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ATTENTION PROCESSES IN MINDFULNESS: THE INFLUENCE OF MINDFULNESS INTERVENTION ON PERFORMING STROOP BASED TASKS

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SUMMARY

Mindfulness is a promising method, based on ideas of eastern culture, used in behavioural and cognitive therapy. These ideas emphasise the health role of meditation in a person's life. An application of *mindfulness* intervention by western therapists triggered an avalanche of scientific research concerning its effects in the context of physical and mental health. Due to the fact that *mindfulness* trains a conscious regulation of attention processes researchers became interested in the influence of such trainings on the improvement of functioning of various aspects of attention, measured with neuropsychological tests. The article aims at outlining a theoretical model of the relationship between *mindfulness* and attention processes. Moreover, a body of research will be presented, which looked for connection between the use of meditation techniques, mainly *mindfulness* intervention, and an improvement of functioning with regard to attention observed in neuropsychological tests. The question of relationship between *mindfulness* and performance of tasks based on the effect of Stroop interference will be discussed in more detail.

Key words: Stroop effect, mind-body therapies, meditation

INTRODUCTION

Mindfulness is one of the methods increasingly used by behavioral and cognitive therapists in the treatment of psychological and mental problems. The key concept in *mindfulness* is attention – conscious, non-judgmental and directed at the present moment (Kabat-Zinn, 1990). Attention understood in such a way is supposed to lead to experiencing the world and things “as they are” (Ray, 2002). The roots of *mindfulness* go back to eastern spiritual traditions, which emphasise the role of meditation as a method of reducing suffering but also leading to personal development by obtaining better self-awareness, insight, wisdom, peacefulness and internal balance (Goldstein, 2002; Kabat-Zinn, 2000). Drawing on the ideas of mindfulness in the western culture led to the creation of a number of psychological interventions and training programmes used more and more often by behavioural and cognitive therapists. The most common are MBSR – *Mindfulness Based Stress Reduction* (Kabat-Zinn, 1982), MBCT – *Mindfulness Based Cognitive Therapy* (Segal, Williams, Teasdale, 2002), DBT – *Dialectical Behavior Therapy* (Linehan, 1993) and ACT – *Acceptance and Commitment Therapy* (Hayes, Strosahl, Wilson, 1999).

There is evidence in literature which stresses the effectiveness of mindfulness intervention in the treatment of symptoms of both somatic and mental illnesses (Kabat-Zinn, 2003; Baer, 2003; Grossman et al., 2004; Kabat-Zinn et al., 1992; Kenny, Williams, 2007; Kutz et al., 1985; Ramel et al., 2004; Miller et al., 1995; Semple et al., 2005). It turns out that the experience of practising *mindfulness* techniques increases the tendency to apply them and to be more *mindful* in everyday life (Baer et al., 2008; Carmody, Baer, 2008), thus contributing to better psychological functioning. High results on the self-evaluation scales such as MAAS (Mindful Attention Awareness Scale; Brown, Ryan, 2003) or KIMS (Kentucky Inventory of Mindfulness Skills; Baer et al., 2004) signifying the level of *mindfulness* in everyday life correlate positively with being open to experiences, reflectiveness, the sense of well-being and negatively with such factors as suppressing negative thoughts, problems with emotional regulation, anxiety of being emotional, rumination (Lykins, Baer, 2009).

Since the key element in *mindfulness* is practising an intentional regulation of attention processes some research was started to check the influence of *mindfulness* intervention on the improvement in various aspects of attention. Bishop et al. (2004) presented a concept in which he distinguished aspects of attention engaged during *mindfulness* intervention – sustained attention (connected with vigilance), attention switching, inhibition of secondary information processing in response to stimulus, which requires efficiency in selective attention. He predicted that practising the regulation of attention processes using *mindfulness* methods leads to an improvement of these functions. In literature one can find the results of research testing this concept and some of them are scientific evidence of the relationship between *mindfulness* intervention and an improvement in various aspects of attention (Torbjorn, Anders, 2010; Moore, Malinowski, 2009;

Chambers et al., 2008; Jha, Krompinger, Baime, 2007; Anderson et al., 2007; Schmertz and Anderson, 2006; Napoli, Krech, Holley, 2005; Wenk-Sormaz, 2005; Valentine, Sweet, 1999; Rani, Rao, 1996;). This field is still being explored by researchers and the results are not always unequivocal. A review of research results bringing up the question of the influence of *mindfulness* on the attention processes will allow to take a closer look at empirical data and how they relate to theoretical deliberations of Bishop et al. (2004) and whether they confirm their claims.

