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Effects of Movement Improvisation and Aerobic Dancing on Motor Creativity and Divergent Thinking

ABSTRACT

Creativity is considered to be an embodied concept, where internal psychological and external behavioral processes are intertwined. Creativity enhancement programs often target the cognitive side of this bi-dimensionality leaving the impact of motor interventions underexplored. To address this gap in the literature, we tested the effectiveness of two motor programs on motor creativity and divergent thinking (*verbal* and *figural*). A total of 92 college students (M_{age} = 25.36, *SD* = 2.66) were randomly allocated to a movement improvisation, an aerobic dance, or a control condition. Participants in both motor programs took part in ten 30-minute classes twice a week over a period of 5 weeks. The findings revealed a significant effect of the motor programs on motor fluency and flexibility. Movement improvisation yielded the greatest effects on those variables, followed by aerobic dancing and control condition. Movement improvisation also impacted significantly more figural originality than the control condition. However, the effects were limited to the motor domain and failed to transfer into other divergent thinking variables. The findings highlighted the contribution of movement programs to creative potential development, and the imperative role of a non-judgmental environment, where individuals are free to move spontaneously.

Keywords: motor creativity, divergent thinking, movement improvisation, aerobic dance.

INTRODUCTION

Creativity is defined as the generation of ideas, insights, or solutions that are new and meant to be useful (Sternberg & Lubart, 1999, p. 411). Creativity not only supports outstanding innovations but is also involved in the deployment of novel solutions to common problems people encounter in their daily lives (Runco, 2014). In traditional creativity theories, there is an implicit assumption that the creative act happens first in the mind, through divergent and convergent cognitive processes, and is then transformed into motor behaviors (Guilford, 1967). Specifically, divergent thinking (DT)—the generation of many alternative ideas—is the umbrella term underpinning cognitive skills such as *fluency, flexibility*, and *originality* (Runco & Jaeger, 2012). Nevertheless, advances in cognitive science highlighted the idea of an embodied extended mind, where mental processes are distributed between brain and body, person, and environment (Rowlands, 2010). Embodying the creative process underlines the bi-dimensionality of creativity: an internal psychological process and an external behavioral one (Glaveanu, 2013).

Orth and colleagues (2017) adopted a similar perspective and argued that creative motor solutions emerge through perception–action coupling within the environmental constraints. According to this ecological dynamics approach, the structure of the physical environment, biomechanics of the body, perceptual information, and task demands determine the boundaries within which the motor system can act, influencing the repertoire of actions available (Araújo, Davids, & Passos, 2013; Seifert, Komar, Araujo, & Davids, 2016; Warren, 2006). The production of new motor patterns to solve a pre-established problem, or to express an idea, or an emotion through the body is defined as motor creativity (Bournelli, Makri, & Mylonas, 2009; Wyrick, 1968). Building on the concept of embodied cognition and ecological dynamics, the current study aims to test the effect of two distinct movement programs on both DT and motor creativity.

IMPROVISATION

Improvisation is a complex form of creative behavior (Beaty, 2015) and is considered a relevant training method to enhance creative potential. Defined as the act of creating something new, on the spur of the moment, improvisation helps people to break away from set patterns of thinking (Lewis & Lovatt, 2013). Over-reliance on mental representation (i.e., schemas) promotes the use of convergent thinking at the expense of divergent thinking (Walton, 2003). Improvisation circumvents this tendency by allowing individuals to think in a divergent manner, making creative behaviors more likely (Medonca & Wallace, 2005).

When improvising with movements, individuals must deal with several simultaneous processes in real time. They must consider their personal constraints (i.e., skills, emotional state, physical condition, etc.) as well as the environmental ones (i.e., instructions, actions of other performers, space, material, surface, etc.) (Torrents, Balagué, Ric, & Hristovski, 2020). Therefore, improvisation is a well-suited method to stimulate the perception–action coupling needed to break motor patterns and promote the emergence of creative movements.

The relationship between improvisation and creativity has been tested using various types of intervention. For instance, a thirty-hour drama course focusing on verbal improvisation produced increased DT task scores in post-graduate students (Karakelle, 2009). Similarly, undergraduate students exposed to a short-term verbal improvisation significantly improved their fluency, flexibility, and originality scores (Lewis & Lovatt, 2013). Evidence also suggests that arts-based improvisation interventions, integrating either dance or acting, positively influenced DT in a population of children (Sowden, Clements, Redlich, & Lewis, 2015). In this vein, elite figure skaters' creative attitude and values were significantly enhanced following a twenty-hour intervention combining both comic and theatrical improvisation (Richard, Halliwell, & Tenenbaum, 2017). Finally, contact improvisation was found to provide the right balance between collective constraints and individual freedom, which facilitated the emergence of creative movement in dancers (Kimmel, Hristova, & Kussmaul, 2018).

