D2.1 Report on the joint use of the creative cognitive tasks

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ABSTRACT	This deliverable presents the development, the validation, and the first outcomes of the new multi-sided test battery aimed at measuring creative abilities and achievement in different knowledge domains: the CREAM test battery.
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Table of Contents

1. Introduction

1.1. State of the art of creativity measurement in neuro-scientific research: the proposal of the CREAM test battery

Creativity has been explored from many perspectives (social, psychological, biological, historical, etc.) and many theories have been proposed (Amabile, 1983; Csikszentmihalyi, 1996; Guilford, 1950; Runco, 2007; Sternberg & Lubart, 1995; Ward, Smith, & Finke, 1999). Despite such abundance of theories, scholars of creativity are still debating the most appropriate definition of creativity. Most researchers would possibly associate creativity with three characteristics: novel (i.e.. original), surprising (i.e. nonobvious), and functional (i.e., useful, adaptive on the basis of the task constraints) (Sternberg & Lubart, 1999; Simonton, 2012). However, even if most researchers agree that creativity may be centred on these three criteria, the principal cognitive and neuroscientific components underpinning these criteria are still largely uncharacterized. The study of the neural correlates associated with creative thinking could be considered one of the main scientific approaches to the understanding of the creative process components.

Neuroscientific research has been influenced by the notion derived from cognitive research that the creativity level of an individual can be assessed by means of performance measures derived from creative thinking tasks. In particular, neuroscientific studies measure creative performance using one of two broad classes of creative cognition tasks: divergent or convergent. Divergent thinking tests are methodologies designed to be open-ended, i.e., to afford multiple correct responses; convergent tests have instead a single correct answer (e.g., problem solving tests). This distinction between convergent and divergent components highlights that the manifestation and causes of creative cognition are plural though both components might be crucial in creative performance. The tasks employed in the neuroscientific research cover different aspect of creative thinking. Most of the tasks were adapted or at least influenced by the classical tasks used in the cognitive study of creativity, such as Torrance', Mednick's and Guilford's tests of creative thinking (Guilford, 1967; Mednick, 1962; Torrance, 1974). Numerous cognitive studies demonstrated a high reliability of these tests in the measurement of convergent and divergent components of creative thinking. However, in most cases the neuroscientific research bases the measurement of creative performance on a single (convergent or divergent) task. The most frequently used tests are the Alternate Uses Test (Guilford, 1967), a classical divergent cognitive test, and the Remote Associates Test (Mednick, 1962), a classical convergent cognitive test. Several neuroscientific studies proposed new methods to measure creativity, such as asking participants to mentally compose a drawing (Bhattacharya & Petsche, 2005), to solve matchstick problems (Knoblich et al. 2001), or to generate a story with given stimulus words (Howard-Jones et al. 2005). Recently, researchers have also associated creativity with the flash of insight, a sudden generation of the solution without any conscious awareness (Jung-Beeman et al. 2004; Kounios et al. 2005; Sandkuhler & Bhattacharya, 2008). This heterogeneity in the measurement approach used to the study of creativity is presumably due to the difficulty in operationalizing creative performance in neuroscientific research. However, the different approaches to the study of creativity have produced a large diversity in neuroscientific findings that are often difficult to compare and to integrate (Dietrich, 2004; Dietrich & Kanso, 2010). This measurement variation in creativity studies leads indeed to an important confound in comparing across studies (Arden et al.. 2010).

Moreover, even if a large debate in creativity research exists about the domain-general or domain-specific nature of creative behaviour, neuroscientific research made no great effort to understand if different neural mechanisms are involved during the creative thinking process in different knowledge domains (such as the scientific or the artistic domain or in different professionals). However, neuroscientific research could bring evidence to disentangle this issue.

The key aim of Task 2.1 of the CREAM project is to develop and to test a new method for the measurement of creativity in different knowledge domains that could be used as a normative method for the measurement of creative behaviour in neuroscientific research. We propose indeed that a neuroscientific study of creativity should start exploring this behaviour in a more comprehensive and reliable way. Starting from this point of view, we test a multi-measure approach to the detection of creative performance in three different knowledge domains: artistic, scientific and creative industry domains. This deliverable in particular present an integrated approach to measure creative abilities and achievement, through the development of a specific multi-sided test battery (named CREAM test battery). By uniquely combining and integrating some of the existing procedures for evaluating creativity, this approach promises to reveal a full-rounded and a comprehensive assessment of a person's creative abilities encompassing both domain-general and domain-specific components. The main aim of this approach is indeed to measure the individual abilities associated to creativity in the artistic, scientific, and creative industry domains, in order to identify (as proposed in Task 2.2) the common principles regulating creativity within these three domains and isolating the creative skills and tendencies primarily associated with each knowledge domain. In the present deliverable, in particular, we first present the structure and the measurement purposes of the test battery, explaining in detail the instruments composing this multi-sided measurement method. Then an analysis of the validity of the battery is presented as well as the main characteristics and the relationships between creative abilities and tendencies.

2. Executive summary

Aim of this deliverable is to present the development, the validation, and the first outcomes of a new multi-sided test battery aimed at measuring creative abilities and achievement in different knowledge domains: the CREAM test battery. By combining and integrating some of the existing procedures for evaluating creativity, this multi-sided measurement approach promises to reveal an extensive and comprehensive assessment of a person's creative abilities encompassing both domain-general and domain-specific components.

The CREAM test battery is in particular centred on the measurement of two main states (stages) of the creative thinking process: ideation (convergent and divergent thinking) and assessment. Beside these creative thinking abilities, the battery also includes two measures of creative achievement devoted to the measurement of creative achievement in scientific, artistic, and everyday areas. Finally, since creative thinking is not an isolated phenomenon within human behaviour, the battery includes the measure of two constructs that the literature demonstrated to be highly related to creativity: intelligence and personality. A representation of the measurement methods included in the CREAM test battery is shown in Figure 1.

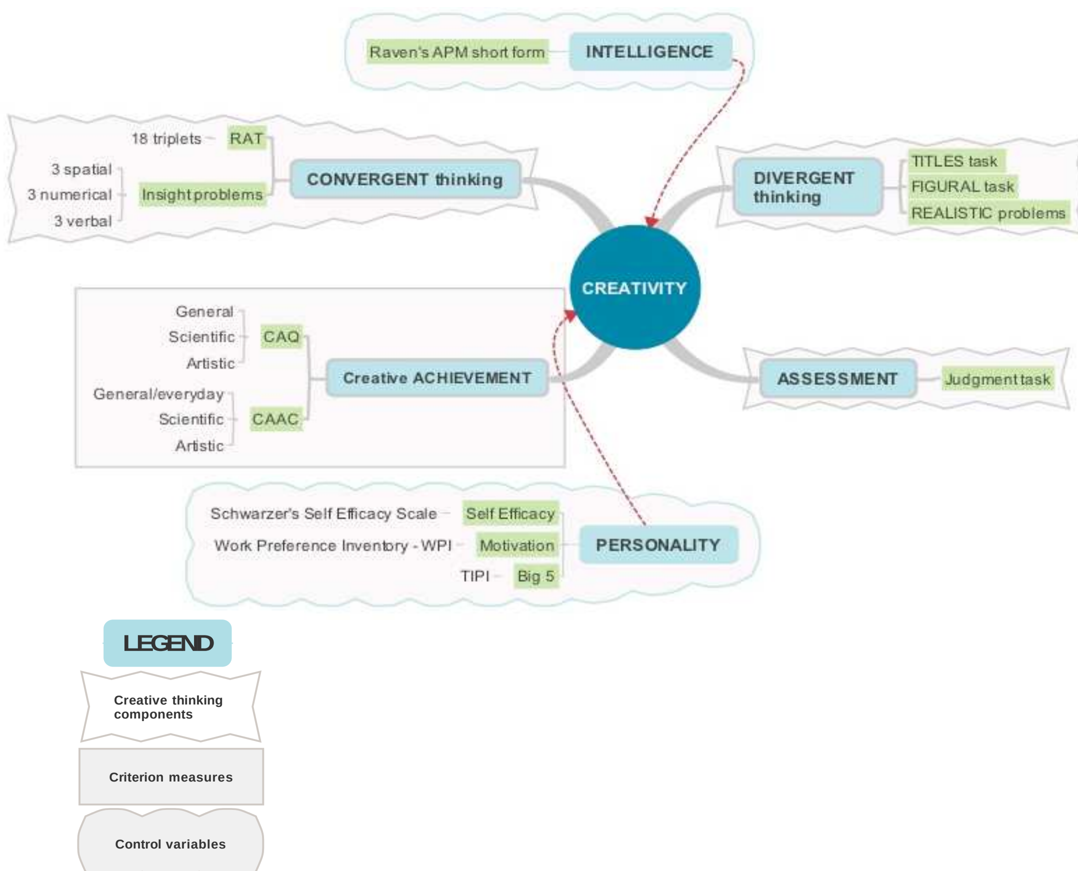

Figure 1. CREAM test battery structure.

In order to understand the domain-general and domain-specific components of creative behaviour, the CREAM test battery has been administered to participants of three different knowledge domains: scientific, artistic, and creative industry domain. An administration campaign was performed at the University of Bologna and at the Engine Group to collect at least 200 participants coming from these three different knowledge domains, as proposed in task 2.1 of WP2. The test battery was administered to 235 participants in total.

An extensive part of this deliverable is devoted to the description and comments of the statistical analyses performed on the data collected during this administration campaign. The main aim of the data analyses is to test the reliability and validity of the battery, and to provide a first description of the creative performance in the three domains tested within the CREAM project, i.e., artistic, scientific, and creative industry domain.

After a brief description of the administration campaign performed during the first year of the project (section 5.1), a description of the sample involved in the analyses is provided, including the adopted data cleaning (section 5.2). Section 5.3 then describes and provides specific references on the different scoring methods used to score the tests. The following section (5.4) presents the analyses performed to test (where possible) the internal consistency of the instruments used in the battery. Starting from section 5.5, the correlational analyses between the different measurement instruments of the battery are described; the aim of these analyses is twofold: 1. to further analyse the validity of the battery, discussing the discriminant and convergent validity of the single instrument through the comparison with other similar or different instruments; 2. correlations are then used to understand the associations between the different abilities, tendencies and performances tested within the battery. In the last analyses section (5.8), differences and similarities between the three knowledge domains are explored, in order to understand the different profiles of the participants of the three domains regarding personality, intelligence, creative abilities and creative achievement.

The results attest a good reliability of the measurement methods adopted within the CREAM test battery. More specifically, these methods show a good reliability in the particular participants' sample recruited within the CREAM project. Correlational analyses in particular strengthen the evidences on the discriminant and convergent validity of the tasks used to measure the creative abilities and achievement within the battery. The results, for example, confirm that convergent and divergent tasks are able to measure two distinct constructs independently, i.e., convergent thinking and divergent thinking, respectively. Moreover, data analyses show that different data trends characterize assessment ability and ideational abilities, highlighting that assessment ability is a clearly distinct ability from ideational abilities, in particular from divergent thinking. Furthermore, general data trends emerged from the associations of convergent and divergent abilities with intelligence and personality: while convergent abilities are mainly related to intelligence, divergent abilities are mainly associated with personality traits and tendencies, in particular with Extraversion and Openness traits, and with higher levels of intrinsic motivation and self-efficacy. Moreover, convergent thinking abilities and divergent thinking abilities results are also differently associated with creative achievement in scientific, artistic and everyday areas. Convergent abilities are mainly related to scientific creative achievement, while divergent abilities are mainly related to artistic and everyday creative achievement. At the same time, intelligence resulted to be more related to scientific creative achievement, while Openness, Extraversion, and intrinsic motivation resulted to be more related to artistic and everyday creative achievement.

Data analyses, moreover, highlight differences and similarities between the three explored knowledge domains. As for personality traits and tendencies, the participants from the scientific domain and the participants from the artistic domain seem characterized by similar personality trends. On the contrary, participants from the Engine Group seem to be characterized by differences in personality compared to science students, in particular they show higher levels of Extraversion, Emotional Stability, and Openness. Differently, art students do not show differences in personality from creative professionals, highlighting that the creative industry domain is characterized by a personality structure that is more similar to the artistic domain than to the scientific domain. Also the results on intelligence highlighted a similar trend, with science students performing better in cognitive tasks than art students and creative professionals. Creative professionals moreover are characterized by a higher level of divergent abilities (fluency in particular) than science and art students, which are characterized by a similar data trend in divergent tasks. In the same way, creative professionals exhibit higher levels of creative achievement in artistic and everyday areas than artistic and scientific domains. As expected, results show that science students are characterized by higher levels of scientific creative achievement than art students and creative professionals, whereas art students are characterized by higher levels of artistic creative achievement than science students.

Finally, the data seem to indicate that creative achievement in scientific, artistic, and everyday areas is associated with different creative abilities, personality traits and tendencies, and cognitive abilities (intelligence). Scientific and artistic domains seem to be characterized by similar structures in personality and divergent thinking abilities (even if scientific domain is characterized by higher convergent thinking abilities and intelligence than artistic domain). However, the professionals of the creative industry domain show higher levels of creative achievement and of creative abilities (both divergent thinking and assessment abilities) than the other two domains, especially with respect to scientific domain.

These findings and their implications will be further extended during the second year's activities. Thanks to the increase of participants' number, further indexes will be introduced (for example originality in the divergent thinking tasks) in the analyses and more in-depth analyses will be provided to understand the significant predictors of creative achievement in the different areas and across the different domains.

3. The CREAM test battery

3.1. Development of a new test battery for neuro-scientific research: the CREAM test battery

3.1.1 Creativity behaviour measurement

The battery developed within the CREAM project (here named CREAM test battery) is centred on the measuring of two main states (stages) of the creative thinking process: ideation and assessment.

Ideation in particular is measured considering both the convergent and the divergent modalities of the ideation process (for the understanding of the meaning of modality into the creative thinking process please refer to the DIMAI model of the creative thinking process; Corazza & Agnoli, 2013; Agnoli & Corazza, 2013). While convergent thinking is usually defined as the thinking modality aimed at finding the right and unique solution, divergent thinking is defined as the thinking modality aimed at producing all possible alternatives. Both modalities are tested using methods of different nature: convergent thinking using tests of verbal, spatial, and numerical nature, divergent thinking using test of verbal, figural, and realistic nature.

Specifically, two different tasks measure the ideation convergent modality: the Remote Associates Test (Mednick, 1962) and insight problems (of verbal, spatial, and numerical nature; Dow & Mayer, 2004). Other three tasks measure the ideation divergent modality: Titles task, Figures task, and Realistic Problems task.

Even if the ideational phase of the creative thinking process is for sure the most explored stage in the creativity research, it alone is not sufficient to represent the complexity of the process. The assessment of the ideas, for example, has been demonstrated to be a completely separate ability with respect to the ideation ability (Runco & Charles, 1993). For this reason a measurement of this ability has been included in the CREAM battery: the Judgment task.