MINDFULNESS AND ATTENTION PROCESSES – THEORY

In cognitive psychology a few different models of attention are distinguished. The most well known and competing are two models of attention: the process of selection (Triesman, 1964; Broadbent, 1958) and the process responsible for managing cognitive resources, which are assigned to particular tasks and determine how well the tasks are accomplished (Kahnemann, 1973). The most relevant for current research is the thesis that attention is a system of independent modules of data processing which involve not only selection of stimuli but also control of executive reaction and coordination of cognitive processes (Allport, 1980). In this approach attention is not an isolated mental function which influences only the selection of information coming from the external world, but it also determines the functioning of the whole mental system. The latter model can be a reference point to assess the legitimacy of using *mindfulness* techniques. It is assumed that training of intentional regulation of attention processes has a positive influence on the functioning of the whole mental system and in this way is connected with an improvement of widely understood physical and mental health. This thought was elaborated by Bishop et al. (2004) who believed that meditation trainings, especially *mindfulness* intervention, influence to a great extent the development of three aspects of attention – *sustained attention* (Posner, Rothbart, 1992), *attention switching* (Posner, 1980) and an ability to inhibit secondary process of attention processing – cognitive inhibition (Williams et al., 1996) associated with *selective attention* (McLeod, 2003, 2007).

Sustained attention is an ability to sustain attention over a prolonged period of time and to wait for the appearance of a particular stimulus called the signal while at the same time ignoring the others called the noise. *Mindfulness* techniques teach being open and vigilant to what is happening ‘here and now’. Sustaining attention on breathing allows one to focus on the current experience, which helps to identify one’s thoughts, feelings and sensations appearing at a given moment in the field of awareness. When one becomes aware of a thought, feeling or sensation attention is switched back to breathing. This requires some skill and flexibility in *switching* attention from one object to another. *Mindfulness* teaches a simple and direct experiencing of thoughts, feelings and sensations without rumination on their sources, consequences and relations. It is not about the suppression mechanism since all thoughts according to *mindfulness* are an

object of observation. After becoming aware of certain thoughts attention is redirected back to breathing in order to avoid their detailed processing, which Bishop et al. (2004) call inhibition of secondary information processing of a stimulus appearing in the stream of consciousness. Thus, it was suggested that *mindfulness* may lead to an improvement of cognitive inhibition especially at the level of stimuli *selection*. This would also increase the possibility to discern new and unexpected stimuli in our field of consciousness which so far have been outside awareness due to rumination – our conjectures, convictions, expectations and needs connected with a particular thought, feeling or sensation.

The results of research described in literature (Torbjorn, Anders, 2010; Chambers et al., 2008; Jha, Krompinger, Baime, 2007; Anderson et al., 2007; Schmertz and Anderson, 2006; Napoli, Krech, Holley, 2005; Valentine, Sweet, 1999; Rani, Rao, 1996) which verify the hypothesis of the influence of meditation trainings, including *mindfulness*, on the improvement of attention processes do not fully confirm the concept put forward by Bishop et al. (2004), therefore this field is still an inexhaustible subject of exploration.

THE INFLUENCE OF MINDFULNESS ON IMPROVING VARIOUS ASPECTS OF ATTENTION – A REVIEW OF RESULTS

In literature there has been an increase in the amount of information on the subject of attention processes in mindfulness. Jha, Krompinger, Baime (2007) described the effects of using *mindfulness* on functioning of three neuronal systems of attention – alerting, orienting, and executive system (Posner, Rothbart; 2007). Chambers et al. (2008) presented the results of research showing the influence of *mindfulness* training on improvement of working memory function, which to a great extent depends on efficient attention processes (Cowan, 1997). However, as far as the notion of Bishop et al. (2004) is concerned let us take a look at the results of research testing the influence of *mindfulness* training on particular aspects of attention – sustained attention, attention switching and inhibition of secondary processes of stimuli selection.

