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Opening the mind through the body: The effects of posture on creative processes

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A B S T R A C T

Body movements and gestures have been found to influence the generation of novel ideas, however, whether posture does, has not yet been investigated. Two studies were conducted in order to assess whether open vs. closed body postures influenced creative thinking. In Study 1, the participants completed two creative tasks when assuming an open or a closed posture, whereas in Study 2 the participants completed creative and logic tasks assuming the same postures. Comfort and physiological indexes, as well as electromyograms were recorded. The scores that were obtained in the creative tasks were significantly higher for those participants who performed the tasks in the open posture rather than in the closed posture. The comfort and physiological indexes were not affected by posture. The data supported the notion that posture modulates a performance in creative tasks, thus facilitating the production of innovative ideas when subjects embody a posture that metaphorically suggests an adoption of a broader mental framework.

1. Introduction

According to the embodied cognition approach, the mind is not an isolated entity, but rather that the mind, the body, and the environment form an integrated system (Shapiro, 2011). Indeed, bodily experiences and the environment have been found to influence cognitive processes, such as memory, decision making, and problem solving (Casasanto, 2011), as well as creative thinking.

Creative thinking is usually defined as a process of generating something that is both novel and useful. Divergent thinking is a core feature of creativity (Guilford & Hoepfner, 1971), which involves at least three distinct components: *fluency* (producing many ideas), *flexibility* (producing differentiated ideas), and *originality* (producing novel ideas) (Nijstad, De Dreu, Rietzschel, & Bass, 2010). A good performance on divergent-thinking tasks (e.g., listing possible uses of an object) requires the overcoming of a mental fixedness and being cognitively flexible (Antonietti & Colombo, 2013).

While one's environment can influence creative thinking (e.g., Jia, Hirt, & Karpen, 2009; Vohs, Redden, & Rahinel, 2013) and physical activity can enhance it (Colzato, Szapora, Pannekoek, & Hommel, 2013; Kurt, Kurt, & Medaille, 2010), few studies have addressed creative thinking from the perspective of an embodied cognition, despite some suggestions that have appeared in earlier works (Antonietti & Cornoldi, 2006).

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Research demonstrating a connection between embodied cognition and creativity has argued that certain bodily states are associated with creative thinking. Friedman, Fishbach, Förster, and Werth (2003, Experiment 3) found that people who contracted their frontalis, relative to their corrugator contraction, generated more original ideas when requested to think of the possible uses for a pair of scissors. Ijzerman, Leung, and Ong (2014) found that physical warmth cues led to more creative drawings and more creative ideas when thinking about possible gifts. Not only body states, but also body movements, may be conducive for creative thinking, because they activate the processes that are involved in overcoming a mental fixedness. This leads to creative generation, cognitive flexibility, and remote associations. A study has suggested that walking more than sitting was associated with the generation of novel ideas (Oppezzo & Schwartz, 2014).

Gestures have been found to affect cognition (Goldin-Meadow & Alibali, 2013; Goldin-Meadow & Beilock, 2010). For instance, by supporting representations which allow people to express spatial properties directly, lessens the need for a verbal code translation and reduces the working memory load (Hostetter & Alibali, 2008). This results in improved problem solving (Thomas & Lleras, 2009). As far as the relationships between gesture and creative thinking are concerned, it was found that by flexing the arm, as opposed to extending it, enhanced a creative performance (Friedman & Förster, 2000, 2002; Hao, Yuan, Hu, & Grabner, 2014). Leung et al. (2012) reported that by rotating the palm of the hand, this gesture suggested a process for considering the opposite sides of an issue. This facilitated creative thinking when in comparison to holding the palm stationary. In another study, Slepian and Ambady (2012) found in three experiments that by executing fluid body movements – which have been shown to modulate the reasoning about social issues (Slepian, Weisbuch, Pauker, Bastian, & Ambady, 2014) – favours the generation of creative ideas, more than does the adoption of rigid movements.