3.1.2 Creative achievement measurement

Beside the creative thinking abilities, the CREAM test battery includes two measures of creative achievement. Creative achievement, specifically, is measured by the Creative Achievement Questionnaire (CAQ; Carson et al., 2005), and by the Creative Activity and Achievement Check List (CAAC). Even if both methods are measures of Pro C, or Big-C Creativity[1], here they will be used both as a measure of achievement in the artistic, scientific, and everyday creativity domains (see CREAM battery structure, Figure 1).

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[1] The most common distinction between the different theoretical conceptions of creativity is the Big-C (eminent)/little-c (everyday) dichotomy (Beghetto & Kaufman, 2007; Kaufman & Beghetto, 2009). While Big-C creativity refers to unambiguous example of creative expressions (e.g., Leonardo da Vinci's paintings, Darwin's theories, etc.), little-c creativity refers to the creativity of everyday life, i.e., to experiences and expressions accessible to most anyone (Kozbelt, Beghetto, & Runco, 2010).

3.1.3 Constructs related to creative performance

Since creative thinking is not an isolated phenomenon within human behaviour, the battery includes the measure of two constructs that the literature demonstrated to be highly related to creativity: intelligence and personality. Specifically, intelligence is measured by the short version of Raven's Advanced Progressive Matrices (APM), a classical measure of intelligence (Raven & Raven, 2008). Psychological literature demonstrates that intelligence and creativity are distinct abilities (Kaufman, 2008; Runco, 2007), but at the same time intelligence is considered as a central element in creative cognition (Nusbaum & Silvia, 2011). Personality measure includes three questionnaires that measure both general traits of personality, using a Big-Five approach, and some specific individual tendencies strictly related to the creative performance, self-efficacy and motivation. The five traits of personality (Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism) theorized by the Big-Five approach are measured by a brief questionnaire, the Ten Item Personality Inventory (TIPI). Participants' self-efficacy is measured by the Self Efficacy Scale (Schwarzer, 1993), and the motivational tendencies by the Work Preference Inventory (WPI; Amabile et al., 1994).

3.2. CREAM test battery structure

In Figure 1 an overview of the CREAM test battery structure is depicted (please find in the Annex, an English version of the CREAM test battery). In particular, Figure 1 shows the methods used for measuring 1) the creative thinking components. 2) the creative achievement (used as criterion measure), and 3) the constructs strictly related to creativity, personality and intelligence (control variables).

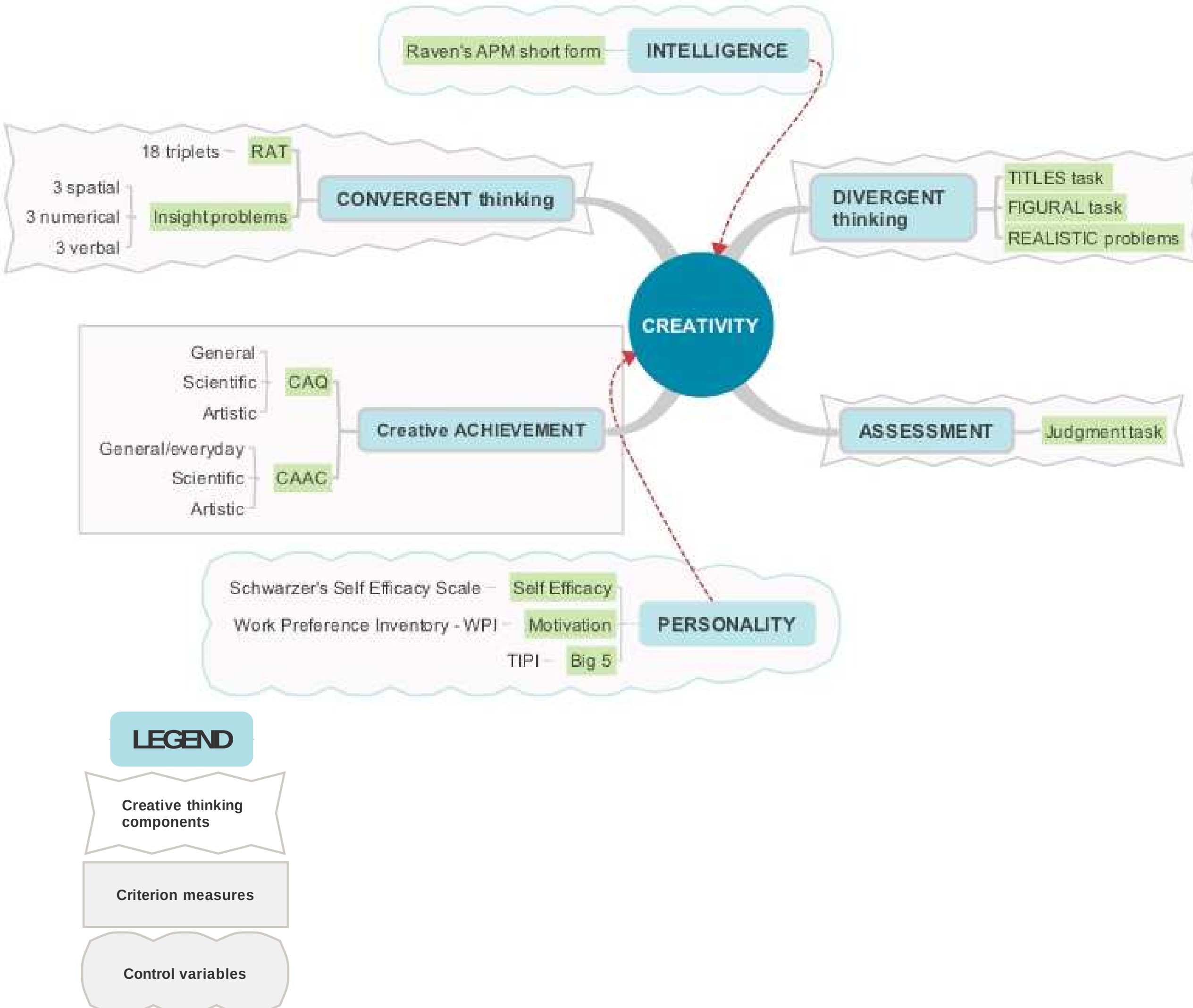


Figure 2. CREAM test battery structure. The Figure depicts the creative thinking components (ideational ability: convergent thinking, divergent thinking; assessment ability), the criterion measure (creative achievement), and the control variables (intelligence, personality) measured by the test battery. Moreover, the instruments used to measure these elements are depicted.

In Figure 2 the order used for the administration of the tasks is depicted. In particular, as can be seen in Figure 2, tasks with different measurement purposes are interleaved, in order to avoid a fatigue effect (i.e., DT and CT tasks are mixed with measures of intelligence, personality, and creative achievement). Moreover, two different presentation orders for the test battery were applied; these counterbalanced conditions will allow avoiding an order effect.

In the next paragraphs the single tasks will be described, starting from the ideational tasks (convergent and divergent), the judgment task, the creative achievement questionnaires, the intelligence test, and finishing with the personality measures.

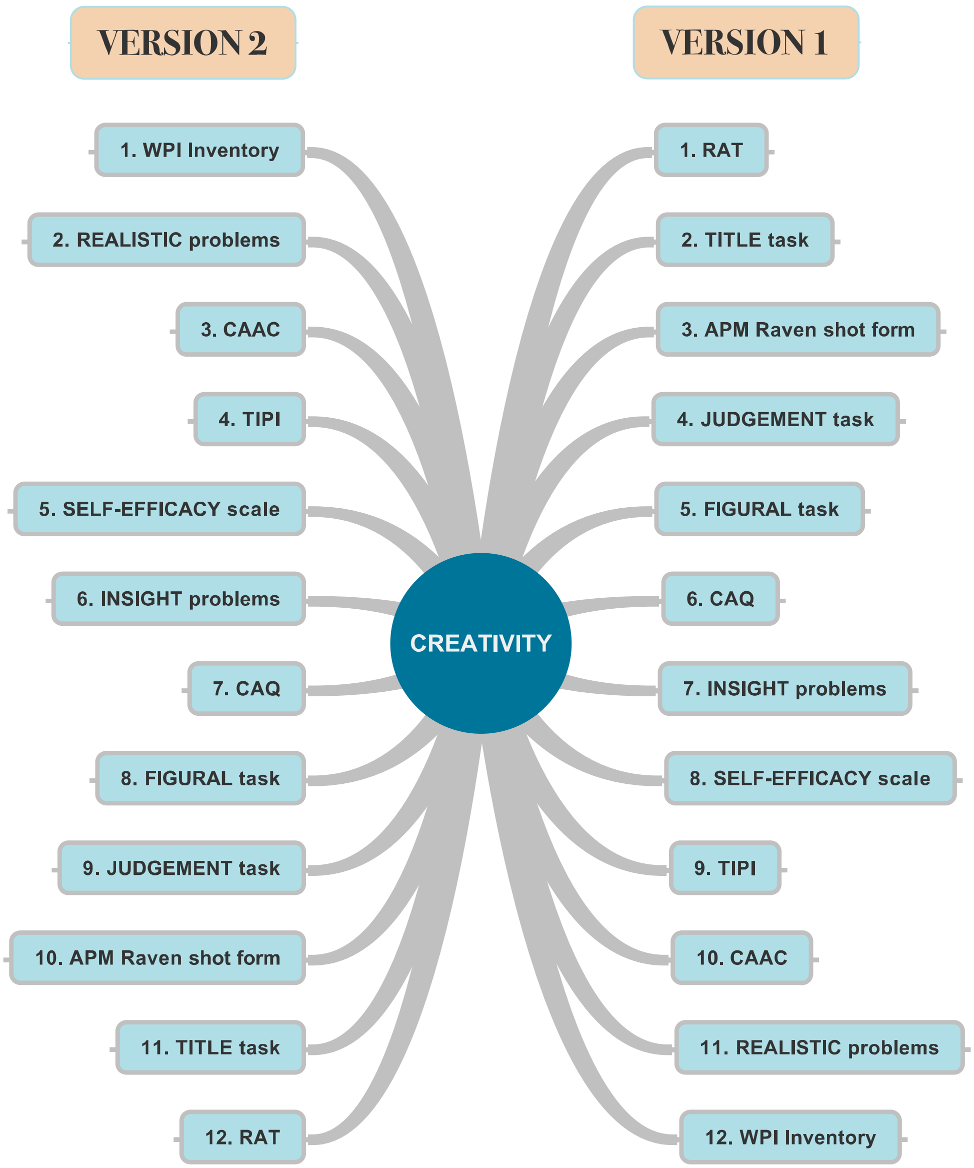


Figure 3. Tasks administration orderings.

3.2.1 Remote Associates Test (RAT)

The Remote Associates Test (RAT) was developed by Mednick (1962) as a measure of creative thought that does not require specific knowledge of any field. Each question on the RAT is composed of three apparently unrelated cue words (triplet) that associate to or associate from a fourth word, which is the correct answer. This test is typically used to study insight or insight-like phenomena, as upon solving RAT items solvers often have an Aha! experience. Since remote associate problems have a single-word, unambiguous solution, RAT is used in the CREAM test battery as a task for testing the verbal convergent thinking (CT) ability.

RAT cue words are usually associated either through semantic association, synonymy, or formation of a compound word. However, triplets based on associations through synonymy or formation of a compound word are highly language dependent, i.e., their associations are related to the language of the three cue words. Differently, the associations based on semantic associations are not language-dependent, as the semantic meaning is the same in the different languages. For this reason, 18 different semantically associated triplets have been chosen for the CREAM test battery. This choice will allow for translating and using the battery in different languages.

Each triplet has been selected from literature. In particular, triplets of different difficulties have been selected (the difficulty of a triplet is defined by the percentage of participants that accurately finds the associated word). Finally, according to the literature (see Bowden & Jung-Beeman, 2003) a time limit of 30 seconds is given to the participants to solve each problem.

3.2.2 Insight Problems

A varied selection of insight problems is found in a paper published by Dow and Mayer in 2004. Insight problems may be seen as a special type of non-routine problems in which the problem primes an inappropriate solution procedure that is usually familiar to the problem solver (Dow & Mayer, 2004). During an insight problem the problem solver must overcome this familiar way of looking at the problem and invent a novel approach. Dow and Mayer (2004) in particular categorized the insight problems into verbal, mathematical, and spatial problems.

In the CREAM test battery a selection of 9 problems has been made, choosing 3 verbal, 3 mathematical, and 3 spatial problems. Participants are asked to find the solution to these nine problems. An example of a problem is given on the exercise presentation page and is always presented before the beginning of the exercise, so that the nature of the task is clear to participants.

3.2.3 Titles Task

Titles task is a measure of participants' divergent thinking. It is one of the divergent thinking tests used in the rCAB, the creativity assessment battery developed by Mark Runco (http://creativitytestingservices.com/) and a divergent test widely used in the literature (Guilford, 1968). In particular, this task asks to produce some alternative titles for some widely known books or movies. This task is considered one of the best divergent thinking tasks, as a person must be both original and give fitting ideas. For adapting the use of this task to the Italian culture, two books and one movie that are very well known to Italian audience have been chosen. For its use in the English culture two books and one movie already used for the testing in this culture are used.

Divergent tests do not concern the identification of the right response, but they aim at stimulating the production of alternatives for some wide and ill-defined problems. To stimulate the production of alternative titles, participants are reassured on the fact that the task does not concern any grades and that their ideas are confidential. Moreover, they are asked to have fun in the production of alternatives and that the more ideas, the better.

3.2.4 Figures Task

Figures task is a divergent thinking task used in the rCAB by Runco. Differently from the verbal tasks, figural tasks are usually associated to higher originality scores as verbal tasks are more constrained than abstract figural tasks (Runco & Albert, 1985). In particular, in the CREAM test battery three abstract black and white line drawings are used and participants are asked to list all off the things they can think of that each figure could represent.

To stimulate the production of alternative ideas, participants should be reassured on the fact that the task does not concern any grades and that their ideas are confidential. Moreover, they should be told to have fun in the production of ideas and that the more ideas, the better.

3.2.5 Realistic Problems

The third divergent thinking task is based on some realistic problems. Literature showed that realistic tasks have an advantage for fluency because they are more interesting, by virtue of their realism, or because the individual has more experience and, therefore, information (Runco, Dow, & Smith, 2006). In particular the problems used in the CREAM test battery derive from the tasks used in the rCAB by Runco and already used in past researches (e.g., Runco, Illies, & Eisenman, 2005). This realistic task asks open-ended questions, but differently from the other two divergent tasks this one is focused on situations which participants (students or professionals) can actually experience. The task indeed describes three problems, which may occur in participants' everyday life.

