laws of 2020, item 1309*) specifies the conditions for organizing education, upbringing and care for children and adolescents with a decision on the need for special education, including students with Autism Spectrum Disorders (ASD). In accordance with art. 127 sec. 10 of the Education Law Act (consolidated text: *Journal of Laws of 2019, item 1148, as amended*), a decision on the need for special education is issued by judging teams operating exclusively in public psychological and pedagogical counselling centres, including specialist clinics. According to § 13 sec. 2 of the *REGULATION OF THE MINISTER OF NATIONAL EDUCATION* on *Decisions and Opinions Issued by Judgment Teams Operating in Public Psychological and Pedagogical Counselling Centres* (*Journal of Laws of 2017, item 1743*), the decision specifies, among others: recommended conditions and forms of support enabling fulfilment of the individual developmental and educational needs of a child or a student; recommended developmental and therapeutic goals to be achieved during classes; all possible forms of special education; recommended actions aimed at improving functioning of a child or a student and strengthening their participation in kindergarten activities, school, centres or facilities; and actions supporting parents of a child or a student. A student covered by special education, and therefore also a student with Autism Spectrum Disorder (ASD), has their curriculum adapted to their individual development, educational needs, and psychophysical abilities. The adaptation is made based on an individual educational and therapeutic program (IETP) that considers recommendations contained in the decision on the need for special education, developed for the student based on § 6 of the regulation. Depending on the type of a disability, including a degree of intellectual disability, the student is provided with education and care that, according to their needs, enables learning within the scope available to them, improvement of impaired functions rehabilitation and resocialization, and/or specialist assistance and care. Individualized education programs for students who have been determined to receive special education are mandatory in both mainstream schools and special and integrated schools. A type of school a child

attends is decided by their parents or, in case of absent parents or deprivation of parental authority, by their legal guardians. A student with a determined need for special education has the right to extend their educational stage, if such a need remains an obvious result of the interpretation of the decision. Education of disabled students may be provided until the end of the school year in the calendar year in which the students reach their 20th (in case of a primary school), or 24th (in case of a post-primary school) year of life.

The role of the school tasked with providing special education is to provide:

- implementation of recommendations contained in the decision
- learning conditions, specialist equipment and teaching aids, appropriate to the individual developmental and educational needs and psychophysical capabilities of the student;
- specialist classes, rehabilitation, resocialization and socio-therapeutic classes;
- integration of the student with their peer environment, including typically developing students;
- preparation of the student for independence in their adult life.

Within the framework of rehabilitation classes indicated in the individual educational and therapeutic program (IETP) developed for a student with ASD, it is expected that the classes provided to such students will develop social skills, including communication skills. As a rule, it is social communication disorders that are the main obstacle to an integration within the school environment. Another right of a student with ASD is the provision of care, upbringing and education in public kindergartens and/or public schools, as well as other forms of preschool education, where these students are covered by special education by teachers, or specialists, or a person for the position of a teacher's assistant with qualifications in the field of special education, so as to be able to responsibly co-organize the education of disabled students. The cited regulation imposes the obligation to employ a supporting teacher or a teacher's assistant, whose tasks include:

- conducting educational work with disabled students together with other teachers, specialists, and educators of educational groups;
- participating - as needed - in educational activities conducted by other teachers and in integrated activities and classes specified in the IETP, conducted by teachers, specialists, and educators of educational groups;

- aiding teachers conducting educational activities and teachers, specialists, and educators of educational groups conducting integrated activities and classes specified in the IETP, in the selection of forms and methods of working with disabled students;
- conducting rehabilitation, resocialization, and socio-therapeutic classes.

The legal situation in the Polish education system for children with ASD creates all the convenient possibilities to support their development in the required areas. The Remember to Remember project (ReToRe) perfectly fits into the implementation of the special educational needs of the students who participated in it.

2. Remember to Remember project

2.1 Preparation phase

The research conducted in Poland as part of the Remember to Remember project took place in the summer semester of the 2023/2024 school year, from May to June. It was conducted in the form of training activities aimed at students diagnosed with ASD and/or learning difficulties. Those activities included training in prospective memory and metacognitive skills, as well as self-assessment.

Due to the context, specific goals of the project and guidelines included in it, the selection of participants was purposeful. The study involved 20 children aged 12 to 15 years, from schools located in the southern part of Poland, Silesian Province. The main research was preceded by a number of preparatory procedures: familiarization of the research team with the tools for training prospective memory and metacognitive skills; adaptation of the tool to the Polish environment (translating sheets; analysing them in terms of correctness and clarity of instructions; obtaining pictures corresponding to Polish realities); searching for schools; centres and organizations open to cooperation within the project; establishing cooperation with the previously mentioned institutions; familiarizing teachers, experts, parents of students with the aim and significance of the project; conducting training for additional experts and teachers involved in the study selected as part of cooperation with selected schools, in order to efficiently conduct the research. After completing the preparatory stages, the training phase and related main research phase began.

Tool adaptations

In the phase of adapting the tool to the Polish conditions, students from the University of Bielsko-Biała from the Faculty of Humanities and Social Sciences, representing the Institute of Pedagogy (preschool and early school pedagogy) and the Institute of Modern Languages (English philology, teaching specialization) also participated in the project in addition to the primary team members.