At the moment most research results in literature concern the relationship between *mindfulness* and sustained attention and inhibition of secondary information processing. The least explored is the question of influence of training on attention switching. Even earlier studies by Valentine and Sweet (1999) carried out in non-experimental conditions demonstrated that people with experience in *mindfulness* perform better at Wilkins' Counting Test (Wilkins et al. 1987), which is a measure of sustained attention, than people who do not use such meditation practice. Schmertz and Anderson (2006) demonstrated that being more *attentive* measured with self-evaluation questionnaire has an influence on better results in Conner's Continuous Performance Test II (CPT-II; Conners, 2000), which measures the aspect of sustained attention. Such correlation was not found in case of

Paced Auditory Serial Addition Test (PASAT; Gronwall, Sampson, 1974). Studies by Chambers et al. (2008) among 20 people who started a 10-day *mindfulness* training showed an improvement in sustained attention after completing the training. Subjects from the study group also had better results in tests measuring sustained attention after completing the training in comparison with the control group.

A lack of correlation between *mindfulness* intervention and sustained attention measured with Test of Everyday Attention for Children (TEA-Ch; Manly et al., 2001) was observed in the study by Napoli, Krech and Holley (2005). Elements of *mindfulness* training for pupils were introduced during PE classes. After 12 meetings it turned out that results of TEA-Ch in the experimental group were not better than in the control group. Similar results demonstrating a lack of correlation between *mindfulness* practice and an improvement in sustained attention were obtained by Anderson et al. (2007) who compared the ability to sustain attention for a longer period of time in healthy subjects before and after 8-week Mindfulness-Based Stress Reduction (MBSR) training. The results did not differ significantly from those obtained in the control group.

The comparison of results of Sustained Attention to Response Task (SART; Robertson et al., 1997) among Buddhist, people practicing *mindfulness* and people who do not meditate and are not Buddhist monks, demonstrated similar outcomes for those who meditate and those who do not use such practices (Torbjörn, Anders, 2010).

The relationship between the use of meditation techniques and attention switching was confirmed in the results of study by Rani i Rao (1996). Children who were taught elements of transcendental meditation at school had better results at Stars Counting Test (SCT; de Jong, Das-Smaal, 1990), which requires an efficient process of alternating attention during counting stars forwards and backwards. Other data do not show a significant correlation between *mindfulness* training and an improvement of attention switching (Anderson et al., 2007; Chambers et al., 2008).

A review of literature allows us to find studies concerning also the effects of *mindfulness* practices on the improvement in cognitive inhibition at the level of stimuli selection (Torbjörn, Anders, 2010; Moore, Malinowski, 2009; Anderson et al., 2007; Schmertz et al., 2006; Wenk- Sormaz, 2005). The most often used tool to assess the selectiveness of attention processes is Stroop test and all its modifications based on the effect of Stroop interference. It is worth taking a closer look at this method in studies evaluating the effects of *mindfulness* on selective attention and the very results of studies, which remain ambiguous.

THE RELATION BETWEEN MINDFULNESS INTERVENTION AND IMPROVEMENT IN TASKS BASED ON STROOP INTERFERENCE EFFECT

The source version of the test created by J.R. Stroop (1935) consists of three white cards. The first has 10 lines of 5 words each naming colours (blue, green,

yellow, red, brown, pink, black) written in black ink (*an achromatic colour-word reading card*). The second card differs in that the words are written in colourful ink different than the colour named (*an chromatic colour-word reading*). The third card has squares of a given colour instead of words (*a pure colour card*). The key element of the test is the part where a subject has to name the colour of the ink different than the meaning of the word (e.g. the word 'green' written in blue ink). In his experiments Stroop noticed that in such case the time needed to complete the task increases. This phenomenon was called the interference effect (Stroop 1935, MacLeod, 1991; Spreen, Strauss; 1998). On the basis of this paradigm numerous versions of Stroop test were created (Spreen, Strauss; 1998) which are used in scientific research.