Participants are asked to first read about the problem and then to try to write down as many solutions as they can for each problem. Similar to the other two divergent thinking tasks. participants should be reassured on the fact that the task does not concern any grades and that their ideas are confidential. Moreover they are asked to have fun in the production of solutions and that the more ideas, the better.

3.2.6 Judgement Task

Judgement task is a measure of participants' evaluation ability. The Judgement of ideas task was previously used in a series of researches to measure the assessment ability (Runco, 2013; Runco & Acar, 2012; Runco & Chand, 1994). The version used in the CREAM test battery represents an adaptation of the Judgement Task used in the rCAB. Participants are asked to judge the originality of 10 uses of five different common objects on a 7 point scale (from 1 "Highly conventional /unoriginal", to 5 "Highly original"). In particular these uses were derived from the uses produced in a previous study by 30 students of the same age range of the students involved in the CREAM project (Agnoli, Franchin, Rubaltelli, & Corazza, in press). In this study the students were asked to produce as many uses as they could think of for some common objects. The originality of the uses was rated by two independent expert raters on the basis of an originality scale. An average rating of the raters' assessment was derived for each use. The 5 most original and the 5 least original uses produced in this previous study have then been chosen for each of the five common objects and included in the Judgement Task of the CREAM test battery. They are listed and presented to the participants in an alphabetical order.

In particular participants are asked to rate the uses for the 5 different common objects choosing a number from a five point scale next to each use to indicate the extent to which the use is conventional/unoriginal or original for them.

3.2.7 Creative Achievement Questionnaire (CAQ)

Creative achievement is assessed by the Creative Achievement Questionnaire (CAQ; Carson et al., 2005). This questionnaire measures creative accomplishments in 10 domains: Visual Arts, Music, Dance, Architectural Design, Creative Writing, Humor, Inventions, Scientific Discovery, Theater and Film, and Culinary Arts. The CAQ aims to capture Pro-c or Big-C creativity (Silvia, Wigert, Reiter-Palmon, & Kaufman, 2012) and it focuses on significant, observable accomplishments. Carson et al. (2005) proposed a two factors solution for the CAQ scores, explaining creative achievement in the scientific and artistic domain.

3.2.8 Creative Activity and Accomplishment Check list (CAAC)

The Creative Activity and Accomplishment Check list (CAAC) is a self-report measure of creative achievement in different life domains. It was first used by Hocevar (1981) and than frequently used in creativity research (e.g., Milgram & Hong, 1999; Runco, Noble, & Luptak, 1990) and included in the rCAB by Runco. The original version of the scale measures creative accomplishments in many domains. The version used in the CREAM test battery uses 45 items to measure creativity accomplishments in the artistic, scientific, and everyday life domains. Each item represents an activity performed in one of these three domains. This scale uses a four-point ordinal response scale. Participants, in particular, are asked to complete each item using the following scale: A = Never did this, B = Did this once or twice, C = 3–5 times, and D = More than 5 times. To take into account also the different levels of motivation in creative activities, each item asks how many times they performed an activity both within (low motivation) and outside (high motivation) the scholastic/working environment.

Participants must respond to the list of activities and accomplishments in the various fields of study. They must circle the response (A-D) that best describes the frequency of the activity both inside and outside the school/work, i.e., how often they have done each of the activities in school and outside the school/work.

3.2.9 Raven's Advanced Progressive Matrices (APM) short form

Raven's Advanced Progressive Matrices are one of the most used intelligence tests in Europe. They are widely employed to assess fluid ability in adolescents and adults (Raven & Raven, 2008). Raven's APM have a high external validity (e.g., they consistently predict success in career). However, since Raven's APM are a measurement of fluid, figural intelligence, they cannot fully account for different kind of intelligent performances. A limitation of this test is its length: to shorten the administration time, we included in the CREAM test battery a short form of the test (APM-SF) developed by Arthur and Day (1994; Chiesi et al., 2012). This short-form is composed of items 1, 4, 8, 11, 15, 18, 21, 23, 25, 30, 31, and 35 of the APM – II Set (see APM Manual; Raven, Raven, & Court, 1998). Consistently with the long form, 3 items derived from Set I were used for practice before completing the APM – SF.

3.2.10 Self-Efficacy Scale

Bandura (1997) suggested that a strong self-efficacy is an important requirement for creativity. This ability influences performance through the adept use of sub-skills, inventiveness, and resourcefulness (Bandura, 1984, 1986). This personality attitude is defined by Bandura (1997) as ‘‘beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments’’ (p. 3). Psychological research demonstrated the importance of self-efficacy to creativity (see for example Lubart, 1994; Prabhu et al., 2008).

Self-efficacy is measured in the CREAM test battery by the General Self-Efficacy Scale (Schwarzer, 1993). It is a ten-items scale that aims at measuring a broad and stable sense of personal competence to deal effectively with a variety of stressful situations. Participants are instructed to choose a number next to each of the 10 statements to indicate the extent to which the statement is true or not true for them. They, in particular, are instructed to use a four-point scale, from 1 “Not at all true” to 4 “Exactly true”.

3.2.11 Ten Item Personality Inventory Scale (TIPI)

The TIPI Scale is included into the Big-Five theoretical framework, which is a hierarchical model of personality traits with five broad factors. According to this framework, the individual differences in human personality can be classified into five dimensions: Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Emotional Stability.

Among different rating instruments developed to measure the Big-Five dimensions, TIPI has been demonstrated to allow a rapid and valid assessment of the five factors (Goslin et al.. 2003). In this 10-items inventory, each item of the scale represents one pole of the five dimensions. In particular, each item consists of two descriptors, separated by a comma, using the common stem, ‘‘I see myself as:’’. Each of the five items is rated on a 7-point scale ranging from 1 (disagree strongly) to 7 (agree strongly). Participants are instructed to write one of the seven numbers next to each of the 10 couple of descriptors to indicate the extent to which they see themselves accordingly to this couple of adjectives. In particular they are asked to rate the extent to which the pair of traits applies to them, even if one characteristic applies more strongly than the other.

3.2.12 Work Preference Inventory (WPI)

The Work Preference Inventory (WPI) was designed as a direct, explicit assessment of individual differences in the degree to which adults (and college students) perceive themselves to be intrinsically and extrinsically motivated toward what they do (Amabile et al., 1994). Motivation is a concept highly related to creativity (Prabhu et al., 2008). Two forms of motivation in particular have been studied in relation to creativity: intrinsic motivation, the motivation to engage in an activity primarily for its own sake, because the activity itself is interesting, engaging, or in some way satisfying; extrinsic motivation, the motivation to work primarily in response to something apart from the activity itself, such as reward or recognition or the dictates of other people (Amabile et al., 1994).

Correlations between WPI scores and behavioural creativity measures showed that intrinsic scores correlated positively with creativity, and extrinsic scores correlated negatively with creativity (Amabile et al., 1994). Even if the original version of the WPI containing 30 items was written for working adults, it was readapted, rewriting some items, for college students. In particular the CREAM test battery uses this college student form for the administration at university students, while it included the form for workers in the administration to professionals.

4. Aims of the analysis

The main objective of Tasks 2.1 was to develop and to assess the reliability of a test battery to measure creative behaviour in different knowledge domains. The aim of the data analyses presented in the next sections of the present deliverable is therefore to test the reliability and validity of the battery, and to provide a first description of the creative performance in the three domains tested within the CREAM project. i.e., artistic, scientific, and creative industry domain. Only after demonstrating the reliability of the developed test battery, more in depth analyses (including qualitative analyses) on the predictors of creative achievement can be provided. These analyses will be performed during the second year of the CREAM project, especially after a further administration campaign aimed at balancing the number of participants across the three domains.

After a brief description of the administration campaign performed during the first year of the project (section 5.1), a description of the sample involved in the analyses will be provided, including the adopted data cleaning (section 5.2). Section 5.3 will then describe and provide specific references on the different scoring methods used to score the tests. The following section will present the analyses performed to test (where possible) the internal consistency of the instruments used in the battery. Starting from section 5.5, the correlational analyses between the different measurement instruments of the battery are described; the aim of these analyses is twofold: 1. to further analyse the validity of the battery, discussing about the discriminant and convergent validity of the single instrument through the comparison with other similar or different instruments; 2. correlations will then be used to understand the associations between the different abilities, tendencies and performances tested within the battery. In the last section (5.8) the differences and similarities between the three knowledge domains are explored, in order to understand the different profiles of the participants of the three domains as regards personality, intelligence, creative abilities and creative achievement.

Data analyses have been performed using SPSS 21.0. After the description of each data analysis a discussion on the meaning of the results is provided.

5. Administration, data analysis, and discussion

5.1. Administration of the CREAM test battery

After the selection of the test to be used in the battery and the preparation of the material, an administration campaign was performed at the University of Bologna and at the Engine Group to collect, as described in the task 2.1 of WP2, at least 200 participants coming from three different knowledge domains: scientific, artistic and creative industry domain. Starting from April 2014 to October 2014, administration was performed in several Departments of the University of Bologna. On September 11, 2014 an entire day was devoted to the collection of data at the Engine Group. For the administration at the Engine Group we used a version of the test battery re-adapted for the use within a working environment (using for example the WPI adapted for work settings).

The entire administration of the battery lasts for 2 hours. Given the complexity of the battery, the administration was divided in three parts balanced in terms of both duration and task type (for more information on the administration and the timing of the tasks, please refer to the CREAM battery manual presented in the Annex). After the completion of each part a short break was granted to the participants. Moreover, in order to avoid a cognitive overload, after each task a brief explanation of the task was provided by the examiner. In order to reduce an experimenter effect the administration of the battery was performed by a single examiner. This allowed for consistency in the instructions provided to the participants.

Before the administration, the examiner provided the participants with some information about the CREAM project, and the general aims and structure of the test battery were explained. Moreover, participants were reassured on the anonymity and the privacy of the data. The three parts of the test were classified and coupled by means of the birth date, which participants had to write on the first part of the three parts.

5.2. Participants

A total of 235 participants were involved in the administration of the test battery. As previously explained, two versions of the battery were used to avoid an order effect. Version 1 was administered to 57.6% of the participants.

To allow a higher consistency and reliability of the statistical analyses, participants with less than 80% of the data were excluded from the analyses. After the cleaning of the data, the final sample used for statistical analyses is composed of 191 participants (109 males). In the following, a description of this sample is provided.

A numerical description of participants is shown in Table 1. 109 students (70 males) from scientific departments are representative of the scientific domain. 46 students (11 males) from artistic departments are representative of the scientific domain. 36 professionals (28 males) from the ENGINE Group are representative of the creative industry domain. The sample is not gender-balanced (χ^2=28.57, p<.001), however this result was in part a consequence of the typical difference in the gender distribution within artistic and scientific study programs. The two scientific and artistic subsamples could therefore be considered good representatives of the scientific and artistic knowledge domains. However, a further administration within the creative industry domain will be performed in order to increase the number of participants and balance the sample by gender.

Table 1. Count and percentages of participants within the three domains, divided by gender.

			Science	Art	Creatives	
Gender	Male	Count	70	11	28	109
		% within gender	64.2%	10.1%	25.7%	100.0%
		% Domain	64.8%	24.4%	77.8%	57.7%
	Female	Count	38	34	8	80
		% within gender	47.5%	42.5%	10.0%	100.0%
		% Domain	35.2%	75.6%	22.2%	42.3%
Total		Count	108(+1)*	46(+1)*	36	191
		% within gender	57.1%	23.8%	19.0%	100.0%
		% Domain	100.0%	100.0%	100.0%	100.0%

Note: * 2 participants did not indicate their gender.

Participants of the scientific domain were recruited in the departments of Astrophysics and Cosmology, Chemistry, Informatics Engineering, Mathematics, Physics, and Telecommunication Engineering of the University of Bologna (see Figure 3). Participants of the artistic domain were recruited in the departments of Drama Art and Music studies, Fashion techniques and culture, and Visual Arts of the University of Bologna (see Figure 4). The participants involved at the Engine Group were characterized by different work specializations, including, for example, art director, copywriter, creative, or creative director (see Figure 5 for the entire work specialization range).

A low number of participants from the scientific and the artistic domains were previously involved in a creative training/course (7% and 3.7% for the scientific and the artistic domain, respectively). A higher percentage of participants (38.9%) from the creative industry domain were involved in a training of creativity before the CREAM administration; this percentage is fully understandable, given the type of work characterizing this domain.

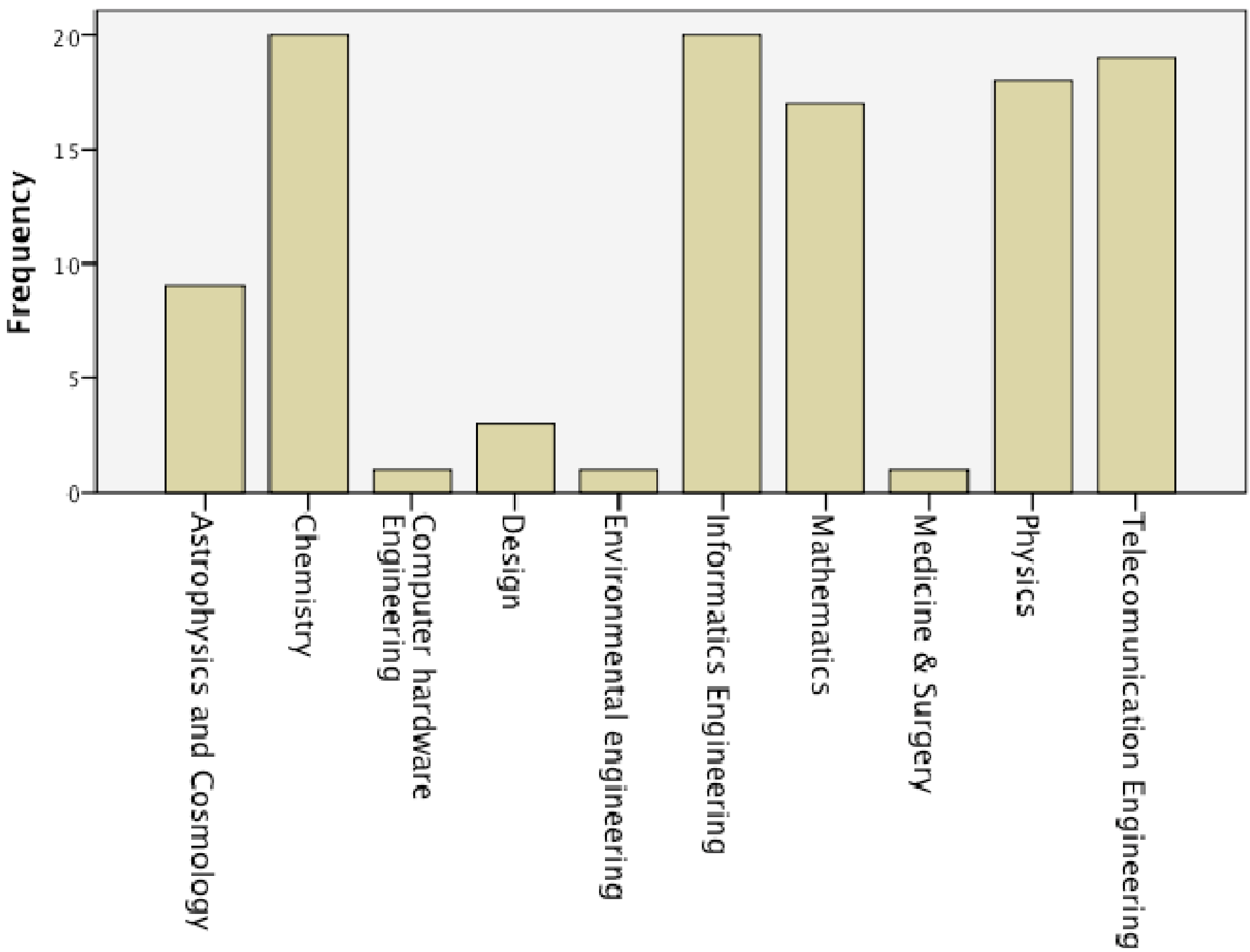


Figure 3. Specialisation of the participants from the scientific domain.

