International Journal of Learning, Teaching and Educational Research
Special Issue, Vol. 13, No. 4, pp. 49-57, October 2015

Effects of a One-Hour Creative Dance Training on Mental Rotation Performance in Primary School Aged Children

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Abstract. The study presented here investigated the influence of one-hour creative dance training on the spatial ability of mental rotation. Two groups of first and second graders solved a paper-pencil mental rotation test. Afterwards, one group received one lesson of creative dance training while the other group attended the regular physical education lesson. At the end of the short training period all children solved the mental rotation test again. The results show that the dance-training group improved their mental rotation performance more than the physical education group. This study expands our further studies where we have shown that five weeks of creative dance training enhances mental rotation performance (Jansen, Kellner, & Rieder, 2013). Further studies have to be conducted which investigate the short-term effects of different kinds of physical activity on different cognitive functions and their relation to academic performance.

Keywords: mental rotation; school-aged children; motor performance; creative dance; regular sports class.

Introduction

Western society is changing. Children spent more time using media and sitting in front of a computer or TV screen. Those "western culturally conditioned" positions lead to a decrease of energy (Peper, 2012). One might assume that due to the reduced time of movement, motor abilities get worse over time. Besides, the pressure gets higher to perform well in school to receive good jobs in later life. Thus, both motor and cognitive performance should be promoted to counteract frequent and long sedentary activities and foster academic achievement. The present study concentrates on the effect of a specific motor activity, i.e., creative dance training, on a specific cognitive ability, i.e., mental rotation. It expands our former study where we have shown that a creative dance training over five weeks ameliorates mental rotation performance (Jansen, Kellner, & Rieder, 2013).

Mental rotation is defined as “the ability to rotate quickly and accurately two- and three-dimensional figures in imagination” (Voyer et al., 1995, p. 25). It plays an important role in science and some work contexts, for example air traffic and pilots (Dror, Kosslyn, & Waag, 1993), but also in education, for instance mathematics (Hegarty & Kozhehvnikov, 1999). Furthermore, it was shown that the mental rotation performance in second graders correlates with the math’s grade (Blüchel, Lehmann, Kellner, & Jansen, 2013). According to this it seems promising to look for methods to improve mental rotation performance. One of these methods is physical activity or motor performance:

Existing studies investigating this relation differ in their methodology concerning the age of the participants (adults or children), methodology design (correlational, quasi-experimental, experimental designs) and the kind of motor training. Here, only the studies with children are presented. In two correlational studies it was shown that motor abilities and mental rotation performance do correlate even if intelligence was controlled (Jansen & Heil, 2010), but that this correlation diminished if working memory measurements were considered (Lehmann, Quaiser-Pohl, & Jansen, 2014). In studies with quasi-experimental designs, it was investigated whether children who show motor disabilities or a weak motor performance reveal an impaired mental rotation performance. This assumption was confirmed in studies with children with spina bifida (Wiedenbauer & Jansen-Osmann, 2007) and overweight children (Jansen, Schmelter, Kasten, & Heil, 2011). Children with spina bifida have an incomplete closure of the embryonic neural tube during the first month of embryonic development, which leads to a paralysis and loss of sensation below the spinal cord defect.

The severity of the symptoms depends on the defect´s location. Therefore, children with spina bifida can only move with the help of crutches or a wheelchair. Being overweight, which is determined by the Body Mass Index according to reference data, leads to impaired motor performance (Graf et al., 2004). Given the association between motor performance and mental rotation, it is not surprising to find impairments in mental rotation performance in overweight children (Jansen et al. 2010). Thus, it seems reasonable to assume that children with overweight suffer from mental rotation impairment. Experimental designs with children are rare. The few existing studies are interference- as well as training studies. Frick, Daum, Walser and Mast (2009) showed that motor performance interferes with mental rotation performance for younger children of 5 and 8 years. In training studies, it has been shown, that the mental rotation performance could be improved by one single lesson of manual rotation training (Wiedenbauer & Jansen-Osmann, 2008). Two groups of ten-year old children received one-hour computer training. In the experimental group, manual rotation training was performed (rotation of objects on a computer screen with the help of a joystick). The control group executed non-spatial computer training, i.e., a knowledge test for children. The improvement in the mental rotation performance from the pre- to the posttest was much higher for the manual rotation group than for the control group. This result was confirmed in training studies with children who learned to juggle over a period of three months (Jansen, Lange, & Heil, 2011) and with children who received a two weeks coordinative training designed for the school context (Blüchel et al., 2013).