The Stroop test is believed to be the most often used tool to assess the function of selective attention (McLeod, 1991). The interference effect induced in the Stroop test involves the need to ignore the word meaning as well as the efficient processes of cognitive inhibition in the automation of word reading. It turns out that reading as an automatic reaction requires far less concentration that is why it is easier to read words denoting colours than name colour of the ink. The efficiency of selective attention permits to redirect attention to previously ignored criterion of reaction and inhibit automatic reaction of reading words, so it helps to resolve a cognitive conflict. *Mindfulness* teaches to direct attention at our thoughts, sensations, feelings, which previously were omitted and to inhibit the automatic reaction of rumination about stimuli appearing in the stream of our consciousness. It involves the process of resolving the conflict among thoughts, feelings and behaviors. Cognitive conflict resolving is thought to be associated with the specific brain network (Posner, Rothbart, 2007). The most significant structure of that network is anterior cingulate, lateral prefrontal cortex and the basal ganglia. Neuroimaging studies data indicate that the interference effect induced during the Stroop test results in activation of ACC and prefrontal cortex (Pardo et al., 1990; Perret et.al. 1974, Gruber et al., 2000; Bench et al. 1993; Vendrell et al. 1994; Egner, Hirsh, 2005; Harrison et. al., 2005; Botvinick et. al., 1999; Carter et. al., 2000; Taylor et. al., 1997; Zysset et. al., 2000; Egner, Hirsh, 2005; Kerns et. al., 2004; MacDonald et. al., 2000; West, 2002). Lately researchers are wondering which part of the brain is more significant for conflict resolving. One of the assumptions is that anterior cingulate cortex contributes to the process of selecting, preparing, and executing motor responses determined by decisionmaking processes mediated by lateral prefrontal cortex (Paus et al., 1993, 1998; Swick, Jovanovic, 2002; Turken, Swick, 1999). Moreover, human ACC might be subdivided into more specific anatomic parts (Voght et.al., 1992). There are results of studies (Turken, Swick, 1999; Gruber et.al., 2000), which have demonstrated that Stroop paradigm mainly activate the region called 'attention to action' (AAA). This area of anterior cingulate is hypothesized to be responsible for focused attention (Posner et al., 1988). Thus, it can be assumed that practising *mindfulness* techniques improves the selective attention processes involved in conflict resolving which is connected with the specific brain

network. That phenomenon should translate into better results in Stroop paradigm tasks. The review of the studies in that issue shows divergent data.

The first reports demonstrate the effects of other meditation techniques. Better Stroop test results were found in subjects practicing transcendental meditation in comparison with the control group (Rani, Rao, 2000). Alexander et al. (1989) compared, among other things, cognitive functioning of elderly people before and after 12-week everyday transcendental meditation training, *mindfulness* and relaxation exercises. All subjects also took Stroop test. It turned out that in elderly people the meditation training weakens the interference effect in Stroop test. Such results were not obtained for subjects practicing relaxation and subjects from the control group. Other studies assessing the selective attention processes in *mindfulness* were presented by Wenk-Sormaz (2005), who divided the experimental group into three subgroups performing for 20 minutes various tasks engaging attention processes. The first was supposed to concentrate on breathing, the second had to perform memorizing tasks, the last group was told to let their thoughts flow. The participants took Stroop test before and after 20-minute task. The meditating group (focused on breathing) demonstrated a significant improvement of results in comparison with subjects from the other two groups. The data obtained from studies of people experienced in Buddhist meditation, who regularly use *mindfulness* techniques, confirm a positive correlation between *mindfulness* and an improvement in Stroop test results (Moore, Malinowski, 2009). In the control group the subjects did not meditate. The study revealed that meditation and the level of experience of using *mindfulness* reduce the interference effect in Stroop test.

In opposition are the results of studies by Schmertz and Anderson (2006), who used two variants of tasks based on the effect of Stroop interference – D-KEFS (Delis-Kaplan Executive Functioning System) Color-Word Interference Test and a computer modification of Stroop test to assess the selective attention processes and cognitive inhibition (Cohen et al., 1999). It was supposed that more *attentive* people – obtaining better results in mindfulness self-evaluation questionnaires – should have better results in the above mentioned tests. However, this hypothesis was not confirmed. A lack of significant influence of an 8-week MBSR training (Mindfulness-Based Stress Reduction) on the processes of selective attention measured with a modified Stroop test was described by Anderson et al. (2007). The effects of *mindfulness* practice in the context of better functioning of selective attention were also contradicted by data obtained from research among Buddhists and people using *mindfulness* meditation, whose Stroop test results were compared with those of non-meditating subjects (Torbjorn, Anders, 2010).

The above review of available research results concerning the reduction of Stroop interference effect as a result of meditation practice, including *mindfulness*, shows divergent data. This is probably due to the differences in the research methodology in this field.