AEROBIC EXERCISE

Aerobic exercise is another activity that positively impacts creative potential. For instance, DT scores were significantly higher in female college students when measured immediately after a 20-minute aerobic dance session compared to when measured before exercising (Gondola, 1987). Blanchette Ramocki O'Del and Casey (2005) measured DT in physically fit students prior to exercise, immediately after completing a 30-minute period of aerobic exercise (jogging, swimming, fast walking, stationary biking, or stair climbing), and 2 hours after the aerobic exercise session. Findings revealed that aerobic workouts positively impacted creative potential, both immediately and 2 hours after completing the workout, indicating a lasting effect of exercising on DT. The physiological arousal induced by aerobic exercise may account for the improvement in cognitive creative tasks (Blanchette et al., 2005). Other evidence suggested that acute aerobic exercise benefits athletes' creative performance through improved convergent thinking skills while impairing creative scores in non-athletes (Colzato, Szapora, Pannekoek, & Hommel, 2013). This can be explained by the fact that exercise depleted cognitive resources in non-athletes to a greater extent than it did in athletes, thus influencing their capacity to solve problems.

THE CURRENT STUDY

Although both improvisation and aerobic exercise revealed positive creativity outcomes, some limitations must be addressed to better capture the dynamics of movement programs on creativity. First, because most improvisation interventions reported in the literature focus on verbal exercises, it is unclear whether the motor component of improvisation has a role to play in the optimization of creative thoughts and movements. Yet, embodiment is imperative for complex cognitive functioning (see Marmeleira & Duarte Santos, 2019, for a review), thus movement represents a relevant tool to develop the mental architecture needed for creativity (Frith, Loprinzi, & Miller, 2019). In line with these recent advances, we designed an improvisation intervention using movement only (i.e., no use of verbal skills). Furthermore, cognitive measures of creativity have predominantly been considered in the studies reviewed above and consequently, the relationship between those motor interventions and motor creativity remains underexplored. To test whether movement programs influence cognitive and motor creativity differently, we measured both variables. Finally, studies interested in the effect of aerobic exercise on adults' creativity overlooked the influence of environmental conditions in which the workout was undertaken. In populations of children, environments promoting the free generation of varied and original movement patterns yielded greater improvement in motor and cognitive creativity in comparison to rigid linear environments where children were taught proper movement techniques (Bournelli, 1998; Bournelli & Mountakis, 2008; Chatoupis, 2013; Richard, Lebeau, Becker, Boiangin, & Tenenbaum, 2018). To explore the impact of environmental conditions on the development of creative potential in adults, the movement improvisation condition in this study encouraged free movement expression, whereas the aerobic exercise condition strictly guided students toward proper movement execution. To facilitate the latter environmental condition, aerobic dance, which can be defined as a choreographed fitness program (Garrick, Gillien, & Whiteside, 1986), was the selected aerobic exercise.

To provide empirical support to the embodied extended mind conceptualization of creativity, this study aims to test the impact of movement improvisation and aerobic dance on DT and motor creativity. Specifically, the impact of movement improvisation and aerobic dance on creative thoughts and movements generation was compared with a control condition. Because encouraging individuals to move in unusual ways forces unique and original adaptations and stimulates creative potential (Hristovski, Davids, Araujo, & Passos, 2011; Slutskaya, 2006), we hypothesized that movement improvisation will have a greater impact on both variables, followed by aerobic dance and control conditions.

METHOD

PARTICIPANTS

Using G*Power (version 3.0; Faul, Erdfelder, Lang, & Buchner, 2007), a power analysis was conducted to estimate the number of participants required for this study. Thus, using three experimental conditions, three measures nested within two time frames in a mixed repeated measures (RM) MANOVA, moderate effect size $f_{(v)} = .35$, $\alpha = .05$, *power* $(1\text{-}\beta) = .80$, correlation among the three dependent measures = .50, a total sample size $N = 72$ or more was required.

One hundred participants were recruited from which eight dropped out immediately after the pre-testing session because of a lack of time to participate in the intervention. Therefore, ninety-two students (46 females, 46 males; $M_{\text{age}} = 25.36$, $SD = 2.66$) from an academic college volunteered to participate in this study. Participants were healthy and physically active ($M_{\text{BMI}} = 27.77$, $SD = 3.19$). On a 5-point Likert scale ranging from 1 (*poor*) to 5 (*excellent*), participants perceived their academic skills as good ($M = 3.16$, $SD = .08$) and their athletic skills as very good ($M = 3.84$, $SD = .08$). They were randomly allocated to either the movement improvisation ($n = 26$), aerobic dance ($n = 30$), or control conditions ($n = 36$). The inequality between the number of participants allocated to each condition can be attributed to this initial attrition. The institutional review board's approval was obtained prior to any data collection in this study.

MEASURES

Verbal and figural DT tasks

The *Runco Creative Assessment Battery* (rCAB; Runco & Jaeger, 2011) was used to measure verbal and figural DT. Adapted from Wallach and Kogan (1965), the *Many Uses of Object* task asks participants to list as many uses as possible for different objects. Toothbrush, tyre, and spoon were used for the pre-test task, while broom, sock, and bowl were used for the post-test task. Similar to the pattern meanings procedure (Wallach & Kogan, 1965), the figural section requires participants to list as many things as they can that a specific figure might be or represent. Compared to other figural tests (e.g., Torrance & Ball, 1984), participants are not required to draw anything (Runco, Abdulla, Paek, Al-Jasim, & Alsuwaidi, 2016). The term "*figural*" accounts for the stimuli that are presented to participants. Three different abstract visual designs were given for each testing session.

