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To Train or to Entertain the Brain: How Does Enhanced Focus of Attention Guide Perception into the Goal Directed Action

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Different areas of cognitive science traditionally perceived the mind as an abstract information processing entity, whose interactions with the outside world should be of small or no relevance at all. However, a recent embodied cognition perspective, view cognitive processes as deeply embedded into the body's interactions with the world. In support of such contention, lots of empirical evidence has been brought and thusly different claims proposed. In this paper, we present the computer based neurocognitive task of sustained attention which is a dual task with many characteristics that obviously mirror some of the above claims. In this regard, we take into consideration both on-line and off-line aspects of the embodied cognition and point out how processing efficiency and attentional functioning are crucial vehicles in bringing perception into effective action (embodied cognition). Furthermore, there is plenty of evidence about the bidirectional relationship between the attentional/cognitive functioning and emotion regulation as well. This rises new possibilities in looking at the cognitive bias modification approaches and brain-cognitive training procedures for human beings without perceiving them as disembodied minds or complex machines but instead proactive and physically involved in the real world. We argue that such cognitive training approaches even though at first glance seemed as mere technical and machine oriented procedures, should be regarded as humanistic in its nature which perfectly mirror the Merleau-Ponty's concept of "embodied subjectivity." Finally, we explain how such approaches can be successfully combined with the neurobiological accounts and effectively implemented into clinical practice (self-regulation, self-directed neuroplasticity, effortful control, behavior change).

Keywords: embodied subjectivity, self-regulation, effortful control, attentional networks, brain-cognitive training, self-directed neuroplasticity

1. Introduction

Embodied cognition perspective posits that functional needs of the body dictate the mind to make it function without necessity of the mind involvement in resolving abstract problems (Barrett 2011; Casasanto and Lupyan 2015). Perceptual and motor systems were many times underestimated and regarded as merely

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peripheral input and output detectors, without consideration of their interaction with the environment and thusly relevant contributors in crucial cognitive processing. However, in the past decades, different opinions about sensorimotor mechanisms evolved from many of diverse cognitive science research fields. These opinions share the common conclusion about their crucial and all-important role in development and maintenance of successful self-regulation behavior and actions within the psychosocial environment. Because of a great expansion of information communication technologies and artificial intelligence assisted by behavior-based robotics, we live in the information society, where there is plenty of our behavior guided by different routines (Brooks 1986). These routines help us efficiently interact with the environment without necessary solving the abstract problems by the strict use of internal representations (Brooks 1986). As our ancestors possessed neural resources, primarily devoted to perception and motor action processing, it was obvious that their cognitive activity occurred prevalently in on-line environmental interactive conditions. In other words, because of the survival and fast changing living conditions, there was no time or a very small portion of time dedicated to off-line cognitive processes. Today, there is a growing tendency towards the idea that the mind should be conceptualized and observed through the psychosocial context and in relationship with a physical body that interacts with environment. Many contemporary experts in the field share the opinion that human cognition, instead of being abstract, and strictly separated from peripheral input and output loops, should rather be studied as if its essential components belong to sensorimotor processing. In order for embodied cognition to retain a purposeful interpretation of its term, we need a careful observation and analysis of many of diverse opinions. Among the frequently mentioned claims in the literature are: (1) Cognition is situated; (2) Cognition is time pressured; (3) We off-load cognitive work onto the environment; (4) The environment is part of the cognitive system; (5) Cognition is for action; (6) Off-line cognition is body based. In the present paper, we will firstly introduce the neurocognitive sustained attention task using ANTI-v paradigm (Roca et al. 2011; 2012), which is computer based and explains in details its basic characteristics and features. After that, we will try to analyze it in the light of embodied cognition perspective by verifying how it fits in all of aforementioned claims. Then we will show how specific conditions of the task support those claims through the attentional processing efficiency and performance effectiveness. We will further discuss the possibility that certain types of computer based cognitive tasks, with high enough cognitive load and lots of repetitions could be regarded as cognitive training protocols or cognitive bias modification candidates which have capacity of preserving a new learning (behavior change) by bringing perception into action through self-directed attentional processes. In addition, we will take into account also motivational and emotional common pool resources and outline the affective and motivational significance of the psychosocial context (Gorjup and Gorjup 2014b).