SUMMARY

Verification of the assumptions of the concept by Bishop et al. (2004) concerning the influence of *mindfulness* training on the improvement of particular aspects of attention does not permit to accept them uncritically. A review of literature shows still very few studies taking up this issue whose results are unequivocal. So far the most extensively studied was the relation between *mindfulness* and selective attention processes measured with tests based on Stroop paradigm. However, also here the available data are divergent, which probably results from too big differences in the procedures and methodology of research. The research procedure is not standardized and there is a lack of replication studies in this field. The results come from experimental and non-experimental studies. In some studies the experimental groups consist of subjects with experience in meditation (Moore, Malinowski, 2009; Torbjorn, Anders, 2010), in others the participants who never before meditated are taught *mindfulness* techniques (Alexander et al.; 1989; Wenk-Sormaz; 2005; Anderson et al.; 2007). We can find Polish studies (Kolańczyk, Mikołajczyk, 2011) in which researchers compared Stroop effect in the three states of attention – after reading the text (focused on the task group), after relaxation (extensive attention group) and after Zen meditation group (post meditation attention group). The third group consisted of meditation experienced individuals. It appeared that post meditation group of individuals manifested reduced Stroop effect comparing with focused on the task group but only after relaxation Stroop effect has been lifted. The researchers explained it by the processing information differences in each of the three groups. Deeper information processing among post meditation individuals results in increased RT scores in Stroop interference task comparing with extensive attention group where we can observe sensory information processing. According to that data meditation experienced individuals and non-meditating subjects differ in the level of information processing. Moreover, the results of neuroimaging study during Stroop task performed by meditation experienced individuals and controls show the differences in brain activation pattern (Brefczynski-Lewis et.al, 2007). Although the Stroop interference scores were similar in both groups, the meditation experienced subjects revealed weaker activity of brain areas responsible for cognitive control. In reference to that we can assume that reaction mechanism in response to incoherence in the Stroop task is different among experienced in meditation individuals comparing with non- meditating controls.

In yet other studies the subjects do not undergo any meditation training, however it is assessed how their level of *attentiveness* measured with *mindfulness* self-evaluation questionnaire correlates with results of tests based on Stroop paradigm (Schmertz, Anderson; 2006). The differences in the research procedure concern also the length of training – sometimes these are only short interventions (Wenk-Sormaz; 2005) and sometimes precisely structured, long lasting and regular trainings (Anderson et al., 2007; Alexander et al.; 1989). The results can also be influenced by the use of different versions of Stroop test, including

its modifications based on the paradigm of interference effect (Schmertz, Anderson, 2006; Anderson et al.; 2007). The time of study may also play an important role since, as the research procedures show, it takes place immediately after a short *mindfulness* intervention (Wenk-Sormaz; 2005) or only after completing a full training in this scope (Alexander et al.; 1989; Anderson et al.; 2007). Carrying out the test after a short *mindfulness* intervention is also controversial since an improvement in selective attention can only be related to this specific situation and the research results cannot be connected with a general and long-term improvement in this scope. Despite these discrepancies, or maybe just because of them, the question of *mindfulness* influence on performance in Stroop test is an interesting subject and encourages to further research.