The different uses of objects and representations of figures listed by the participants were scored for fluency (i.e., total number of ideas), flexibility (i.e., number of ideas relating to different categories), and originality (i.e., number of unique ideas). To do so, a lexicon containing every idea from all of the participants was created for each item. Synonyms were grouped together to avoid bias in the originality scores. Fluency was scored as the sum of the discrete ideas mentioned by each participant. To create a flexibility score, similar ideas were grouped together under a general category. The number of categories ranged from 7 to 10 for the objects section and 10 to 14 for the figural one; each answer was allocated to only one category. The flexibility score represents the number of categories to which a participant's ideas were allocated. Two researchers independently categorized all ideas, and the inter-rater reliability was 88.5% for flexibility. This procedure is consistent with recommended guidelines (Acar & Runco, 2014; Runco, 1999). Finally, the originality score corresponds to the number of ideas that were mentioned by <5% of the sample in the verbal section and less than 1% in the figural section. For the verbal DT task in the current study, the internal consistency (Cronbach α coefficient) for verbal fluency ($\alpha = .91$), flexibility ($\alpha = .86$), and originality ($\alpha = .82$) were strong. The figural DT task revealed strong internal consistency α coefficients for fluency ($\alpha = .90$), for flexibility ($\alpha = .90$), and weak coefficient for originality ($\alpha = .64$).

Motor creativity (MC)

The agility ladder task was used to measure motor creativity. A ladder measuring 3.80 m long and composed of ten 34 cm × 43 cm squares was outlined on the floor using tape to avoid having to replace the ladder every time a participant touched it. Sufficient space surrounded the ladder to ensure unrestricted performance of the drills. Similar to the procedure used by Moraru and colleagues (2016), participants were asked to think of and execute as many different drills as possible for 6 minutes. Participants were free to perform familiar existing drills, but were encouraged to produce new ones. Furthermore, participants were not required to perform the drills at top speed. Finally, participants were informed that their drills would not be shared with and judged by others, and as such should not criticize their own idea. The testing session was only video recorded for analysis purposes. If a participant stopped performing for a while, the researcher encouraged him/her to try any ideas that came to mind.

To assess motor creativity, different procedures were used to create fluency, flexibility, and originality scores. First, all of the different drills performed were summed up to produce a fluency score per participant. Then, to create a flexibility score, each drill was classified using a modified version of Moraru and colleagues' (2016) coding grid. This grid considers the mode of locomotion (i.e., coordination modes), the number of limbs that were involved in propulsion, and the way they were temporally coordinated. Categories included steps, bouncing, jumping on one leg, skipping, a combination of the aforementioned categories, plank position, crawling, dorsal plank, gymnastic/acrobatic moves, sitting position, flexibility movements, combination of the aforementioned categories and others. A random subset of 25% of the video clips was coded by two independent observers. The inter-rater agreement among raters was .92, which is commonly regarded as very strong (Altman, 1991). Originality considered drills that were infrequent, novel and unique, and was rated as one entity for the 6-minute performance on the agility ladder task, using a scale ranging from 1 (*not original at all*) to 5 (*very original*). This is in line with Moraru's (2016) procedure. All performances were rated by two independent raters resulting in an inter-rater agreement of .82.

MOVEMENT PROGRAMS

Participants in the movement improvisation and the aerobic dance condition received ten 30-minute classes, twice a week, over a period of five weeks. Different class periods were offered for both improvisation and aerobic dance during the week to accommodate participants' schedules. A manager took attendance at the beginning of each class to ensure that each participant attended two classes a week. Because of the nature of each intervention, movement improvisation was conducted in groups of five to 10 participants (participants interacting and moving freely in the room), whereas aerobic dance was conducted in groups of five to 20 (participants lining up without interaction). The same instructor (the leading author) delivered both interventions.

Movement improvisation condition

The movement improvisation class was regulated using two rules. The first rule invited participants to "leave their judgments at the door; the judgment of others, but most of all the judgment of themselves." The second rule stipulated that there were no other rules. The participants were thus allowed to respond to the stimuli suggested by the different improvisation activities in the way they wanted. At the start of each session, a different warm up activity, aimed at helping participants connect their body with their mind, was conducted. Then, the main movement improvisation activity was explained. Five different movement stimuli were explored: opposition, weight and speed, transformation, emotions, and object embodiment. In between each of the five-movement exploration sessions, a comic movement session was conducted. Those sessions promoted exaggeration and imagination to help participants engage in the suggested improvisation situations. Most improvisation activities were supported by a specific piece of music. Throughout the entire intervention, only movement was used to improvise and, while participants could make noises, the use of verbal speech was prohibited during improvisation.