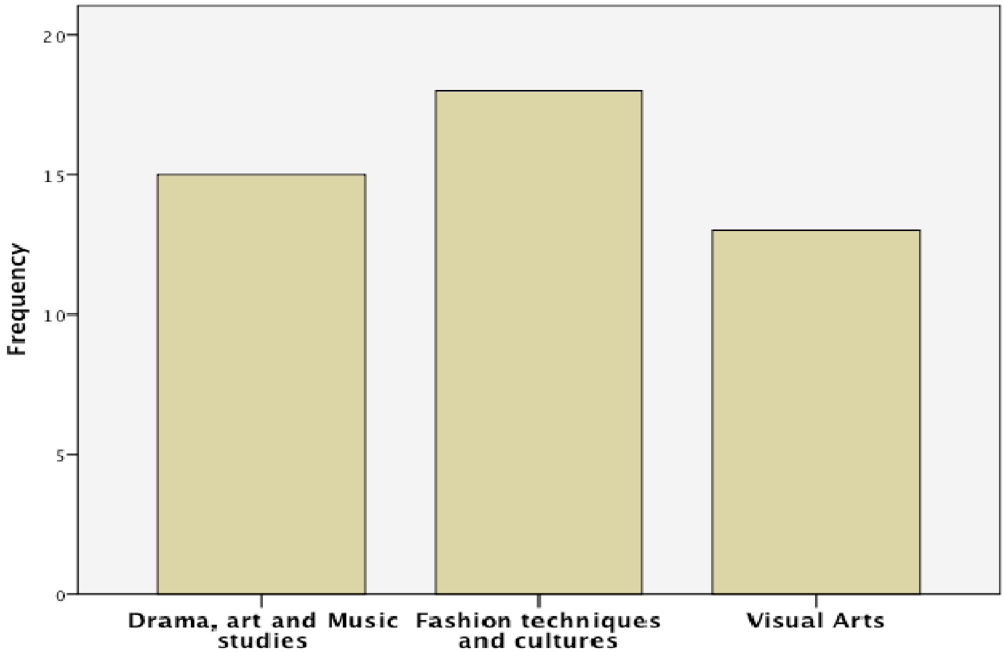


Figure 4. Specialisation of the participants from the artistic domain.

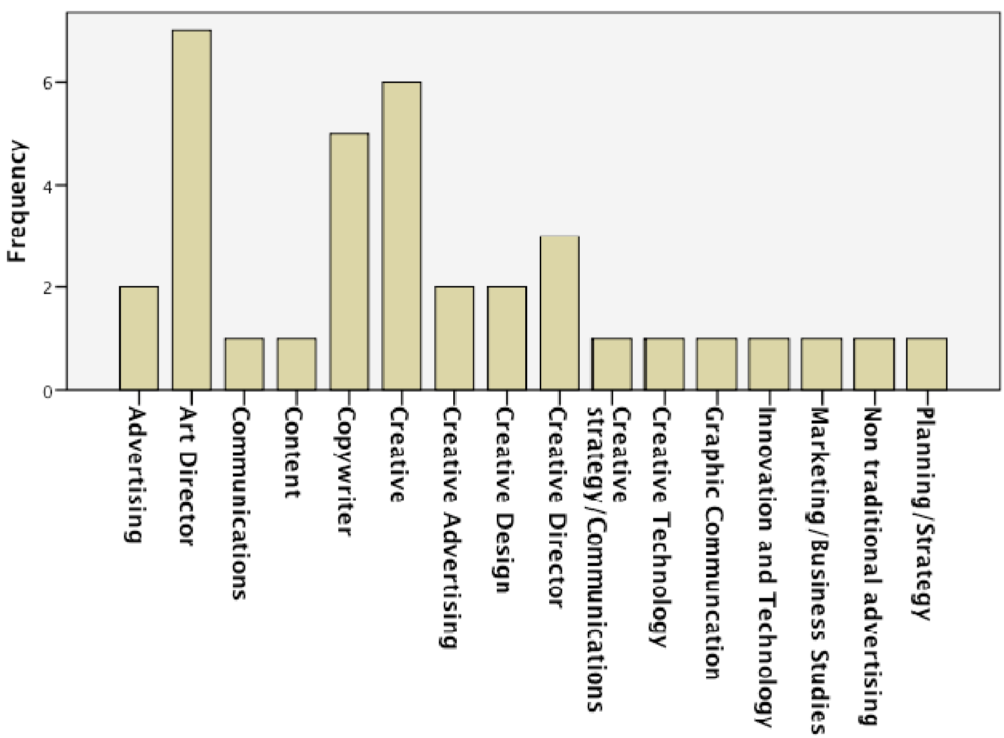


Figure 5. Work specialization of the creative professionals from the Engine Group.

5.3. Tests scoring and descriptive variables

Self-report questionnaires and tasks performance were mainly scored according to the literature.

Convergent tasks (RAT and problem solving) were scored calculating the percentage of solutions (Bowden & Jung-Beeman, 2003; Dow & Mayer, 2004), obtaining a mean solution percentage for each participant.

From the divergent tasks (Figures, Titles, and Real Problems task) we derived two scores: fluency and frequency (that is a measure strictly related to the sample productivity). Fluency was scored summing the number of alternatives produced in the three divergent tasks, obtaining a total fluency score for each participant. Frequency was derived from the frequency of appearance within the sample of each alternative produced by a participant; a frequency average score was then calculated for each participant, from the mean of the appearance frequencies of his/her alternatives. No originality scores are included at this level of analyses; this analysis is indeed extremely dependent on the experimental sample. Originality of an alternative is indeed related to the originality of the other alternatives produced by the sample. Increasing the number of participants can determine a change in the originality of the single alternative. This analysis will be therefore performed at the end of the participants' recruitment foreseen during the second year of the project, where it is aimed to increase the number of participants especially in the artistic and creative industry domains.

Assessment ability was scored calculating the variance of the participants' ratings from the expert coders' ratings (here defined as the norm). In particular, assessment score was calculated as the mean of the absolute values derived from the differences between participant's ratings and expert judges' ratings of the 50 uses presented in the task (10 uses for 5 common objects). This score is therefore a summarizing value, which defines the variance between participants' assessment and expert norm rate, with 0 defining the lack of difference between the two evaluations.

According to Carson et al. (2005), CAQ score was calculated summing the total number of points within each domain to determine the domain score; if an item was marked by an asterisk, we multiplied the number of times the item has been achieved by the number of the question to determine points for that item. Finally, the ten domains scores were summed to obtain a total CAQ score.

Scoring of CAAC produced 6 different creative achievement scores for each participant. In particular, we obtained an average score (from a minimum of 0 to a maximum of 4) for: scientific creative achievement within school/work, artistic creative achievement within school/work, everyday creative achievement within school/work, scientific creative achievement outside school/work, artistic creative achievement outside school/work, everyday creative achievement outside school/work.

Raven was scored by calculating the total number of solutions found by the participants in the 12 trials (Arthur & Day, 1994).

According to Schwarzer et al. (1997) the 10 items of the Self-efficacy scale were summed to obtain a final score indicating the level of a generalized self-efficacy for each participant.

Following the instruction provided by Goslin et al. (2003), we obtained 5 scores for each participant describing his/her mean level of: Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Emotional Stability.

Finally, following the instructions provided by Amabile et al. (1994), we obtained two scores from the scoring of the two WPI inventory subscales, the first representing participant's intrinsic motivation score, the second his/her extrinsic motivation score.

In the following a summarizing table showing the main descriptive statistics obtained from the CREAM test battery is presented (Table 2).

Table 2. Main descriptive statistics obtained from the CREAM test battery.

	N	Minimum	Maximum	Mean	Standard deviation
RAT	190	.00	.94	.5599	.16956
Mathematical Problems	191	.00	1.00	.6632	.33506
Verbal Problems	191	.00	1.00	.4712	.31745
Spatial Problems	191	.00	1.00	.4948	.32575
Figures Task Fluency	190	6.00	71.00	25.2526	10.70723
Figures Task Frequency	190	.18	1.00	.6171	.17677
Real Problems Task Fluency	181	1.00	33.00	14.3094	6.37036
Real Problems Task Frequency	178	.55	1.00	.8833	.09290
Titles Task Fluency	189	.00	72.00	16.7196	9.83647
Titles Task Frequency	185	.34	1.00	.8623	.12657
Judgment Task	191	.30	2.21	.9020	.22965
CAQ	191	.00	260.00	15.4450	26.41104
CAAC SA within school/work	191	1.00	2.88	1.5225	.39229
CAAC AA within school/work	190	1.00	3.50	1.6553	.49209
CAAC EA within school/work	191	1.00	3.23	1.7369	.47325
CAAC SA outside school/work	191	1.00	2.82	1.3778	.37473
CAAC AA outside school/work	190	1.00	3.64	1.8171	.53036
CAAC EA outside school/work	191	1.00	3.79	2.4321	.52712
Raven	191	3.00	12.00	9.2723	2.21697
Self Efficacy	190	16.00	39.00	29.3684	3.85189
Extraversion	191	1.00	7.00	4.1963	1.53878
Agreeableness	191	1.50	7.00	4.6073	1.17999
Conscientiousness	191	2.00	7.00	5.1440	1.29430
Emotional Stability	191	1.00	7.00	4.1675	1.54773
Openness	191	2.50	7.00	5.6911	1.03942
Intrinsic Motivation	188	19.00	56.00	46.2500	5.78364
Extrinsic Motivation	189	6.00	55.00	37.8413	6.59273

Notes: CAAC SA = CAAC Scientific Achievement; CAAS AA = CAAC Artistic Achievement; CAAC EA = CAAC Everyday Achievement

5.4. Tests reliability

The calculation of the internal reliability of the instruments is the basis for establishing the reliability of the test battery. In particular, calculating the internal consistency of the different tests can indicate that each test (or scale) is measuring exactly the single unidimensional construct on the basis of which it was developed. The tests included in the battery have been chosen also on the basis of the internal reliability shown in past research. More importantly for the purposes of the project, this analysis can indicate if the tests included in the battery are reliable in measuring the constructs in the particular sample recruited within the CREAM project.

In particular, we used the scoring of the Cronbach's alpha for measuring the reliability of the tests. However, some tests, because of their structure and nature, cannot be statistically tested for their internal consistency. This is the case for example for the TIPI, which has been chosen since it allows a rapid measurement of the Big 5 personality traits. Because of the length and complexity of the test battery we could not include a classic long form questionnaire for the measurement of personality, but we preferred a short and rapid measure that already demonstrated a good validity (for example with good test-retest reliability; Gosling et al.. 2003). While multi-items scales can afford to bolster internal consistency by using several items with high content overlap, TIPI is constituted only by 2-item subscales that do not allow a convincing reliability analysis.

Table 3. Internal consistency for the tests used in the CREAM test battery.

	Cronbach's Alpha	N. of items
RAT	.706	18
Insight Problems	.678	9
CAAC SA within school/work	.797	17
CAAC AA within school/work	.760	14
CAAC EA within school/work	.774	14
CAAC SA outside school/work	.795	17
CAAC AA outside school/work	.760	14
CAAC EA outside school/work	.765	14
Raven	.680	12
Self Efficacy	.768	10
Intrinsic Motivation	.737	15
Extrinsic Motivation	.706	15

Notes: CAAC SA = CAAC Scientific Achievement; CAAS AA = CAAC Artistic Achievement; CAAC EA = CAAC Everyday Achievement

All internal consistency of the tests resulted from acceptable to good. As for the RAT task, the selection of triplets based on semantic association allowed to obtain a good internal consistency of the task, which is therefore based on univocal association ability. At the same time, the alpha value of insight problems shows that all these problems consistently measure the same construct, in particular the construct of insight. The good reliability obtained in CAAC testifies that the six sub-scales developed for the CREAM battery consistently measure the creative achievement in the scientific, artistic, and everyday areas both within and outside scholastic or working environment. Further consideration on tests validity will be drawn in the next sections concerning the correlational analyses between the instruments.

5.5. Correlational analyses: Creative abilities

Results obtained from correlation analyses are organized accordingly to the two main measures of the creative behaviour used in the test battery: creative abilities and creative achievement. A first section presents the associations between convergent, divergent and assessment abilities, and their association with personality and intelligence measures. A second section presents the association between CAQ and CAAC subscales, and their association with personality and intelligence measures. A third section shows the association of convergent, divergent, and assessment abilities with creative achievement.

5.5.1 Ideation: convergent and divergent tasks

We start with some considerations about the tasks used in the battery. Pearson's correlations show that divergent and convergent tasks are essentially unrelated tasks (Table 4). Neither problem solving tasks (mathematical, verbal, or spatial problems) nor the RAT task indeed show significant associations with the three divergent tasks (Figures, Real problems, and Titles tasks), and in particular with their fluency and frequency measures. Convergent and divergent tasks evaluate therefore separate abilities. This result testifies a mutual discriminant validity of the two measurement methods, which, on the basis of these data, measure distinct constructs.