The participation of students in this phase brought mutual benefits. First, the students familiarized themselves with a new tool supporting the training of prospective memory and metacognitive skills. Second, they expanded their knowledge in the field of psychology, which is of key importance in the work of a teacher. Their participation in the process not only contributed to adapting the tool to Polish realities, but also allowed for the discovery of its additional applications within the ReToRe project. Thanks to their observations, the tool was improved in terms of language, especially in the scope of instructions addressed to children and adolescents. Working on the English version of the tool allowed many students not only to develop language competences, but also to acquire new skills that they can use in the future, supporting students with special educational needs.

Issues related to prospective memory and metacognitive skills were consistent with the topics of subjects taught as part of the study program, such as the psychological and pedagogical foundations of teaching a foreign language to children (a compulsory subject taught by a member of the research team for students of pedagogy) and the methodological foundations of working with students with special educational needs (a compulsory subject taught for students of English philology, teaching specialization).

2.2 Characteristics of the test participants and specialists participating in the project

The testing phase of the ReToRe tools involved 20 students from educational centres with whom the Polish project team established cooperation as part of the project. The group of participants included five students aged 15, six students aged 14, four students aged 13 and five students aged 12. Eleven girls and nine boys were included, which ensured diversity in terms of both gender and age in the study sample. Each of the students participating in the tool testing was characterized by different learning difficulties, which required an individual approach from the trainers. Therefore, in addition to the project team from the University of Bielsko-Biała, specialists, who work with students daily in schools or individually as part of pedagogical and psychological support, were also involved in assessing the

tools. They were school pedagogues, oligophrenopedagogues, an educational therapist, a psychologist, English teachers, and a certified behavioural therapist.

Table 1: Identified problems in students participating in ReToRe

Identified problems in students' learning: slow pace of work; difficulties in reading social relations and emotions; difficulties in finding oneself in a new situation; difficulties in understanding longer instructions; high stress related to accepting a possible failure; high difficulties in accepting criticism; quick discouragement; anxiety and fear in new and unusual situations; disharmonious development; disturbed visual and auditory memory; difficulties in auditory perception; problems with concentration; reduced logical and cause-and-effect thinking; difficulties in solving tasks based on visual-spatial processing; reduced level of verbal-conceptual understanding; reduced development of motor functions; problems with arithmetic understanding and the ability to operate numbers; problems with memory and general knowledge; reduced level of phonemic hearing.

The team of specialists cooperated with institutions in terms of educating children and adolescents with learning disabilities and/or ASD in a controlled environment. Scholars employed by the University of Bielsko-Biała conducted research on the practical verification of metacognitive-training intervention in children with ASD, or learning disabilities and the development of a distant form of supporting prospective memory rehabilitation, using innovative exercises developed as part of the project and in cooperation with caregivers from the Maria Grzegorzewska Special Educational and Upbringing Centre in Żywiec and the New School in Bielsko-Biała. Identification of learning disabilities was the main focus of the testing phase. The identified difficulties of students were organized and categorized, which allowed for the detection of recurring problems. Above (**Table 1**) is a list of characteristic issues of students participating in the project, which were identified during the analysis of their learning disabilities. Awareness of the issues enabled better understanding of individual educational needs of students participating in the testing phase of the ReToRe tools.

2.3 Training phase

In the training phase of the project, the following tools were used: the Proxy QB tool (a plastic box containing a tablet, four cubes connected to the tablet via Bluetooth, and a charger), prospective memory training sheets and executive functions (EFs) training sheets. All sheets were adapted to the linguistic and socio-cultural requirements of the Polish country.

In order for the training procedures to run smoothly, paper task sheets were prepared along with student self-assessment cards. Individual folders were prepared and contained the Proxy QB user manual, task sheets for participants, and instruction sheets for the administrator/trainer. Executive functions tasks folder contained the following task sheets: Reading and naming colours, Task cancellation sheet, Working memory – phonological loop, Working memory – visual-spatial sketchpad, Working memory – episodic buffer, Inhibition. The prospective memory sheets contained five tasks: Task one: Pharmacy - Helping a Friend - Cinema; Task two: School - Library - Playground; Task three: Shopping Centre - Zoo - Café and Sweet Shop; Task four: Grocery Store - Home - Amusement Park; Task five: "Shopping Centre - Flower Shop - Grocery Store". In addition, a game map was also included. Last folder contained a sheet with prospective homework assignments which included five special tasks, ten tasks to be completed by students during the day, and five tasks to be completed while using social media. Each session also ended with the student answering questions included in the prepared student self-assessment sheet.

2.4 Testing phase

The testing phase of the ReToRe prospective memory and executive skills training was planned for a minimum of ten weeks and conducted in May and June of 2024. During this time, regular training sessions were conducted with students, however, the number of sessions varied due to several factors, such as the organization of school classes, absences due to students' illnesses, and additional events (such as trips and previously planned meetings of children with specialists). Of the twenty participants, fifteen completed five training sessions, whereas the remaining five completed six sessions. Data obtained from five sessions were included in the final analysis, as they provided a common point of reference for the majority of the group. Each session lasted 45 minutes and was divided into two stages: 15 minutes of work with the ProxyQB tool; and 30 minutes with the worksheets.