Aerobic dance condition

In the current study, the aerobic dance class was divided into three parts. The first choreographed fitness sequence was high in intensity and was comprised of various combinations of steps, skips, and hops. The second choreography was high in intensity and was comprised of basic dynamic muscular exercises. Meanwhile, the last choreography was used as a cool down and was comprised of stretching and breathing exercises. Each fitness choreography was associated to a specific piece of music. The five first sessions aimed to teach the participants the choreography. At the beginning of each session, they were reminded that their task was to learn and reproduce the choreography to the best of their ability. The instructor remained at the front of the class, guiding the participants through the different choreographies and correcting them when needed. Once learned, the participants followed the instructor through each of the three choreographies. They were encouraged to engage fully in each choreography. Similar to Gondola (1987), the fitness choreographies were not geared toward creative expression.

Control condition

Participants allocated to the control conditions received 3 short readings about creativity. To ensure they were engaging in the task, they were asked to respond to 3 questions per text.

PROCEDURES

Two testing sessions were organized before and after the 5-week intervention. All participants completed the consent and demographic forms at the outset. They were then introduced to the divergent thinking tasks. No time limit was imposed to complete the divergent thinking tasks. This procedure allowed participants to generate as many ideas as they could without feeling any time pressure. After completing the DT tasks, the ladder drill task was explained to the participants and they were given six minutes to complete it. All testing sessions were conducted individually.

RESULTS

BASELINE MEASURES: DEMOGRAPHIC DATA

Participants' demographic data and baseline measures are presented in Table 1. Participants in the control, the movement improvisation, and the aerobic dancing conditions distributed equally on gender, χ^2 (2) = 1.06, $p = .59$. A univariate ANOVA revealed a significant age difference among conditions F (2,87) = 5.32, $p < .007$. The control condition participants were older ($M = 26.48$, $SD = 2.89$) than the ones in the improvisation and aerobic dance conditions ($M = 24.71$, $SD = 2.51$ and $M = 24.65$, $SD = 2.10$). However, the 2-year difference is not meaningful and is not considered a limitation herein. Non-significant differences were revealed for body mass index (BMI), $F(2,88) = 1.00$, $p < .37$, perceived academic skills, F (2,86) = 1.76, $p < .18$, perceived athletic skills, $F(2,80) < 1.99$, $p < .14$, MC fluency $F(2,89) = .01$, $p < .94$, MC flexibility $F(2,89) = 1.09$, $p < .30$; MC originality, $F(2,89) = .00$, $p < .96$, verbal DT fluency F (2,89) = .76, $p < .39$, verbal DT flexibility, $F(2,89) = 1.09$, $p < .30$, verbal DT originality, $F(2,89) = .16$, $p < .69$, figural DT fluency, $F(2,89) = 1.63$, $p < .21$, figural DT flexibility, $F(2,89) = .03$, $p < .40$, and figural DT originality, $F(2,89) = .16$, $p < .40$.

CORRELATIONAL ANALYSIS

Prior to testing the study's hypotheses, Pearson product-moment correlation (PPMC) was computed among the creativity dimensions. The detailed PPMC among all dimensions is presented in Table 2. The PPMC among the MC fluency, flexibility, and originality dimensions was low–moderate. The PPMC among the verbal DT and the figural DT dimensions of fluency, flexibility, and originality was very strong. The PPMC between the MC and verbal DT dimensions was low. The PPMC between the MC and figural DT dimensions was low to moderate. Finally, the correlations between the verbal DT and figural DT the correlations were moderate to strong.

TESTING VARIANCE AND MEAN EQUALITY ASSUMPTIONS AT THE OUTSET OF THE EXPERIMENT

Levene's tests of homogeneity of variance, conducted on the MC, verbal DT and figural DT components, revealed non-significant ($p > .05$) variance differences among the 3 experimental conditions. A follow-up one-way ANOVAs revealed non-significant ($p > .05$) means' differences among the three experimental

TABLE 1. Mean and SD for Demographic Data and Baseline Measures of MC, Verbal DT, and Figural DT

Variable	Movement improvisation (n = 26)		Aerobic dance (n = 30)		Control (n = 36)	
	Mean	*SD*	Mean	*SD*	Mean	*SD*
Age	24.72	2.51	24.65	2.1	26.48	2.89
BMI	28.33	3.10	27.14	2.45	27.89	3.75
Perceived skills						
Academic skills	3.38	.70	3.14	.83	3.00	.82
Athletic skills	3.72	.614	3.35	.75	3.66	.79
Motor Creativity						
Fluency	23.58	6.64	22.00	6.58	24.94	5.98
Flexibility	6.85	2.01	6.50	1.80	6.50	2.30
Originality	3.54	1.03	3.13	1.01	3.31	1.09
Verbal DT						
Fluency	4.14	1.75	3.83	1.69	4.65	2.46
Flexibility	3.13	1.01	2.90	.92	3.34	1.41
Originality	1.60	1.41	1.43	1.56	2.05	1.71
Figural DT						
Fluency	6.09	2.61	5.26	2.02	6.16	3.11
Flexibility	3.91	1.12	3.68	1.26	3.92	1.72
Originality	1.17	.88	.96	.74	1.44	1.41

