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Enhancing creativity by training metacognitive skills in mental imagery

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Enhancing creativity by training metacognitive skills in mental imagery

Abstract

In a three-year longitudinal study, 240 undergraduate dance students were recruited to assess the effectiveness of a series of workshops designed to develop metacognitive skills in use of mental imagery to support choreographic creativity. The workshops were based upon a theoretical model of mental representations and cognition. The students also completed a creativity test before the workshops, and a newly designed test of flexible thinking before and after the workshops, and a year later. Five forms of the flexible thinking test were created to allow for repeated administration over time, and the forms were shown to be equivalent and to correlate with the creativity test. Students who had taken part in the imagery workshops showed a greater improvement in flexible thinking a year after the training, compared to the scores of students who had not received the training. Evaluations of choreographic assessments by the students' teachers were rated for positive and negative mentions of imagery and creativity, and the imagery group scored worse than the control group on use of imagery immediately after the training, but better than the control group on creativity and use of imagery four months after the workshop. The findings show that domain-specific creativity can be enhanced through developing skills in the use of mental imagery to produce novel ideas, and that this also improves domain-general flexible thinking.

222 words

Keywords

imagery; creativity; measurement; dance; choreography; training; flexibility; fluency; originality; novelty

Highlights

- development of workshops to develop dance students' metacognitive imagery skills
- development and validation of a repeatable measure of flexible thinking
- training improved students' scores on the flexible thinking test
- training improved students' creativity on an objective choreographic assessment
- creativity can be enhanced through developing skills in the use of mental imagery

Supplemental materials

Training materials, assessment materials, data and analysis scripts are available from the project website www.dancersmind.org.uk and from the Open Science Framework at doi: 10.17605/OSF.IO/URDJ4

Introduction

Creativity is popularly understood as a more or less fixed trait: some people are creative, others less so, and some people might never have a novel idea. We recognise the outstanding creativity of individual writers and artists through their works and performances (Kaufman, 2002), of architects who pioneer new technologies and build wonderful structures (MacKinnon, 1962), of scientists who make breakthroughs that open-up new fields of research and change the way we understand our place in nature (Fiest & Gorman, 1998). In fact, these achievements are just the smallest tip of an iceberg, for it has been argued that the creations that these individuals produce arise from mental action that we all engage in during our day to day lives, even if we do not all follow our creative processes through to generate products that can be recognised as novel and useful by others (e.g., Baughman & Mumford, 1995; Bink & Marsh, 2000; Finke, Ward, & Smith, 1992; Weisberg, 1999).

In this paper we challenge the idea that creativity is a trait by developing and evaluating training materials based upon metacognitive imagery skills, and by creating a brief test of creativity that can be used repeatedly in longitudinal studies. We show that five different forms of this test are equivalent and correlate with a widely used test of creativity. We then use these materials in a three-year longitudinal study to assess the effect of an imagery-based intervention upon flexible thinking, and hence creativity. We also collect objective evaluations from a creative task, and show that these are also improved by the intervention.

Measuring changes in creativity

The idea that creativity is a trait has influenced the development of the psychological tests that have been designed to measure it. In a broad taxonomic review of creativity assessments, Hocevar & Batchelor (1989) identified eight types of tests. Three types assessed attitudes, personality, or ratings made by other people, so directly measuring trait-like variables; four assessed biographical achievements, eminence, activities, or creative products which are cumulative over one's lifetime; and a final type assessed performance on divergent thinking tasks (as defined by Guilford, 1956), where any familiarity with the problem content precludes repeated testing. Such one-off tests reinforce the idea that creativity does not change, and are a barrier to any research that does seek to examine longitudinal changes following education or training.

Despite this, there have been many attempts to train or improve creativity, and a review of 70 studies (Scott, Leritz & Mumford, 2004a, 2004b) concluded that training could indeed enhance creativity, with an average effect size $d = 0.64$. Paradoxically, a content analysis of the training courses indicated that the largest effects upon creativity came from courses that emphasised analytic approaches to solving divergent problems: constraint identification, critical thinking, convergent thinking and metacognition. Training in expressive activities, imagery, metaphors, illumination and elaboration had a negative relationship with effect size. One interpretation of these findings is that the techniques that led to the best performance were those that helped people make the poorly-defined or ambiguous problems typical in divergent tasks more amenable to convergent solution: allowing non-creative thought to work.