During training, an administrator/trainer assigned tasks according to the instructions and monitored student's progress. If the student forgot what to do next, the trainer offered partial guidance. In addition, the trainer repeatedly checked whether the student understood everything; in case of problems, answers to questions were provided.

While working with the Proxy QB, the project team also focused on observing students in terms of their interest in the tool, attitude to the designed tasks, understanding of instructions and the way of performing tasks using manual cubes. The team also paid attention to the functioning of the device itself.

3. Executive functions – summary of research results

3.1 Session progress

Executive functions (EFs) are a multidimensional and complex construct. EFs encompass inhibition of reactions, the ability to solve problems, planning activities and initiating their flexible implementation, as well as monitoring stages of activity with specific goals. Their role is especially significant for self-regulation. As observed by Brzezińska and Nowotnik (2012), EFs play an important role, especially in terms of school readiness.

Table 2 on pages 150 and 151 summarizes progress of each session and tasks fulfilled during the session. Each session included different types of tasks from the EF sheets.

3.2 Quality of materials and instruction comprehension analysis

During training, children's comprehension of instructions in the sheets was assessed. The variety of tasks constituted a comprehensive training of many key cognitive functions. The number of tasks performed and their gradual increase in subsequent sessions show that students effectively learned the content of the instructions and tasks. Such results can be recognized as an evidence of a well-thought-out construction of tasks, each of them being understandable and adapted to the age and abilities of the students. The structure of the sessions (ranging from 1 to 5) facilitated the systematic monitoring of students' progress. Furthermore, the design of the sessions fostered the development of cognitive skills and provided opportunities for students to engage in learning through a diverse array of tasks.

The summary of results for each student also shows that the participants were able to perform repetitive tasks, which could strengthen their memory, concentration, and self-control (inhibition) abilities, which are generally recognized to play an important role in cognitive training. The type of presented training covering various components of EFs, such as working memory (episodic buffer), language functions (phonological loop) and the ability to focus (inhibition), gave the students the opportunity to develop a wide range of cognitive competences. A comprehensive approach to training accounting for different cognitive spheres allows us to assume that such a method can be effective in developing children's general intellectual abilities, which can be useful in their education and everyday challenges.

Table 2: Session progress and tasks

No.	Sheet name						Number of tasks performed in each session						Identification number of tasks performed by a student per session					
	Session number																	
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1.	Reading and naming colours	Visual-spatial sketchpad	Episodic buffer	Phonological loop	Inhibitions	-	2	2	2	2	3	-	1, 3	2, 4	1, 3	1, 4	1, 2, 3	-
2.	Reading and naming colours	Visual-spatial sketchpad	Episodic buffer	Phonological loop	Inhibitions	-	2	2	2	2	3	-	1, 3	2, 4	1, 3	1, 4	1, 2, 3	-
3.	Reading and naming colours	Visual-spatial sketchpad	Episodic buffer	Phonological loop	Inhibitions	-	3	3	3	3	3	-	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	-
4.	Phonological loop	Cancellation	Reading and naming colours	Visual-spatial sketchpad	Episodic buffer	-	7	4	4	3	4	-	1, 2, 3, 4, 5, 6, 7	1, 2, 3, 4	1, 2, 3, 4	1, 2, 3,	1, 2, 3, 4	-
5.	Phonological loop	Reading and naming colours	Cancellation	Visual-spatial sketchpad	Episodic buffer	-	2	4	4	3	4	-	1, 3	1, 2, 3, 4	1, 2, 3, 4	1, 2, 3,	1, 2, 3, 4	-
6.	Cancellation	Phonological loop	Visual-spatial sketchpad	Reading and naming colours	Episodic buffer	-	2	2	2	2	3	-	1, 3	2, 4	2, 3	1, 4	1, 2, 3	-
7.	Reading and naming colours	Phonological loop	Visual-spatial sketchpad	Reading and naming colours	Episodic buffer	-	2	4	4	3	4	-	1, 3	1, 2, 3, 4	1, 2, 3, 4	1, 2, 3,	1, 2, 3, 4	-
8.	Reading and naming colours	Visual-spatial sketchpad	Episodic buffer	Phonological loop	Inhibitions	-	2	2	2	2	3	-	1, 3	2, 4	2, 3	1, 4	1, 2, 3	-
9.	Reading and naming colours	Phonological loop	Cancellation	Inhibitions	Episodic buffer	-	3	3	8	4	2	-	1, 2, 3	1, 2, 3	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4	2, 4	-
10.	Phonological loop	Cancellation	Inhibitions	Reading and naming colours	Episodic buffer	-	3	8	3	3	3	-	1, 2, 3	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3	1, 2, 3	1, 2, 3	-