TABLE 2. Pearson Product Moment Correlations Between MC, Verbal DT, and Figural DT Dimensions

Variable	1	2	3	4	5	6	7	8	9
1. MC fluency									
2. MC flexibility	.24*								
3. MC originality	.37**	.49**							
4. Verbal DT fluency	.07	.37**	.31**						
5. Verbal DT flexibility	.11	.40**	.29**	.93**					
6. Verbal DT originality	.09	.28**	.27*	.89**	.81**				
7. Figural DT fluency	.26*	.35**	.38**	.73**	.71**	.61**			
8. Figural DT flexibility	.17	.33**	.44**	.71**	.68**	.64**	.89**		
9. Figural DT originality	.31**	.30**	.40**	.54**	.50**	.52**	.78**	.72**	

Note * $p < .05$, ** $p < .01$.

conditions at the outset of the study. Skewness and Kurtosis coefficients were all < |2|. Thus, no adjustments for assumption violations were required for testing the study's hypotheses.

HYPOTHESES TESTING

To test the pre-post changes in the creativity dimensions, mixed RM MANOVAs were separately performed for each dimensional cluster, followed by mixed RM ANOVA for each within cluster dimension. The treatment conditions were considered the between-subject (BS) factor and the time (pre–post) the within subject (WS) repeated factor. Fluency, flexibility, and originality were the dependent variables nested within time. Prior to applying the repeated measures (RMs) procedures, the three experimental conditions mean scores were compared with each other on all the creativity dimensions using MANOVAs followed by univariate ANOVAs.

MC FLUENCY, FLEXIBILITY, AND ORIGINALITY

RM MANOVA using three experimental conditions as a BS factor, time (pre–post) as WS repeated measures factor and dimension (fluency, flexibility, and originality) nested within time resulted in a significant time by dimension effect, *Wilks'* $\lambda = .70$, $F(2,88) = 18.50$, $p < .001$, $\eta_p^2 = .30$. However, the time by dimension by condition effect was non-significant, *Wilks'* $\lambda = .92$, $F(4,176) = 1.90$, $p < .13$, $\eta_p^2 = .04$. RM ANOVAs for each of the three creativity dimensions by time and experimental condition follow next.

MC fluency

The RM ANOVA for MC fluency revealed significant main effects for time, *Wilks'* $\lambda = .67$, $F(1,89) = 43.66$, $p < .001$, $\eta_p^2 = .33$, but not for experimental condition, $F(2,89) = 1.41$, $p < .25$, $\eta_p^2 = .03$. The experimental condition by time interaction was significant, *Wilks'* $\lambda = .92$, $F(2,89) = 3.65$, $p < .03$, $\eta_p^2 = .08$, and is presented in Figure 1a. Scheffe post hoc tests resulted in one significant ($p < .008$) difference. The improvisation condition participants improved more than their control counterparts ($M = 4.38$, $SD = 4.09$ vs. $M = 1.47$, $SD = 4.86$). However, the other mean contrasts were non-significant ($p > .05$). Cohen's effect size revealed a moderate effect for improvisation vs. control ($d = .46$) and low effect for improvisation vs. aerobic dancing ($d = .23$) and for aerobic dancing vs. control ($d = .22$).

MC flexibility

The RM ANOVA for MC flexibility revealed significant main effects for time, *Wilks'* $\lambda = .91$, $F(1,89) = 8.93$, $p < .004$, $\eta_p^2 = .09$, but not for experimental condition, $F(2,89) = 1.51$, $p < .23$, $\eta_p^2 = .03$. The experimental condition by time interaction was significant, *Wilks'* $\lambda = .93$, $F(2,89) = 3.44$, $p < .04$, $\eta_p^2 = .07$, and is presented in Figure 1b. Scheffe post hoc tests resulted in two significant differences ($p < .05$). The improvisation condition participants improved more than the control ($M = 1.25$, $SD = 1.77$ vs. $M = 0.25$, $SD = 1.40$) and the aerobic dancing ($M = 0.13$, $SD = 1.98$). Cohen's effect size coefficients revealed moderate effects for improvisation vs. control ($d = .45$) and vs. aerobic dancing ($d = .58$), and no effect for aerobic dancing vs. control ($d = -.06$).

MC originality

The RM ANOVA for MC originality revealed non-significant main effects for time, *Wilks'* $\lambda = .97$, $F(1,89) = 3,27$, $p < .07$, $\eta_p^2 = .04$, but significant effects for experimental condition, $F(2,89) = 3.03$, $p < .05$, $\eta_p^2 = .06$. The experimental condition by time interaction was non-significant, *Wilks'* $\lambda = .98$, $F(2,89) = 1.04$, $p < .36$, $\eta_p^2 = .02$, and is presented in Figure 1c. Cohen's effect size coefficients revealed a low to moderate effect for improvisation vs. control ($d = .39$) and low effect for improvisation vs. aerobic dancing ($d = .18$) and for aerobic dancing vs. control ($d = .23$).

