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The impact of experimental manipulation of body schema on creative potential in mid-adolescence

Abstract: *The study explored the impact of experimental manipulation of body schema on creative potential in mid-adolescence. The experiment was conducted in a group of 140 adolescents at the age of 14-16: 68 boys (M = 15.03; SD = .93) and 72 girls (M = 15.01; SD = .81), randomly allocated to equinumerous groups: experimental and control. The aim of experimental manipulation was to obtain a temporarily disturbance of body schema. It was gained by the use of glasses reversing the field of vision in the vertical up/down plane, and measured by the Body Schema Disturbance Questionnaire. In both groups the Urban and Jellen's Test for Creative Thinking – Drawing Production (TCT-DP, Urban & Jellen, 1986) was administered twice (in A and B versions, randomly selected). Statistical analyses was run with a mixed model ANOVA (2 drawings x 2 groups x 2 sexes). The interaction effect of drawing production and group assignment on creative potential was significant, while the interaction effect of drawing production and sex on creative potential turned out to be insignificant.*

Keywords: *body schema, creative potential, mid-Adolescence, experimental manipulation*

INTRODUCTION

The body-creativity relationship is gaining more attention with increasing knowledge of the mind-body relationship (e.g. Slepian & Ambady, 2012) and a great deal of interest in creativity as a one of the most desirable personal and social ability (Ananiadou & Claro, 2009). It has been established that there are two directions of mutual body-mind interaction (Payne, 1990): the body shapes the mind (e.g. Kim, 2015) and the mind shapes the body (e.g. Zhong & Leonardelli, 2008). Presented study is a part of the research trend referring to the first type of dependence. Body is treated as a system of mental representations (Gallagher, 2005; Mirucka, 2018) and mind is explored based on the example of creativity potential. Thus, in current study the causal relationship between the body schema (one of body representations) and the individuals' creative potential (mental process) is explored. Literature in the field emphasizes the importance of creativity which raises the question of its growth potential. Two premises of enhancing creativity are indicated: individuals have the potential to be creative and creativity can be developed (Lin, 2011). The inclusion of the bodily perspective in the field of research on creativity allowed for further answers to the question of when people are more creative. For example it was found that they are more creative when they stretch, rather than flex their arms (Friedman & Förster, 2000). Verifying whether there is a significant impact of the manipulation of body schema on the creative potential of adolescents allows us to refine our knowledge about body-creativity relationship.

Body and cognition

The knowledge of the relationships between body and mind is rooted in science and practice. The scientific ground consists of the array of research on embodied cognition (Shapiro, 2019), and conceptual metaphor theory (Lakoff & Johnson, 1999). According to the concept of embodied cognition, the foundation of cognitive development lies in a subjective experience of one's body in action. An act of cognition commences when the body engages with the physical world and is conceptualized as dynamic interactions between one's body and the environment (Gibbs, 2006). So far embodied cognition has formed multiple research programs rather than a coherent, well-defined theory. Despite this it is referred to as the next step in the evolution of standard cognitive science due to its great influence on the contemporary understanding of cognition (Shapiro, 2019). Irrespective of the existing differences, all attempts at describing and understanding embodied cognition share the conviction of there being an impact of body (or its representations) on cognitive

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processes (Alsmith & de Vignemont, 2012). For example, bodily sensations can influence cognition processes. Touching a hard surface more than a soft one induces the perception of strictness and rigidity (Ackerman, Nocera, & Bargh, 2010) or squeezing a hard ball, as compared to a soft ball, makes people categorize sex--ambiguous faces predominantly as male (Slepian, Weisbuch, Rule, & Ambady, 2011). These effects may exist because abstract concepts are metaphorically grounded in concrete, bodily experience (Lakoff & Johnson, 1999). Bodily experiences connected with gesture can impact various aspects of cognition. For instance, the firming of muscles (e.g. clenched fists) help enhance self-control and will-power (Hung & Labroo, 2011) and performing gestures can influence thought processes (Casasanto, 2011). Cognition could also be changed by previous motor experience. Right-hand individuals evaluate items on the right more positively, whereas left-hand individuals prefer items on the left (Casasanto, 2009).

The conceptual metaphor theory (Lakoff & Johnson, 1999) assumes that primary metaphorical systems are grounded in physical and social experience, and that basic sensorimotor concepts are literal, because they are directly abstracted from physical interaction with the environment. For instance, holding heavy things induced the assessment of the items as more important (Jostmann, Lakens, & Schubert, 2009). This was due to the connection between the metaphor "weighty" which references sensation of holding something and the abstract concept of importance. Body maintains a kind of scaffold for abstract concepts (Williams, Huang, & Bargh, 2009). Cognitive concepts are metaphorically embodied in sensorimotor system (Landau, Meier, & Keefer, 2010). Research conducted on the basis of this theory shows how much concepts are grounded in bodily movement and sensation.

Also the therapeutic practice provides abundant inspiration to search for the relationships between the body and creativity. For example, dance therapies stimulate creativity (Levy, 1988) and even short dance improvisation can enhance divergent thinking and creativity (Sowden, Clements, Redlich, & Lewis, 2015). Body and mind are interchangeably connected (Lakoff & Johnson, 1999; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005), although the essence of these mechanisms is still being explored (Shapiro, 2019).

Body and creativity

Since the body can impact cognition, and creativity being a mental process that includes cognitive processes, then it can be assumed that the body influences different aspects of creativity. Indeed, this outcome has recently been proven by various scientific studies. There are different relations between the body in action and individual cognition aspects, such as the impact of physical activity on creating (Klatzky, Pellegrino, McCloskey, & Doherty, 1989) as well as recalling (De Vega, Robertson, Glenberg, Kaschak, & Rinck, 2004) semantic concepts or a positive impact on maintaining general mental capabilities by preventing cognitive decline (Kramer, Erickson, & Colcombe, 2006). Mild physical activity (walking) influences divergent thinking, but it does not have any impact on convergent thinking. The effect is not caused by the external flow of stimulation during movement but is related to the performance of movement itself (Oppezzo & Schwartz, 2014). Running can strengthen verbal creative performance (Gondola and Tuckman, 1985) and the self-reported hours of sport activities per week improve performance in a figural creative ideation task (Cavallera, Boari, Labbrozzi, & Bello, 2011). Moderate aerobic exercise (Ramocki, 2002) improved creative performance (Blanchette, Ramocki, O'del, & Casey, 2005). Creativity can be influenced even by certain types of movement. For example, fluid movement improves creativity in three domains: creative generation, cognitive flexibility and the ability to make remote connections (Slepian & Ambady, 2012). Squeezing a softball, rather than a hard ball, improves divergent thinking creativity tasks. Squeezing a hard ball, rather than a softball, in its turn increases the effectiveness of convergent thinking creativity tasks (Kim, 2015). One of the recent paper by Andreas Fink et al. (2018) on movement imagery and creative moves confirms the interdependence of motor and creative processes, also on the neuronal level. Barbot (2018) indicates that physical self-esteem relates to creative performance in several domains. In sum, there exists evidence that body shapes creativity although, as is the case with embodied cognition, the satisfactory understanding of the issue is still unavailable.