No.	Sheet name						Number of tasks performed in each session						Identification number of tasks performed by a student per session					
	Session number																	
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
11.	Reading and naming colours	Phonological loop	Visual-spatial sketchpad	Reading and naming colours	Episodic buffer	-	2	4	4	3	4	-	1, 3	1, 2, 3, 4	1, 2, 3, 4	1, 2, 3,	1, 2, 3, 4	-
12.	Inhibition - Phonological loop	Reading and naming colours	Visual-spatial sketchpad	Reading and naming colours	Episodic buffer	-	2	4	4	3	4	-	1, 3	1, 2, 3, 4	1, 2, 3, 4	1, 2, 3,	1, 2, 3, 4	-
13.	Inhibitions	Visual-spatial sketchpad	Episodic buffer	Phonological loop	Reading and naming colours	-	2	2	2	2	3	-	1, 3	2, 4	2, 3	1, 4	1, 2, 3	-
14.	Cancellation	Phonological loop	Reading and naming colours	Inhibitions	Episodic buffer	-	7	3	8	4	2	-	1, 2, 3, 4, 5, 6, 7	1, 2, 3	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4	2, 4	-
15.	Reading and naming colours	Visual-spatial sketchpad	Episodic buffer	Phonological loop	Inhibitions	-	2	3	3	3	3	-	1, 3	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	-
16.	Reading and naming colours	Cancellation	Phonological loop	Visual-spatial sketchpad	Episodic buffer	-	2	3	3	3	3	-	2, 3	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	-
17.	Reading and naming colours	Visual-spatial sketchpad	Episodic buffer	Phonological loop	Inhibitions	-	2	2	2	2	3	-	1, 3	2, 4	1, 3	1, 4	1, 2, 3	-
18.	Phonological loop	Reading and naming colours	Cancellation	Visual-spatial sketchpad	Episodic buffer	-	4	6	3	4	4	-	1, 2, 3, 4	1, 2, 3, 4, 5, 6, 7,	1, 2, 3, 4	1, 2, 3, 4	1, 2, 3, 4	-
19.	Reading and naming colours	Visual-spatial sketchpad	Episodic buffer	Phonological loop	Inhibitions	-	3	3	3	3	3	-	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	-
20.	Cancellation	Reading and naming colours	Phonological loop	Visual-spatial sketchpad	Episodic buffer	-	4	6	3	4	4	-	1, 2, 3, 4	1, 2, 3, 4, 5, 6, 7	1, 2, 3, 4	1, 2, 3, 4	1, 2, 3, 4	-

Considering the results and a structure of the sessions, the present type of training can be recommended as an effective method supporting the cognitive development of children aged 12-15. The well-structured sequence of sessions, with an increasing level of task difficulty, enabled students their gradual progress. As such, the ReToRe project training can be considered effective and adapted to the development of young people at this age.

To summarise, the results obtained during from the present study confirmed the training conducted with the application of task sheets and instructions was well-adapted to the needs of the age group, and also effective in terms of the development of multi-faceted cognitive functions. Its implementation can be recommended as a valuable tool in education, especially in the context of supporting cognitive skills in young people. Moreover, based on the interviews conducted with trainers, it can be clearly stated that the sheets developed for training executive skills are characterized by clear instructions and tasks. The structure of the sheets supports the gradual development of students and also promotes comprehensive development of their executive functions.

Prospective memory and self-assessment (metacognitive competences) of the student – research results

Prospective memory is a complex cognitive process related to the functioning of many brain areas. Following Witkowska (2010), this is a "(...) specialized type of information processing and refers to functional, i.e. strategic-organizing aspects of memory". Jodzio (2008) observes that prospective memory combines executive functions with declarative memory by recalling previously remembered information and using it to perform an intended action in the future; it also requires involvement of working memory that monitors the information processing process during the implementation of the planned action. Such processes can take place because they are phase-based in prospective memory and include creation, storage, initiation, and execution of the intention (Kliegel, Eschen, Thöne-Otto, 2004). Unlike retrospective memory, which concerns remembering events and facts from the past, prospective memory concerns the future; it focuses on the memory of tasks that are to be performed at a specific time and place in the future. While the function of retrospective memory is to recall information from the past, in prospective memory, information for future action may need to be recalled multiple times. The task will only be fulfilled if the information is retrieved from memory at the moment when the planned action should be performed (Stuart-Hamilton, 2006). Prospective memory is responsible for remembering so-called deferred intentions, i.e. actions that we want to perform in the future. Thus, what is important concerns not only what we want to do, i.e. the content of the intention,

but also when the planned action should be performed, i.e. the conditions for the implementation of the intention. The stimulus initiating action can sometimes be an external event; this is when we are dealing with prospective memory with the so-called event context. In other situations, however, time plays a decisive role. In such cases, researchers talk about prospective memory with the so-called time context (cf. Einstein, McDaniel, Thomas, Mayfield, Shank, Morrisette, Breneiser, 2005). Apart from that the research results of Kvavilashvili and Ellis (1996) distinguished prospective memory based on activity. Following their observation, this kind of prospective memory is similar to the event-based one in that the implementation of the intention is activated by an external signal, but in this case such a signal is either the completion or commencement of a specific activity by the individual themselves.