The only significant correlation that emerged from the analyses is the positive association between verbal problems and the mean frequency in the real problems tasks. Real problems are the most complex tasks among the three divergent tasks; we can therefore assume that the production of alternatives (in particular alternatives at lower frequency of appearance) require high verbal abilities. This could in part explain the significant positive association between the real problems frequency (the higher the participant's frequency rate, the lower the frequency of appearance of the alternatives produced by the participant across the sample) and the scores of verbal problem solving, that is mainly based on the ability of brilliantly using verbal capabilities to solve the insight problems. Another remarkable association emerged from the analyses is the significant negative correlation between the RAT task and the frequency score of divergent tasks, in particular Titles and Figures tasks, which means that at the increasing of the convergent ability to find the right word associated to other three words, the ability to produce alternatives of lower frequency of appearance decreases. While the associative ability required to solve RAT triplets is the ability to find the only right word associated to the other three words, the ability at the basis of low frequency solutions in a divergent tasks is divergent in nature, as it requires finding different solutions that have not been generated by other participants in the sample. The different kind of ability at the basis of the two tasks could explain the negative association between the two measures.

Table 4. Correlations between convergent and divergent abilities (divided in 2 pages).

		Figures Task Fluency	Figures Task Frequency	Real Problems Task Fluency	Real Problems Task Frequency	Titles Task Fluency	Titles Task Frequency	RAT	Math Problems	Verbal Problems	Spatial Problems
Figures Task Fluency	r	1	.192**	.615**	.015	.634**	.146*	-.065	.059	.130	-.015
	Sig.		.008	.000	.840	.000	.048	.377	.418	.074	.835
	N	190	190	180	177	189	185	189	190	190	190
Figures Task Frequency	r		1	.354**	.245**	.332**	.403**	-.189**	-.079	.044	-.087
	Sig.			.000	.001	.000	.000	.009	.279	.547	.233
	N		190	180	177	189	185	189	190	190	190
Real Problems Task Fluency	r			1	-.095	.628**	.220**	-.066	.088	.325**	.051
	Sig.				.208	.000	.003	.378	.237	.000	.497
	N			181	178	179	175	180	181	181	181
Real Problems Task Frequency	r				1	.013	.124	-.027	-.051	-.101	-.129
	Sig.					.867	.106	.722	.499	.181	.086
	N				178	176	172	177	178	178	178
Titles Task Fluency	r					1	.262**	-.097	-.046	.092	-.050
	Sig.						.000	.185	.532	.206	.492
	N					189	185	188	189	189	189
Titles Task Frequency	r						1	-.368**	-.123	.041	-.071
	Sig.							.000	.096	.576	.334
	N						185	184	185	185	185

RAT	r Sig. N							1 190	.318** .000 190	.098 .177 190	.129 .076 190
Math Problems	r Sig. N								1 191	.362** .000 191	.386** .000 191
Verbal Problems	r Sig. N									1 191	.375** .000 191
Spatial Problems	r Sig. N										1 191
		Figures Task Fluency	Figures Task Frequency	Real Problems Task Fluency	Real Problems Task Frequency	Titles Task Fluency	Titles Task Frequency	RAT	Math Problems	Verbal Problems	Spatial Problems

Notes: ** **α** ≤ 0.01; * **α** ≤ 0.05

High associations emerged from the analyses within convergent and divergent tasks. The internal high associations within the two tasks testify a convergent validity of the convergent and divergent tasks. The three problem solving tasks and the three divergent tasks therefore consistently measure the construct of convergent thinking and the construct of divergent thinking, respectively. The low associations between RAT and insight problems show that RAT cannot be considered as a "pure" insight task, but the positive significant association suggests that problem solving and RAT are associated by common abilities (as sustained also by Bowden, Jung-Beeman, Fleck, & Kounios; 2005).

5.5.2 Assessment vs. Ideation

A first correlation analysis (Table 5) is devoted to the understanding of the relationships between convergent thinking (RAT associations and problem solving scores) and the assessment ability (Judgment Task scores).

Table 5. Correlations between assessment and convergent thinking abilities.

		Judgment Task	RAT	Math Problems	Verbal Problems	Spatial Problems
Judgment Task	r	1	-.198**	-.069	-.218**	.082
	Sig.		.006	.346	.002	.261
	N	191	190	191	191	191
RAT	r		1	.318**	.098	.129
	Sig.			.000	.177	.076
	N		190	190	190	190
Math Problems	r			1	.362**	.386**
	Sig.				.000	.000
	N			191	191	191
Verbal Problems	r				1	.375**
	Sig.					.000
	N				191	191
Spatial Problems	r					1
	Sig.					
	N					191

Notes: ** **α** ≤ 0.01; * **α** ≤ 0.05

The analyses seem to demonstrate a weak but significant negative association between assessment ability and convergent ability, even if only for RAT and the verbal insight problems. This result shows that with the increase of the assessment ability (higher the scores in the judgment task lower the consensus of participants' rates with the norm) the ability to solve insight problems (in particular verbal problems) and the ability to find the right words associated with the three words proposed in the triplets increase. According to these results the convergent and assessment abilities seem slightly associated, suggesting that they are distinct abilities but associated by some common elements. We could hypothesize that this element is the comparison with the norm or the right answer. Like the convergent ability concerns the ability to converge to a correct answer, the assessment ability indeed concerns a convergence, a comparison with established, defined rules (cultural, social, etc.) through which to evaluate a product, an idea, or, as in the case of the Judgment task, an uncommon use.

A second correlation analysis explored the relationships between divergent thinking (Figures, Titles, and Realistic Problems tasks) and assessment ability (Table 6).

Table 6. Correlations between assessment and divergent thinking abilities.

		Judgment Task	Figures Task Fluency	Figures Task Frequency	Real Problems Task Fluency	Real Problems Task Frequency	Titles Task Fluency	Titles Task Frequency
Judgment Task	r	1	-.104	-010	-156*	-076	-139	084
	Sig.		.152	.895	.036	.310	.057	.253
	N	191	190	190	181	178	189	185
Figures Task Fluency	r		1	192**	615**	.015	.634**	.146*
	Sig.			.008	.000	.840	.000	.048
	N		190	190	180	177	189	185
Figures Task Frequency	r			1	.354**	.245**	.332**	.403**
	Sig.				.000	.001	.000	.000
	N			190	180	177	189	185
Real Problems Task Fluency	r				1	-.095	.628**	.220**
	Sig.					.208	.000	.003
	N				181	178	179	175
Real Problems Task Frequency	r					1	.013	.124
	Sig.						.867	.106
	N					178	176	172
Titles Task Fluency	r						1	.262**
	Sig.							.000
	N						189	185
Titles Task Frequency	r							1
	Sig.							
	N							185

Notes: ** **α** ≤ 0.01; * **α** ≤ 0.05

The analysis does not show significant associations between the two abilities, except a slight negative correlation between the realistic problems task fluency and the assessment ability. Summarizing, these analyses demonstrate, as sustained also by Runco (Runco & Charles, 1993), that assessment and divergent thinking are two distinct abilities within the creative thinking process, highlighting the importance of analyzing them separately in the measurement of creativity.

5.5.3 Personality vs. creative abilities

Starting with the analyses on the relationships between convergent abilities (measured through the insight problems and RAT) and personality (measured through the Big 5 personality traits, motivational tendencies and self-efficacy), results do not highlight any association between the variables. Neither insight problems (Table 7 and 8) nor RAT (Table 9) indeed are associated with personality traits and attitudes. This result testifies that convergent abilities and personality (intended both as Big 5 traits and as attitudes like intrinsic or extrinsic motivation or self-efficacy) are essentially unrelated variables. Even if literature suggested that creativity and personality (in particular Openness and Extraversion, see Agnoli, Franchin, Rubaltelli, & Corazza, in press; Batey and Furnham, 2006; Feist, 1988), motivation (in particular intrinsic motivation, see Prabhu et al., 2008), and self-efficacy (see for example Lubart, 1994; Prabhu et al., 2008) are related phenomena, past studies investigated only divergent abilities, excluding from the analyses convergent abilities. Accordingly to the results emerged from the present analyses, we can assume that finding the right solutions is essentially unrelated to personal tendencies.

On the contrary, and consistently with the results of past research, divergent abilities (here intended as fluency and frequency of alternatives in the Figures, Realistic Problems, and Tittles tasks) and personality trait and tendencies are positively associated. Table 10, in particular, shows that fluency and frequency in the three divergent tasks are positively associated, in accordance with past research (see for example see Agnoli, Franchin, Rubaltelli, & Corazza, in press, or Batey and Furnham, 2006), with Extraversion and Openness personality traits. Higher level of Extraversion and Openness are associated with a higher performance in the three divergent thinking tasks. The replication of past results using measurement methods different compared to those conventionally used, comes out on the side of the reliability of the measurement methods used in the CREAM test battery, and in particular of TIPI and of the three divergent tasks. At the same time, the analyses (Table 11) show significant positive associations between the divergent tasks performance and intrinsic motivation and self-efficacy. Higher levels of intrinsic motivation and self-efficacy are therefore associated to higher divergent thinking performance, in accordance with past literature (see for example Lubart, 1994; Prabhu et al., 2008).

Finally, Table 12 shows the correlational analyses between assessment and personality traits and tendencies. On the basis of these results assessment ability and personality seem unrelated variables. Only one significant association emerged from the analysis, which highlights that at the increase of extrinsic motivation, the assessment ability increases. This result seems to indicate that the ability to assess accordingly to the norm is increased by the motivation to be consistent with and to follow external rules.

A final consideration can be drawn on the relation between intrinsic motivation and self-efficacy. The analyses show that these personal tendencies are significantly positively associated, testifying that higher levels of intrinsic motivation are associated to higher self-efficacy levels. This result seems to show that to be intrinsically motivated, an individual must also be confident in his/her own abilities to face the task.

Table 7. Correlations between insight problems and Big 5 personality traits

		Math Problems	Verbal Problems	Spatial Problems	Extraversion	Agreeableness	Conscientiousness	Emot. Stability	Openness
Math Problems	r	1	.362**	.386**	-.070	-.199**	-.086	-.100	-.106
	Sig.		.000	.000	.335	.006	.238	.167	.143
	N	191	191	191	191	191	191	191	191
Verbal Problems	r		1	.375**	-.137	-.133	.052	.117	-.086
	Sig.			.000	.060	.066	.477	.107	.239
	N		191	191	191	191	191	191	191
Spatial Problems	r			1	-.155*	-.061	.094	.096	-.140
	Sig.				.032	.400	.194	.188	.054
	N			191	191	191	191	191	191
Extraversion	r				1	.143*	-.080	-.152*	.390
	Sig.					.049	.273	.036	.000
	N				191	191	191	191	191
Agreeableness	r					1	-.013	.165*	.143*
	Sig.						.861	.022	.048
	N					191	191	191	191
Conscientiousness	r						1	.272**	.034
	Sig.							.000	.638
	N						191	191	191
Emot. Stability	r							1	-.090
	Sig.								.214
	N							191	191
Openness	r								1
	Sig.								
	N								191

Notes: ** $\alpha \leq 0.01$; * $\alpha \leq 0.05$

Table 8. Correlations between insight problems, motivation (intrinsic and extrinsic), and self-efficacy.

		Math Problems	Verbal Problems	Spatial Problems	Intr. Motivation	Extr. Motivation	Self Efficacy
Math Problems	r	1	.362**	.386**	-.010	-.049	-.034
	Sig.		.000	.000	.890	.499	.637
	N	191	191	191	188	189	190
Verbal Problems	r		1	.375**	-.057	.005	.118
	Sig.			.000	.440	.949	.105
	N		191	191	188	189	190
Spatial Problems	r			1	-.050	-.139	.027
	Sig.				.495	.057	.714
	N			191	188	189	190
Intr. Motivation	r				1	.087	.358**
	Sig.					.237	.000
	N				188	188	187
Extr. Motivation	r					1	.075
	Sig.						.309
	N					189	188
Self Efficacy	r						1
	Sig.						
	N						190

Notes: ** $\boldsymbol{\alpha} \leq 0.01$; * $\boldsymbol{\alpha} \leq 0.05$

Table 9. Correlations between RAT, Big 5 personality traits, motivation (intrinsic and extrinsic), and self-efficacy.

		RAT	Extraversion	Agreeableness	Conscientiousness	Emot. Stability	Openness	Intr. Motivation	Extr. Motivation	Self Efficacy
RAT	r	1	-.121	-.133	.034	-.090	-.055	.130	-.038	-.011
	Sig.		.097	.068	.637	.218	.447	.077	.607	.882
	N	190	190	190	190	190	190	187	188	189
Extraversion	r		1	.143*	-.080	-.152*	.390	.155*	.051	.224**
	Sig.			.049	.273	.036	.000	.034	.486	.002
	N		191	191	191	191	191	188	189	190
Agreeableness	r			1	-.013	.165*	.143*	-.048	-.070	.145*
	Sig.				.861	.022	.048	.515	.336	.047
	N			191	191	191	191	188	189	190
Conscientiousness	r				1	.272**	.034	-.142	.067	.132
	Sig.					.000	.638	.052	.359	.069
	N				191	191	191	188	189	190
Emot. Stability	r					1	-.090	.003	-.055	.303**
	Sig.						.214	.970	.450	.000
	N					191	191	188	189	190
Openness	r						1	.338**	.011	.380**
	Sig.							.000	.876	.000
	N						191	188	189	190
Intr. Motivation	r							1	.087	.358**
	Sig.								.237	.000
	N							188	188	187
Extr. Motivation	r								1	.075
	Sig.									.309
	N								189	188
Self Efficacy										1
										190

Notes: ** **α** ≤ 0.01; * **α** ≤ 0.05

Table 10. Correlations between divergent tasks (Figures, Realistic Problems, Titles) and Big 5 personality traits (on two pages).

		Figures Task Fluency	Figures Task Frequency	Real Task Fluency	Real Task Frequency	Titles Task Fluency	Titles Task Frequency	Extraversion	Agreeableness	Conscientiousness	Emot. Stability	Openness
Figures Task Fluency	r	1	.192**	.615**	.015	.634**	.146*	.313	-.005	-.007	.058	.397**
	Sig.		.008	.000	.840	.000	.048	.000	.941	.929	.426	.000
	N	190	190	180	177	189	185	190	190	190	190	190
Figures Task Frequency	r		1	.354**	.245**	.332**	.403**	.210**	.215**	-.144*	-.039	.256**
	Sig.			.000	.001	.000	.000	.004	.003	.047	.594	.000
	N		190	180	177	189	185	190	190	190	190	190
Real Task Fluency	r			1	-.095	.628**	.220**	.277**	.081	-.032	.141	.272**
	Sig.				.208	.000	.003	.000	.280	.666	.059	.000
	N			181	178	179	175	181	181	181	181	181
Real Task Frequency	r				1	.013	.124	.090	.008	-.113	-.180*	.158*
	Sig.					.867	.106	.235	.911	.133	.016	.035
	N				178	176	172	178	178	178	178	178
Titles Task Fluency	r					1	.262**	.283**	.131	-.085	.062	.358**
	Sig.						.000	.000	.073	.246	.393	.000
	N					189	185	189	189	189	189	189
Titles Task Frequency	r						1	.235**	.195**	-.037	.098	.228**
	Sig.							.001	.008	.620	.184	.002
	N						185	185	185	185	185	185

Extraversion	r							1	.143*	-.080	-.152*	.390**
	Sig.								.049	.273	.036	.000
	N							191	191	191	191	191
Agreeableness	r								1	-.013	.165*	.143*
	Sig.									.861	.022	.048
	N								191	191	191	191
Conscientiousness	r									1	.272**	.034
	Sig.										.000	.638
	N									191	191	191
Emot. Stability	r										1	-.090
	Sig.											.214
	N										191	191
Openness	r											1
	Sig.											
	N											191
		Figures Task Fluency	Figures Task Frequency	Real Task Fluency	Real Task Frequency	Titles Task Fluency	Titles Task Frequency	Extraversion	Agreeableness	Conscientiousness	Emot. Stability	Openness

Notes: ** **α** ≤ 0.01; * **α** ≤ 0.05

Table 11. Correlations between divergent tasks (Figures, Realistic Problems, Titles), motivation (intrinsic and extrinsic), and self-efficacy.