Body schema as a body mental representation

The body explored from a psychological perspective is a multidimensional phenomenon that includes not only the experience of the body as an object, but also the body as a subject (Mirucka, 2018). Experiencing the body is an expression of the functioning of the body self, which constantly processes somatosensory information from the inside and the outside of the body. It is processed in the form of various mental representations (Damasio, 2010; Gallagher, 2005; Krueger, 2002; Mirucka, 2018; Riva, 2018) such as body schema, body image (Gallagher 2005; Mirucka, 2018) and body awareness (Mirucka, 2018; Mehling et al., 2009).

The body schema is the most primary and central of body representations. Its privileged position among other body representations can be attributed to the role it performs in the process of monitoring and using the body (Stamenov, 2005). Mental representations of body schema are based mostly on the arrangement of proprioceptive information resulting from the motion and movement in space (Gallagher, 2005). They are formed in the neuronal maps that show multi-modal aspects of the present body state and the functioning of the organism (Gallagher, 2005; Mirucka, 2018). Body schema enables changes of movement and posture, performing intentional actions, being aware of the body form and body spatiality, and the sensation of movement. It is also responsible for basic identity senses, including the awareness of one's own body, and being the subject of one's own actions (Rossetti,

Rode, Farne, & Rossetti, 2005; Tsakiris & Haggard, 2006; Tsakiris, Schutz-Bosbach, & Gallagher, 2007). Because of the variety of functions it fulfills, the body schema is characterised by multi-sensory integration and dynamic plasticity (Gallese & Sinigaglia, 2010).

Initially, body schema was described mainly in relation to the neural level but now it is described as a complex structure that also manifests a mental and identity dimension (Mirucka, 2018). It turns out that activation of body schema even on neuronal, unconscious level can affect cognition. Holding a pen with the teeth compared to holding it with the lips causes greater satisfaction in watching a cartoon (Strack, Martin, & Stepper, 1988). The present study concerns a second, mental level of body schema. Exploration of its role in cognition on the example of creative potential is another step towards precise meaning of role of body schema in mental functioning.

Creative potential

Creative potential it is an ability to produce original and valuable ideas (Lubart, Barbot, & Besançon, 2019) and to generate something useful and original (Runco & Jaeger, 2012). It is a normally distributed trait (Eysenck, 1995), which exists in various configurations in the population (Runco, 2004; Urban, 2005; Urban & Jellen, 1996). Runco (2016) posits that creative potential includes not only personality but also other functions like cognition, affection, attitude, metacognition, and brain function. Individual creative potential becomes apparent during creative activities, creative achievements (Jauk, Benedek, & Neubauer, 2013; Runco, Millar, Acar, & Cramond, 2010) and creative behavior (Karwowski & Beghetto, 2019). The transition from creative potential to creative behavior is a kind of agentic action (Karwowski & Beghetto, 2019). It requires the intention of being creative (Nickerson, 1985) and a willingness to overcome obstacles (Sternberg & Lubart, 1991), thus not everyone with high creative potential can make creative achievements (Sordia, Martskvishvili, & Neubauer, 2019). A person's creative potential also depends on the quality of match between her unique profile of personal-level resources and the specific demands of a particular creative task (e.g. Barbot & Tinio, 2015; Lubart, Zenasni, & Barbot, 2013). From this point of view a person enjoys extensive potential for creativity since there exist various creative tasks and creativity is seen as multifaceted and partly domain- and task-specific (Barbot, Lubart, & Besançon, 2016). Contemporary creative potential assessment methods treat body movement as one of the relevant domains in which creative potential can be expressed ideas (Lubart et al., 2019). It is therefore a reference to the body schema as an instance associated with movement and its engagement in creative process.

Creative potential has a complex structure. Componential models of creative potential indicate mutual relations between its specific factors (several interrelated cognitive and non-cognitive factors) (Ivcevic, 2009; Sternberg & Lubart, 1995). It exists in various configurations in the population (Runco, 2004; Urban, 2005; Urban & Jellen,1996). Furthermore, creative potential can be observed and measured with various indicators, like divergent and convergent thinking (Runco, 2010). Components models of creativity (Urban, 1991, 1995) include most of the cognitive and non-cognitive dimensions. This model has become the basis for the Test for Creative Thinking-Drawing Production (TCT-DP), (Urban & Jellen, 1996). It includes different qualitative and quantitative indicators of creative potential (despite the name of the test that emphasizes creative thinking) (Jastrzębska & Limont, 2017) and enables its assessment via drawing production (Urban & Jellen, 1986).

Body schema and creativity in adolescents

The development of mental body representations, including body schema is particularly intensive during the period of adolescence (Assaiante, Barlaam, Cignetti, & Vaugoyeau, 2014; Cash & Pruzinsky, 2002; Gallagher, 2005). The structure of the body schema and of sensorimotor representations is susceptible to the effects of changes affecting the body, and is accompanied by other sensory information (Decety & Boisson, 1997). Increasing body height and weight temporarily change adolescents' body representation, which results in changes in their capability of motor control (Choudhury, Charman, Bird, & Blakemore, 2007; Viel, Vaugoyeau, & Assaiante, 2009). The development of adolescents' body schema involves continuous transformation in the status of body shape and movements held in the brain (neural level of body schema) as well as in the subconscious and reflective experiencing of the body (body schema mental level) (Mirucka, 2018). Changes in the body schema may result not only from developmental trends, but also from intentional activity. The type of physical activity undertaken in adolescence, relative to the engagement of fine and gross motor skills, translates into the degree of body schema activation and its level of development (higher/ lower) (Mirucka, 2016). Body schema plays also an important role in shaping the personality of adolescents. A higher level of body schema (e.g. a strong sense of being able to direct one's own body, good movement coordination), is significantly related to high self-esteem and the use of mainly mature and neurotic defense mechanisms in threat situations what contributes to reaching psychological maturity (Mirucka, 2016). Study of the impact of changes in the body schema on some of mental abilities presents itself as an interesting and promising line of research that can enhance our understanding of the specifics of adolescence. Current research explores the impact of changes in the mental level of body schema on one of mental abilities – creative potential. These changes are effected in an experimental manner. Although mental representations of the body are fairly stable (Mirucka, 2018), due to puberty-related transformations and a greater susceptibility to social and cultural factors (Aubrey, 2007; Fredrickson & Roberts, 1997; Martin & Gentry, 1997), adolescents' body schema is more susceptible to influence and experimental manipulation (Bell, Lawton, & Dittmar, 2007; Cignetti, Caudron, Vaugoyeau, & Assaiante, 2013).

