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Fostering creative thinking in ageing may prevent cognitive decline: selected behavioural and neural data

Rozwój kreatywnego myślenia w wieku zaawansowanym w kontekście zapobiegania upośledzeniu funkcji poznawczych związanych z wiekiem: wybrane dane behawioralne i neuronalne

Streszczenie. Kreatywne lub innowacyjne myślenie może być rozumiane jako proces umysłowy prowadzący do powstawania nowych i użytecznych idei. Jest kluczową umiejętnością kognitywną pozwalającą skutecznie reagować na zmieniające się wyzwania życiowe. Zachowanie tej umiejętności jako elastycznej i dającej się adaptować jest możliwe. W niniejszym artykule przedstawiam wybrane badania nad myśleniem innowacyjnym, których przedmiotem analiz był rozwój kreatywności i zdolności kognitywnych poprzez trening. Doniesienia z psychologii uzupełniane są danymi neurobiologicznymi, dzięki czemu podłoże behawioralnych efektów treningów innowacyjnego myślenia można wyjaśnić mechanizmami neuronalnymi zachodzącymi w mózgu, czyli mechanizmami neuroplastycznymi. Spostrzeżenie, że zachowanie i rozwijanie kreatywnego myślenia jest możliwe w starszym wieku, motywuje do podejmowania wysiłku w kierunku poznania i wykorzystania związków między innowacyjnym myśleniem a umiejętnościami kognitywnymi potrzebnymi w codziennym życiu; co z kolei może zapobiec związanemu z wiekiem uwstecznianiu procesów kognitywnych. Obiecujące modele treningów wzmacniających kreatywne myślenie oraz leżące u nich podstaw mechanizmy neuronalne nie przestają się pojawiać i udoskonalać.

Słowa kluczowe: myślenie kreatywne; myślenie innowacyjne; trening kognitywny; neuroplastyczność; wiek zaawansowany

Summary. Creative or innovative thinking can be understood as a mental process that supports the generation of novel and useful ideas. As such, creative thinking is a vital cognitive capacity allowing a person to respond effectively to changing and challenging life demands. Keeping that faculty adaptive and flexible is possible. In this article, I highlight some developments in the science of innovative thinking which focus on reinforcing creativity and cognitive capabilities across the lifespan through training programs. Data in psychology is supported by data in neuroscience, therefore behavioural effects of training of innovative thinking can be explained with neural mechanisms in the brain (neuroplastic mechanisms). The findings that creative thinking can be preserved and fostered in ageing motivates for a further push to explore and exploit relations between innovative thinking and cognitive abilities necessary in daily life; which in turn can prevent the cognitive decline with advancing age. New promising trainings enhancing creative thinking and neural mechanisms underlying them are still emerging and developing.

Keywords: creative thinking; innovative thinking; cognitive training; neuroplasticity; older adults

Creativity refers to **ability** to be creative and also to a **process** by which this ability is used. The latter term includes a vast span of creative activities many of which are used in different forms of cognitive training and therapies. Those activities include various forms of art, such as painting, designing, crafts, music (Hannemann 2006), and also storytelling (Phillips et al. 2010), and innovative thinking (Rritter and Mostert 2017). Creative activities can improve cognitive and daily living abilities. The benefits of creative training on those abilities was demonstrated by Zaho and colleagues (2018). They showed that adding creative aspects to a cognitive training is more efficient than standard cognitive training in preserving or reinforcing cognitive capabilities. Adult patients (at least 60 years old) with mild cognitive impairment at risk of dementia but without psychiatric disorders received either standard cognitive training or cognitive training with creative expression program which included imaging, storytelling, and drawing. The training consisted of 25 hour-long sessions over 16 weeks. Cognitive functioning and daily living abilities were assessed with the Montreal Cognitive Assessment, Auditory Verbal Learning Test, Category Verbal Fluency Test, Digit Span Test, Trail Making Test, Activities of Daily Living scale, and Memory Satisfaction Questionnaire. Greater improvements in cognitive faculties including attention, memory, language, executive and complex social functioning, as well as activities of daily living were recorded after the creative cognitive training program than after the standard cognitive therapy. Moreover, they were maintained during 6 months follow-up. Thus, the results strongly suggest that incorporating a creative facet in a program of cognitive training can enhance a positive impact of the training on cognitive capabilities and daily living ability.