		Figures Task Fluency	Figures Task Frequency	Real Task Fluency	Real Task Frequency	Titles Task Fluency	Titles Task Frequency	Intr. Motivation	Extr. Motivation	Self Efficacy
Figures Task Fluency	r	1	.192**	.615**	.015	.634**	.146*	.244**	.139	.305**
	Sig.		.008	.000	.840	.000	.048	.001	.057	.000
	N	190	190	180	177	189	185	187	188	189
Figures Task Frequency	r		1	.354**	.245**	.332**	.403**	.163*	.151*	.154*
	Sig.			.000	.001	.000	.000	.026	.038	.035
	N		190	180	177	189	185	187	188	189
Real Task Fluency	r			1	-.095	.628**	.220**	.148*	.124	.274**
	Sig.				.208	.000	.003	.048	.099	.000
	N			181	178	179	175	179	179	180
Real Task Frequency	r				1	.013	.124	.163*	-.038	-.056
	Sig.					.867	.106	.031	.614	.457
	N				178	176	172	176	176	177
Titles Task Fluency	r					1	.262**	.180*	.098	.197**
	Sig.						.000	.014	.180	.007
	N					189	185	186	187	188
Titles Task Frequency	r						1	-.007	.117	.169*
	Sig.							.921	.114	.022
	N						185	182	183	184
Intr. Motivation	r							1	.087	.358**
	Sig.								.237	.000
	N							188	188	187
Extr. Motivation	r								1	.075
	Sig.									.309
	N								189	188
Self Efficacy	r									1
	Sig.									
	N									190

Notes: ** $\boldsymbol{\alpha} \leq 0.01$; * $\boldsymbol{\alpha} \leq 0.05$

Table 12. Correlations between Assessment (Judgment tasks), Big 5 traits, motivation (intrinsic, extrinsic), and self-efficacy.

		Judgment Task	Extraversion	Agreeableness	Conscientiousness	Emot. Stability	Openness	Intr. Motivation	Extr. Motivation	Self Efficacy
Judgment Task	r	1	.104	.065	-.062	-.123	-.081	-.081	-.159*	-.057
	Sig.		.154	.374	.396	.090	.265	.267	.029	.438
	N	191	191	191	191	191	191	188	189	190
Extraversion	r		1	.143*	-.080	-.152*	.390**	.155*	.051	.224**
	Sig.			.049	.273	.036	.000	.034	.486	.002
	N		191	191	191	191	191	188	189	190
Agreeableness	r			1	-.013	.165*	.143*	-.048	-.070	.145*
	Sig.				.861	.022	.048	.515	.336	.047
	N			191	191	191	191	188	189	190
Conscientiousness	r				1	.272**	.034	-.142	.067	.132
	Sig.					.000	.638	.052	.359	.069
	N				191	191	191	188	189	190
Emot. Stability	r					1	-.090	.003	-.055	.303**
	Sig.						.214	.970	.450	.000
	N					191	191	188	189	190
Openness	r						1	.338**	.011	.380**
	Sig.							.000	.876	.000
	N						191	188	189	190
Intr. Motivation	r							1	.087	.358**
	Sig.								.237	.000
	N							188	188	187
Extr. Motivation	r								1	.075
	Sig.									.309
	N								189	188
Self Efficacy	r									1
	Sig.									
	N									190

Notes: ** $\alpha \leq 0.01$; * $\alpha \leq 0.05$

5.5.4 Intelligence vs. creative abilities

The correlations between Raven and convergent tasks (insight problems and RAT) show significant positive (medium/strong) associations between the two measurement methods (Table 13). These results indicate that higher levels of intelligence are associated to better solution percentages in the two convergent tasks, i.e., to higher convergent thinking abilities. On the contrary, intelligence results slightly negatively associated with divergent thinking abilities, in particular with Figures and Titles tasks (Table 14). Finally, no significant association emerged between intelligence and assessment ability (Table 14).

From these analyses intelligence seems to support convergent thinking abilities, while it seems to “counteract” divergent thinking abilities. Raven test measures two main components of a general cognitive intelligence ability (Raven, 2000), and in particular, eductive ability (the ability to generate high level schemata which can allow for an easier handling of complexity) and reproductive ability (the ability to absorb, recall, and reproduce information). These two components have been demonstrated to be good proxies of a general intelligence factor (factor g). However, even if these components are essential to organize the information in order to converge towards a correct solution, they result totally different to the abilities required to obtain a good divergent performance. Different from the ability to generate schemata to organize complexity (conveyed by the eductive ability), for example, divergent thinking tasks require to produce more and more complexity, producing continuously different alternatives. From these results, we can therefore assume that the abilities usually measured from intelligence tests (or better, from crystalized intelligence tests) are negatively associated with the abilities required from divergent thinking tasks.

Table 13. Correlations between Raven, insight problems and RAT

		Raven	Math Problems	Verbal Problems	Spatial Problems	RAT
Raven	r	1	.320**	.263**	.411**	.193**
	Sig.		.000	.000	.000	.008
	N	191	191	191	191	190
Math Problems	r		1	.362**	.386**	.318**
	Sig.			.000	.000	.000
	N		191	191	191	190
Verbal Problems	r			1	.375**	.098
	Sig.				.000	.177
	N			191	191	190
Spatial Problems	r				1	.129
	Sig.					.076
	N				191	190
RAT	r					1
	Sig.					
	N					190

Notes: ** **α** ≤ 0.01; * **α** ≤ 0.05

Table 14. Correlations between intelligence (Raven) and divergent tasks (Figures, Realistic Problems, Titles tasks).

		Raven	Figures Task Fluency	Figures Task Frequency	Real Task Fluency	Real Task Frequency	Titles Task Fluency	Titles Task Frequency	Judgment task
Raven	r	1	-.024	-.146*	.008	-.121	-.175*	-.184*	-.041
	Sig.		.747	.045	.916	.106	.016	.012	.571
	N	191	190	190	181	178	189	185	191
Figures Task Fluency	r		1	.192**	.615**	.015	.634**	.146*	-.104
	Sig.			.008	.000	.840	.000	.048	.152
	N		190	190	180	177	189	185	190
Figures Task Frequency	r			1	.354**	.245**	.332**	.403**	-.010
	Sig.				.000	.001	.000	.000	.895
	N			190	180	177	189	185	190
Real Task Fluency	r				1	-.095	.628**	.220**	-.156
	Sig.					.208	.000	.003	.036
	N				181	178	179	175	181
Real Task Frequency	r					1	.013	.124	-.076
	Sig.						.867	.106	.310
	N					178	176	172	178
Titles Task Fluency	r						1	.262**	-.139
	Sig.							.000	.057
	N						189	185	189
Titles Task Frequency	r							1	.084
	Sig.								.253
	N							185	185
Judgment task	r								1
	Sig.								
	N								191

Notes: ** $\alpha \leq 0.01$; * $\alpha \leq 0.05$

5.6. Correlational analyses: Creative achievement

5.6.1 CAQ and CAAC

A second order of analyses is devoted to explore the associations between the two measures of creative achievement used within the CREAM test battery and personality, intelligence and creative abilities.

The first analysis explores the relation between the two creative achievement measures, CAQ and CAAC. Both instruments measures creative achievement in different areas, but while the CAAC version used in the CREAM test battery explicitly aims at measuring creative achievement in three different areas (scientific, artistic, and everyday creativity) using distinct subscales, CAQ does not explicitly divide the measurement of creative achievement in different macro areas. Usually, indeed, CAQ is used to measure a general creative achievement (see for example Agnoli et al., in press). Also the factorial analysis provided by Carson et al. (2005) of the questionnaire did not highlight a clear two factors structure of the CAQ, showing that the instrument does not separately evaluate scientific and artistic creative achievement. The correlational analysis will therefore explore the convergence between the two instruments, and, thanks to the high specificity of CAAC (that measures scientific, artistic, and everyday creative achievement both within and outside scholastic/working environment), can reveal which kind of creative achievement is measured by CAQ. Correlations shown in Table 15 reveals that CAQ scores are significantly positively associated with the CAAC artistic and everyday creative achievement scores, but not with the scientific scores. In particular the associations strengthen if these are referred to the outside school/work environment. These results seem to testify that the CAQ scores are essentially referred to the measurement of an artistic and everyday creative achievement, and in particular to a highly motivated creative achievement (that founds its application outside the scholastic or working environment). However, these results highlight that CAQ does not consider the measurement of scientific creative achievement in university students. A final consideration on the associations between CAQ and CAAC concerns the validity of the two instruments. The high associations (in particular in the artistic area) between the two instruments highlight a mutual concurrent validity of CAQ and CAAC, showing that both are measuring (even if with the previously explained differences) the same construct.

5.6.2 Personality and creative achievement

Past research highlighted that creative achievement is associated with personality trait, in particular with Openness (see for example Agnoli et al., in press) and Extraversion (see Batey & Furnham, 2008). Consistent with past research, results (see Table 15) show significant positive associations between CAQ scores and both Extraversion and Openness. However, the results on CAAC highlight that

Table 15. Correlations between CAAC, CAQ, and Big 5 personality traits (on two pages).

		CAQ	CAAC Science S/W	CAAC Art S/W	CAAC Every day S/W	CAAC Scienc e Out S/W	CAAC Art Out S/W	CAAC Everyd ay Out S/W	Extrave rsion	Agreea bleness	Conscien tiousness	Emot. Stabilit y	Openness
CAQ	r	1	-.084	.409**	.284**	.046	.504**	.298**	.254**	.051	-.091	.027	.228**
	Sig.		.250	.000	.000	.526	.000	.000	.000	.486	.210	.709	.001
	N	191	191	190	191	191	190	191	191	191	191	191	191
CAAC Science S/W	r		1	-.035	.050	.619**	-.006	.296**	-.061	-.169*	.018	-.089	-.018
	Sig.			.632	.489	.000	.929	.000	.401	.020	.802	.223	.806
	N		191	190	191	191	190	191	191	191	191	191	191
CAAC Art S/W	r			1	.707**	-.002	.637**	.457**	.354**	.106	-.012	-.038	.242**
	Sig.				.000	.976	.000	.000	.000	.144	.869	.603	.001
	N			190	190	190	190	190	190	190	190	190	190
CAAC Everyday S/W	r				1	.157*	.528**	.623**	.374**	.194**	-.037	.012	.205**
	Sig.					.030	.000	.000	.000	.007	.615	.865	.005
	N				191	191	190	191	191	191	191	191	191
CAAC Science Out S/W	r					1	.184*	.365**	.072	.042	.026	.022	.127
	Sig.						.011	.000	.321	.567	.726	.764	.080
	N					191	190	191	191	191	191	191	191
CAAC Art Out S/W	r						1	.609**	.357**	.095	-.162*	.057	.370**
	Sig.							.000	.000	.192	.025	.433	.000
	N						190	190	190	190	190	190	190
CAAC	r							1	.349**	.062	-.021	.020	.254**

		CAQ	CAAC Science S/W	CAAC Art S/W	CAAC Every day S/W	CAAC Science Out S/W	CAAC Art Out S/W	CAAC Everyday Out S/W	Extraversion	Agreeableness	Conscientiousness	Emot. Stability	Openness
Everyday Out S/W	Sig.								.000	.391	.776	.786	.000
	N							191	191	191	191	191	191
Extraversion	r								1	.143*	-.080	-.152*	.390**
	Sig.									.049	.273	.036	.000
	N								191	191	191	191	191
Agreeableness	r									1	-.013	.165*	.143*
	Sig.										.861	.022	.048
	N									191	191	191	191
Conscientiousness	r										1	.272**	.034
	Sig.											.000	.638
	N										191	191	191
Emot. Stability	r											1	-.090
	Sig.												.214
	N											191	191
Openness	r												1
	Sig.												
	N												191

Notes: ** **α** ≤ 0.01; * **α** ≤ 0.05; S/W = School/Work; Out S/W= Outside School/Work

Table 16. Correlations between motivation (intrinsic and extrinsic), self-efficacy, CAAC, and CAQ (on two pages).

		Intr. Motiv.	Extr. Motiv.	Self Efficacy	CAQ	CAAC Science S/W	CAAC Art S/W	CAAC Everyday S/W	CAAC Science Out S/W	CAAC Art Out S/W	CAAC Everyday Out S/W
Intr. Motiv.	r	1	.087	.358**	.142	.081	.160*	.051	.123	.305**	.204**
	Sig.		.237	.000	.053	.267	.029	.489	.093	.000	.005
	N	188	188	187	188	188	187	188	188	187	188
Extr. Motiv.	r		1	.075	.092	-.043	.111	.084	-.073	.068	.033
	Sig.			.309	.209	.555	.130	.252	.318	.352	.651
	N		189	188	189	189	188	189	189	188	189
Self Efficacy	r			1	.172*	.144*	.227**	.298**	.250**	.384**	.374**
	Sig.				.017	.047	.002	.000	.000	.000	.000
	N			190	190	190	190	190	190	190	190
CAQ	r				1	-.084	.409**	.284**	.046	.504**	.298**
	Sig.					.250	.000	.000	.526	.000	.000
	N				191	191	190	191	191	190	191
CAAC Science S/W	r					1	-.035	.050	.619**	-.006	.296**
	Sig.						.632	.489	.000	.929	.000
	N					191	190	191	191	190	191
CAAC Art S/W	r						1	.707**	-.002	.637**	.457**
	Sig.							.000	.976	.000	.000
	N						190	190	190	190	190

CAAC Everyday S/W	r							1	.157*	.528**	.623**
	Sig.								.030	.000	.000
	N							191	191	190	191
CAAC Science Out S/W	r								1	.184*	.365**
	Sig.									.011	.000
	N								191	190	191
CAAC Art Out S/W	r									1	.609**
	Sig.										.000
	N									190	190
CAAC Everyday Out S/W	r										1
	Sig.										
	N										191
		Intr. Motiv.	Extr. Motiv.	Self Efficacy	CAQ	CAAC Science S/W	CAAC Art S/W	CAAC Everyday S/W	CAAC Science Out S/W	CAAC Art Out S/W	CAAC Everyday Out S/W

Notes: ** $\boldsymbol{\alpha} \leq 0.01$; * $\boldsymbol{\alpha} \leq 0.05$; S/W = School/Work; Out S/W= Outside School/Work personality, and in particular Extraversion and Openness, is associated especially with artistic and everyday creative achievement. No association emerges between personality and scientific creative achievement. These results show that higher artistic and everyday creative achievement levels are associated with higher levels of Openness to experience and Extraversion, while scientific achievement is not associated with personality traits.