Creativity is one of the important mental abilities that intensify in adolescence (Rothenberg, 1990). Adolescents' creative ability is characterized by several "slumps and jumps" (Barbot, et al., 2016). A relative peak of visuospatial divergent thinking takes place around the age of fifteen. At the same time there are no age-related differences in verbal divergent thinking (Kleibeuker, De Dreu, & Crone, 2013). As regards other forms of divergent thinking, three common "slumps" can be observed. One of them features in adolescents around age twelve (Kim, 2011; Krampen, 2012; Lau & Cheung, 2010) while the other two occur earlier on in life. The "slumps" can be caused by different puberty-related physical changes such as hormonal changes (e.g. spike in testosterone) (Hassler & Nieschlag, 1989), neuronal changes (e.g. processes in the pre-frontal cortex) (Nelson & Guyer, 2011) and progressive myelination process (Barbot & Tinio, 2015; Spear, 2013), so bodily maturation manifests an important line of explanation of this effect. Can changes in the mental representation of body schema significantly affect the creative potential of adolescents as well?

THE CURRENT STUDY: AIM AND HYPOTHESES

The present study, preliminary in nature, aims to answer whether the disturbance of mental representations of adolescents' body schema may affect the creative potential. We hypothesize that an experimental, temporary disturbance of body schema is likely to decrease significantly the creative potential in girls and boys. Such an outcome can be effected by a temporary disruption of proprioceptive information coming from disturbed movement (body schema), which can result in a decrease in creative performance.

METHOD

Participants

Participants were 140 adolescents at the age of 14-16: 68 boys (M = 15.03; SD = .93) and 72 girls (M = 15.01; SD = .81) from a junior high school. They were assigned at random to two equinumerous groups: experimental (E) and control (C), separately for each sex (34 boys and 36 girls in each group). All participants were Polish natives. Participation in the study was voluntary and unpaid. The examined persons were minors and therefore, apart from their freewill consent for participation in the study, the parent's or legal guardian's consent was also obtained. At the beginning of the research participants received information about the procedure and signed a consent form.

Measures

Demographical and psychological variables

Apart from standard questions (e.g. age, sex), the Demographic Data Questionnaire also included queries about height and body weight, felt physical discomfort (*How many days in the past month have you felt bad due to physical discomfort (e.g. pains, allergy)?*) and mental discomfort (*How many days in the past month have you felt bad due to psychological difficulties, e.g. stress, sadness, fear?*), as well as questions regarding physical illness. The information was used to exclude those individuals whose health condition could have substantially affected research results. They were not included in the study.

Mental representations of body schema

The Body Schema Test (BST) constitutes a part of the Battery of Tests for Researching Mental Body Representations (Mirucka, 2017), and comprises 6 items. Statements are rated on a 7-point scale ranging from *I totally disagree* to *I totally agree*. Each scale is unidimensional and it has its own *a priori* key. High scores in BST indicate a strong feeling of one's own body control and an efficient coordination of one's own movements and actions, whereas low scores indicate a weak body schema, insufficient movement coordination, and a weakened feeling of body ownership. An example of a BST item: "*I think that my movements are not coordinated*". The construction of scales was a multi-stage process completed according to the rules for creating psychological research tools based on advanced statistical procedures (Mirucka, 2017). The reliability of test in the present study was acceptable: 1) in the group of girls α = .70; and in the group of boys α = .73.

Disturbance of body schema

The Body Schema Disturbance Questionnaire (DQ-BS) served to measure the intensity of disturbance in body schema representation induced by experimental manipulation. It comprised 10 statements rated on a 7-point scale ranging from *I totally disagree* to *I totally agree*. An example of a DQ-BS item: "*I had difficulties with synchronizing body movements".* The reliability of DQ-BS in present study was acceptable in the group of girls (α = .82), and good in the group of boys (α = .79).

Creative potential

Test for Creative Thinking – Drawing Production (TCT-DP) (Urban & Jellen, 1986, 1996) in the Polish adaptation (Matczak, Jaworowska, & Stańczak, 2000) was administered. It is used to assess creative potential (e.g. Fink et al., 2018; Urban, 2004) and is one of the most frequently used instruments for the measurement of this phenomenon (Nogueira, Almeida, & Lima, 2017). A particular benefit of the tool is a multi-aspect assessment of creative works, i.e. the qualitative assessment, which takes into account the specifics and individual features of a given work, and the quantitative assessment related to the volume of work (Urban, 2005). For this reason, TCT-DP was assumed to be adequately sensitive to capture changes in the creative potential during creative performance in the visual domain.

The test sheet contains a square frame and six graphic elements – five inside the frame (a semicircle, a point, a polygonal chain, a curved line, and a short dashed line),

and one outside the frame (a small square without one side). The participant's task is to finish the drawing according to their own idea. The test has two versions: A and B; in Form B, the original layout (Form A) is rotated by 180 degrees. The two versions are treated as alternatives as they meet the condition of parallel testing (Anastasi, 1999). The results obtained during the Polish (Matczak et al., 2000) and Portugal (Almeida, Ibérico Nogueira, Bahia, & Urban, 2007) studies show that there were no significant differences between the results in Forms A and B. Both Forms are used in experimental studies (e.g. Welter, Jaarsveld, van Leeuwen, & Lachmann, 2016).

In the present study, A and B versions were used. In order to eliminate a possible effect related to the sequence of test versions being completed, Forms A and B were randomly selected. The resulting drawings were rated according to fourteen specific criteria. The evaluations performed by two independent, competent coders (evaluators) were compared in terms of their compatibility in order to estimate the adequacy of the evaluation manner adopted for the drawings. The Spearman's coefficient of rank correlation was .84, which affirms the drawing evaluation system as sufficiently objective, and the obtained results as credible.

PROCEDURE

An experiment was developed in order to verify the research hypothesis. It was carried out in two phases (Table 1), each in a group of girls and boys in mid-adolescence.

The first phase of the study was conducted in groups consisting of several subjects, while in the second phase the participants were examined individually. The delay between the baseline assessment of phase I and the individual assessment of phase II was one week.

In phase I the participants were given a relevant TCT-DP_1 sheet and started to make drawings (a dependent variable pre-test). The sequence of sheets presented to individual persons was set with a random number generator. After the drawing was finished the participants were asked to fill in the questionnaire methods.