Scott et al. conclude that the most effective training included the generation of new ideas, specifically problem finding, conceptual combination, and idea generation, in line with

the idea that creative problem solving involves the initial divergent production of novel ideas followed by the convergent selection and development of the useful ones. Koestler (1964) defined creativity as 'the defeat of habit by originality' (Koestler, 1964), and Campbell (1960) described it as a result of the two processes of 'blind variation and selective retention'. This long-established view of creativity recognises that creative products result from a great deal of effortful work, involving the generation, recognition, selection, evaluation, and elaboration of ideas related to a task or problem (Simonton, 2011). Without the initial generation of unusual ideas, habit cannot be defeated; but unless the useful ideas are recognised and selected from amongst the unusable ideas, no amount of elaboration will produce a truly original product.

Scott et al. also point out theoretical and methodological weaknesses in many creativity training studies. Based on their analysis, they advocate that training should have a firm theoretical basis for the cognitive activities underlying creative efforts; training should be lengthy and challenging, with principles being applied to relevant 'real-world' problems; and with exercises appropriate to the domain of interest. They also criticise studies where post-tests of creativity were made immediately after training, and the testing used materials similar to the training materials, with little or no transfer problems.

Given the emphasis in the creativity and problem solving literature upon problem representation, illumination and elaboration, it is puzzling that Scott et al. did not find that training in these specific skills improved creativity. It may be that these skills are particularly hard to train, that making people aware of their importance is not sufficient to support their application in practice when faced with an assessment. We argue that mental imagery is an essential component of problem representation and the generation of novel ideas, and that its use and application is subject to strategic skills that can be acquired, developed and practiced. Accordingly, we set out to develop a suite of training materials based upon a theoretical

model of mental imagery, following Scott et al.'s recommendations for the design and evaluation of a creativity intervention.

Creativity and Imagery in Choreography

We chose to work in the domain of choreographic creativity, because contemporary dance places a high value in novelty and creativity, and dance teachers have used mental imagery as part of their pedagogical repertoire for many years (Overby & Dunn, 2011). Todd (1975) described her anatomically-based imagery as a method of refining neuromuscular co-ordination, and these ideas were further developed by Sweigard (1978), who popularised the term ideokinesis, meaning an idea of movement. Her aim was to help dancers develop greater control over their posture and spinal alignment, to unlearn bad movement habits and make new ways of moving automatic.

Franklin (1996) extended this idea, arguing that mental imagery supported changes in the mental representation of movement that were necessary precursors for physical changes in the musculature, enabling a wider movement repertoire. Similar ideas have become popular within sports psychology, where research has shown benefits for practitioners of imagining movement when combined with physical practice or when opportunities for actual movement are limited by for example, injury (Schuster, Hilfiker, Oliver et al., 2011). The development of the Dance Imagery Questionnaire (DIQ; Nordin & Cummings, 2006) was driven by a perceived need to link research into dance imagery with work in the sports domain, where Hall, Mack, Paivio & Hausenblas (1998) had identified imagery as supporting cognitive skill, cognitive strategies, goal-oriented motivation and mastery motivation.

Beyond the physical and motivational aspects, imagery has also been used to intervene with dancers' cognitive representations of movement. Overby, Hall & Haslem (1988) identified different forms of sensory imagery (visual, auditory and kinaesthetic), perspectives (first or third person views), and referent (contextual, character or metaphor) used by dance teachers and sport coaches to enrich their range and style of movement, and a review by Overby & Dunn (2011) concluded that kinaesthetic imagery helped with skill development, and metaphorical imagery with skill learning, both forms having beneficial effects upon performance.

This supports earlier work by Rosenberg and Trusheim (1989) reporting the ways that a variety of creative artists including dancers used mental imagery in their work, although other work in this area has produced ambiguous results. Morrison and Wallace (2001) emphasised the need to distinguish between participation and achievement in creative arts, finding that individual differences in visual imagery vividness were related to psychometric measures of divergent production and fluency, but not to ratings of creativity provided by judges or to a self-report creative behaviour inventory. Vivid imagery supported creativity but creativity was more than vividness; the original ideas had to be worked upon and selected, as argued by Campbell (1960).