REFERENCES

1. Alexander C. N., Langer, E. J., Newman, R. I., Chandler, H. M., Davies, J. L. (1989). Transcendental meditation, mindfulness, and longevity: An experimental study with the elderly. *Journal of Personality and Social Psychology*, 57, 950-964.
2. Allport, D. A. (1980). Attention and performance. In G. Claxton (Ed.), *Cognitive psychology* (pp. 112-153). London: Routledge & Kegan Paul.
3. Anderson, N. D., Lau, M. A., Segal, Z. V., Bishop, S. R. (2007). Mindfulness-based stress reduction and attentional control. *Clinical Psychology and Psychotherapy*, 14, 449-463.
4. Baer, R. A. (2003). Mindfulness training as a clinical intervention: A conceptual and empirical review. *Clinical Psychology: Science and Practice*, 10, 125-143.
5. Baer, R. A., Smith, G. T., Allen, K. B. (2004). Assessment of mindfulness by self-report. *Assessment*, 11, 191-206.
6. Baer, R. A., Smith, G., Lykins, E. L. B., Button, D., Krietemeyer, J., Sauer, S., Walsh, E., Duggan, D., Williams, J. M. G. (2008). Construct Validity of the Five Facet Mindfulness Questionnaire in meditating and nonmeditating samples. *Assessment*, 15, 329-342.
7. Bench, C.J., Frith, C.D., Grasby, P.M., Friston, K.J., Paulesu, E., Frackowiak, R.S.J., Dolan, R.J. (1993). Investigations of the functional anatomy of attention using the Stroop test. *Neuropsychologia* 31, 907– 922.
8. Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., et al. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice*, 11, 230-241.
9. Botvinick, M., Nystrom, L.E., Fissell, K., Carter, C.S., Cohen, J.D., (1999). Conflict monitoring versus selection-for-action in anterior cingulate cortex. *Nature*; 402, 179–181.
10. Brefczynski-Lewis, J. A., Lutz, A., Schaefer, H. S., Levinson, D. B., Davidson, R. J., (2007). Neural correlates of attentional expertise in long-term meditation practitioners. *Proceedings of the National Academy of Sciences of the United States of America*. 104, 11483–11488.
11. Broadbent, D. E. (1958). Perception and communication. London: Pergamon.
12. Brown, K. W., Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, 84, 822-848.
13. Carmody, J., Baer, R. A. (2008). Relationships between mindfulness practice and levels of mindfulness, medical and psychological symptoms, and well-being in a mindfulness-based stress reduction program. *Journal of Behavioral Medicine*, 31, 23-33.
14. Chambers, R., Lo, B. C. Y., Allen, N. B. (2008). The impact of intensive mindfulness training on attentional control, cognitive style, and affect. *Cognitive Therapy and Research*, 32, 303-322.
15. Cohen, J. D., Barch, D. M., Cameron, C., Servan-Schreiber, D. (1999). Context processing deficits in Schizophrenia: Converging evidence from three theoretically motivated cognitive tasks. *Journal of Abnormal Psychology*, 108, 120-133.

16. Conners, C. K. (2000). *Continuous Performance Test II Technical Guide and Software Manual*. Toronto: Multi-Health Systems Inc.
17. Cowan, N. (1997). *Attention and memory: An integrated framework*. Oxford: Oxford University Press.
18. De Jong, P.F., Das- Smaal, E. A., (1990). The Star Counting Test: An attention test for children. *Personality and Individual Differences*, 11, 597-604.
19. Delis, D.C., Kaplan, E., Kramer, J.H. (2001). *Delis- Kaplan Executive Function System technical manual*. San Antonio, TX: The Psychological Corporation.
20. Egner, T. , Hirsch, J. (2005). The neural correlates and functional integration of cognitive control in Stroop task. *NeuroImage*, 24, 539– 547.
21. Goldstein, J. (2002). *One Dharma: The emerging Western Buddhism*. San Francisco: Harper Collins.
22. Gronwall, D. (1977). Paced auditory serial-addition task: a measure of recovery from concussion. *Perceptual and Motor Skills*, 44, 367–373.
23. Grossman, P., Niemann, L., Schmidt, S., Walach, H. (2004). Mindfulness-based stress reduction and health benefits: A meta-analysis. *Journal of Psychosomatic Research*, 57, 35-43.
24. Harrison, B.J., Shaw, M., Yucel, M., Purcell, R., Warrick, J. B., Strother, S.C., Egan, G., Oliver, J.S., Nathan, P.J., Pantelis, C.(2005). *Functional connectivity during Stroop task performance*. *Neuroimage*, 24, 181-191.
25. Hayes, S. C., Strosahl, K., Wilson, K. (1999). *Acceptance and commitment therapy: An experiential approach to behavior change*. New York: Guilford Press.
26. Jha, A. P., Krompinger, J., Baime, M. J. (2007). Mindfulness training modifies subsystems of attention. *Cognitive, Affective, & Behavioral Neuroscience*, 7, 109-119.
27. Kabat-Zinn, J. (1982). An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: Theoretical considerations and preliminary results. *General Hospital Psychiatry*, 4, 33-47.
28. Kabat-Zinn, J. (1990). *Full catastrophe living: Using the wisdom of your mind and body to face stress, pain, and illness*. New York: Delacorte.
29. Kabat-Zinn, J. (2000). Indra's net at work: The mainstreaming of Dharma practice in society. In G. Watson & S. Batchelor (Eds.), *The psychology of awakening: Buddhism, science, and our day-to-day lives* (pp. 225-249). North Beach, ME: Weiser.
30. Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present, and 44 Future. *Clinical Psychology: Science and Practice*, 10, 144-156.
31. Kabat-Zinn, J., Massion, M. D., Kristeller, J., Peterson, L. G., Fletcher, K. E., Pbert, L., et al. (1992). Effectiveness of a meditation-based stress reduction program in the treatment of anxiety disorders. *American Journal of Psychiatry*, 149, 936-943.
32. Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice Hall.
33. Kenny, M. A., Williams, J. M. G. (2007). Treatment-resistant depressed patients show a good response to Mindfulness-based Cognitive Therapy. *Behaviour Therapy and Research*, 45, 617-625.
34. Kerns, J.G., Cohen, J.D., MacDonald, A.W., Cho, R.Y., Stenger, V.A., Carter, C.S., (2004). Anterior cingulate conflict monitoring and adjustments in control. *Science* 303, 1023–1026.
35. Kolańczyk, A., Mikołajczyk, P.(2011). Uwaga postmedytacyjna osób doświadczonych w medytowaniu. *Studia psychologiczne*, 49 (3), 57-73.
36. Kutz, I., Leserman, J., Dorrington, C., Morrison, C., Borysenko, J., Benson, H. (1985). Meditation as an adjunct to psychotherapy: An outcome study. *Psychotherapy and Psychosomatics*, 43, 209-218.
37. Linehan, M. M. (1993a). *Cognitive-behavioral treatment of borderline personality disorder*. New York: Guilford.
38. Linehan, M. M. (1993b). *Skills training manual for treating borderline personality disorder*. New York: Guilford.
39. Lykins, E. L. B., Baer, R. A. (2009). Psychological functioning in a sample of individuals with long-term meditation experience. *Journal of Cognitive Psychotherapy*, 23, 226-241.