According to Albiński (2009), the basic features of tasks involving prospective memory include:

- requirement of suspension or interruption of the action typical for the current task and carrying out the planned intention in response to the target stimulus;
- limitation of the time in which the intention can be
- obligatory necessity of appearance of a consciously formed intention in the mind of the subject;
- postponement of the moment of performing the intention, i.e. tasks involving prospective memory are not performed immediately after a subject becomes familiar with instructions.

The tasks included in the sheets concerning prospective memory were conducted in accordance with the instructions. During the training sessions, three tasks from sheets One to Five were completed during five consecutive sessions. The sheets concerned the following topics:

- pharmacy – helping a friend - cinema;
- school - library - playground;
- shopping centre - zoo - playground and candy store;
- grocery store - home - amusement park;
- shopping centre - flower shop - grocery store.

When designing the perspective tasks, both basic and more complex tasks were combined. The principle assumed that frontally mediated processes (the domain of executive control) affect the perspective of memory performance and are stronger than time-mediated processes (controlled by retrospective memory). Therefore, cognitive components other than prospective memory itself were selected as background tasks. During the training, a trainer assigned background tasks and monitored the

progress of memory training. When a student did not remember what to do next, the teacher offered partial instructions. At the beginning of each task, the student received a *map* and was read the task instructions to which the task pertained. The teacher continuously checked whether the student had understood everything and had answered questions. The analysis of the collected research material shows that each of the examined students completed three tasks in each of the five sessions. All tasks were performed correctly according to the instructions.

During the implementation of prospective memory tasks, students performed all tasks in metacognition and meta-learning. Metacognitive processes play an important role in the development and education of every student, including both ASD students and these suffering from other learning disabilities, because they enable making decisions important for learning, controlling its course and effects. They are closely related to cognitive strategies, i.e. tools used when mastering specific content, responsible for controlling their application and/or making any necessary modifications. Thanks to the understanding and ability to use metacognitive strategies, students can have a significant share in creating the shape of their own learning and, as a result, a significant share in their own development.

The process of metacognition consists of declarative knowledge, which concerns information processing, monitoring one's own thinking process and its corresponding action, regulating personal cognitive strategies in learning situations, as well as performing complex cognitive actions. The second element of metacognition is procedural knowledge contained in the child's experiences, which relate to the ability to assess behaviour in situations of cognitive activity and to use appropriate strategies in solving intellectual tasks. Following Kulawska (2018), teachers can help students develop their learning abilities by consciously managing this process and indicating cognitive strategies depending on the type of knowledge, external conditions (time of day, place of study) and internal conditions (motivation, physical condition) in which intellectual processes take place.

In the conducted studies, tasks being the subject of training in students' metacognitive competences were included, among others, in the self-assessment sheet. The sheets referred to each of the conducted sessions and contained questions/statements addressed to the student referring to several areas, as shown below (**Table 3**).

Table 3. Elements of student's self-assessment

Self-assessment subject	Questions/statements put to the student
Prospective memory	• What did I have to remember? • Was this task important to me?
Assumptions	• I expected the tasks to be easy/difficult... • I chose the following aids/strategies to help me remember and complete the task better...
Form of assessment	• Did I complete the tasks as requested? • I completed the task well because.../ I did not complete the task well because... • The aids/strategies I chose were useful/useless... • Next time I would like to use the following aids...

Source: Self-assessment sheet

The questions/statements included in the first category of self-assessment were intended to check whether the student/s remembered the task/command they had to perform and whether the task was important to them. The analysis of the collected research material shows that for the vast majority of students (17 people), the task they undertook was important. The remaining students assessed the task as of little importance to them. In the group of 20 students studied by us, all were able to give the command they had to perform, but some of them (6 people) did not remember the content of the task verbatim with the one given in the instructions (however, its essence was preserved).

The vast majority (16) of the students surveyed during the research declared that they expected the tasks to be easy for them to complete. Four students expressed concern that the tasks would be difficult to complete, but this concerned self-assessment referring to only one or two sessions, after which the students developed a positive attitude towards the tasks. It can therefore be concluded that the surveyed students had a positive attitude towards the tasks, which certainly influenced their level of motivation to act. All the students declared that they completed the tasks well, i.e. in accordance with the teacher's request.

Table 4. Correctly performed prospective memory tasks selected by students

Category of task	Type of task	Number of choices	% N=
Special tasks	In the morning, put a piece of paper in your pocket. When you see a red car, throw the piece of paper in the trash	6	30%
	Every time you eat breakfast, write down what you will do throughout the day.	2	10%
	Every time you come home, read a page from any book.	3	15%
	Every time you eat dinner, check the time	2	10%
Special tasks in social media	Every time you open social media on your phone (e.g. Instagram, Facebook, TikTok), have a drink with you.	3	15%
	Every time you text someone, eat a piece of vegetable or fruit.	4	20%

Source: Own elaboration based on research results

Another aim of the study was to determine whether and what metacognitive strategies the students used in the learning process, in this case in connection with memorizing the task for everyday performance. Only a limited number of the respondents (14 people) were able to name/define the strategies they used to remember the task.