Not only gestures, but postures also affect cognitive functioning. For example, people who sat down with their backs in an erect position were more confident in themselves than those people sitting with their backs in a curved position (Briñol, Petty, & Wagner, 2009). A specific kind of postures, namely, expansive-open vs. contractive-closed, has been investigated. An expansive posture, as opposed to a contractive one, was found to influence judgment and decision-making processes (Yap, Wazlawek, Lucas, Cuddy, & Carney, 2013). The opposite attitudes that were expressed by these postures signalled a social dominance or submissiveness and they are easily caught by observers (Holland, Wolf, Looser, & Cuddy, 2017). However, the effects of postures, and particularly, expansive vs. contractive ones, have never been investigated in the domain of creativity.

It has been argued that openness to experience is related to creative thinking (McCrae, 1987). Openness to experience is included in the Five Factor Model. This model involves a variety of dimensions, including an active imagination, an aesthetic sensitivity, attentiveness to inner feelings, a preference for variety, and an intellectual curiosity (McCrae & John, 1992). Previous research has highlighted the relationship between openness to experience and creative thinking, by claiming that some dimensions of openness to experience promote the creative processes in the arts and in science (Kaufman, 2013). The present research has looked at openness to experience from an embodied perspective. In other words, whether having an open as opposed to a closed bodily posture could promote creativity.

2. Study 1

2.1. Method

One hundred and two students attending a bachelor's degree in psychology in Milan, Italy, took part in the study voluntarily, by answering an announcement that was posted on the virtual board of the faculty. Three days after the announcement was posted, the recruitment was halted. The experimenters controlled, through a questionnaire that was administered before the task, that the participants had no previous knowledge regarding embodied cognition and creativity theories or experiments. Extra-credits were given to the participants.

The participants were randomly divided into two subsamples of 51 students each. The randomisation occurred by writing the names of the participants on slips of paper, folding the slips and putting them into an urn, and then by extracting the slips and placing one in the first subsample and the following slip into the second subsample, and so on. The distribution of men and women was similar in the first subsample (men = 15; women = 36) and in the second subsample (men = 18; women = 33), as well as their ages (first subsample: M = 21.20 yrs., SD = 1.43; second subsample: M = 20.53 yrs., SD = 1.39).

Each subsample completed one of two creative tasks from the Torrance Tests of Creative Thinking (TTCT, Torrance, 1974). In the Product Improvement Task, the participants were asked to bring forth the most imaginative and creative ideas about how to modify a stuffed elephant so that children could have more fun playing with it. The exact wording of the instructions was as follows: "Now I will show you a stuffed elephant. Make a list of the most ingenious, interesting, and unusual ideas about possible changes to the stuffed elephant that you are willing to construe, in order to make it more fun for the children. Do not worry if the changes might be expensive. Merely think about what might make it funnier. Tell me all of the ideas that come into your mind and I will take notes." In the Just Suppose Task, the participants were asked to identify as many consequences as possible of an unusual fact. The exact wording of the instructions was as follows: "Now I am going to present to you an unlikely situation that perhaps will never happen. Use your imagination to think of all of the interesting things that would happen if this unlikely situation occurred. Make a list of the greatest number of assumptions possible. The unlikely situation is the following: Suppose that there are ropes that hang down to the ground that are attached to the clouds. What would happen? Tell me all of the ideas that come into your mind." For both of these tasks, the creativity thinking indexes (i.e., *fluency*, *flexibility*, and *originality*) were computed according to the TTCT manual. In the Product Improvement Task, *fluency* corresponded to the number of generated ideas, *flexibility* was the number of divergent idea categories, and

Fig. 1. Open posture.

Fig. 2. Closed posture.

originality corresponded to the infrequency of the generated ideas. In the Just Suppose Task , *fluency* corresponded to the number of generated ideas, *flexibility* was a point for every change of perspective from the first answer, and *originality* was exactly the same as in the Product Improvement Task.