40. MacDonald III, A.W., Cohen, J.D., Stenger, V.A., Carter, C.S., (2000). Dissociating the role of the dorsolateral prefrontal and anterior cingulate cortex in cognitive control. *Science*, 288, 1835– 1838
41. MacLeod, C. M. (1991). Half a century of research on the Stroop effect: an integrative review. *Psychological Bulletin*, 109, 163-203.
42. MacLeod, C. M. (2007). The concept of inhibition in cognition. In: D.S. Gorfein, C.M. MacLeod (Eds.), *Inhibition in cognition* (pp. 3-23). Washington, DC: American Psychological Association.
43. MacLeod, C. M., Dodd, M. D., Sheard, E. D., Wilson, D. E., Bibi, U. (2003). In opposition to inhibition. In: B. H. Ross (Ed.), *The psychology of learning and motivation* (Vol. 43, pp. 163-214). San Diego, CA: Academic Press.
44. Manly, T., Nimmo-Smith, I., Watson, P., Anderson, V., Turner, A., Robertson, I. H. (2001). The differential assessment of children's attention: The Test of Everyday Attention for Children (TEA-Ch): Normative sample and ADHD performance. *Journal of Child Psychology and Psychiatry*, 42, 1065-1081.
45. Miller, J. J., Fletcher, K., Kabat-Zinn, J. (1995). Three-year follow-up and clinical implications of a mindfulness meditation-based stress reduction intervention in the treatment of anxiety disorders. *General Hospital Psychiatry*, 17, 192-200.
46. Moore A., Malinowski P. (2009). Meditation, mindfulness and cognitive flexibility. *Consciousness and cognition*, 18, 176-186.
47. Napoli, M., Krech, P. R., Holley, L. C. (2005). Mindfulness training for elementary school students. *Journal of Applied School Psychology*, 21, 99-125.
48. Paus, T., Koski, L., Caramanos, Z., and Westbury, C. (1998). Regional difference in the effects of task difficulty and motor output on blood flow response in the human anterior cingulate cortex: A review of 107 pet activation studies. *Neuroreport*, 9, R37–R47.
49. Paus, T., Petrides, M., Evans, A., and Meyer, E. (1993). Role of the human anterior cingulate cortex in the control of oculomotor, anual, and speech responses: A positron emission tomography study. *J. Neurophysiol.*, 70, 453–469.
50. Perret, E. (1974). The left frontal lobe of man and the suppression of habitual responses in verbal categorical behavior. *Neuropsychology*, 12, 323-330.
51. Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology*, 32, 3-25.
52. Posner, M. I., Petersen, S. E., Fox, P. T., Raichle, M. E. (1988). Localization of cognitive operations in the human brain. *Science*, 240, 1627–1631.
53. Posner, M. I., Rothbart, M. K. (1992). Attentional mechanisms and conscious experience. In A. D. Milner & M. D. Rugg (Eds.), *The neuropsychology of consciousness* (pp. 91-111). Toronto: Academic Press.
54. Posner, M. I., Rothbart, M. K. (2007). Research on attention networks as a model for the integration of psychological science. *Annual Review of Psychology*, 58, 1-23.
55. Ramel, W., Goldin, P. R., Carmona, P. E., McQuaid, J. R. (2004). The effects of mindfulness meditation on cognitive processes and affect in patients with past depression. *Cognitive Therapy and Research*, 28, 433-455.
56. Rani, N. J., Rao, P. V. K. (1996). Meditation and attention regulation. *Journal of Indian Psychology*, 14, 26-30.
57. Rani, N. J., Rao, P. V. K. (2000). Effects of meditation on attention processes. *Journal of Indian Psychology*, 18, 52-60.
58. Ray, R. A. (2000). *Indestructible truth: The living spirituality of Tibetan Buddhism*. Boston: Shambhala.
59. Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., Yiend, J. (1997). Oops: performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neuropsychologia*, 35, 747–758.
60. Schmertz, S. K., Anderson, P. L. (2006). The relation between self-report mindfulness and performance on tasks of attention. Poster presented at Association for Behavioral and Cognitive Therapies (ABCT).