At the beginning of the next phase of research, the participants were randomized to the groups. Phase II in experimental group (E) commenced with the experimental manipulation aimed at a temporary destabilization of body schema. The manipulation was carried out with the use of glasses which reverse the field of vision in the vertical up/down plane. The reversing effect of the glasses is due to light-bending optical prisms that were installed into spectacle frames. Looking through reversing glasses hinders free action by generating discrepancies between visual information and sensorimotor data related to body movement. Glasses of this type are used for educational purposes and as an attractive tool for the popularization of science. After putting on and fitting the glasses the participants were asked to start performing three tasks that required employing different types of movement. At first they were asked to stick ten elements representing different parts of the body (eyes, nose, mouth, ears, hands, navel, heart) in the right place on a life-size human body contour placed on a wall (Task 1). Furthermore, they sat at a desk and performed two tasks with paper and pencil. The first one was to join the dots according to the provided instructions (Task 2). An A4 sheet was divided into six equal rectangles, and in different places on every rectangle two (first sheet) or three (second sheet) dots were put. The participants joined the dots according to the instructions (e. g. from the top right to the bottom left corner). The last task was to write letters by tracing dotted lines, where the letters formed words of increasing length, ranging from three to eight letters (Task 3). Each task was performed for approx. 3.3 minutes. After this time the participants were presented with another task, regardless of the effect obtained in the previous task. The quality of the tasks was not measured, because the main purpose of the tasks was only to create opportunities to experience difficulties in using the body schema. The total duration of the experimental manipulation was 10 minutes. The adolescents in the control group were asked to read a text silently and write down all words beginning with "p" (Task 1), with "w" (Task 2), and with "s" (Task 3). The duration of each task was approx. 3.3 minutes, and the total duration of all three tasks was 10 minutes. The text read by the subjects was a technical description of varnish materials applied for finishing wooden surfaces. It was assumed that a theoretical, technical text without any descriptions of actions, movement, activities, or any description of characters would allow effective focusing, and at the same time it would have a marginal effect on the respondents' mental body representations on every level these representations are manifested. The participants of the control group (C) were not exposed to the experimental manipulation

Table 1. Experiment Plan

Experiment	Phase I	Delay		Phase II	
Group E	TCT-DP_1 + QM	1 week	S_1	TCT-DP_2 + DQ-BS	Debriefing
Group C	TCT-DP_1 + QM	1 week	S_2	TCT-DP_2	Debriefing

Note. Groups: E – Experimental, C – Control. Methods: QM – Questionnaire Methods (Demographic Data Questionnaire, Body Schema Test), TCT-DP – Test for Creative Thinking - Drawing Production (TCT-DP_1 – pretest, TCT-DP_2 – posttest), DQ-BS – Body Schema Disturbance Questionnaire. Stimuli: S_1 – Reversing glasses; S_2– Writing out words from the text.

of body schema. Hence, they performed a task that involved the following conditions: it required attention (similar to the task in the experimental group) but only slightly activated body schema (a complete deactivation of body schema being impossible to obtain), and was of a reproductive nature, so it didn't require creativity. Direct repetition of the tasks in the control group was applied to obtain the slightest possible activation of body schema.

Upon the conclusion of experimental exposure (in Group E) or the completion of the control task (in Group C) the participants were given a relevant, randomly selected sheet (other than in the pre-test) of TCT-DP_2 (post-test). Finally, the adolescents from the experimental groups filled in DQ-BS (Group E) to check the level of body schema disturbance. Since the tasks in the control group were intended to minimize the activation of body schema, it was decided not to use DQ-BS in this group. The last phase of the examination was the debriefing. All participants were informed about the purpose and strategy of the study. All questions were answered and all doubts were clarified. Every participant was asked about their degree of commitment to the task, general sensations and feelings during the experimental manipulation. The procedure of the present research complied with APA ethical standards in the treatment of participants.

STATISTICAL ANALYSES

To test whether the experimental manipulation of body schema significantly affects creative potential in girls and boys in mid-adolescence, we computed a two-way analysis of variance in a 2x2x2 mixed model ANOVA.

RESULTS

The experimental and control groups of girls and boys did not differ significantly from each other in terms of: BMI, $t_{boys}(66) = -.42$; $p = .67$ and $t_{girls}(70) = -.14$; $p = .88$. Similarly, the groups were homogeneous as regards declared physical discomfort suffered during the week: $t_{boys}(66) = -.03$; $p = .97$ and $t_{girls}(70) = -.48$; $p = .63$; and physical illness: $t_{boys}(66) = -.32$; $p = .75$ and $t_{girls}(70) = .54$; $p = .59$. In every group there was a similar number of ill persons, i.e. in the group of boys approx. 5-6, and in the group of girls approx. 8-10. The groups did not differ significantly in terms of body schema representations: $t_{boys}(66) = .99$; $p = .33$ and $t_{girls}(70) = .49$; $p = .62$ (Table 2).

The experimental manipulation carried out with reversing glasses proved to be effective, i.e. it temporarily disturbed the representation of body schema in the group of boys, as well as in the group of girls (results of DQ-BS). The obtained mean scores in both groups were relatively high, for girls $M_{girls} = 51.97$ ($SD = 9.22$; min. = 25; max. = 69), and for boys $M_{boys} = 46.44$ ($SD = 9.96$; min. = 15; max. = 67). In each group there was only one participant who revealed a very low score what could indicate that in these cases the experimental manipulation of body schema wasn't sufficiently effective. For that reason those two participants were excluded from the main statistic analyses. As a consequence, in the experimental groups of both sexes the minimum score increased to 38 (girls) and 33 (boys). Girls, compared to boys, revealed a significantly higher susceptibility to a temporary change in body schema $t(66) = -2.72$; $p < .01$.

In order to verify whether the creative potential changes in line with experimental manipulation of body schema, a two-way analysis of variance was carried out in a mixed model (mixed model ANOVA): 2 drawings (TCT-DP_1, TCT-DP_2) x 2 groups (control and experimental) x 2 sexes (boys and girls). A drawing was an intra-object factor: the first one was produced before the introduction of an experimental stimulus, while the other one was produced after the experimental manipulation. The first inter-object factor was the membership in one of the two groups: experimental, where participants were subjected to body schema manipulation, or control, where participants were protected from any body schema activation. The second inter-factor was sex. A dependent variable was creative potential (operationalized as creative performance in the visual domain) controlled by the manner in which a drawing was produced and assessed according to the principles of TCT-DP. The analysis of variance was carried out with ANOVA univariate repeated-measures.