VERBAL DT FLUENCY, FLEXIBILITY, AND ORIGINALITY

RM MANOVA using three experimental conditions as a BS factor, time (pre–post) as a within subjects factor, and dimension (fluency, flexibility, originality) nested within time, resulted in a significant time by dimension effect, *Wilks'* $\lambda = .56$, $F(2,88) = 34.45$, $p < .001$, $\eta_p^2 = .44$, and non-significant ($p > .05$) effect for time by dimension by condition effect.

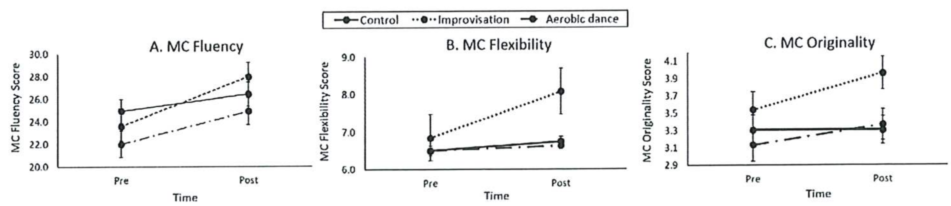

FIGURE 1. Mean scores of fluency (a), flexibility (b), and originality (c) for the motor creativity task at pre- and post-program for the control, improvisation, and aerobic dance conditions. Error bars represent standard errors.

Verbal DT fluency

The RM ANOVA for verbal DT fluency revealed significant main effects for time, *Wilks'* $\lambda = .93$, $F(1,89) = 6.37$, $p < .01$, $\eta_p^2 = .07$, but not for experimental condition, $F(2,89) = .45$, $p < .64$, $\eta_p^2 = .10$. The experimental condition by time interaction was non-significant, *Wilks'* $\lambda = .96$, $F(2,89) = 2.11$, $p < .13$, $\eta_p^2 = .05$, and is presented in Figure 2a. Cohen's effect size coefficients revealed a low effect for improvisation vs. control ($d = .23$) and aerobic dancing vs. control ($d = .33$), and no effect for improvisation vs. aerobic dancing ($d = .06$).

Verbal DT flexibility

The RM ANOVA for verbal DT flexibility revealed non-significant main effects for neither time, *Wilks'* $\lambda = .97$, $F(1,89) = 2,39$, $p < .13$, $\eta_p^2 = .03$, nor for experimental condition, $F(2,89) = 0.50$, $p < .61$, $\eta_p^2 = .01$. The experimental condition by time interaction was non-significant, *Wilks'* $\lambda = .96$, $F(2,89) = 1,73$, $p < .18$, $\eta_p^2 = .04$, and is presented in Figure 2b. Cohen's effect size coefficients revealed a low effect for improvisation vs. control ($d = .27$), and aerobic dancing vs. control ($d =.33$), and no effect for improvisation vs aerobic dancing ($d = -.07$).

Verbal DT originality

The RM ANOVA for verbal DT originality revealed significant main effects for time, *Wilks'* $\lambda = .74$, $F(1,89) = 31.73$, $p < .001$, $\eta_p^2 = .26$, but not for experimental condition, $F(2,89) = .72$, $p < .49$, $\eta_p^2 = .02$. The experimental condition by time interaction was non-significant, *Wilks'* $\lambda = .95$, $F(2,89) = 2.23$, $p < .11$, $\eta_p^2 = .05$, and is presented in Figure 2c. Cohen's effect size coefficients revealed a low to moderate effect for improvisation vs. control ($d = .38$) and for aerobic dancing vs. control ($d = .33$), and no effect for improvisation vs. aerobic dancing ($d = .03$).

FIGURAL DT FLUENCY, FLEXIBILITY, AND ORIGINALITY

RM MANOVA using three experimental conditions as a BS factor, time (pre–post) as a WS factor and dimension (fluency, flexibility, originality) nested with time, resulted in a non-significant ($p > .05$) time by dimension effect, and a non-significant ($p > .05$) effect for time by dimension by condition effect.

Figural DT fluency

The RM ANOVA for figural DT fluency revealed non-significant main effects for time, *Wilks'* $\lambda = 1.00$, $F(1,89) = .19$, $p < .89$, $\eta_p^2 = .00$, and for experimental condition, $F(2,89) = 1.12$, $p < .33$, $\eta_p^2 = .03$. The experimental condition by time interaction was non-significant, *Wilks'* $\lambda = .97$, $F(2,89) = 1.27$, $p < .29$, $\eta_p^2 = .03$, and is presented in Figure 3a. Cohen's effect size coefficients revealed low effects for improvisation vs. control ($d = .33$), for improvisation vs. aerobic dancing ($d = .13$), and for aerobic dancing vs. control ($d = .25$).

Figural DT flexibility

The RM ANOVA for figural DT flexibility revealed a non-significant main effect for time, *Wilks'* $\lambda = .99$, $F(1,89) = .07$, $p < .80$, $\eta_p^2 = .001$, and experimental condition, $F(2,89) = .52$, $p < .60$, $\eta_p^2 = .01$. The experimental condition by time interaction was non-significant, *Wilks'* $\lambda = .98$, $F(2,89) = .94$, $p < .39$, $\eta_p^2 = .02$, and is presented in Figure 3b. Cohen's effect size coefficients indicated low effects for improvisation vs.