The two tasks were completed while the participants assumed either an open posture or a closed posture. The open posture participants were seated on a chair with their legs slightly bent and with their feet on the floor, their arms were on the armrests, and their head was resting on the edge of their seat (Fig. 1). The closed posture participants were seated on a chair with their legs crossed, their arms were folded across their chest, their hands were on their shoulders, and their head was bowed over and nearly touching their arms (Fig. 2). The participants in each subsample were randomly assigned to either an open posture or a closed posture. The randomisation occurred according to the same procedures with the slips of paper as was previously described.

The two groups in each subsample were similar with reference to their gender distribution and their age. In the first subsample, 8 men and 18 women were assigned to the open posture condition and 7 men and 18 women were assigned to the closed posture condition ($\chi^2(1; n = 51) = 0.047$, $p = 0.83$). In the second subsample, 9 men and 15 women were assigned to the open posture condition and 9 men and 18 women were assigned to the closed posture condition ($\chi^2(1; n = 51) = 0.097$, $p = 0.76$). In the first subsample, the mean age of the participants was 20.88 yrs. (SD = 1.39) in the open posture condition and it was 21.52 yrs. (SD = 1.42) in the closed posture condition ($t_{49} = -1.61$, $p = 0.11$). In the second subsample, the mean

Table 1
Creativity scores in the two tasks under the two postures (study 1).

Creativity scores		Product Improvement Task				Just Suppose Task			
		M(SD)	*t*(50)	*p*	*Cohen's d*	*M(SD)*	*t(50)*	*p*	*Cohen's d*
Fluency	Open Closed	8.04 (5.73) 2.80 (1.96)	4.40	<0.001	1.22	7.50 (3.98) 5.15 (2.41)	2.51	0.016	0.71
Flexibility	Open Closed	8.81 (4.09) 6.28 (2.34)	2.72	0.010	0.76	6.87 (4.20) 4.48 (2.47)	2.44	0.020	0.69
Originality	Open Closed	7.54 (4.99) 4.20 (2.33)	3.08	0.004	0.86	9.70 (4.99) 5.52 (2.33)	2.69	0.011	1.07

age of the participants was 20.41 yrs. (SD = 1.50) in the open posture condition and it was 20.63 yrs. (SD = 1.31) in the closed posture condition ($t_{49} = -0.54$, $p = 0.59$).

Each participant was welcomed into a small room in one of the buildings of the university campus. The researchers asked the participant to embody either an open posture or a closed posture by a showing of the corresponding figure and to read the instructions for either the Product Improvement Task or the Just Suppose Task. The participants responded orally while an experimenter recorded their responses in a notebook. This way of responding is not usual in the TTCT, but we were forced to apply it, in order to avoid leading the participants to change their posture when writing down their answers (this often occurs in creative thinking testing). The experimenters sat at the back of the participants so as to prevent him or her being inhibited.

Each task was completed in about 10 min and the entire experimental session lasted about 15 min.

2.2. Results and discussion

According to what is reported in the manual, the Italian standardisation of the test showed that this version of the TTCT has adequate psychometric properties (Sprini & Tomasello, 1989). For the Product Improvement Task, we compared the scores that we had recorded in the samples of those taking part in the present experiments with the values that had been recorded in a previous investigation (Colombo, Bartesaghi, Simonelli, & Antonietti, 2015). This was where the same Italian version of such a task was employed and we checked that the former ones were similar to the latter ones. The distributions of fluidity, flexibility, and originality scores, in the Product Improvement Task, showed acceptable asymmetry values (respectively, 0.83, 1.49, and 0.65) and kurtosis values (respectively, −0.04, 2.04, and −0.30). The same was true for the Just Suppose Task (fluidity: asymmetry = 0.66, kurtosis = −0.25; flexibility: asymmetry = 0.71, kurtosis = −0.20; originality: asymmetry = 0.73, kurtosis = −0.07). In addition, we computed Pearson's correlation coefficients between the creativity scores that we had recorded in our samples and found that they were highly correlated, as should have happened, so supporting the validity of the versions of tasks that we had used (Product Improvement Task: fluidity-flexibility $r = 0.75$, $p < 0.001$; fluidity-originality $r = 0.87$, $p < 0.001$; flexibility-originality $r = 0.83$, $p < 0.001$; Just Suppose Task: fluidity-flexibility $r = 0.98$, $p < 0.001$; fluidity-originality $r = 0.88$, $p < 0.001$; flexibility-originality $r = 0.89$, $p < 0.001$).