In their recent review of motor imagery research, Moran, Guillot, MacIntyre & Collet (2012) conclude that meta-imagery processes, or people's knowledge of and control over their own mental imagery skills and experiences, is a key new direction for imagery researchers, citing evidence that people have little insight into the role that imagery plays in behaviour on tasks such as mental scanning or rotation, or in its effects upon motor performance.

Our metacognitive, imagery-based creativity training applies a cognitive theory of mental representations called Interacting Cognitive Subsystems (ICS, Barnard, 1985). ICS

distinguishes between three internal ‘cognitive loops’ that give rise to imagery about space and movement, sound and speech, and intuitive emotional schemas, respectively. These loops are linked together through a common sense of meaning. Working with the educational arm of Wayne McGregor’s dance company Random Dance and its research director Scott deLahunta, Barnard helped to develop a set of training materials for secondary school pupils studying dance (McGregor, 2013). These gave the pupils practical experience in working with their mental imagery to gain confidence in manipulating ideas in their minds, moving between visual imagery, sound imagery, and emotional imagery. The materials included a named set of twelve mental transformations that could be applied to a mental representation, and diagrams to provide a link between the core ideas and practical tasks (Figure 1).

Figure 1

We took the core conceptual ideas from Mind and Movement and worked with choreography teachers at two leading UK dance schools, Trinity-Laban Conservatoire of Music and Dance in Greenwich, London and the School of Performing Arts at Coventry University, to produce a new suite of materials, with content suitable for students on undergraduate dance programmes. Our intention was to build on the model of imagery based creativity proposed by McGregor (2013) to give dance students the confidence to incorporate imaginal strategies when faced with creative tasks in their choreography.

Our final ‘In the Dancer’s Mind’ materials included 37 separate exercises which could be selectively combined in a modular fashion to support the delivery of six ‘targets’ (learning objectives). These targets were to introduce students to basic phenomena in mental imagery; to experience manipulating their visual imagery, their sound imagery, and their emotional schematic imagery; and then to move between these forms of imagery in a creative manner; before extending these exercises into the physical domain of movement creation.

Some exercises were didactic, with video-based delivery by a member of the research team; others were movement based, so that students could experience the relationship between imagery and dance; some were discursive and reflective. These exercises were supported by posters, flash-cards and a revised set of 'principles' based upon the twelve mental transformations, grouped into sets that helped students to modify a whole image, edit part of an image, or modify their mental image. The full set of materials is available online at the project website www.dancersmind.org.uk.

As recommended by Scott et al. (2004a) we evaluated these materials using a pre-post design including a control group. As the training was to be included within the students' curriculum, we could not randomly allocate students to control and imagery training groups. Instead, all students beginning their course in the first year of the study served as a control group, and all students beginning their course in the subsequent year served as the intervention group, and received the imagery training. A cohort-based design like this has known weaknesses, as any effects of the intervention may be confounded with other co-incidental changes in teaching provision or differences in recruitment, but is better than delivering additional or different teaching to half of the students in a year group, when they work closely together and the intervention group would share resources and materials with the control group.

Our post-test was scheduled for a year after the delivery of the training, to allow students time to practice using the imaginal strategies and to incorporate them into their normal choreographic practice. Although we included a post-test soon after the training, we did not expect students to have had the opportunity to become confident in the imaginal strategies at this point.

Method

Participants

We recruited 240 dance students in total, 111 to the control group in the 2015-16 academic session (76 females, 68%; 24 males, 22%; 11 did not state sex), and 129 to the imagery group in 2016-17 (103 females, 80%, 24 males, 19%; 2 did not state sex). 204 were recruited from Trinity-Laban Conservatoire of Music and Dance; and 36 from a smaller programme at Coventry University. Ages at recruitment overall ranged from 17.9 years to 28.2 years, with a median of 19.0, and did not differ between groups $t(238) = 0.25$, $p = .800$ or institution $t(238) = 0.44$, $p = .662$. There were 187 whose native language was English, and 53 (22%) who spoke English as a second language. All of the latter spoke English to IETL Level 6 (Competent User, with effective command of the language despite some inaccuracies).