In the same way, scientific creative achievement is not associated with motivational attitudes, neither with intrinsic motivation not with extrinsic motivation (see Table 16). On the contrary, artistic and everyday creative achievements are significantly positively associated with intrinsic motivation: a higher tendency to be intrinsically motivated is associated to higher creative achievement in artistic and everyday areas. The associations between intrinsic motivation and artistic and everyday achievement measured by CAAC are particularly significant in the outside school/work environment. This result highlights that the measurement of creative achievement both within and outside school/work is effectively able to distinguish between different kinds of motivational attitudes, with creative achievement outside school/work associated with higher levels of intrinsic motivation.

5.6.3 Intelligence and creative achievement

The analyses exploring the relationships between creative achievement and intelligence (Table 17) highlight that intelligence is significantly positively associated with scientific creative achievement and negatively associated with artistic and everyday creative achievement. While scientific creative achievement and intelligence are significantly associated both within and outside the scholastic/working environment, the associations with the artistic and everyday creative achievement are significant only within the scholastic/working environment. This result seem to indicate that at higher levels of intelligence low levels of creative achievement in art and normal activities within school and work are associated, suggesting that the artistic and everyday creativity within school or work does not require (i.e., is not associated with) the cognitive abilities measured by Raven. However, scientific creative achievement is always associated with intelligence.

Table 17. Correlations between Intelligence (Raven), CAQ, and CAAC.

		Raven	CAQ	CAAC Science S/W	CAAC Art S/W	CAAC Everyday S/W	CAAC Science Out S/W	CAAC Art Out S/W	CAAC Everyday Out S/W
Raven	r	1	-.039	.217**	-.227**	-.244**	.171*	-.112	-.011
	Sig.		.589	.003	.002	.001	.018	.124	.875
	N	191	191	191	190	191	191	190	191
CAQ	r		1	-.084	.409**	.284**	.046	.504**	.298**
	Sig.			.250	.000	.000	.526	.000	.000
	N		191	191	190	191	191	190	191
CAAC Science S/W	r			1	-.035	.050	.619**	-.006	.296**
	Sig.				.632	.489	.000	.929	.000
	N			191	190	191	191	190	191
CAAC Art S/W	r				1	.707**	-.002	.637**	.457**
	Sig.					.000	.976	.000	.000
	N				190	190	190	190	190
CAAC Everyday S/W	r					1	.157*	.528**	.623**
	Sig.						.030	.000	.000
	N					191	191	190	191
CAAC Science Out S/W	r						1	.184*	.365**
	Sig.							.011	.000
	N						191	190	191
CAAC Art Out S/W	r							1	.609**
	Sig.								.000
	N							190	190
CAAC Everyday Out S/W	r								1
	Sig.								
	N								191

Notes: ** **α** ≤ 0.01; * **α** ≤ 0.05; S/W = School/Work; Out S/W= Outside School/Work

5.7. Correlational analyses: Creative abilities and creative achievement

5.7.1 Convergent abilities and creative achievement

The present and the next two sections present the associations between creative achievement and creative abilities. Starting from the correlation analyses between convergent abilities and creative achievement (Table 18), the results show that convergent tasks scores (both RAT and insight problems tasks) are positively associated with the scientific creative achievement and negatively associated with the artistic and everyday creative achievement. These results therefore show that an increase in convergent thinking abilities is associated with an increase in scientific creative achievement, while it is associated with a decrease in artistic and everyday creative achievement. These associations are particularly evident within the scholastic/working environment, suggesting that convergent thinking abilities are more required within a more structured environment, where creative activities are proposed and defined by others.

5.7.2 Divergent abilities and creative achievement

Consistently with past research, divergent thinking performance in positively associated with creative achievement; this result is evident in the association of divergent tasks scores with both the CAAC (Table 19) and the CAQ scores (Table 20). However, the most specific CAAC scores highlight that fluency and frequency in divergent thinking tasks are particularly associate with the artistic and everyday creative achievement. Moreover, a general trend in the results showed as divergent thinking performance is negatively associated with scientific creative achievement and positively associated with the other two forms of creative achievement. Even if the negative associations with scientific creative achievement are of a small size, these results seem to suggest that an increase in divergent thinking abilities is associated with lower levels of scientific creative achievement (in particular within a scholastic/working environment).

However, the increase in divergent thinking abilities (and in particular in the fluency in producing alternatives) is associated with an increase of artistic and everyday creative achievements. These positive associations seem particularly strong if we refer to creative achievement in art outside scholastic/working environment, where an increase of divergent thinking abilities seems particularly associated with an increase in creative achievement.

Table 18. Correlations between convergent tasks (RAT and insight problems) and creative achievement (CAQ and CAAC).

		RAT	Math Problems	Verbal Problems	Spatial Problems	CAQ	CAAC Science S/W	CAAC Art S/W	CAAC Everyday S/W	CAAC Science Out S/W	CAAC Art Out S/W	CAAC Everyday Out S/W
RAT	r	1	.318**	.098	.129	-.212**	.224**	-.225**	-.277**	-.063	-.134	-.061
	Sig.		.000	.177	.076	.003	.002	.002	.000	.386	.067	.404
	N	190	190	190	190	190	190	189	190	190	189	190
Math Problems	r		1	.362**	.386**	-.121	.262**	-.195**	-.166*	.099	-.074	-.021
	Sig.			.000	.000	.097	.000	.007	.022	.173	.312	.771
	N		191	191	191	191	191	190	191	191	190	191
Verbal Problems	r			1	.375**	-.073	.105	-.078	-.085	.022	-.035	-.051
	Sig.				.000	.312	.150	.285	.241	.765	.631	.484
	N			191	191	191	191	190	191	191	190	191
Spatial Problems	r				1	-.225**	.247**	-.303**	-.233**	.212**	-.161*	-.061
	Sig.					.002	.001	.000	.001	.003	.027	.403
	N				191	191	191	190	191	191	190	191
CAQ	r					1	-.084	.409**	.284**	.046	.504**	.298**
	Sig.						.250	.000	.000	.526	.000	.000
	N					191	191	190	191	191	190	191
CAAC Science S/W	r						1	-.035	.050	.619**	-.006	.296**
	Sig.							.632	.489	.000	.929	.000
	N						191	190	191	191	190	191

CAAC Art S/W	r							1	.707**	-.002	.637**	.457**
	Sig.								.000	.976	.000	.000
	N							190	190	190	190	190
CAAC Everyday S/W	r								1	.157*	.528**	.623**
	Sig.									.030	.000	.000
	N								191	191	190	191
CAAC Science Out S/W	r									1	.184*	.365**
	Sig.										.011	.000
	N									191	190	191
CAAC Art Out S/W	r										1	.609**
	Sig.											.000
	N										190	190
CAAC Everyday Out S/W	r											1
	Sig.											
	N											191
		RAT	Math Problems	Verbal Problems	Spatial Problems	CAQ	CAAC Science S/W	CAAC Art S/W	CAAC Everyday S/W	CAAC Science Out S/W	CAAC Art Out S/W	CAAC Everyday Out S/W

Notes: ** $\alpha \le 0.01$; * $\alpha \le 0.05$; S/W = School/Work; Out S/W= Outside School/Work

Table 19. Correlations between divergent tasks (Figures, Realistic Problems, Titles tasks) and CAAC creative achievement.

		Figures Task Fluency	Figures Task Frequency	Real Task Fluency	Real Task Frequency	Titles Task Fluency	Titles Task Frequency	CAAC Science S/W	CAAC Art S/W	CAAC Everyday S/W	CAAC Science Out S/W	CAAC Art Out S/W	CAAC Everyday Out S/W
Figures Task Fluency	r	1	.192**	.615**	.015	.634**	.146*	-.079	.364**	.298**	-.018	.423**	.257**
	Sig.		.008	.000	.840	.000	.048	.279	.000	.000	.808	.000	.000
	N	190	190	180	177	189	185	190	189	190	190	189	190
Figures Task Frequency	r		1	.354**	.245**	.332**	.403**	-.155*	.162*	.199*	-.026	.304**	.164*
	Sig.			.000	.001	.000	.000	.033	.026	.006	.721	.000	.024
	N		190	180	177	189	185	190	189	190	190	189	190
Real Task Fluency	r			1	-.095	.628**	.220**	-.175*	.287**	.267**	-.077	.399**	.243**
	Sig.				.208	.000	.003	.019	.000	.000	.301	.000	.001
	N			181	178	179	175	181	180	181	181	180	181
Real Task Frequency	r				1	.013	.124	-.002	-.015	-.090	.015	.057	.023
	Sig.					.867	.106	.977	.847	.231	.846	.451	.764
	N				178	176	172	178	177	178	178	177	178
Titles Task Fluency	r					1	.262**	-.095	.328**	.321**	.021	.448**	.260**
	Sig.						.000	.191	.000	.000	.772	.000	.000
	N					189	185	189	188	189	189	188	189
Titles Task Frequency	r						1	-.181*	.157*	.166*	-.002	.177*	.028
	Sig.							.014	.033	.024	.973	.017	.702
	N						185	185	184	185	185	184	185

CAAC Science S/W	r Sig. N							1 191	-.035 .632 190	.050 .489 191	.619** .000 191	-.006 .929 190	.296** .000 191
CAAC Art S/W	r Sig. N								1 190	.707** .000 190	-.002 .976 190	.637** .000 190	.457** .000 190
CAAC Everyday S/W	r Sig. N									1 191	.157* .030 191	.528** .000 190	.623** .000 191
CAAC Science Out S/W	r Sig. N										1 191	.184* .011 190	.365** .000 191
CAAC Art Out S/W	r Sig. N											1 190	.609** .000 190
CAAC Everyday Out S/W	r Sig. N												1 191
		Figures Task Fluency	Figures Task Frequency	Real Task Fluency	Real Task Frequenc y	Titles Task Fluency	Titles Task Frequenc y	CAAC Science S/W	CAAC Art S/W	CAAC Everyd ay S/W	CAAC Science Out S/W	CAAC Art Out S/W	CAAC Everyd ay Out S/W

Notes: ** **α** ≤ 0.01; * **α** ≤ 0.05; S/W = School/Work; Out S/W= Outside School/Work

Table 20. Correlations between divergent tasks (Figures, Realistic Problems, Titles tasks) and CAQ creative achievement.

		Figures Task Fluency	Figures Task Frequency	Real Task Fluency	Real Task Frequency	Titles Task Fluency	Titles Task Frequency	CAQ
Figures Task Fluency	r	1	.192**	.615**	.015	.634**	.146*	.198**
	Sig.		.008	.000	.840	.000	.048	.006
	N	190	190	180	177	189	185	190
Figures Task Frequency	r		1	.354**	.245**	.332**	.403**	.209**
	Sig.			.000	.001	.000	.000	.004
	N		190	180	177	189	185	190
Real Task Fluency	r			1	-.095	.628**	.220**	.243**
	Sig.				.208	.000	.003	.001
	N			181	178	179	175	181
Real Task Frequency	r				1	.013	.124	.072
	Sig.					.867	.106	.337
	N				178	176	172	178
Titles Task Fluency	r					1	.262**	.335**
	Sig.						.000	.000
	N					189	185	189
Titles Task Frequency	r						1	.169*
	Sig.							.022
	N						185	185
CAQ	r							1
	Sig.							
	N							191

Notes: ** **α** ≤ 0.01; * **α** ≤ 0.05; S/W = School/Work; Out S/W= Outside School/Work

5.7.3 Assessment and creative achievement

The last correlational analyses are devoted to the exploration of the relationships between assessment ability (measured through the Judgment task) and creative achievement (Table 21). These analyses do not highlight clear evident trends in the associations between assessment ability and creative achievement. The only significant correlation emerged from the analyses is the positive association between assessment ability and scientific creative achievement outside the scholastic/working environment. This result seems to suggest that higher creative achievement in science is associated with a lower ability to assess the produced ideas or solutions especially in an environment with less well-defined problems or tasks, such as environments outside school or work.

Table 21. Correlations between assessment ability (Judgment tasks) and creative achievement (CAQ and CAAC).

		Judgment Task	CAQ	CAAC Science S/W	CAAC Art S/W	CAAC Everyday S/W	CAAC Science Out S/W	CAAC Art Out S/W	CAAC Everyday Out S/W
Judgment Task	r	1	-.062	.045	.007	.113	.150*	-.036	.060
	Sig.		.394	.534	.921	.121	.039	.626	.411
	N	191	191	191	190	191	191	190	191
CAQ	r		1	-.084	.409**	.284**	.046	.504**	.298**
	Sig.			.250	.000	.000	.526	.000	.000
	N		191	191	190	191	191	190	191
CAAC Science S/W	r			1	-.035	.050	.619**	-.006	.296**
	Sig.				.632	.489	.000	.929	.000
	N			191	190	191	191	190	191
CAAC Art S/W	r				1	.707**	-.002	.637**	.457**
	Sig.					.000	.976	.000	.000
	N				190	190	190	190	190
CAAC Everyday S/W	r					1	.157*	.528**	.623**
	Sig.						.030	.000	.000
	N					191	191	190	191
CAAC Science Out S/W	r						1	.184*	.365**
	Sig.							.011	.000
	N						191	190	191
CAAC Art Out S/W	r							1	.609**
	Sig.								.000
	N							190	190
CAAC Everyday Out S/W	r								1
	Sig.								
	N								191

Notes: ** **α** ≤ 0.01; * **α** ≤ 0.05; S/W = School/Work; Out S/W= Outside School/Work

5.8. Creative performance and creative achievement in different domains

5.8.1 Science vs. Art vs. Creative domains: personality

Before investigating the differences in creative abilities and creative achievement between the three domains analysed within the CREAM project, the differences in personality traits and attitudes and intelligence are explored. These analyses aim at understanding the differences and similarities in these basic variables between the three knowledge domains.

A first analysis is devoted to the analyses of the differences in personality traits (Big 5 traits) and attitudes (self-efficacy and motivation) in the scientific, artistic, and creative industry domains. The differences were explored through a multivariate analysis of variance (MANOVA), with the personality score in the 5 traits as dependent variable and the domain as independent variable (three levels: science, art, and creative).