Table 5. Strategies used by students and assessment of their potential for reuse in the learning process

Strategy type	Number of choices	% N=20
Writing down the task content on a piece of paper and placing it in a visible place	4	20%
Repeating the task	3	15%
Turning on the so-called „reminder“ on the phone	2	10%
Visualization, „imagining the situation“	3	15%
„Unnecessary” because the task was easy	5	25%
No response or inability to name, define the strategy	3	15%

Source: Own elaboration based on research results

The data presented above indicate that some of the respondents justified the lack of strategies and aids used to complete the task by its low level of difficulty. Three people did not indicate the metacognitive strategy they used, perhaps because they either were not aware of using it or were unable to verbally define it.

The students rated the memory strategies they selected as useful and expressed their readiness to use them again. They often used them in the learning process. Two students who did not use any

strategy reported to use visualization in the future-oriented tasks. Based on the conducted research, it can be stated that the students studied mainly used repetition strategies (repeating, copying tasks). Elaboration strategies in the form of associations and creating analogies were rare. No student used organizing strategies, e.g. grouping, concept maps.

The ability to select and use strategies during the learning process largely determines its effectiveness. To this end, students should be encouraged to use different strategies to check which one facilitates effective content acquisition. The use of known methods will be helpful in the future, in processes aimed at adapting to existing conditions and/or expanding knowledge and lifelong learning.

Student feedback

The project also included an analysis of student feedback after the tests. The results are illustrated in **Table 6** below:

Table 6. Feedback from students (after session)

No of student	Feelings during the research						Meeting evaluation						Research evaluation					
	Session number						Session number						Session number					
	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5	
1.	3, 7	1, 5	1, 8	4, 5	4, 5		a	a	a	a	a		b	b	a	b	b	
2.	3, 6	1, 5	1, 8	4, 5	4, 5		b	a	a	a	a		b	b	a	b	b	
3.	1, 5	4, 5, 8	1, 8	4, 5	1, 4		a	a	a	a	a		b	b	b	b	b	
4.	5	4, 5	1, 5	5	4, 5		a	a	a	a	a		b	b	b	b	b	
5.	3	4	4, 5	4	4, 5		a	a	a	a	a		b	b	b	b	b	
6.	5	6	6	5	5		a	a	a	a	a		b	b	b	b	b	
7.	5, 8	1, 5	6, 7	1, 5	6, 7		a	a	a	a	a		b	b	b	b	b	
8.	1, 3	1, 5	1, 8	4, 5	4, 5		b	b	b	a	a		c	b	b	b	b	
9.	5	6	6	5	5		a	a	a	a	a		b	b	b	b	b	
10.	1, 5	5	1	5	1		a	a	a	a	a		c	b	b	b	b	
11.	4, 5	4, 5	4, 5	4, 5	4, 5		a	a	a	a	a		b	b	b	b	b	
12.	3, 7	1, 5	1, 8	4, 5	4, 5		a	a	a	a	a		b	b	a	b	b	
13.	3, 6	1, 5	1, 8	4, 5	4, 5		b	a	a	a	a		b	b	a	b	b	
14.	1, 5	4, 5, 8	1, 8	4, 5	1, 4		a	a	a	a	a		b	b	b	b	b	
15.	5	4, 5	1, 5	5	4, 5		a	a	a	a	a		b	b	b	b	b	
16.	3	4	4, 5	4	4, 5		a	a	a	a	a		b	b	b	b	b	
17.	5	6	6	5	5		a	a	a	a	a		b	b	b	b	b	
18.	5, 8	1, 5	6, 7	1, 5	6, 7		a	a	a	a	a		b	b	b	b	b	
19.	1, 3	1, 5	1, 8	4, 5	4, 5		a	b	b	a	a		c	b	b	b	b	

No of student	Feelings during the research						Meeting evaluation						Research evaluation					
	Session number						Session number						Session number					
	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5	
20.	5	6	6	5	5		a	a	a	a	a		b	b	b	b	b	
Legend	Feelings during tasks: 1-joy 2-sadness 3-nervousness 4-calmness 5-curiosity 6-boredom 7-fear, fear 8-feeling of relaxation 9-other						Training/meeting rating: a-interesting training b-boring training						Task difficulty level rating: a-very easy b-easy c-moderately difficult d-difficult e-very difficult					

Source: Own elaboration based on research results

As indicated in the table above, during the tasks, students experienced various feelings that ranged from joy up to nervousness. Most students were found to be calm and curious while performing the tasks. Boredom and anxiety were rare. It was also observed that a feeling of relaxation was the one more often noticed among the students. The vast majority of students assessed the training as interesting; only four people partially indicated selected elements of the training as boring. The level of difficulty of the tasks was assessed as easy; only three people indicated selected parts as moderately difficult. The results show that the training was recognized by the vast majority of students as enjoyable, combined with joy; the tasks were not difficult and did not cause students more difficulties than they could solve.