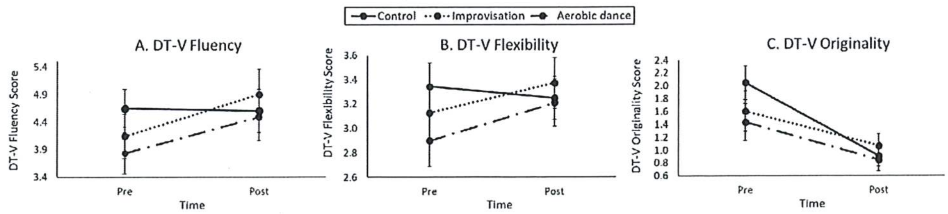

FIGURE 2. Mean divergent thinking scores of fluency (a), flexibility (b), and originality (c) for the verbal task at pre- and post-program for the control, improvisation, and aerobic dance conditions. Error bars represent standard errors.

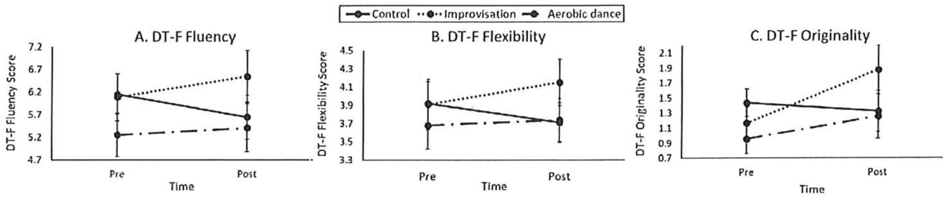

FIGURE 3. Mean divergent thinking scores of fluency (a), flexibility (b), and originality (c) for the figural task at pre- and post-program for the control, improvisation, and aerobic dance conditions. Error bars represent standard errors.

control (d = .29), for improvisation vs. aerobic dancing (d = .15), and for aerobic dancing vs. control (d = .18).

Figural DT originality

The RM ANOVA for figural DT originality revealed a significant main effect for time, *Wilks'* $\lambda = .96$, $F(1,89) = 3.96$, $p < .05$, $\eta_p^2 = .04$, but not for experimental condition, $F(2,89) = 0.89$, $p < .41$, $\eta_p^2 = .02$. The experimental condition by time interaction was non-significant, *Wilks'* $\lambda = .95$, $F(2,89) = 2.50$, $p < .09$, $\eta_p^2 = .05$, and is presented in Figure 3c. However, Scheffe post hoc tests resulted in one significant difference ($p < .03$). The improvisation condition participants improved more than the control participants ($M = .71$, $SD = 2.13$ vs. $M = -.11$, $SD = .98$). Cohen's effect size coefficients revealed a moderate effect for improvisation vs. control (d = .67) and aerobic dancing (d = .50) and low to moderate effect for aerobic dancing vs. control (d = .35).

DISCUSSION

The overarching goal of this study was to test the effects of movement improvisation and aerobic dancing on motor creativity and divergent thinking. Compared to a control condition, our results revealed significant positive effects of both motor programs on MC. However, no significant effect was found for most of the DT variables indicating a different effect of motor programs on cognitive and motor creativity. In accordance with our expectations, movement improvisation yielded the greatest effects on MC, followed by aerobic dancing and control condition.

The findings revealed a significant time by conditions interaction for MC fluency and flexibility. Interestingly, the effect sizes of the motor interventions on MC variables differed; movement improvisation having a greater impact on MC than aerobic dancing. This difference was found to be significant for motor flexibility. The movement improvisation intervention followed non-linear pedagogy principles (Santos, Memmert, Sampaio, & Leite, 2016). Specifically, building on the dynamical system theory perspective, the non-linear pedagogy approach stipulates that, because there is an infinite number of individual dynamical systems (Phillips, Davids, Renshaw, & Portus, 2010), it is by manipulating specific task constraints, removing barriers, and increasing freedom, that movers uncover innovative and functional movement patterns (Chow et al., 2006; Hristovski, Davids, & Araújo, 2006). In the current study, participants allocated to the movement improvisation condition were encouraged to answer freely and spontaneously in response to each of the movement stimuli presented, whereas participants in the aerobic dance condition were asked to strictly follow the instructor and execute the fitness choreographies correctly. Because of its spontaneous and unpredictable nature, improvisation may sometimes feel uncomfortable (Edmund & Keller, 2020). Therefore, the approach destabilizes the participants' psychological and motor systems to a greater extent than it does when following an aerobic dance instructor. To reorganize into a new state of stability, improvisers were required to adapt by stretching their internal psychological processes and external movement behaviors. Movement improvisation thus represents a way of embodying the bi-dimensional creative process (Glaveanu, 2013). Previous studies reached similar conclusions, showing that improvisation increased creative attitude and values (Richard et al., 2017) and non-linear environments benefited motor creativity in children (Bournelli & Mountakis, 2008; Richard et al., 2018).