2. Attention Networks and ANTI-V Paradigm: Bottom-up vs. Top-down Attentional Functioning

The computer-based neurocognitive task (the ANTI-V task; Roca et al. 2011; 2012) is used to obtain a direct measure of vigilance in addition to the usual attention network scores: alerting and orienting as stimulus driven or bottom-up networks and executive control as goal directed or top-down network (Corbetta and Shulman 2002). Instructions present the task as a game. A row of five objects (cars) is presented to participants above or below the fixation point, superimposed on one of two parking lines in the background road. Participants must choose between pressing the left or right button (“c” for the leftward and “m” for the rightward direction of the central car). The row of cars is presented for 200 ms, but responses are allowed up to

2000 ms. To analyze the functioning of the executive control network, in half (congruent) trials the flanker cars point in the same direction as the target car whereas in the other half trials (incongruent) the flanker cars point in the opposite direction. To manipulate the orienting factor, a 50 ms visual cue (an asterisk) is presented for 100 ms before the row of cars, either in the same (valid cue) or in the opposite location (invalid cue). In one third of trials, there is no asterisk (no cue condition), so there is a 33% of cue ambiguity. Alerting is manipulated by the presence or absence of a 50 ms warning auditory signal presented 500 ms before the target car. To obtain a direct measure of vigilance, the ANTI-V dual-task paradigm requires participants to detect infrequent stimuli (central car displaced to the left or right), to inhibit the response to the main task ("c" vs. "m" buttons), and to press instead the spacebar (for a more detailed explanation of the ANTI-V paradigm see: Roca et al. 2011; 2012).

3. Putting on the Lens of Embodied Cognition Perspective

Now that we have a detailed explanation of the ANTI-V paradigm, we are ready to put on the glasses of embodied cognition perspective and take a look of how these claims fit well into the ANTI-V paradigm. The first claim that cognition is situated posits that cognitive processes occur under the pressures of real-time situation in interaction with sensorimotor mechanisms. Indeed, spatial cognition in particular tends to be situated. ANTI-V task provides context real environment. As it consists of relevant inputs and outputs which create a motivational-affective significance at the target relevant location, it guides the cognition through the perception according to action demands (Clark 1997; Pfeifer and Scheier 1999). The next claim, cognition is time pressured, fits well in the ANTI-V paradigm as its basic purpose is to perform as fast and accurate as possible in a time limited and repetitive task conditions (time locked perceptual-motor activity) in a form of a videogame (Roca et al. 2011; 2012). The human behavioral research outlines the importance of time pressure as a main principle that creates a situated cognition (Kirsh and Maglio 1994; Brooks 1991b). While off-loading cognitive work onto the environment is a common strategy, this is impossible to do during the on-line performance of ANTI-V task, because we cannot simply leave information encoding for later time or alter the environment. Perhaps the only off-line strategy available in the ANTI-V task is to try to rely on preloaded representations acquired during the practice block trials of the task (prior learning). By the claim that environment is part of the cognitive system, researchers outline that it is not solely mind guiding the cognition but instead there is an interaction of psychosocial context with the mind, body and environment as a whole (Wertsch 1998; Clark 1998). This is exactly what happens in the ANTI-V paradigm, where cognitions and motor actions must follow predetermined perceptual routine while being prepared for the unpredictable environmental conditions. The last but not least claim that cognition is for action was nicely expressed by Glenberg (1997) who argued that cognition aroused in order to bring the perception into action in a three-dimensional environment. Indeed, perception is bringing into action through attentional and cognitive processes adequately with the affective and motivational significance of environment resulting in a motor response in a three-dimensional world. Furthermore, such processes, usually happen under very high cognitive load conditions and are modulated by or depend on emotional states (low level threat) and motivational approaching behavior (Gorjup and Gorjup 2016) even when stimuli are not necessarily emotional in their nature. There is evidence for the possible existence of bidirectional relationship between the attentional system and emotions (MacLeod, Koster, and Fox 2009; Pesoa 2009). Some authors propose that attentional processes of effortful control could be usefully applied in self-regulation of cognitive-affective and motivational states

(see for example Gross 1998; Pesoa 2009; Gorjup and Gorjup 2014b; 2016; 2017).