Materials

Baseline Creativity

We used the Abbreviated Torrance Test for Adults (ATTA, Goff & Torrance, 2002) as a general baseline measure of creativity. The test consists of three activities, each lasting three minutes. In Activity 1, participants list problems that might result from an unfamiliar situation; in Activity 2, participants use two incomplete line drawings to make some unusual pictures that tell a story; in Activity 3, participants create pictures based on a 3x3 matrix of identical geometrical shapes. The test is scored using four norm referenced measures of fluency, originality, elaboration, and flexibility, which are summed to provide the ATTA

Creativity Index ranging from zero to 100, which is then binned into a 1 to 7 ordinal categorical measure, the ATTA Creativity Level.

An initial sample of 12 randomly selected booklets were scored by two researchers, to obtain a measure of inter-rater reliability, achieving an IRR of .87. (indicating a very good level of reliability between raters; McHugh, 2012). The remaining booklets were divided between the two researchers. Any queries which arose during scoring were discussed by the two researchers. Half way through the scoring process, a further random 12 questionnaires were scored by both researchers, this time achieving an IRR of.82.

Longitudinal Flexible Thinking Tasks

As the ATTA can only be administered to an individual once, we also created five forms of a Flexible Thinking Test (FTT), intended to allow repeated measurement of creativity. We based the FTT on three tests from the Comprehensive Ability Battery (Hakastian & Cattell, 1975): Ideational Fluency, Spontaneous Fluency, and Originality. These three tests had previously been found to cohere as a flexible thinking factor and to correlate with performance on lateral thinking problems (May, 1987). Spontaneous Fluency (Fs) is measured by the number of different ways that participants can group subsets of seven everyday items, in three minutes, where each group shares a common feature. Ideational Fluency (Fi) is the number of adjectives that a participant can think of in 30 seconds to describe a given object. Originality (O) is the number of new objects participants can create in six minutes from a list of fifteen pairs of items. The FTT score was obtained by summing the total obtained on each of the three tests. We created five different versions by using different sets of objects for Fs, different given objects for Fi, and by recombining the pairs of items to produce sixteen different pairs for O. The booklets used are available from the project website www.dancersmind.org.uk

Domain Creativity

As part of their undergraduate course, students from Trinity-Laban completed two assessment tasks for which their choreography teacher provided written feedback on pieces of dance they had created and either performed themselves (the performance task, completed in December of their first year, shortly after the imagery group's training sessions) or directed another student to perform (the direction task, completed in March of their first year, fourth months after the imagery group's training sessions). We were able to use this feedback to obtain objective, domain based measures of the teacher's perceptions of their students' creativity and evidence of imagery or imaginative ideas as guiding their work.

Imagery Training

The workshops consisted of six 90-minute sessions delivered as part of the students' timetabled curriculum by a member of their teaching staff. Each session used four or five exercises drawn from the complete set, and addressed a core learning target. The content of the sessions was chosen by the choreography teachers as a team at the start of the academic year, and the same programme was used with all of the students. At Trinity-Laban these sessions were scheduled at weekly intervals in October and November; at Coventry the sessions were scheduled between October and December.

Procedure

Ethical approval for the research was obtained from the three collaborating institutions' ethical approval committees, and all procedures complied with the guidelines of the APA and BPS. Students took part in three data collection sessions, one at the start of their first year, a second time half way through their first year, and then a third time, halfway

through their second year. The imagery group additionally received the imagery workshops between the first and second data collection sessions.

In the first data collection session, the students completed the ATTA, the FTT, and then took part in a momentary assessment of imagery exercise, which is reported elsewhere. The second and third sessions included the FTT and the imagery exercises, but not the ATTA.

Results

Although 240 students took part in total, not all attended every testing session. Table 1 shows the attendance at each session, with 104 (51 control, 53 imagery) attending all three, and 117 attending the first and final sessions (57 control, 60 imagery).