Up to now there is only one study, which investigates the effect of creative dance training on mental rotation performance. The results show that five weeks of creative dance training improve mental rotation. This result is in line with studies with adults who show the beneficial effect of dance on cognitive performance (Coubard, Duretz, Lefebvre, Lapalus, & Ferrufino, 2011; Kattenstroth, Kolankowska, Kalisch, & Dinse, 2010) or other kinds of visual-spatial skills (Keinänen, Hetland, & Winner, 2000). The relevant factor underlying this positive effect is that in dance training, orientation in space and spatial awareness-two of the main cognitive abilities–are trained (Bläsing & Schack, 2012).

Beside the positive effect of motor activity on mental rotation there are a lot of studies showing a benefit of a single intervention of motor activity, especially aerobic exercise, on executive functions (Best, 2010). Best has reviewed studies, which differentiated between a single bout of an aerobic and complex exercise intervention with cognitive engagement (ball games) on the one side and studies with aerobic exercise only. The effect was smaller with less complex forms of aerobic exercise. These results provide a hint that a complex activity like creative dance enhances complex cognitive functions like mental rotation after one single bout of exercise only. Until now this was not investigated for the mental rotation performance in school-aged children, which is the goal of this study and an extension of the previously mentioned study (Jansen, Kellner, & Rieder, 2013).

Material and Methods

Participants

Sixty-four first and second grade pupils (30 girls and 34 boys) participated in this study. The children were between 6 and 9 years old (mean age: 7.09 years, SD = 0.73) and were recruited from a primary school in Bavaria, Germany. Because the children were tested in their school context, two classes (35 children) received a creative dance lesson. Two other classes (29 children) were assigned to the control group (CG), and took part in the regular physical education at school. Parents were informed and gave their written consent. Data was collected anonymously. The experiment was conducted according to the guidelines of the Declaration of Helsinki.

Measures

Mental rotation performance was tested with the picture mental rotation test. The Picture Mental Rotations Test (PMRT, Neuburger, Jansen, Heil, & Quaiser-Pohl, 2011) is a paper pencil mental rotation test with animal pictures as stimuli. Each row has one target item on the left side and four comparison items on the right side. Two of the four items on the right side were identical (non-mirrored) but picture plane rotated versions of the target item on the left side (45°, 90°, 135°, or 225° rotated compared to target item). The other two items were mirrored versions (see Figure 1). The children's task was to cross out the two correct items on the right side. There was a time limit of two minutes. There were two items provided as examples and two more items for practice before the test began. Rotation performance was defined as the number of correctly solved items in the PMRT.

Figure 1: Example item of the picture mental rotation test.

Intervention

Creative dance training was taught in one single session of one hour. In the training, children got the possibility to express oneself by moving in accordance to the music instead of just reacting and repeating formerly learned moves. The session started with a short warm-up phase by trying to "wake up sleeping limbs", i.e. shaking their limbs at their own choice. After this a short story was narrated about the wind blowing and becoming a hurricane. Several other elements followed. For example, children had to imagine wearing a crown on their head and balancing through the room, or they were taught some rotational movements. At the end of the lesson children were narrated a story of a bewitched garden where strange things happen. All children were prompted to move according to this story. The lesson ended with a short relaxing phase. The theme of the physical education lesson was "throwing and catching". To make it comparable to the creative dance lesson regarding the "fun factor", the children got different tasks where they had to hit small buckets with the ball, or hit different objects on a cabinet. At the end of the lesson a ball game with two teams was established.

Procedure

Children were tested with the PMRT in their classroom during regular school time. Training started immediately after fulfilling the PMRT. The experimental group received the dance training; the control group took part in the regular physical education lessons. The mental rotation performance of all children was tested again immediately after the training.

Analysis

An analysis of variance was conducted with the dependent variable "mental rotation difference" which was defined as the difference between the pre- and posttest in mental rotation performance (value of posttest – values of pretest). The independent variable was the factor "group" (experimental group, control group). Furthermore, to find out if groups initially differed in their mental rotation performance, a univariate analysis of variance was calculated with group as independent and pretest PMRT-scores as dependent variable.

Results

Effect of training on mental rotation performance

There was a significant main effect of "group" [$F(1,61)=5.14$, $p<.05$, partial eta^2 =.08] on the difference score in mental rotation, which was higher for the children in the experimental group (EG) compared to the children in the control group (CG; EG: M=3.00, SD=2.02; CG: M= 1.79, SD=1.87). The EG (M=3.17, SD=3.60) and the CG (M=5.10, SD=4.33) did not significantly differ in their mental rotation performance in the pre-test [$F(1,62)=3.79$, $p=.056$]. However, the difference favoring the control group failed to reach significance only barely. To find out if initial performance in the PMRT was associated with the degree of improvement after training, we calculated a correlation between the pre-test-score and the difference score, which did not reach significance (r=.117, n.s.). Figure 2 illustrates the mean changes from pre- to posttest in the experimental and control group.