4. Bringing Perception into Effective Action through Self-directed Brain Training

The integration of neuroscience and psychology in the last few decades revealed new insides about better understanding of human behavior. There is plenty of evidence that changing behavior is not that easy as it seemed at the beginning and that carrot and stick did not bring the effective and long lasting results. The same holds true for the humanistic attempt towards the individual oriented treatments through persuasion and empathy. For that reason, our research was narrowed in developing of a new generation of computerized brain training (self-directed) neurosolutions. The improvement of behavioral change was predicted and followed up through improvement on attentional, emotional, and motivational measures. This was obtained by specific design of the brain training protocol through biasing of affective and motivational significance at the target relevant location in a repetitive sustained attention routine (for info about the method contact the author or visit: www.entertainforbrain.com). In this regard, processing efficiency and attentional functioning were crucial vehicles in bringing perception into effective and long lasting action/behavioral change. Theoretical background for a new generation of brain training neurosolutions supported by contemporary neuroethics (Gorjup and Gorjup 2014b) stands on Quantum Zeno Effect (today empirically well validated principle; Hebb 1955), Processing Efficiency Theory (Eysenck and Calvo 1992), Attention Control Theory (Eysenck, Derakshan, Santos, and Calvo 2007), and Dual Competition Model Framework (Pesoa 2009). Our research so far together with experimental data (Gorjup 2013; Gorjup and Gorjup 2014b; Gorjup et al. 2014a; Gorjup and Gorjup 2016; 2017) shows that providing the sufficiently intense and precisely preprogrammed “sustained saturation of attention” at the target relevant location is achieved through specific brain training protocol. In this regard, the unique feature of such cognitive bias training is its ability to guide the subject gradually into the state of a heightened anticipatory level. In addition, concentrating on such anticipated strategy of perceptual and executive experience over a sufficient period of time at the target relevant location during self-directed brain training routine produces neuroplasticity changes which result into new established neural circuits. In support of such contention, according to Quantum Zeno Effect (QZE) stronger expectation levels of possible mental thought or experience should produce higher mental density. In our recent experiment, we tested 102 subjects using the 25 minutes brain training neurosoultion protocol. During the same experiment, we run the EEG Power Analysis of 27 randomly assigned subjects while measuring attentional performance effectiveness and processing efficiency (Gorjup and Gorjup 2017).

The data analysis of cognitive training showed significant improvement of performance indices (sensitivity and % of hits was higher at the end of the session then it was at the beginning, there was also lower % of false alarms). Analysis of electro-physiological measures (EEG Power) also showed that ratios of theta/low beta and theta/high beta bands gradually decreased from the first to the last minute within the same session which indicate better processing efficiency (linear regressions for both ratios showed gradual decrease indicating less effortful control for the same level of performance effectiveness).

These results are in line with the predictions from the research on performance effectiveness and processing efficiency of attentional functioning using different kinds of low level threat but high cognitive load visual tasks (Eysenck and Calvo 1992; Eysenck, Derakshan, Santos, and Calvo 2007; Eysenck and Derakshan 2011; Walkenhorst and Crowe 2009; Pesoa 2009; MacLeod, Koster, and Fox 2009; see also Wang et al. 2016). However, we have to point out that tasks used in the above experiments differed in their designs so it would be

wise to take conclusions as not unequivocal and with caution. No doubt to elucidate and further verify the obtained results additional evidence through replicated research designs needs to be done.

5. Conclusion

Processing efficiency and attentional functioning seems to be crucial vehicles in bringing perception into effective action. Furthermore, there is evidence of bidirectional relationship between attentional-cognitive functioning and emotion regulation as well. This rises new possibilities in looking at the cognitive bias modification approaches and brain/cognitive training procedures for human beings without perceiving them as disembodied minds or complex machines but instead proactive and physically involved in the real world. We strongly believe that such cognitive approaches even though at first glance seemingly technical and machine oriented, could be regarded as humanistic in its nature. Finally, we propose that such approaches should be successfully combined with the neurobiological accounts and effectively tested within the clinical practice for the human wellbeing. However, more research must be done in the field in order to elucidate and strengthen the effectiveness and usefulness of such brain training approaches.

Let us conclude with the statement of Maurice Merleau-Ponty:

> … Man is not an object, locked within his essence like a chair, and, although we may stand out as objects, we also connect to other objects through our consciousness. We are "intentional," directed toward things without being simply reduced to a thing ourselves. Inter-subjectivity is an attempt to understand that we are both, subject and object, in which "the subject is his body, his world, and his situation, by a sort of exchange." (Merleau-Ponty 1967, 113-7)

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