Table 1

Baseline Creativity

The ATTA was completed by 215 students, with a mean Index of 62.1 (SD=5.9) and mean Level of 4.4 (SD=1.5), and there was no difference in these scores between the control and imagery groups (Index: $t(213) = 1.52$, $p = .130$; Level: $t(213) = 1.66$, $p = .098$) or the institutions (Index: $t(213) = 1.79$, $p = .074$; Level: $t(213) = 1.79$, $p = .075$). The non-native English speakers (Index M=58.8, SD=6.4; Level: M = 3.7, SD=1.5) did score lower than the native English speakers (Index M=63.1, SD=5.4, $t(213) = 4.66$, $p < .001$; Level: M = 4.6, SD=1.4, $t(213) = 3.87$, $p < .001$). According to the manual, an ATTA Level of 4 is 'average', and the distribution obtained from our sample did not differ from the normed distribution $\chi^2(6) = 10.2$, $p = .115$.

Longitudinal Flexible Thinking task validity

Of the complete sample, 217 students completed the Flexible Thinking Tests (FTT) at the first testing session, 188 at the second session, and 126 at the final session. Combining the data from all sessions, FTT scores were normally distributed (skew = .35, kurtosis = .07) and ranged from 3 to 40, with a mean of 19.6. The five different versions of the FTT were each completed by between 99 and 109 different individuals over the course of the study, with people completing between one and three tests. A simple oneway ANOVA showed no difference in means between the five versions $F(4, 526) = 1.39$, $p = .237$, $\eta_p^2 = .01$, so we conclude that the five forms are equivalent.

As with the ATTA, the FTT scores were lower for non-native English speakers (first session: M=14.0, SD=4.9; second: M=18.0, SD=6.3; final: M=18.1, SD=6.0) than for native English speakers (first session: M=18.7, SD=5.8, $t(215) = 5.10$, $p < .001$; second: M=21.4, SD=5.7, $t(186)=3.40$, $p = .001$; final: M=22.4, SD=6.5, $t(124) = 3.00$, $p = .003$).

Individuals' FTT scores from different sessions were positively correlated for both groups: control $r = .55$ to .64, all $p < .001$; imagery $r = .54$ to .73, all $p < .001$. FTT Scores also correlated positively with ATTA Index (first session $r = .40$; second $r = .43$, final $r = .43$, all $p < .001$) and ATTA Level (first session $r = .39$; second $r = .48$; final $r = .53$, all $p < .001$). The FTT thus appears to capture individual differences in creativity, and to be measuring a construct comparable to that measured by the ATTA.

Effect of intervention upon flexible thinking

We had not expected to detect any differential change in the two groups' FTT scores by the second session, soon after the imagery training, and an ANOVA comparing the change from the first to second sessions showed just a main an effect of time $F(1,169) = 53.4$,

$p < .001$, $\eta_p^2 = .06$, no effect of group $F<1$, nor an interaction of time by group $F<1$. The control group and the imagery group did not differ in FTT scores at any of the testing sessions, when all those attending each session were compared directly (first: $t(215) = 1.48$, $p = .141$; second: $t(186)=0.38$, $p = .707$; final: $t(124)=1.03$, $p = .305$).

However, we had predicted that FTT scores would differ by the time of the third session, a year after training. An ANOVA comparing the change from first to final session showed both an effect of session $F(1,115) = 21.5$, $p < .001$, $\eta_p^2= .04$, and an interaction with group $F(1,115) = 4.49$, $p = .036$, $\eta_p^2= .01$; again there was no main effect of group $F<1$.

Two-tailed t tests on the students who completed both the first and final sessions showed that the change in the control group's FTT scores was not statistically significant $t(56) = 1.79$, $p = .079$ but that the imagery group did improve $t(59) = 4.76$, $p < .001$, (see figure 2).

Figure 2

The first and final FTTs were both completed by 117 of the students, 57 in the control and 60 in the imagery group (Table 1). Those who completed both sessions had scored higher on the first test (M=18.9, SD=6.0) than the 100 who did not return for the final session (M=16.3, SD=5.6), $t(215) = 3.30$, $p = .001$, and this was true for both groups (control $t(92) = 2.34$, $p = .021$; imagery $t(121) = 2.14$, $p = .034$).