61. Segal, Z. V., Williams, J. M. G., Teasdale, J. D. (2002). *Mindfulness-based cognitive therapy for depression: A new approach to preventing relapse*. New York: Guilford.
62. Semple, R. J., Reid, E. F. G., Miller, L. (2005). Treating anxiety with mindfulness: An open trial of mindfulness training for anxious children. *Journal of Cognitive Psychotherapy: An International Quarterly*, 19, 379-392.
63. Spreen, O.; Strauss, E. (1998). A compendium of neuropsychological tests. NY: Oxford University Press.
64. Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, 18, 643-662.
65. Swick, D., Jovanovic, J. (2002). Anterior cingulate cortex and the Stroop task: neuropsychological evidence for topographic specificity. *Neuropsychologia*, 40(8), 1240-1253.
66. Taylor, S.F., Kornblum, S., Lauber, E.J., Minoshima, S., Koeppe, R.A. (1997). Isolation of specific interference processing in Stroop task: PET activation Studies. *Neuroimage*, 6, 81-92.
67. Torbjorn, J., Anders B. (2010). Meditators and non-meditators on sustained and executive attentional performance. *Mental Health, Religion & Culture*, 14, 49-58.
68. Triesman, A. (1964). Selective attention in man. *British Medical Bulletin*, 20, 12-16.
69. Turken, A., Swick, D. (1999). Response selection in the human anterior cingulate cortex. *Nature Neurosci.*, 2(10), 920-924.
70. Vogt, B. A., Finch, D. M., Olson, C. R. (1992). Functional heterogeneity in cingulate cortex: The anterior executive and posterior evaluative regions. [Review]. *Cerebral Cortex*, 2(6), 435-43.
71. Valentine, E. R., Sweet, P. L. G. (1999). Meditation and attention: a comparison of the effects of concentrative and mindfulness meditation on sustained attention. *Mental Health, Religion, & Culture*, 2, 59-70.
72. Wenk-Sormaz, H. (2005). Meditation can reduce habitual responding. *Alternative Therapies in Health & Medicine*, 11, 42-58.
73. West, R. (2003). Neural correlates of cognitive control and conflict detection in the Stroop and digit-location tasks. *Neuropsychologia*, 41, 1122-1135
74. Wilkins, A. J., Shallice, T., McCarthy, R. (1987). Frontal lesions and sustained attention. *Neuropsychologia*, 25, 359-365
75. Zysset, S., Muller, K., Lohmann, G., Yves von Cramon, D. (2001). Color – word matching Stroop task: separating interference and response conflict. *NeuroImage*, 13, 29-36.

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