Table 2. Mean differences of the variables of interest between the two study groups of mid-adolescents: the independent samples *t-test*

Variables	Mean and standard deviation								Significance of differences			
	Experimental group (n = 70)				**Control group** (n = 70)				**Boys**		**Girls**	
	Boys (n = 34)		Girls (n = 36)		Boys (n = 34)		Girls (n = 36)		*t*(66)	*p*	*t*(70)	*p*
BMI	20.50	3.17	21.39	4.77	20.79	2.26	21.53	3.67	-.42	.67	-.14	.88
Physical discomfort	4.56	6.03	5.64	5.45	4.60	5.43	6.31	6.41	-.03	.97	-.48	.63
Physical illnesses	.15	.36	.28	.45	.18	.39	.22	.42	-.32	.75	.54	.59
Body schema	25.38	6.37	23.11	6.78	23.76	7.07	22.33	6.53	.99	.33	.50	.62

The interaction effect of drawing production and group assignment on creative potential was significant, $F(1, 135) = 30.59$, $p < .001$; $eta^2 = .185$. In the experimental group the effective manipulation of body schema caused a significant decrease in creative potential so the difference between mean scores of TCT-DP$_1$ (M_{E1} = 17.48, SD_{E1} = 7.72) and TCT-DP$_2$ (M_{E2} = 13.95, SD_{E2} = 5.90) was relevant, while in the control group this difference (M_{C1} = 15.04, SD_{C1} = 6.58; M_{C2} = 16.66, SD_{C2} = 8.49) wasn't significant (see Figure 1). The experimental manipulation of the body schema interacting with the produced drawing controls 18.5% of creative potential variability of the examined adolescents. The other interaction effect of drawing production and sex on creative potential turned out to be insignificant, $F(1, 135) = .54$, p = .46.

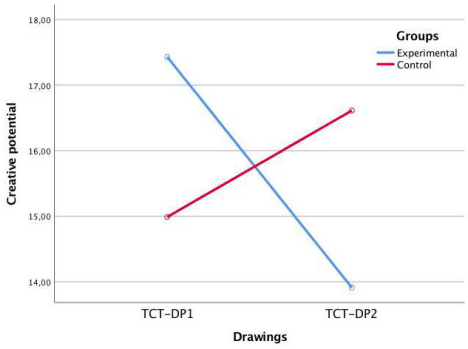

Figure 1. Interaction effect of drawing production (TCT-DP1, TCT-DP2) and group assignment (experimental, control) on creative potential: univariate repeated-measures ANOVA

DISCUSSION

This main research problem was the importance of body schema in cognitive processes in relation to creative potential in the group of mid-adolescents. The aim of the study was to investigate the impact of a temporary destabilization of body schema representation on the level of TCT-DP performance as an indicator of creative potential in the visual domain.

In the present study body schema has been disturbed in the experimental group. The manipulation turned out to be sufficiently effective, i.e. reversing glasses significantly disturbed the temporary mental representation of body schema. Despite the fact that the induced disturbances by means of reversing glasses differed from the illusion of rubber hand incorporation (Botvinick & Cohen, 1998), or an illusory attribution of a surrogate whole body as the subject's own body (Petkova & Ehrsson, 2008), their underlying mechanisms may be similar and be associated with a disturbed processing of sensorimotor information.

These mechanisms probably referred to: 1) the disturbance of sensorimotor information integration, i.e. bottom-up processes of information processing (Botvinick & Cohen, 1998; Armel & Ramachandran, 2003), and/or 2) insufficient modulation and limitation of sensorimotor information flowing through mental body representations based on top-down processes (Tsakiris, Carpenter, James, & Fotopoulou, 2010; Tsakiris & Haggard, 2005). Hence, body schema can be treated as an emulator in the system of movement control (Slaughter, 2004), which could mean that using reversing glasses induces a discrepancy between real movement required to perform the experimental tasks (bottom-up processes) and the current state of an emulator (top-down processes), with a resulting experience of significant disruptions in movement control.

In line with previous research it was proved that adolescents' body schema is susceptible to experimental manipulation (Bell, et al., 2007; Cignetti, et al., 2013). A possible explanation points to the fact that only at the end of adolescence the ability to control fine and gross motor skills guided by proprioception is fully developed. Until this time, structures involved in the central integration of dynamic proprioceptive information are not mature enough. The process of cortical maturation particularly involves the frontal and parietal regions, which constitute the neural basis for motor functions, and thus they are related to the development of body schema (Goble, Lewis, Hurvitz, & Brown, 2005). Insufficient maturity of the cortical neural networks (Casey, Tottenham, Liston, & Durston, 2005; Uhlhaas, Roux, Rodriguez, Rotarska-Jagiela, & Singer, 2010) in mid-adolescence may seem an important reason for the difficulties in controlling one's movements mainly with proprioception. The temporary deficiency in the central integration of proprioceptive information most probably results in the fact that adolescents, to a great extent, rely on exteroceptive and visual information in the control of their movements and actions (Assaiante, et al., 2014). In particular, adolescents at the age of 14 and 15 temporarily ignore proprioceptive information during the control of body orientation and stabilization, and make more frequent and intensive use of visual information. Compared to adults, their control of fine and gross motor skills is based substantially more on visual than proprioceptive information (Mallau, Vaugoyeau, & Assaiante, 2010; Viel et al., 2009). The visual cues were disrupted during the experiment, which may have amplified the strength of the disturbance of teenage body schema.

In conformity with the hypothesis, experimental manipulation involving a temporary disturbance of body schema significantly decreased creative potential of adolescents. The study group of adolescents with the temporarily disturbed body schema obtained significantly lower scores in TCT-DP than the control group. The explanation of this effect may be found in relation to the specific functions of body schema that is responsible for body posture, body position, awareness of body form, and awareness of the body in space (Jacob & Jeannerod, 2005; Mirucka, 2018). These functions underlie the sense of agency needed in any performance. Creative potential requires confidence in the ability to perform tasks (Bandura, 1997). A disturbed body schema impedes

performance which may lead to lower self-confidence and thus reduce creative potential.

Another possible explanation points to the way in which the body can shape the mind. Earlier studies deliver evidence that concepts are grounded in bodily movement and sensation (Lakoff & Johnson, 1999), so manipulation of bodily sensations (sensorimotor information) is not irrelevant to performance. For example, individuals who made fluid movements demonstrated greater fluency and originality compared to individuals manifesting non-fluid movements (Slepian & Ambady, 2012), which proves that the quality of the movements performed and the associated metaphorical meanings exert influence on creative processes. A similar effect may have occurred in the presented study. Movements performed while executing the tasks with reversing glasses were incoherent and non-fluid due to the discrepancy between visual and proprioceptive information. This factor was arguably instrumental in diminishing creative potential. According to the conceptual metaphor theory (Lakoff & Johnson, 1999) non-fluid movement as being grounded in basic physical experience can literally translate into "non-fluid creativity".

Although various studies on embodied cognition have not been fully explained and described in a well-defined theory, they make an important contribution to the discussion about body-mind relationships. As Shapiro (2019) said a current research program may become a reigning paradigm in the future. The presented study is in line with these research trends. It provides evidence that disturbance of body schema can influence cognitive processes in terms of creative potential. This finding is important from the prevention perspective as the identification of factors diminishing creative potential opens up the possibility of extending creativity training programmes to adolescents.