Effect of intervention upon Domain Creativity

Feedback from the performance task was available for 164 students (75 from the control and 72 from the imagery groups, and 17 other students), and from the direction task for 186 (75 control, 89 imagery, and 21 other students). We collated all 902 unique sentences from the performance feedback into a single file, sorted them alphabetically and then two of

the authors (JM and KL) independently classified each sentence as mentioning creativity or use of imagery/ideas. Mentions could be positive or negative, so sentences were scored as +1, 0 or -1 for each criterion. For example, a sentence with a positive mention of imagery/ideas was 'An excellent piece of work with lovely spacing and a great opening image'; a negative mention of creativity was 'Continue to challenge yourself to explore new material'. Of the 1804 classifications, the judges agreed on 1777 (98.5%), and agreement was reached for the remaining 27. As agreement was so high, only one judge classified the 787 unique sentences collected from the feedback for the direction task. Table 2 summarises the outcome of this classification process for the two tasks.

Table 2

Each students' feedback was then compared against this classification to obtain a total value for creativity and imagery/ideas, which ranged from -3 to +4 for Imagery/Ideas and -4 to +5 for Creativity. Within the two assessments, Creativity and Imagery/Ideas correlated (performance $r(147) = .18$, $p = .03$; direction $r(164) = .32$, $p < .001$), but neither measure correlated across assessments (Creativity $r(136) = -.09$, $p = .30$; Imagery/Ideas $r(136) = .02$, $p = .79$). After correction for multiple comparisons, there were no statistically significant correlations between these scores and the ATTA or the FTT measures ($-.16 < r < .18$)

In the performance task, shortly after the training, the groups did not differ in Creativity $t(145)=0.47$, $p=.637$, but controls scored higher than the imagery group in use of Imagery/Ideas, $t(145)=2.96$, $p=.004$. Three months later, in the direction task, the imagery group scored better for both Creativity $t(162)=2.34$, $p=.021$ and use of Imagery/Ideas $t(162)=2.83$, $p=.005$ (Figure 3).

Figure 3

Discussion

In the months following the imagery training workshops, undergraduate dance students improved more on a pencil and paper test of domain-general flexible thinking, and on their teachers' ratings of domain-specific creativity in a choreographic task, compared to an equivalent group of students who had not received these workshops. This supports the idea that creativity can be enhanced through training, and specifically that using mental imagery can help people avoid routine ideas and so think more creatively. The workshops and training materials that we developed were motivated by a theoretical model of mental representations and so although the exercises and framing of the training was specific to the domain of choreography, the core principles are generic and the training should be adaptable for other domains, or for domain-general use.

The central role of imagery in our research is consistent with the long-standing idea that creative ideas arise from mentally reconfiguring problem representations in novel ways, and then inspecting, selecting and elaborating those ideas. Scott et al. (2004a, b) found that imagery based creativity training was ineffective despite being the most frequent form reported in the literature, reviewing 43 studies. This reflects the nature of the imagery training used, as the courses Scott reviewed often focussed on expressive activities and imaginative exercises, and tended to be short, using unstructured exercises and instructor feedback to encourage exploratory thinking, while providing little support in the processes or strategies to apply to achieve those goals. Scott et al. (2004b) contrast this with the more successful cognitive approaches which seek to develop various processes held to be involved in creative thought, and are typically lengthy, with substantial practice on realistic exercises,

accompanied by discussion of problem-solving processes and their role in creative thought. Our imagery based training is clearly more like this in format, with training spaced over several workshops, realistic domain-specific exercises, and explanations and discussion of the nature of imagery and its place in thought, experience and behaviour, giving the dance students practical guidance in the application of the strategies.

We were able to detect improvements in flexible thinking through our development of the five parallel forms of the FTT, which we showed to be reliable over time and also to correlate with an established measure of creativity. The FTT is in itself a valuable contribution to the study of creativity, as it should allow within participant testing over time to evaluate the effectiveness or otherwise of creativity interventions. While we used the total of the three components in this research, and found the five forms equivalent, there is scope to further examine the three components to ensure that the forms of the test are truly balanced. As a short test, the FTT probably lacks individual sensitivity and so is of more use in assessing the distribution of creativity within groups of participants. We did not find differences between the two groups at any of the three assessments, and both groups improved over time: our effect was due to the imagery group improving more than the control group over the year. The general improvement may be due to experience with the measure, a general benefit upon their creativity of the other content of their undergraduate course, or selective drop-out from the sessions of students who did not do well at the tasks.