An embodiment of the open posture was associated with higher scores across all of the creative indexes for both of the tasks (Table 1). The findings supported the hypothesis that posture influences creative task performances.

The results of the first experiment did not allow us to conclude that the facilitating effects of the open posture are specific to creativity. Further, it was not possible to understand if such effects were due to the physiological states (relaxation vs. arousal and tension) and to the level of comfort/discomfort that was associated with the posture, or to the symbolic meanings of the postures which metaphorically suggested a particular mental disposition. The second study was devised in order to disentangle these issues.

3. Study 2

Study 2 was planned in order to replicate the findings of Study 1 but with a slightly different experimental design. As in Study 1, the participants completed the Just Suppose Task, but a non-creative task was added in order to assess whether by embodying an open posture would lead to an improved performance for this non-creative task as well. Study 2 also tested whether by embodying the open posture or the closed posture was associated with differing physiological indexes. This specifically regarded the cardiovascular reactivity and whether the level of personal comfort/discomfort that was quantified by the subjective ratings and by the electromyography (EMG) was associated with the embodiment of either of these two postures. It has been shown that cognitive demands affect the physiological functions, causing an increase in the cardiovascular reactivity, a decrement of the heart rate variability (HRV), and an increment of muscle activity (Finsen, Jensen, Søgaard, Borg, & Christensen, 2001; Hallman, Lindberg, Arnetz, & Lyskov, 2011; Hjortskov et al., 2004), which are all associated with mental and physical stress (Taelman, Vandeput, Spaepen, & Van Huffel, 2009), as well as task performances (Srinivasan et al., 2016).

The physiological activations were introduced in order to assess if physical discomfort was linked to the different postures that were assumed by the subjects and could they affect their cognitive elaboration. As has been described in the literature,

Table 2
Creativity scores in the creative and logic tasks under the two postures (study 2).

Task	Score	Posture	*M(SD)*	*t*(18)	*p*	*Cohen's d*
Just Suppose Task	Fluency	Open	8.30 (3.65)	2.13	0.047	0.95
		Closed	5.30 (2.54)			
	Flexibility	Open	7.20 (3.71)	2.13	0.047	0.96
		Closed	4.20 (2.41)			
	Originality	Open	10.90 (4.84)	2.71	0.014	1.21
		Closed	5.60 (3.84)			
Syllogisms	Correct answers	Open	11.50 (2.42)	0.69	0.498	0.31
		Closed	10.80 (2.09)			

physiological indices could be monitored during a task as an indirect measure of mental effort (Kim et al., 2013; Sutarto, Wahab, & Zin, 2013). A pre-decisional phase, as well as the completion phase of a task, is sometimes associated with a physiological process that is characterised by an increase in heart rate and blood pressure and a decrement in their variability, highlighting the preparation for the task at hand (Palomäki, Kosunen, Kuikkaniemi, Yamabe, & Ravaja, 2013). Specifically, a decrease in the heart rate variability index has been associated to mental stress in laboratory experiments (Myrtek, Weber, Brügner, & Müller, 1996; Sloan et al., 1994). These reactions could mean a loss of ability in order to respond to physiological complexity and variability, making the participants physiologically rigid, and therefore, more vulnerable (Horsten et al., 1999).

4. Method

Twenty students (6 men and 14 women; mean age = 21.0 yrs., SD = 1.29), coming from the same faculty and recruited according to the same procedures as in Study 1, took part in the experiment for extra-credits. The number of participants matched the size of the usual samples that were recruited in experiments where the physiological measures were recorded.