The present study has several methodological limitations that should be considered when interpreting and generalizing its outcomes. First, there is a lack of the DQ--BS measurement in the control group for comparison. Unfortunately, the DQ-BS was only administered to the experimental group on a doubtful rationale that being in the control group (i.e. out of experimental manipulation of the body schema) would guarantee the absence of any disturbance in the body schema representation, especially since the control tasks completely independent of movement activate this representation only to a limited extend, if at all. Further research should administer the DQ-BS measurement in both groups. Second, the control tasks could be designed in a more accurate way in order to achieve an appropriate control manipulation. Instead of using the tasks that are completely different from those in the experimental condition, the control tasks should consist in the same movement-based exercises but without the disruption of the visual field through the reversing glasses. Third, the sample size within cells (i.e. sex and group assignment) was moderate. Bigger sample sizes of mid-adolescents are needed to investigate the impact of experimental manipulation of body schema on creative potential in both sex groups.

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REFERENCES

Ackerman, J. M., Nocera, C. C., & Bargh, J. A. (2010). Incidental haptic sensations influence social judgments and decisions. *Science*, *328*, 1712-1715.

Almeida, L., Ibérico Nogueira, S., Bahia, S., & Urban, K. (2007, July). *Assessing creativity: The Test for Creative Thinking-Drawing Production (TCT-DP). The concept, application, evaluation and Portuguese studies*. Prague: Poster session presented at Xth European Congress of Psychology.

Alsmith, A. J. T., & de Vignemont, F. (2012). Embodying the Mind and Representing the Body. *Review of Philosophy and Psychology 3*, 1-13.

Ananiadou, K., & Claro, M. (2009). 21st century skills and competencies for new millenium learners in OECD countries (EDU Working paper no. 41). Paris: OECD.

Anastasi, A. (1999). *Testy psychologiczne* (1st ed.). Warszawa: Pracownia Testów Psychologicznych Polskiego Towarzystwa Psychologicznego.

Armel & Ramachandran, 2003; Botvinick & Cohen, 1998. Rubber hands "feel" touch that eyes see. *Nature, 391*(6669), 756.

Armel, K. C., & Ramachandran, V. S. (2003). Projecting sensations to external objects: Evidence from skin conductance response. *Proceedings of the Royal Society of London: Biological, 270,* 1499-1506.

Assaiante, C., Barlaam, F., Cignetti, F., & Vaugoyeau, M. (2014). Body schema building during childhood and adolescence: A neurosensory approach. *Clinical Neurophysiology*, *44*(1), 3-12.

Aubrey, J. S. (2007). The impact of sexually objectifying media exposure on negative body emotions and sexual self-perceptions: Investigating the mediating role of body self-consciousness. *Mass Communication and Society*, *10*(1), 1-23.

Bandura, A. (1997). *Self-Efficacy The Exercise of Control.* W.H. Freeman and Company, New York.

Barbot, B. (2018, published online). Creativity and Self-esteem in Adolescence: A Study of Their Domain-Specific, Multivariate Relationships. *The Journal of Creative Behavior*. https://doi.org/10.1002/jocb.365

Barbot, B., & Tinio, P. P. L. (2015). Where is the "g" in creativity? A specialization differentiation hypothesis. *Frontiers in Human Neuroscience*, *8*, 1041.

Barbot, B., Lubart, T. I., & Besançon, M. (2016). "Peaks, slumps, and bumps": Individual differences in the development of creativity in children and adolescents. In B. Barbot (Ed.), *New directions for child and adolescent development. Perspectives on creativity development* (Vol 151, pp. 33–45). Jossey-Bass.

Bell, B. T., Lawton, R., & Dittmar, H. (2007). The impact of thin models in music videos on adolescent girls' body dissatisfaction. *Body Image*, *4*(2), 137-145.

Blanchette, D. M., Ramocki, S. P., O'del, J. N. & Casey, M. S. (2005). Aerobic exercise and creative potential. Immediate and residual effects. *Creativity Research Journal*, *17*, 257-264.

Casasanto, D. (2009). Embodiment of abstract concepts: Good and bad in right- and left-handers. *Journal of Experimental Psychology: General*, *138*, 351-367.

Casasanto, D. (2011). Different bodies, different minds: The body specificity of language and thought. *Current Directions in Psychological Science*, *20*, 378-383.

Casey, B. J., Tottenham, N., Liston, C., & Durston, S. (2005). Imaging the developing brain: What have we learned about cognitive development? *Trends in Cognitive Science*, *9*(3), 104-110.

Cash, T. F., & Pruzinsky, T. (Eds.). (2002). Body Image. *A handbook of theory, research, and clinical practice* (1st ed.). New York, London: Guilford Press.

Cavallera, G. M., Boari, G., Labbrozzi, D. & Bello, E. D. (2011). Morningness-eveningness personality and creative thinking among young people who play recreational sport. *Social Behavior and Personality*, *39*, 503-518.

Choudhury, S., Charman, T., Bird, V., & Blakemore, S. J. (2007). Adolescent development of motor imagery in a visually guided pointing task. *Consciousness and Cognition*, *16*, 886-896.

Cignetti, F., Caudron, S., Vaugoyeau, M., & Assaiante, C. (2013). Body schema disturbance in adolescence: From proprioceptive integration to the perception of human movement. *Journal of Motor Learning Development*, *1*, 49-58.

Damasio, A. R. (2010). *Self comes to mind: Constructing the conscious brain* (1st ed.). New York: Pantheon Books.

De Vega, M., Robertson, D. A., Glenberg, A. M., Kaschak, M. P., & Rinck, M. (2004). On doing two things at once: Temporal constraints on actions in language comprehension. *Memory and Cognition*, *32*, 1033-1043.

Decety, J., & Boisson, D. (1997). Anticipation, représentations et schéma corporel à la lumière des neurosciences cognitives. *Annales de Réadaptation et de Médecine Physique*, *40*, 63-73.

Eysenck, H. J. (1995). *Genius: The natural history of creativity*. New York, NY: Cambridge University Press.

Fink, A., Rominger, C., Benedek, M., Perchtold, C. M., Papousek, I., Weiss, et al. (2018). EEG alpha activity during imagining creative moves in soccer decision making situations. *Neuropsychologia*, *114*,118-124.

Fredrickson, B. L., & Roberts, T. A. (1997). Objectification theory: Toward understanding women's lived experiences and mental health risks. *Psychology of Women Quarterly*, *21*(2), 173-206.

Friedman, R. S., & Förster, J. (2000). The effects of approach and avoidance motor actions on the elements of creative insight. *Journal of Personality and Social Psychology*, *79*, 477-492.

Gallagher, S. (2005). *How the body shapes the mind* (1st ed.). Oxford: Oxford University Press.

Gallese, V., & Sinigaglia, C. (2010). The body self as power for action. *Neuropsychologia*, *48*, 746-755.

Gibbs, R. W. (2006). *Embodiment and cognitive science* (1st ed.). Cambridge: Cambridge University Press.

Goble, D. J., Lewis, C. A., Hurvitz, E. A., & Brown, S. H. (2005). Development of upper limb proprioceptive accuracy in children and adolescents. *Human Movement Science*, *24*, 155-170.