Final Conclusions

As part of the research process, in addition to training with children, uncategorized interviews were conducted with key groups of participants: students, experts, teachers, organizers and members of the research team about the tools themselves, i.e. sheets for training prospective memory and metacognitive skills, as well as Proxy QB. The collected data were subjected to detailed analysis, which allowed for the formulation of final conclusions. During the analysis of interviews with key groups of participants, positive aspects related to the use of sheets for training prospective memory and metacognitive skills and the Proxy QB device emerged. Firstly, both teachers (trainers), experts and organizers assessed the sheets as an effective tool supporting children's cognitive development. The exercises included in the sheets were perceived as engaging, and their structure supported systematic training of memory and reflective skills, which allowed children to better plan and monitor their actions. Proxy QB proved to be particularly useful as a device supporting practical aspects of training. Its innovativeness and interactive form attracted a lot of interest from both children and adults. Trainers noticed that the

device effectively increased students' motivation to participate in exercises, because the opportunity to work with a modern and an interactive tool made children more engaged and eager to learn. Teachers working with children noted that Proxy QB made it easier for them to conduct classes and strengthened their authority, which resulted in greater job satisfaction. Moreover, interviews showed that regular use of the sheets and Proxy QB promoted the development of metacognitive skills in children. The trainings not only contributed to better memorization, but also helped children to manage their own learning process more consciously. This had a positive effect on their ability to independently organize tasks and set priorities, which may bring long-term benefits to their education. Finally, all participants emphasized that the innovativeness of the tools and their adaptation to the needs of children with different needs and educational difficulties meant that the experience of working with them was not only of educational, but also of inspiring value. Proxy QB and the training sheets were recognized as tools that can be successfully used in future educational programs, both in schools and during additional classes developing children's cognitive and social competences.

The added value of the conducted trainings was not only the achieved effects, but also the conclusions for the future, which were drawn by both the students involved in the project and the trainers. The project involved students of pedagogy with a specialization in preschool and early school education and students of the Institute of Modern Languages with a specialization in English philology, as well as trainers conducting research and training. Both the scholars (representing the fields of English philology) and the students of English philology brought another perspective in particular, which emphasized the interdisciplinary nature of the project and the diversity of approaches. They all agreed that tools such as the Prospective memory training sheets and the Proxy QB device could be effectively used in work with Polish students in English as well. These tools not only support prospective memory training, but also facilitate learning English as a foreign or a second language. The tasks, which were developed in an accessible way, could be adapted to different age groups and skill levels. This makes them particularly helpful for students with memory difficulties or executive function problems, at the same time offering them additional support in both memory and language learning.

In the phase of adapting the tool to Polish conditions, the participation of students from the University of Bielsko-Biała, Faculty of Humanities and Social Sciences, representing the fields of pedagogy and English philology, brought significant, although unplanned, added value to the project. Their cooperation with the research team brought benefits not only in the context of adapting the tool to Polish educational realities, but also allowed for the aforementioned discovery of new, practical applications of tools within the Remember to Remember project. Thanks to the involvement of the students, the tool was improved,

especially in terms of language - in the scope of instructions addressed to children and youth. Moreover, their work on the English version of the tool was a valuable opportunity to develop language competences and acquire new skills in working with students with special educational needs. This experience not only enriched their knowledge in the field of psychology, pedagogy, and linguistics, but also allowed them to apply theory in practice, which had a great impact on their future professional careers. Work on this project was closely linked to subjects taught at the university, such as: Psychological and pedagogical foundations of teaching a foreign language to children and Methodology of working with students with special educational needs, which meant that the project participants could combine theory with practice. This unique opportunity was an additional educational value that positively influenced their future professional competences.

The popularization of the Remember to Remember project and the development of international and local cooperation brought further, significant educational benefits that go beyond the original assumptions and goals of the project. Thanks to the involvement of the substantive coordinator, Małgorzata Jopek-Bizoń, PhD, the project was presented at the international forum of the Blended Intensive Programme (BIP) - '*The key competences in early childhood education*', held at the University of Bielsko-Biała. The intense exchange program combined physical and virtual mobility, enabling not only the promotion of the project, but also the transfer of knowledge about the project tools to students and experts from different countries. As part of a lecture dedicated to students with special educational needs, the students participating in the program were introduced to the issues of prospective memory and metacognitive skills, which was a valuable contribution to their future teaching activities. The physical mobility of the students was also an additional value, including a visit to the Special Educational and Upbringing Centre where training for children was conducted as part of the project. Thanks to this visit, the students had the opportunity to have direct contact with SEN students, including students on the autism spectrum. Meeting with teachers and specialists from the Centre involved in the project allowed for the exchange of experiences and helped obtaining valuable information on the tools used, which resulted in further promotion of training tools for prospective memory and metacognitive skills. Continuation of project activities also led to the signing of a formal cooperation agreement between the University of Bielsko-Biała and the Special Educational and Upbringing Centre in Żywiec. The agreement assumes further cooperation, within the framework of which workshops, trainings, publications and exchange of knowledge and experiences are planned. The aim of this cooperation is to support educational and integration initiatives for the Centre's students, which will bring long-term benefits for the development of educational competences of students and support for students with special educational needs in the region. Thus, the dissemination of the project and the established partnerships

contributed to the strengthening of local and international educational cooperation, giving project participants the opportunity to develop practical competences as well as to build a support network for students with diverse educational needs.