The participants completed a creative (i.e., the Just Suppose Task from Study 1) and a non-creative task (i.e., a logical reasoning task). The Just Suppose Task was administered and was coded in the same way as in Study 1. The logical reasoning task required the participants to verify if the conclusion of 20 syllogisms followed the premises. Examples of the syllogisms were: "Some shop assistants are boring. All shop assistants are kind. Hence, some kind people are boring" or "All mammals suckle their puppies. No snake suckles its puppies. So no snake is a mammal". The syllogism difficulty was assessed in a pre-test where 30 syllogisms were presented to 20 participants, similar to those participating in Studies 1 and 2. The syllogisms where the conclusion was correct 50% of the time were included in the final set of items that were used in Study 2. Each syllogism was presented orally and the participant had to say "true" or "false", according to the evaluation of the conclusion that he or she had arrived at. The task lasted 10 min. The participants received one point for each correct response and the sum of all of the correct responses was their overall score for the logic task.

The Biofeedback 2000^{x-pert} from Schuhfried procedure was used in order to monitor the physiological activation at the baseline (2 min immediately before the task) and immediately after the completion of the task (when the participants were asked to embody the posture for a further 2 min) for each posture, for both the creative and the logic tasks. Electrodes were placed over the participant's middle finger of the left hand in a sitting position, allowing for the measurements of the skin's conductance, the skin temperature, the blood volume pulse (average blood flow near the skin's surface), the blood volume amplitude (the difference between the highest and the lowest blood volume levels), and the heart rate variability.

The physical discomfort of the postures was measured by the EMG data which was recorded by using Neuroscan 4.2 Acquisition Software and a DC SymAmp amplifier system. Thanks to the EMG, the superficial muscle tensions were evaluated both immediately before (baseline) and after the creative task and the logic task when in the two postures.

The creative and the non-creative tasks were carried out by embodying the open or the closed posture as used in Study 1. Before completion of the tasks, biofeedback sensors were attached to the index finger of the non-dominant hand of each participant in order to detect his or her physiological baseline and to measure the variations across the tasks. The EMG electrodes were placed bilaterally on the upper part of the trapezius muscle.

In an identical manner to Study 1, the participants responded orally for both the creative task and the non-creative task, while one of the current authors recorded the responses in a notebook. Each task was completed in about 10 min and the entire experimental session lasted less than 30 min. The task/posture order was counterbalanced within the participants.

At the end of each task/posture combination, the participants were asked to rate on a 7-point scale (1 = lowest; 7 = highest) the level of comfort that they perceived while carrying out that particular task/posture combination.

5. Results and discussion

The embodiment of the open posture was associated with the highest scores across all of the creative indexes when tested in the creative task. The syllogism task differences between the postures were slight and they were not statistically significant (Table 2).

Table 3
Biofeedback and EMG scores in the Creative and Logic Tasks Under the Two Postures (Study 2).

Creative Task							
Index	Posture				ANCOVA (effect of the independent variable)		
	Open		Closed				
	M	*SD*	*M*	*SD*	$F(1, 17)$	*p*	η^2
Skin conductance	5.586	5.663	7.513	6.906	4.062	0.060	0.193
Skin temperature	27.558	3.185	30.105	3.481	2.883	0.108	0.145
Blood volume pulse	49.741	0.172	49.664	0.412	0.216	0.648	0.013
Blood volume amplitude	41.072	18.018	39.366	24.482	0.009	0.927	0.001
Pulse frequency	81.92	9.406	79.626	7.335	0.160	0.694	0.009
EMG	0.015	0.015	0.013	0.014	1.129	0.303	0.062
Logic Task							
Index	Posture				ANCOVA (effect of the independent variable)		
	Open		Closed				
	M	*SD*	*M*	*SD*	$F(1, 17)$	*p*	η^2
Skin conductance	6.045	6.672	8.602	7.559	0.328	0.574	0.019
Skin temperature	28.287	3.689	30.546	3.227	0.595	0.451	0.034
Blood volume pulse	50.034	1.338	49.567	.451	0.919	0.351	0.051
Blood volume amplitude	41.072	18.018	39.366	24.482	0.006	0.937	<0.001
Pulse frequency	90.029	17.719	79.429	10.95	0.623	0.441	0.035
EMG	0.014	0.018	0.011	0.010	0.456	0.508	0.026

Table 4
Comfort scores in the creative and logic tasks under the two postures (study 2).