Gondola, J. C. & Tuckman, B. W. (1985). Effects of a systematic program of exercise on selected measures of creativity. *Perceptual and Motor Skills*, *60*, 53-54.

Hassler, M., & Nieschlag, E. (1989). Masculinity, femininity, and musical composition psychological and psychoendocrinological aspects of musical and spatial faculties. *Archives of Psychology*, *141*(1), 71-84.

Hung, I. W., & Labroo, A. A. (2011). From firm muscles to firm willpower: Understanding the role of embodied cognition in self--regulation. *Journal of Consumer Research*, *37*, 1046-1064.

Ivcevic, Z. (2009). Creativity map: Toward the next generation of theories of creativity. *Psychology of Aesthetics, Creativity, and the Arts*, *3*, 17-21.

Jacob, P., & Jeannerod, M. (2005). The motor theory on social cognition: a critique. *Trends in Cognitive Sciences*, *9*(1), 21-25.

Jastrzębska, D., & Limont, W. (2017). Not Only Jumps, Slumps, but also Mini Plateau. Creative Potential Assessed by the Test for Creative Thinking-Drawing Production. A Cross-Sectional Study of Polish Students Aged from 7 to 18. *Creativity Research Journal*, *29*(3), 337-342.

Jauk, E., Benedek, M., & Neubauer, A. C. (2013). The road to creative achievement: A latent variable model of ability and personality predictors. *European Journal of Personality*, *28*, 95-105.

Jostmann, N. B., Lakens, D., & Schubert, T. W. (2009). Weight as an embodiment of importance. *Psychological Science*, *20*, 1169-1174.

Karwowski, M., & Beghetto, R. A. (2019). Creative behavior as agentic action. *Psychology of Aesthetics, Creativity, and the Arts*, *13*(4), 402-415.

Kim, J. H. (2015). Physical Activity Benefits Creativity: Squeezing a Ball for Enhancing Creativity. *Creativity Research Journal*, *27*(4), 328-333.

Kim, K. H. (2011). The creativity crisis: The decrease in creative thinking scores on the Torrance Tests of Creative Thinking. *Creativity Research Journal*, *23*(4), 285-295.

Klatzky, R. L., Pellegrino, J. W., McCloskey, B. P., & Doherty, S. (1989). Can you squeeze a tomato? The role of motor representations in semantic sensibility judgments. *Journal of Memory and Language, 28*, 56-77.

Kleibeuker, S. W., De Dreu, C. K., & Crone, E. A. (2013). The development of creative cognition across adolescence: Distinct trajectories for insight and divergent thinking. *Developmental Science*, *16*(1), 2-12.

Kramer, A. F., Erickson, K. I., & Colcombe, S. J. (2006). Exercise, cognition, and the aging brain. *Journal of Applied Physiology*, *101*, 1237-1242.

Krampen, G. (2012). Cross-sequential results on creativity development in childhood within two different school systems: Divergent performances in Luxemburg versus German kindergarten and elementary school students. *Europe's Journal of Psychology*, *8*(3), 423-448.

Krueger, D.W. (2002). *Integrating body self and psychological self* (1st ed.). New York – London: Brunner-Routledge.

Lakoff, G., & Johnson, M. (1999). *Philosophy in the flesh: The embodied mind and its challenge to western thought.* New York, NY: Basic Books.

Landau, M. J., Meier, B. P., & Keefer, L. A. (2010). A metaphor-enriched social cognition. *Psychological Bulletin*, *136*, 1045-1067.

Lau, S., & Cheung, P. C. (2010). Developmental trends of creativity: What twists of turn do boys and girls take at different grades? *Creativity Research Journal*, *22*(3), 329-336.

Levy F. (1988). The Evolution of Modern Dance Therapy. *Journal of Physical Education, Recreation and Dance*, *59*(5), 34-41.

Lin, Y. (2011). Fostering creativity through education – A conceptual framework of creative pedagogy. *Creative Education*, *2*, 149-155.

Lubart, T. I., Zenasni, F., & Barbot, B. (2013). Creative potential and its measurement. *International Journal of Talent Development and Creativity*, *1*(2), 41-51.

Lubart, T., Barbot, B., & Besançon, M. (2019) Creative potential: assessment issues and the EPoC Battery/Potencial creativo: temas de evaluación y batería EPoC, *Studies in Psychology*, *40*(3), 540-562.

Mallau, S., Vaugoyeau, M., & Assaiante, C. (2010). Postural strategies and sensory integration: No turning point between childhood and adolescence. *PLoS One*, *5*(9), e13078.

Martin, M. C., & Gentry, J. W. (1997). Stuck in the model trap: The effect of beautiful models in ads on female pre-adolescents and adolescents. *Journal of Advertising*, *26*, 19-33.

Matczak, A., Jaworowska, A., & Stańczak, J. (2000). *Rysunkowy Test Twórczego Myślenia TCT-DP K.K. Urbana i H.G. Jellena. Podręcznik* (1st ed.). Warszawa: Pracownia Testów Psychologicznych Polskiego Towarzystwa Psychologicznego.

Mehling, W. E., Gopisetty, V., Daubenmier, J., Price, C. J., Hecht, F. M., & Stewart, A. (2009). Body Awareness: Construct and Self-Report Measures. *PlosOne*, *4*(5), e5614.

Mirucka, B. (2016). The meaning of the body schema in reaching maturity during late adolescence, *Polish Psychological Bulletin*, *47*(1), 149-158.

Mirucka, B. (2017). A Battery of Tests of the Body Self Representations. *The Review of Psychology*, *60*(2), 243-263.

Mirucka, B. (2018). *Podmiot ucieleśniony. Psychologiczna analiza reprezentacji ciała i tożsamości cielesnej* (1st ed.). Warszawa: Scholar.

Nelson, E. E., & Guyer, A. E. (2011). The development of the ventral prefrontal cortex and social flexibility. *Developmental Cognitive Neuroscience*, *1*, 233-245.

Nickerson, R. S. (1985). Enhancing creativity. In R. J. Sternberg (Ed.), *The nature of creativity* (pp. 11-38). Cambridge, UK: Cambridge University Press.

Niedenthal, P. M., Barsalou, L. W., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005). Embodiment in attitudes, social perception, and emotion. *Personality and Social Psychology Review*, *9*, 184-211.

Nogueira, S. I., Almeida, L., & Lima, T. J. S. (2017). Two Tracks of Thought: A Structural Model of the Test for Creative Thinking-Drawing Production (TCT-DP). *Creativity Research Journal*, *29*(2), 206-211.

Oppezzo, M., & Schwartz, D. L. (2014). Give your ideas some legs: The positive effect of walking on creative thinking. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *40*(4), 1142-1152.