Participation in the Remember to Remember project has shown the key importance of integrated cooperation between students, teachers, experts, and organizations supporting various kinds of SEN students. The results of the conducted trainings (assessing the developed tools) and the related research confirm that effective support for these students is not based solely on the implementation of appropriate didactic tools, but above all on the involvement of a wide range of people co-participating in the educational process. Joint actions of all stakeholders are the foundation of effective support for these students, especially the ones having autism spectrum disorders. The conducted research has also shown the complexity of support for students with special educational needs, resulting from their individual predispositions, specific requirements, and organizational activities of individual organizations. For this reason, it is difficult to clearly determine the optimal duration of support using the tools developed as part of the project, which is confirmed by the experience of experts and trainers participating in the project. In connection with the above, it is assumed that the training program will need to be flexibly adjusted using the tools developed in the project in the future, which is determined by time, organizational and health constraints (including students' illnesses, consultations with specialists, school trips, parental burdens). These conclusions prove that the effectiveness of activities supporting students with special educational needs depends on continuous adaptation to changing conditions and individual needs of students, and the success of educational projects requires close and organized cooperation of all parties involved.

References:

Albiński R. (2009). Pamiętanie o zamierzonych działaniach. Przegląd badań nad pamięcią prospektywna [Remembering intended actions. A review of research on prospective memory], *Psychologia Jakości Życia* [*Psychology of Life Quality*], vol. 6, no 2, 209, 2010.

Brzezińska A. I., Nowotnik A. (2012). Funkcje wykonawcze a funkcjonowanie dziecka w środowisku przedszkolnym i szkolnym [Executive functions and child functioning in preschool and school environment], In: *Edukacja* [Education], 1 (117), 61, 63.

Einstein G., McDaniel M., Thomas TR., Mayfield S., Shank H., Morrisette N., Breneiser J. (2005). *Multiple processes in prospective memory retrieval: factors determining monitoring versus spontaneous retrieval*. J. Exp. Psychol. Gen.

Jodzio K. (2008). *Neuropsychologia intencjonalnego działania. Koncepcje funkcji wykonawczych*, [*Neuropsychology of intentional action. Concepts of executive functions*], 'SCHOLAR' Scientific Publishers, Warszawa.

Kliegel M., Eschen A., Thöne-Otto AI (2004). *Planning and realization of complex intentions in traumatic brain injury and normal aging*. Brain Cogn. 56 (1).

Kulawska E. (2018). Metapamięć i strategie pamięciowe uczniów w młodszym wieku szkolnym w perspektywie poznawczej koncepcji uczenia się [Metamemory and memory strategies of students in early school age in the perspective of cognitive concept of learning], *Pedagogika Przedszkolna i Wczesnoszkolna* [*Preschool and Early School Pedagogy*], vol. 6 1 (11), 69-82.

Kvavilashvili L., Ellis J. (1996). 'Varieties of intentions: Some distinctions and classifications.' In: *Prospective memory: theory and application,* Brandimonte, M. A., Einstein, G. O., & McDaniel, M. A. (Eds.), Erlbaum: Mahwah, NJ, 23-51.

Stuart-Hamilton I. (2006). *Psychologia starzenia się* [*Psychology of Aging*]*,* Zysk i S-ka Publishers, Poznań 2006.

Witkowska M. (2010). Pamięć prospektywna: od teorii do praktyki. [Prospective memory: from theory to practice.] In: *Neuronalne ścieżki poznania i zachowania.* [*Neuronal paths of cognition and behavior*], Jodzio K., Szepietowska E.M. (Eds.), UMCS Publishing House, 31.

Regulation of the Minister of Education and Science of August 31st, 2023, on the 'Announcement of a Uniform Text of the Regulation of the Minister of National Education on Decisions and Opinions Issued by Adjudicating Teams Operating in Public Psychological and Pedagogical Counseling Centers' (*Journal of Laws* of 2023, item 2061).

Regulation of the Minister of National Education of August 9th, 2017 on the 'Conditions for Organizing Education, Upbringing and Care for Disabled, Socially Maladjusted and At Risk of Social Maladjustment Children and Youth' (*Journal of Laws* of 2020, item 1309).

Act of July 20th, 2018 – 'Law on Higher Education and Science' (*Journal of Laws* of 2019, item 1148).

Contacts:

Małgorzata Jopek-Bizoń, University of Bielsko – Biala, mbizon@ubb.edu.pl
Ewa Kochanowska, University of Bielsko – Biala, ekochanowska@ubb.edu.pl
Dagmara Mika, University of Bielsko – Biala, dmika@ubb.edu.pl
Justyna Wojciechowska, University of Bielsko – Biala, jwojciechowska@ubb.edu.pl
Ernest Zawada, University of Bielsko – Biala, ezawada@ubb.edu.pl

Title: Remember To Remember: The international experience
of prospective memory training (between theory and practice)

Graphics: Lenka Kolarčíková
Typesetting: Petr Zeman
Proofreading: Tereza Rošíková

Publisher: VSB – Technical University of Ostrava
1. edition, Ostrava, 2024

Co-funded by
the European Union

VSB - Technical University of Ostrava
ISBN 978-80-248-4781-8 (print)
ISBN 978-80-248-4782-5 (online)
DOI 10.31490/9788024847825