A question emerges whether creativity *per se* can be trained and enhanced and if its training can be effective in older people. Creative activities such as art therapies (for review see Noice et al. 2014) and storytelling (George and Houres 2014) have been used in older adults and resulted in their increased creativity and improved quality of life. Of special interest among creative activities is innovative thinking which is the main focus of this article. Evidence suggests that innovative thinking represents an ability necessary for many forms of creative performance (e.g. Mumford et al. 1998; Plucker and Renzulli 1999; Vincent et al. 2002; Scott et al. 2004). Innovative thinking, a mental process that supports the generation of multiple alternatives and solutions which are both novel and useful ideas, can be also described as creative thinking (Runco and Jaeger 2012). In literature, innovative thinking is referred to as divergent thinking, too. Those terms will be used interchangeably throughout the text. Creative thinking by definition allows a person to respond effectively to changing and challenging life demands. Keeping that faculty adaptive and flexible is both essential and possible.

Meta-analysis of different training programs aimed to enhance creativity capabilities including innovative thinking at different age groups were published and it was revealed that creativity training does work (e.g Scott et al. 2004). What is interesting, creativity skills can be improved even through short interventions. It was demonstrated that even a brief training of a single session of 1.5 hr could improve divergent thinking (Ritter and Mostert 2017). Techniques used during training included brainstorming, generating random connections (serendipitous creativity), thinking of possible lines of evolution of the current form of an idea or product (e.g. its form, consistency), thinking of possible changes to an existing idea or product facilitated with a list of thinking techniques (i.e. eliminating, substituting, combining, rearranging, reversing, modifying, or adapting elements). Divergent thinking was measured before and after training with Alternative Uses Task in which participants were asked to list as many as possible uses for a common object. Additionally, convergent thinking (finding the single best answer to a question) and creative problem solving were measured, too. Three elements of divergent thinking were assessed: creativity which indicates novelty and usefulness of an idea, fluency which tells how many ideas are generated (e.g. build a well, build stairs), and cognitive flexibility which depicts the number of distinct categories of generated ideas (e.g. building, demolishing). The creativity training session improved divergent thinking and creative problem solving. Though the improvements were not dramatic but rather small, yet (considering the fact that the training was short (1.5 hr)) they were promising and suggested that creativity skills, including creative thinking, can be trained. Worth noting is the relatively young age of the participants (mean age 23.23 years, SD = 5.76) which could contribute to the training success. Effective training of creative thinking in older people may require much longer programmes.

A promising cognitive training protocol aiming at the improvement of innovative thinking in older adults was presented by Sandra Chapman et al. (2017). Participants who were healthy adults (56–75 years old) with at least high school diploma, no history of psychiatric or neurological conditions, were screened for cognitive status, intelligence, and mood. Cognitive training program aimed at enhancing metacognitive strategies: strategic attention, integrated reasoning, and innovation (SMART, Strategic Memory Advanced Reasoning Training). Strategic attention teaches individuals to filter important data from less relevant information, for example to prioritize goals and block distractions. Integrated reasoning is the ability to synthesize data by extracting the essence, for example to construct generalized interpretations and application of ideas, make informed decisions, and solve problems. Innovation concentrates on flexible thinking and problem solving and includes updating ideas and seeking ways to improve tasks. Overall, SMART taught participants to approach challenging cognitive tasks with their brains prepared to think deeply, continually synthesising daily-encountered data, and to practice innovative thinking by generating a variety of perspectives, interpretations, and solutions. Training consisted of 60 min. sessions in small groups, once a week for 12 weeks. Additionally, participants had to complete 60 min. homework twice a week. Innovative cognition was assessed with the Multiple Interpretation Measure, which measures an individual's ability to generate multiple interpretations of the expository text, their quality and quantity. Cognitive training increased the number of high-quality innovations after 6 weeks and post training, which supported the potential of cognitive training to ameliorate cognitive deficits and promote innovative thinking. The behavioural results were associated with changes at the neural level which affected large scale neuronal networks, namely the default mode network (DMN) and the central executive network (CEN).