In addition to encouraging freedom and spontaneity, creativity training must target the domain in which the creativity enhancement is desired (Baer, 2015). In this vein, our findings showed that verbal and figural

DT variables were weakly correlated with MC. The fact that DT and MC are two distinct concepts may explain the reason movement improvisation failed to affect DT significantly. These results contradict previous studies supporting the positive influence of improvisation on DT skills (Karakelle, 2009; Lewis & Lovatt, 2013). Yet, in those studies, the improvisation interventions tested mainly verbal activities. The use of verbal skills in a context of improvisation may broaden the participants' range of language, priming a wider network of verbal options when performing a DT task (Lewis & Lovatt, 2013). Movement improvisation promoted the use of the body as a mean of self-expression. Therefore, participants developed a broader repertoire of movements, instead of words impacting motor creativity more than divergent thinking.

"The specific structural, functional, affective, relational, and symbolic features of our bodies play a critical role in our perceptions, cognitions, emotions, behaviors, and human relations"(Marmeleira & Duarte Santos, 2019, p.411). Despite the domain-specific importance of creativity enhancement training, the above embodied cognition principle supports the assumption that movement interventions could also positively impact cognitive skills, such as divergent thinking. Descriptive statistics revealed promising trends, highlighting the potential impact of movement improvisation on divergent thinking components. In fact, participants engaged in the improvisation class improved their figural DT originality scores significantly more than those in the control condition. Future research must continue to develop movement improvisation activities and test them using interventions that vary in duration and intensity within different cultures. Movement improvisation is a promising avenue that is worth further investigation to better capture the effect of embodiment on cognitive function linked to creativity.

LIMITATIONS AND CONCLUSIONS

While advancing the literature about different types of motor intervention affecting DT and MC, several limitations must be acknowledged. First, DT tasks used in the current study evaluate fluency, flexibility, and originality, using scores derived from response data generated from the same quantitative instruction—that is, as many uses or representations as possible (Heausler & Thompson, 1988). This might explain the high correlation between DT component scores, which make it challenging to identify which DT components were most influenced by motor interventions. Furthermore, DT originality scores were obtained by compiling ideas within the sample and identifying which ones were given infrequently. Since participants generate on average one or two infrequent ideas, using this method results in a floor effect, which makes significant intervention effects difficult to reach. Furthermore, verbal DT tasks allow rote associations. The reliance on acquired knowledge makes the verbal test less sensitive to changes in original thinking than the figural test (Runco & Albert, 1985). Recent investigations have explored these issues indicating promising solutions. First, adding qualitative instruction (e.g., creative) to the traditional quantitative ones results in the generation of more creative and potentially more original ideas (Acar, Runco, & Park, 2020). Secondly, alternative scoring methods, such as the semantic networks approach, have been shown to be highly objective and cost-efficient methods for quantifying originality and flexibility (Acar & Runco, 2019). Researchers should follow these recommendations to enhance the measurement quality of future studies interested in creativity change and development.

To avoid the repeated exposure to DT tasks effect, the current study opted for the alternate form tasks method (i.e., different objects and figures were presented to assess DT pre- and post-intervention). However, this method does not account for the stimulus dependency effect, which refers to the fact that people might perform differently on apparently similar tasks (e.g., it might be harder to generate original uses for a broom then a toothbrush). This might explain the drop in verbal DT originality from pre- to post-test scores for all conditions in the current study. A recent review on measuring creativity change and development, suggested that a pre- post-test control design, that counterbalances two DT tasks over time, represents the best practice to cancel out the relative difficulty of two DT alternate forms (Barbot, 2019). Although being a more complex design, which increases the demands on test takers, future studies should seek to replicate the current study results using that method. Finally, the two motor interventions presented distinct physical demands. However, the physical effort deployed by the participants was not assessed throughout the current study. To explore the mechanisms of various types of movement program on creative potential in more depth, physiological measures (e.g., heart rate, rating of perceived exertion) must be considered.

Cognition depends on the types of embodied experiences that one has, which interact closely with environmental conditions (Marmeleira & Duarte Santos, 2019). When it comes to unleashing ones' creative potential, moving in a structured way is not sufficient. The environment must promote spontaneous movement in an environment free of social judgment. Unfortunately, gyms are full of structured fitness classes that give almost no freedom to the participant and creativity development programs for adults rarely involve movement. The current study calls for more multi-modal interventions, which combine creativity enhancement with movement activities. Embodiment has only recently joined the domain of cognitive science (Marmeleira & Duarte Santos, 2019). Most research using body-oriented interventions to enhance cognitive functioning have done so with psychopathologic (Galbusera, Fellin, & Fuchs, 2019), elderly (Pereira, Rosado, Cruz-Ferreira, & Marmeleira, 2018), or children populations (Frith et al., 2019). The current study highlights the potential of embodiment to optimize the mind and body of healthy adults. Practitioners are thus invited to either enhance the freedom within movement programs or allow people to move in creative classes. By adopting these recommendations, these programs could potentially improve people's health and creativity.

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