Task	Posture				*t*-test		
	Open		Closed		*t(18)*	*p*	Cohen's *d*
	M	*SD*	*M*	*SD*			
Creative Task	4.20	1.32	4.30	1.49	−0.16	0.876	−0.07
Logic Task	4.30	1.34	3.70	1.06	1.11	0.281	0.50

The physiological and the EMG indexes were analysed with the mean baseline value as the covariant when using the Analysis of Covariance (ANCOVA). The postures were considered (open vs. closed) as an independent variable and the mean values were recorded immediately after the task as the dependent variables. The results are reported in Table 3. As far as the creative tasks were concerned, the analyses revealed a lack of significant differences when in the postures for the skin's conductance, the skin temperature, the blood volume pulse, the blood volume amplitude, the heart rate variability, and the EMG. Significant differences also failed to emerge in the logic task. The subjective ratings for comfort were also not affected by the postures when in both the creative and the logic tasks and they were not statistically significant (Table 4).

The findings of Study 2 supported the notion that the effects of the postures were specific to the creative task performances, since they emerged only in the Just Suppose Task, but not in the logic task. Furthermore, Study 2 suggested that such effects were not due to possible differences in the muscle tensions and the physiological activations and that they did not result from the differences in the perceived comfort/discomfort situations that were associated with the postures.

6. General discussion and conclusions

If openness is associated with creative thinking (McCrae, 1987; Kaufman, 2013) and the body "shape" thinking processes (as claimed in the embodied cognition approach), then a bodily posture where the body parts are extended and open should promote creative thinking. The investigation that has been presented in this paper has tested that question, by assessing the possible influences of posture on the generation of new, unusual, and meaningful ideas, so as to extend our understanding of how embodiment influences creativity.

In the two studies, an open posture was associated with better performances regarding the creativity tasks for all of the indexes, i.e., fluency, flexibility, and originality. Interestingly, in Study 2, posture was not associated with more correct judgments for the logical syllogisms. In addition, Study 2 showed that the cardiovascular indexes and the skin state measurements – which depend upon the activity of the autonomous nervous system – as well as the levels of muscular tension, were not affected by the postures. This lack of differences in the physiological parameters was mirrored by the lack of differences in the subjective ratings of the comfort/discomfort feelings that were experienced by the participants when embodying the two different postures.

It was not clear whether the open posture enhances creative thinking, but the closed posture was detrimental to creativity. In order to resolve this question, a baseline measure, where people embody a "neutral" posture, seems to be needed. However, in previous research assessing the influence of physical features on creative thinking neutral conditions were never included (Hao et al., 2014; Ijzerman et al., 2014; Leung et al., 2012; Oppezzo & Schwartz, 2014; Slepian & Ambady, 2012; Vohs et al., 2013). This is not meant as a methodological flaw, since it is conceptually hard to identify what can be a "neutral" posture, because each body disposition implicitly embeds a specific mental disposition. Nevertheless, indirect predictions, of how participants would perform in a "neutral" condition, can be drawn on the basis of the response rates that were previously recorded. As far as the logic task that was employed in Study 2 is concerned, we can refer to the data that were collected in the pilot study, in which the participants carried out the task by sitting at a table. The mean number of correct answers that were recorded in this pilot study was 10.99, and therefore the open postures (11.52) and the closed postures (10.80) only slightly modulated the baseline response rates. As far as creativity was concerned, we can refer to the scores that were recorded in a previous application of the Italian version of the TTCT tasks (Colombo et al., 2015). Such scores were similar to those that we obtained in the closed-posture condition. Therefore, we can argue that the open postures facilitated the creative performances, rather than the closed postures inhibited it.

The facilitation that was produced by the open postures emerged only in the creative and divergent thinking task, but not in the task with different features (namely, the syllogism tasks, which involved logic and convergent thinking). This supports the notion that the effects of the open vs. closed posture are not related to generalised facilitation/inhibition processes, but they are specific to creative thinking.