Recent developments in psychology and neuroscience complement each other making it possible to explain behavioural effects of cognitive training with neural mechanisms in the brain known as neuroplastic mechanisms (Leszkowicz 2017), which are commonly assessed with a MRI technique, a standard method applied in experimental psychology (e.g. Leszkowicz et al. 2017). Data in the neuroscience of creative thinking suggest that creative thoughts in various domains and tasks engage similar patterns of brain activity which involves interactions of large-scale brain networks such as the DMN and CEN (Beaty et al. 2016). The former, with nodes in the (ventro)medial prefrontal cortex, posterior cingulate cortex/precuneus, and angular gyrus is connected with rest and internally-oriented attention such as autobiographical retrieval, self-monitoring, mind-wandering, as well as social cognition; the latter is anchored in the dorsolateral prefrontal cortex and posterior parietal cortex and is associated with externally-directed attention and cognitively demanding tasks (Bressler and Menon 2010). Those two networks can exhibit an antagonistic relationship at rest and during numerous cognitive tasks. Preserving that relationship and networks integrity seems crucial for effective cognitive performance in healthy ageing. It has been suggested that creative cognition involves dynamic interaction of the DMN and CEN, where the DMN could influence the generation of candidate and new ideas, and the CEN could curb and direct this process to meet task-specific goals (Beaty et al. 2016). And indeed, in Chapman and colleagues study (2017), the gains in innovative thinking were connected with changes in these two networks, the DMN and CEN. Namely, the innovation score in the training group was inversely correlated with resting state functional connectivity of the DMN, and positively correlated with resting state functional connectivity of the CEN. Those changes, together with training-induced increase in cerebral blood flow in the DMN reflected training-induced neuroplastic effects in the brain that subserved enhanced innovative thinking. Thus, the cognitive training potential to ameliorate cognitive deficits and promote innovative thinking was further supported.

There is no uniform model of neuroplastic changes which accompany enhanced creative thinking. Depending on the experimental design, its objectives and analysis, the creativity-relevant neural structures and functions can vary to some extent. Sun and colleagues (2016) reported the results of divergent thinking training which consisted of 20 sessions of 28 min. practising of generating novel and unusual uses for an everyday object. The training induced functional changes, that is increased activity, not only in the precuneus, a nod in the DMN, and the dorsolateral prefrontal cortex and inferior parietal lobule, nods in the CEN, and but also in the dorsal anterior cingulate cortex (dACC), which is a hub in yet another large brain network: the salience network, which drives the switching between the DMN and CEN (Goulden et al. 2014). The training evoked structural changes, too;

it increased the volume of gray matter in the dACC. Those neuronal changes accompanied training-induced increases in the fluency (number) and originality (uniqueness) of generated ideas which were original uses for everyday objects measured with an alternative uses tasks. The similarity between pre-/post-training tests and divergent training tasks was a certain limitation of the study which did not allow any speculation on possible transfer effects of a widely understood creativity/cognitive training on innovative thinking and vice versa. Nonetheless, it supported the idea that training of creative thinking can induce both structural and functional neuroplastic changes in the brain, together with measurable behavioural effects.

Getting insights into the neural correlates of creativity and innovative thinking in particular may bring yet another benefit apart from leading to more effective training protocols and therapeutic approaches; it may help to enhance the efficacy of the training *per se*. An interesting concept of creativity training was presented by Balder Onarheim and Morten Friis-Olivarius (2013), namely using neuroscience as a framework for training creativity. In the Applied NeuroCreativity program, participants were first introduced to cognitive concepts of creativity built on neuroscience before applying these concepts to relevant real world creative problems. The course aimed at young to middle aged participants (22–44 years), and ran for 8 weeks, with four-hour supervised session per week and two to six hours of an independent group work per week. Giving the participants thorough understanding of the neuroscience of creativity resulted in more fluency in divergent thinking than in those in very similar courses without the neuroscience component. The evidence indicated that inclusion of neuroscience background and principles in the creativity training contributed to the success of the training and produced measurable effects. The concept of adding a neuroscience background to creativity training is a promising approach and worth continuing across more advanced age groups including older adults whose brains show capacity for neuroplastic changes (Leszkowicz 2017).

Creativity, including innovative thinking, is one of the most cherished assets and fruitful outputs of the human mind across the lifespan. The findings that innovative thinking can be preserved and might be fostered even during the ageing is encouraging. It motivates for a further push to explore and exploit connections between creative thinking and daily living abilities, especially that creative activities such as art therapies and storytelling have been successfully used in ameliorating age-related cognitive decline and improving daily cognitive capabilities. Promising approaches to enhance creative thinking based on developments in psychology and neuroscience are still emerging and developing, giving hope to future generations of older adults to retain an active mental lifestyle, intellect and psychological well-being with advancing age.

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