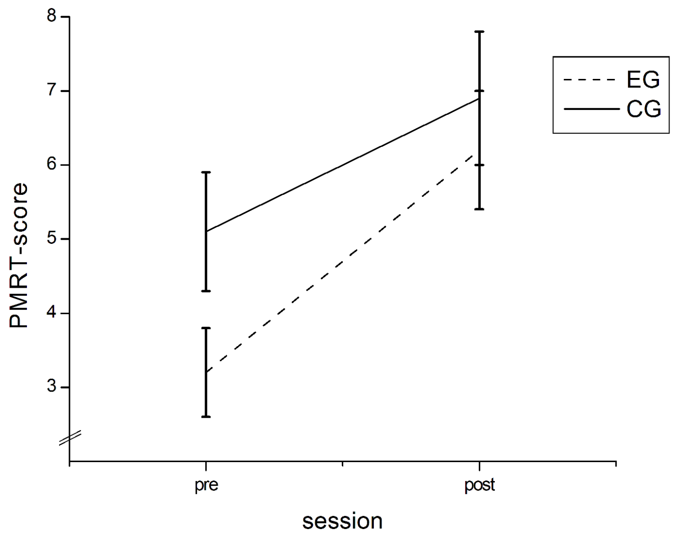

Figure 1: Mean changes in PMRT-score from pre- to posttest and standard errors of the mean in the experimental and control group.

Because of the well-documented gender differences in the psychometrical mental rotation performance even in children (Neuburger et al., 2011), the analysis above was again conducted with gender and group as a independent variables. The results showed that gender did not influence the mental rotation difference [$F(1,60)=2.51$, n.s.].

Discussion

The results of the present experiment showed that mental rotation performance could be improved by a single physical education lesson and a single creative dance-training lesson. The improvement was higher for the creative dance training compared to physical education lesson. Children of both groups received the same amount of attention so that the higher improvement of the EG could not be explained by a higher amount of attention. In contrast to regular physical education lesson, the dance training required spatial orientation and rotation around the body axes. We suggest that this is the crucial difference between interventions, which led to the better performance of the dance group. This result is in line with two experimental studies of our own working group. In adults, Jansen and Pietsch (2010) showed that only one single 45-minutes lesson of physical education improved mental rotation performance compared to a control group who received a theoretical learning session. Jansen, Kellner and Rieder (2013) showed that a longer lasting creative dance training in second graders enhanced mental rotation performance. Hence, the results of the present study build a link between the results of those former studies.

Gender usually plays a crucial role in mental rotation performance insofar as male advantages are often observed (Jansen, Schmelter, Quaiser-Pohl, & Heil, 2013). However, these advantages could not be shown in this study, which might be due to the fact that not the mental rotation performance per se but the improvement between pre- and post-test was investigated. This result gives a hint that boys did not profit more from the training than girls.

The enhancing effect of dance on the visual-spatial task can also be inferred from other studies with older participants (e.g. Kattenstroth et al., 2010) or through the comparison of novice and experienced dancers (Overby, 1990). In the latter study it was shown that experienced dancers showed better spatial imagery ability. Furthermore, the literature is growing that dance, in this case Tango, might improve spatial cognition in patients with Parkinson`s Disease (McKee & Hackney, 2013). In addition, the results of the present study are important for the educational setting due to the positive relation between spatial ability and mathematical ability, especially mathematical word problem solving (e.g. Casey, Nuttal, Pezaris, & Benbow, 1995). The theoretical link is that children with good spatial skills are better at making visual schematic representations, which is positively related to the solution of mathematical word problems (e.g. Van Garderen, 2006). According to this, creative dance may also improve mathematical word problems solving. This assumption has to be investigated in further studies.

Finally, the study has some limitations, which should be investigated in more detail in further studies. First, it has been shown that the relation between motor behavior and mental rotation performance might be mediated by working memory (Lehmann, Quaiser-Pohl, & Jansen, 2014), so the influence of creative dance has also to be investigated with reference to working memory. Second, we did not control for intelligence and general motor ability in this study, assuming that the semi-randomization of the four classes to the two conditions eliminates possible differences. Thus, the influence of these three aspects – working memory, intelligence and general motor ability – should be considered in future studies to provide a more accurate picture about the origins of mental rotation performance.

Conclusion

To conclude, this study gives support to the assumption that only one lesson of creative dance training in primary school-aged children can enhance mental rotation performance, and that this kind of training is more effective than regular physical education lessons. Future studies are needed to disentangle the reasons why dance ameliorates spatial ability more than regular physical lesson – is it the rotation of one`s own body, the moving through space or the coupling of action and expression to music? Regarding future research directions, it would be interesting to find out if this effect transfers to cognitive, social, and emotional skills, such as a possible enhancement of self-esteem.

Acknowledgement

The authors thank Kathrin Hommer and Franziska Pohl for the data acquisition and the children for their participation.

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