Payne, H. (1990). *Creative movement and dance in groupwork*. Speechmark: Oxon

Petkova, V. I., & Ehrsson, H. H. (2008). If I were you: Perceptual illusion of body swapping. *PLoS ONE*, *3*(12), e3832.

Ramocki, S. P. (2002). Creativity interacts with fitness and exercise. *The Physical Educator*, *59*(1), 8-17.

Riva, G. (2018). The neuroscience of body memory: From the self through the space to the others. *Cortex*. *104*, 241-260.

Rossetti, Y., Rode, G., Farne, A., & Rossetti, A. (2005). Implicit body representations in action. In H. Preester & V. Knockaert (Eds.), *Body Image and Body Schema: Interdisciplinary perspectives on the body* (1st ed., pp. 111-125). Amsterdam/Philadelphia: John Benjamins Publishinmpany.

Rothenberg, A. (1990). Creativity in adolescence. *Psychiatric Clinics of North America*, *13*(3), 415-434.

Runco, M. A. (2004). Everyone has creative potential. In R. J. Sternberg, E. L. Grigorenko, & J. L. Singer (Eds.), *Creativity: From potential to realization* (pp. 21-30). Washington, DC: American Psychological Association.

Runco, M. A. (2016). Commentary: Overview of developmental perspectives on creativity and realization of potential. In B. Barbot (Ed.), *Perspectives on creativity development. New directions for child and adolescent development* (Vol. 151, pp. 97-109). San Francisco, CA: Jossey-Bass.

Runco, M. A., & Jaeger, G. J. (2012). The standard definition of creativity. *Creativity Research Journal*, *24*, 92-96.

Runco, M. A., Millar, G., Acar, S., & Cramond, B. (2010). Torrance tests of creative thinking as predictors of personal and public achievement: A fifty-year follow-up. *Creativity Research Journal*, *22*, 361-368.

Shapiro, L. (2019). *Embodied Cognition* (2nd ed.). Second Ed. Routledge. New York: Routledge.

Slaughter, V. (2004). Emulator as body schema. *Behavioral and Brain Sciences*, *27*(3), 415-416.

Slepian, M. L., & Ambady, N. (2012). Fluid movement and creativity. *Journal of Experimental Psychology: General*, *141*(4), 625-629.

Slepian, M. L., Weisbuch, M., Rule, N. O., & Ambady, N. (2011). Tough and tender: Embodied categorization of gender. *Psychological Science*, *22*, 26-28.

Sordia, N., Martskvishvili, K., & Neubauer, A. (2019). From Creative Potential to Creative Achievements Do Emotional Traits Foster Creativity? *Swiss Journal of Psychology*, *78*(3-4), 115-123.

Sowden, P. T., Clements, L., Redlich, C., & Lewis, C. (2015). Improvisation facilitates divergent thinking and creativity: Realizing a benefit of primary school arts education. *Psychology of Aesthetics, Creativity, and the Arts*, *9*(2), 128-138.

Spear, L. P. (2013). Adolescent neurodevelopment. *Journal of Adolescent Health*, *52*, S7-S13.

Stamenov, M. (2005). Body schema, body image, and mirror neurons. In H. Preester & V. Knockaert (Eds.), *Body Image and Body Schema: Interdisciplinary perspectives on the body* (1st ed., pp. 21-43). Amsterdam/ Philadelphia: John Benjamins Publishing Company.

Sternberg, R. J., & Lubart, T. I. (1995). *Defying the crowd: Cultivating creativity in a culture of conformity*. New York, NY: Free Press.

Sternberg, R. J., & Lubart, T. I. (1991). An Investment Theory of Creativity and Its Development. *Human Development*, *34*, 1-31.

Strack, F., Martin, L., & Stepper, S. (1988). Inhibiting and facilitating conditions of the human smile: A nonobtrusive test of the facial feedback hypothesis. *Journal of Personality and Social Psychology*, *54*, 768-777.

Tsakiris, M., & Haggard, P. (2005). The rubber hand illusion revisited: Visuotactile integration and self-attribution. *Journal of Experimental Psychology: Human Perception and Performance*, *31*(1), 80-91.

Tsakiris, M., & Haggard, P. (2006). Having a body versus moving your body: How agency structures body-ownership. *Consciousness and Cognition*, *15*(2), 423-432.

Tsakiris, M., Carpenter, L., James, D., & Fotopoulou, A. (2010). Hands only illusion: Multisensory integration elicits sense of ownership for body parts but not for non-corporeal objects. *Experimental Brain Research*, *204*, 343-352.

Tsakiris, M., Schutz-Bosbach, S., & Gallagher, S. (2007). On agency and body-ownership: Phenomenological and neurocognitive reflections. *Consciousness and Cognition*, *16*, 645-660.

Uhlhaas, P.J., Roux, F., Rodriguez, E., Rotarska-Jagiela, A., & Singer, W. (2010). Neural synchrony and the development of cortical networks. *Trends in Cognitive Science*, *14*(2), 72-80.

Urban, K. K. (1991). On the development of creativity in children. *Creativity Research Journal*, *4*, 177-191.

Urban, K. K. (1995). Different models in describing, exploring, explaining and nurturing creativity in society. *European Journal for High Ability*, *6*, 143-159.

Urban, K. K. (2004). Assessing creativity: The Test for Creative Thinking - Drawing Production (TCT-DP). The concept, application, evaluation, and international studies. *Psychology Science*, *46*(3), 387-397.

Urban, K. K. (2005). Assessing creativity: The Test for Creative Thinking - Drawing Production (TCT-DP). *International Education Journal*, *6*(2), 272-280.

Urban, K. K., & Jellen, H. G. (1986). Assessing creative potential via drawing production: The Test for Creative Thinking - Drawing Production (TCT-DP). In A. J. Cropley, K. K. Urban, H. Wagner & W. Wieczerkowski (Eds.), *Giftedness: A continuing worldwide challenge* (1st ed., pp.163-169). New York: Trillium.

Urban, K. K., Jellen, H. G. (1996). Test for Creative Thinking-Drawing Production (TCT-DP). Lisse, Netherlands: Swets & Zeitlinger.

Viel, S., Vaugoyeau, M., & Assaiante, C. (2009). Adolescence: A transient period of proprioceptive neglect in sensory integration of postural control. *Motor Control*, *13*(1), 25-42.

Welter, M. M., Jaarsveld, S., van Leeuwen, C., & Lachmann, T. (2016). Intelligence and creativity: Over the threshold together? *Creativity Research Journal*, *28*(2), 212-218.

Williams, L. E., Huang, J. Y., & Bargh, J. A. (2009). The scaffolded mind: Higher mental processes are grounded in early experience of the physical world. *European Journal of Social Psychology*, *39*, 1257-1267.

Zhong, C., & Leonardelli, G. J. (2008). Cold and lonely: Does social exclusion literally feel cold? *Psychological Science*, *19*, 838-842.