One might argue that the different creative performances that were recorded in the two postures were due to the different levels of arousal or tensions that the postures elicited and/or to the more or less comfortable conditions in which the participants were placed. It has been reported that the resting state of cerebral blood flow is positively associated with cognitive functions when related to creative thinking (Takeuchi et al., 2011) and that by spending time in natural and peaceful places enhances creative performances and problem-solving skills (Atchley, Strayer, & Atchley, 2012). An explanation that is based on comfort and/or relaxation has to be rejected based upon the Study 2 findings, which demonstrated that the self-reported measures of comfort/discomfort, as well the physiological and the EMG indexes for activation/effort, were not significantly different in the two postures. It is worth noting that the two postures that were embodied by the participants corresponded to postures that people spontaneously adopt in everyday situations and the investigation did not force the participants to remain for too long in an unnatural body position. It should, therefore, come as no surprise that neither the subjective comfort nor the physiological and EMG indexes differed for the embodied postures (Blangsted, Søgaard, Christensen, & Sjøgaard, 2004).

It is possible though, that mental dispositions – which have been reported to affect performances in creativity tasks (Colombo et al., 2015) – explain and inspire the postures in our findings. Yap et al. (2013) claimed that the open posture suggests a sense of power that people use to infringe upon common honesty norms. However, such an account cannot be applied to our findings, as the open postures should have led our participants to be more confident in their capabilities, so leading to better performances on both the creativity and logic tasks, but this failed to occur.

The open postures might also be interpreted as being metaphorically open-minded. Leung et al. (2012) found that performances were better when body movements metaphorically mirrored the mental operations that promote creativity. Our findings regarding posture are consistent with this interpretation. The open posture might, therefore, suggest a broader mental framework in order to explore different options and opportunities, by preventing a rigid mindset. This might lead people, as observed in the experiments reported here, to let their thoughts wander freely in order to find various solutions to a problem. The closed posture, instead, might induce individuals to operate in a narrower mental space, in order to converge on a restricted set of categories. They might be reluctant to take into consideration those possibilities that are far from the mainstream of common thought.

We have to take into account that the debate is still ongoing about the measurements of creative thinking (Baer, 2011). The need for new possible tools to be applied in order to assess creativity skills was underlined by Piffer (2012). Nevertheless, TTCT, or the tasks inspired to such a test, continues to be the most largely used instrument in order to measure creative thinking, even though it has to be administered with sensitivity by qualified professionals (Treffinger, 1985), because variations in testing procedures can affect scores (Swartz, 1988). This is a problematical issue which may lead to reliability fallacies (Kim, 2006). Being aware of these limitations, Kim (2006, p. 9) concluded that "TTCT appears to be a good measure, not only for identifying and educating the gifted, but also for discovering and encouraging everyday life creativity in the general population".

The results of the present investigation might have practical implications. The message that emerges is that – in order to facilitate people to generate many different and unusual ideas – bodily postures matter. In educational (Craft, 2005) and work settings (Glaveanu, 2013), as well as in the art activities (Antonietti & Colombo, 2014), where creativity is needed, people might benefit from an open posture. The programmes that are aimed at the training of creative skills are mostly focused on the exercises to be carried out, so as to lead people to internalise the use of productive strategies. This eventually suggests that a proper emotional state should accompany the activities to be performed (Michalko, 2010). Little or no attention has been given to the physical conditions in which the trainees should be placed. Asking individuals to embody an open posture might be fruitful advice in order to maximise the outcomes of this type of training. In this sense, an embodied creativity training approach (Byrge & Tang, 2015) might actually be implemented.

Future studies might try to expand the findings of the present investigation, by employing alternative measures for creative thinking, rather than the tasks that are derived from the TTCT procedure. Future studies might also test whether other kinds of postures are as equally effective as the expansive vs. contractive ones, in modulating creative thinking performances. This can only enhance our knowledge and our understanding of the role played by body in creative thinking.

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