As a pencil and paper test the FTT relies upon English, and our participants who had English as a second language scored lower on the test, as indeed they did on the ATTA, which is a more graphical test but with a strong linguistic component (especially in Part 1). It should be possible to develop translations of the FTT for use with other language groups, although comparisons across languages would remain problematic.

The students who received our imagery training did improve over time, but the effects of the training were not immediate, with flexible thinking showing equivalent improvement for both groups at the second session, and the domain Performance task showing better performance for the control group. Four months after training though, the trained students scored better than the controls on the Direction task, and a year after training they showed a larger improvement in flexible thinking. It is not unreasonable to expect changes in thinking strategies to take time to become ingrained enough to affect domain-general tests, and future research into creativity training should take this into account. Scott et al (2004a) highlighted the weakness of immediate testing as it measures short-term effects that cannot be maintained, but it also underestimates longer-term effects that take time to develop.

The two domain specific assessments are not directly comparable, as they targeted different aspects of the students' choreographic skills. The first assessment of the students' own performance was commented upon more positively overall than the second assessment, in which the students' direction of another dancer was evaluated. As these assessments were made by the same staff who had been involved in the design and delivery of the workshops, it is possible that they might have become more aware of students' use of imagery and creativity over time and this might have influences the observed changes in from the first to second assessment; contrary to this, though, the total number of mentions of imagery and creativity actually decreased slightly in the second assessment.

We chose to work with dance as a domain because of its acceptance of creativity. Creativity is actually a criterion for entry onto both institutions' courses, with applicants being assessed for creativity at an audition before being offered a place. The profile of ATTA scores did not differ from that expected according to the manual, though, so this pre-selection may be based upon domain-specific aspects of creativity. How this interacts with the imagery training, which had both general and specific content, requires further investigation.

In conclusion, the role of imagery in creativity has been paradoxical, because theories of creativity give it a central role, yet reviews of creativity training have disputed the value of imagery training. Our research has shown that when based upon a theoretical account of the function that imagery plays in creativity, imagery training can be successful, and creativity can be enhanced.

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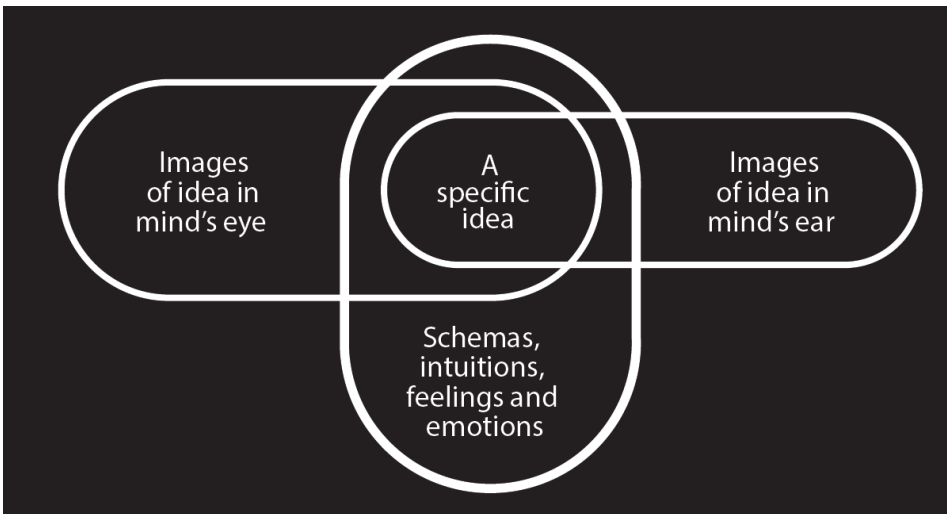

Figure 1: The 'Loops diagram' illustrating the concept of transformations between different forms of mental representation in the ICS theoretical model of cognition, in terms of mental imagery (McGregor, 2013, reproduced with permission).

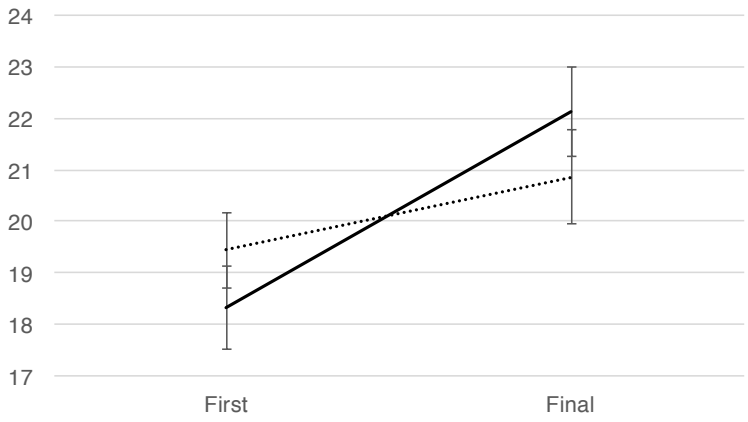

Figure 2: The improvement in Flexible Thinking Test scores over time was statistically significant for the imagery group (solid line) but not for the control group (dotted line). The groups did not differ statistically at either time. Bars show one standard error.

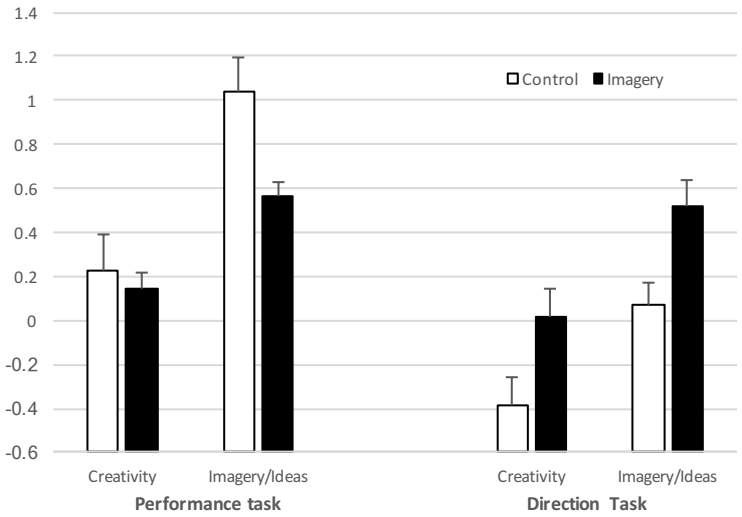

Figure 3: In the performance task assessed midway through the students' year, the groups did not differ in creativity but the imagery group (solid bar) were worse on imagery and ideas than the controls (white bar). By the end of the year, the imagery group were assessed as better than the control group on both criteria. (error bars show +1 SE).

Table 1: Number of participants attending each session, with those missing a session shown in parentheses. Thus in the control group, 57 of the students who attended the third session had also attended the first session, but 16 had not.

Control N=111	Session 1	94				(17)		
	Session 2	75		(19)		11		(6)
	Session 3	51	(24)	6	(13)	10	(1)	6
Imagery N=129	Session 1	123				(6)		
	Session 2	96		(27)		6		(0)
	Session 3	53	(43)	7	(20)	2	(4)	0

Table 2: Of over two thousand sentences in students' choreography feedback, around a third referred to creativity or imagery/ideas (positively or negatively).

Task	Sentences	Imagery/Ideas		Creativity		classification
Performance	1080	26	*2.4%*	68	*6.3%*	negative
		156	*14.4%*	103	*9.5%*	positive
				353	*32.7%*	total
Direction	995	48	*4.8%*	120	*12.1%*	negative
		93	*9.3%*	76	*7.6%*	positive
				337	*33.9%*	total

Data Transparency Appendix

The data reported in this manuscript have not been previously published.

Other measures were collected at the three workshops and may form the basis of further publications. These include:

MS 1: Attitudes to Dreams – collected at the second workshop. Status: planned

MS 2: Imagery Vividness (collected at the first workshop) and Experiential Imagery Scales (collected at all three workshops): Status - planned