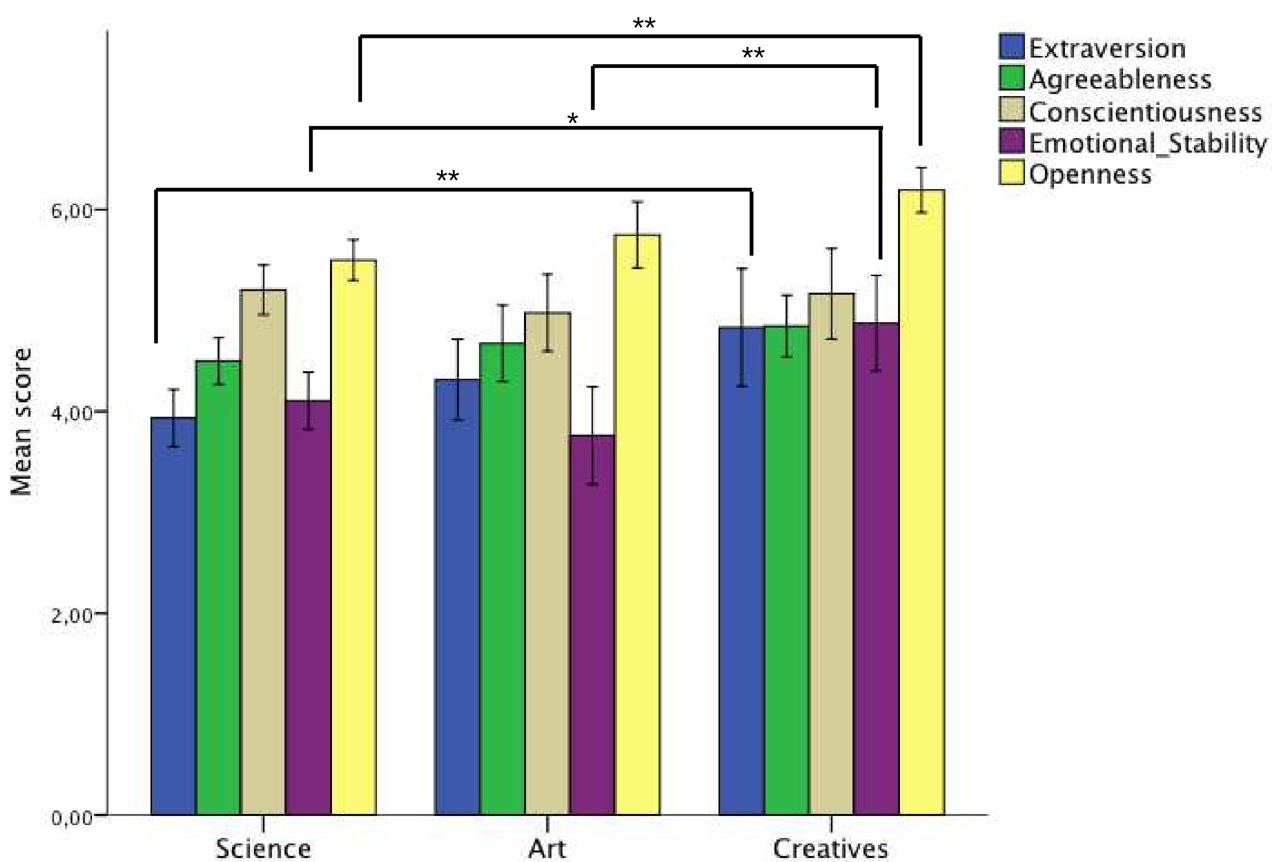


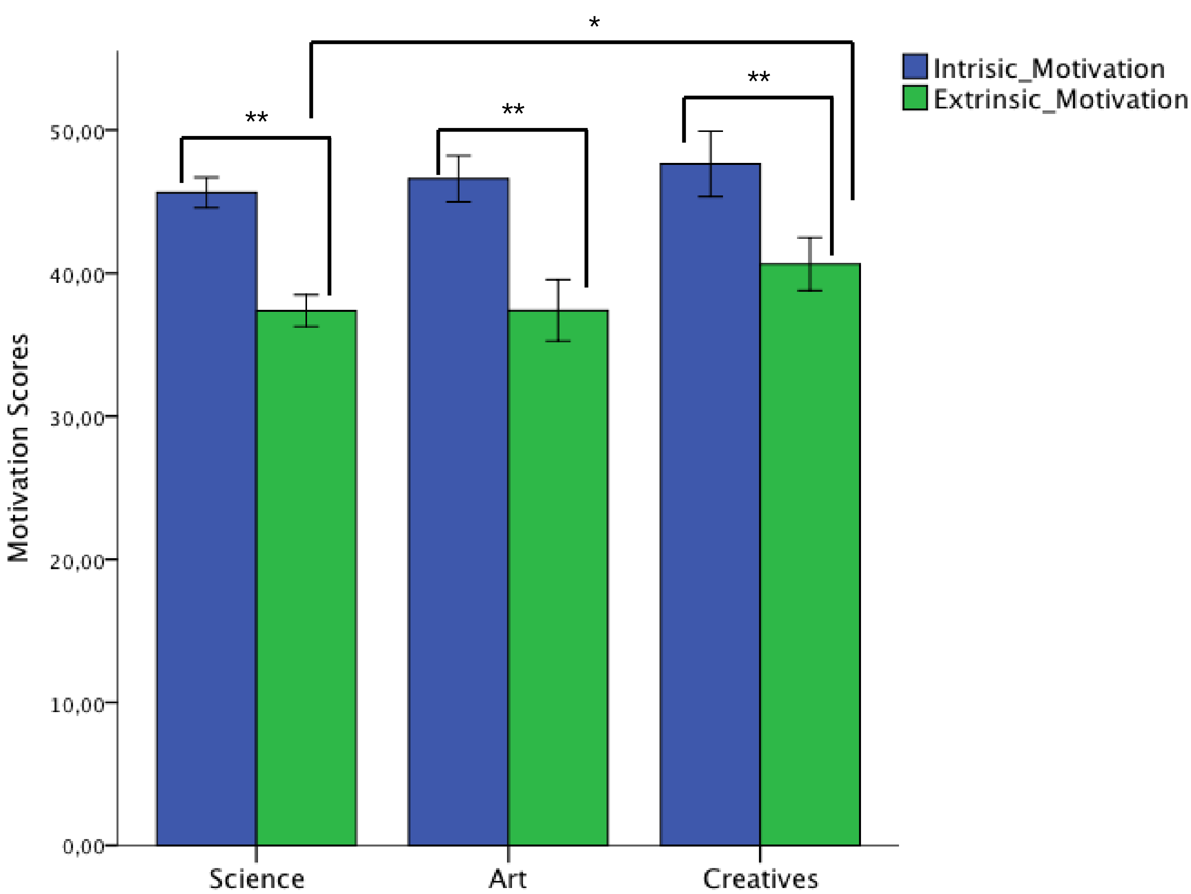
Figure 6. Big 5 personality traits in the scientific, artistic and creative industry domains. Significant differences in the personality traits between the three domains are depicted in the Figure (** α ≤ 0.01; * α ≤ 0.05). For more information on the significant differences within each domain please refer to the text.

Moreover, post-hoc analyses (with Bonferroni's correction) were used to analyse the significant results emerging from univariate analyses. This analysis shows that personality is significantly different in the three knowledge domains, $F(10,370)=3.339$, $p<.001$, $\eta^2_p=.083$ (see Figure 6). In particular, univariate analyses show that this difference is significant in three personality traits, Extraversion, $F(2,188)=11.329$, $p=.008$, $\eta^2_p=.050$, Emotional stability, $F(2,188)=13.022$, $p=.004$, $\eta^2_p=.057$, and Openness, $F(2,188)=6.630$, $p=.002$, $\eta^2_p=.065$. More specifically, post-hoc analyses reveal that creative professionals are characterized by higher levels of Extraversion than science students ($p=.007$), but not than art students. Moreover, creative professionals are characterized by higher levels of Emotional Stability than science and art students ($p=.026$ and $p=.003$, respectively). Finally, creative professionals exhibit higher Openness levels than science students ($p=.001$). These results seem to highlight that science and art students are characterized by a similar personality. At the same time science students differ from creative professionals in several personality traits, Extraversion, Emotional Stability, and Openness, highlighting that science and creative industry knowledge domains are characterized by different personalities. However, results show that creative professionals are characterized by a personality that is not highly different from the art students' personality.

Finally, separated repeated-measures analyses of variance (ANOVA), with personality traits as within-subjects variables, for the three knowledge domains explore if differences in the personality traits within each domain exist. A first analysis show that science students' personality is characterized by different levels of the five personality traits, $F(4,432)=30.395$, $p<.001$, $\eta^2_p=.220$, with Openness and Conscientiousness at the highest levels ($ps<.001$), and Emotional Stability and Extraversion at the lowest levels ($ps\leq .001$). The analyses showed that also art students' personality is characterized by different levels of the five personality traits, $F(4,180)=14.689$, $p<.001$, $\eta^2_p=.246$, with Openness at the higher level ($p<.001$) and Emotional Stability at the lowest level ($p<.001$); Extraversion, Agreeableness, and Conscientiousness do not differ among them. Finally, creative professionals' personalities are characterized by a high level of Openness that is in turn higher than the other four traits levels ($p<.001$), where no statistical differences were found. The differences in personality traits emerging from these analyses could be imputed from the one side to the differences between the three domains, and from the other side to the age differences between the creative professionals and the students. Creative professionals are indeed characterized by a more equilibrate personality, and these results can be ascribed to the higher mean age of the creative industry sample than the age of the other two students samples.

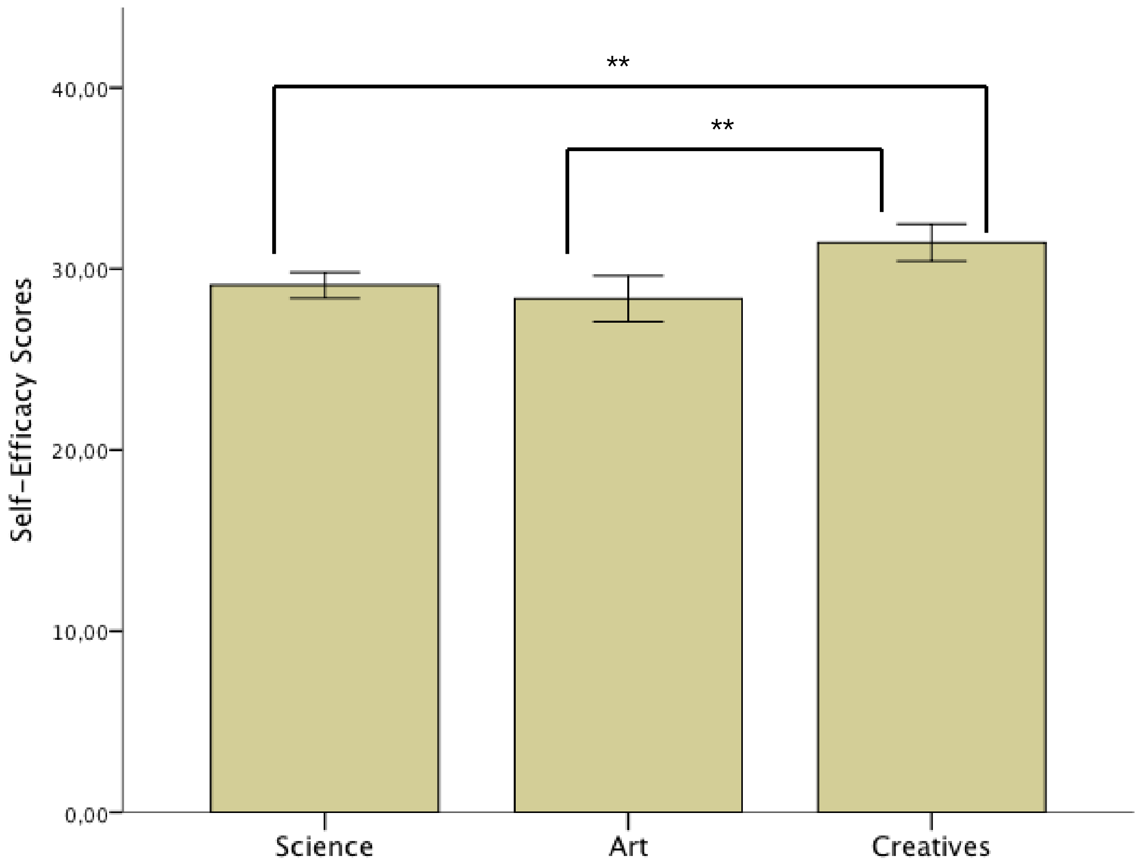
A second order of analyses explores the differences in the motivational tendencies between the three knowledge domains (Figure 7). The MANOVA shows that differences in the motivational tendencies across the three domains exist, $F(4,370)=2.746$, $p=.028$, $\eta^2_p=.029$. In particular univariate analyses highlight as this difference is significant only in the tendency to be extrinsically motivated, $F(2,185)=4.157$, $p=.017$, $\eta^2_p=.043$, while the three domains are characterized by a similar level of intrinsic motivation (see Figure 7). The post-hoc analyses showed in particular that creative professionals are characterized by a higher level of extrinsic motivation than science students ($p=.018$) and, even with a partially significant effect, than art students ($p=.055$). This result could be explained on the basis of some environmental differences between creative professionals and students. Creative professionals are indeed professionals who must find their motivation also from external sources, such as the clients' requests. The working environment requests could therefore influence the individual's motivational attitudes, increasing the ability to find motivation also from the outside. This hypothesis, however, should be further explored during the next periods of the project. Finally, a further analysis demonstrates that in all domains the intrinsic motivational attitude is higher than the extrinsic motivation attitude (ps<.001).

Figure 7. Intrinsic and extrinsic motivation in the scientific, artistic and creative industry domains. Significant differences in motivational tendencies both within and between the three domains are depicted in the Figure (** $\alpha \leq 0.01$; * $\alpha \leq 0.05$).



A final analysis explores the differences in self-efficacy between the three domains. An univariate ANOVA, in particular, shows that self-efficacy is different in the three domains, $F(2,187)=7.535$, $p=.001$, $\eta^2_p=.075$. Post-hoc analyses specifically demonstrate that self-efficacy in the creative industry domain is higher than in the scientific (p=.004) and in artistic (p=.001) domains (see Figure 8). This result shows that while in the scientific and artistic domains self-efficacy is similar, in the creative industry domain it is significantly higher. This effect could be imputed to the different expertise of creative professionals compared with science and art students. The creative professionals involved at the Engine Group are indeed all renown and appreciated professionals; the different expertise level could therefore explain the differences in self-efficacy between the three explored domains.

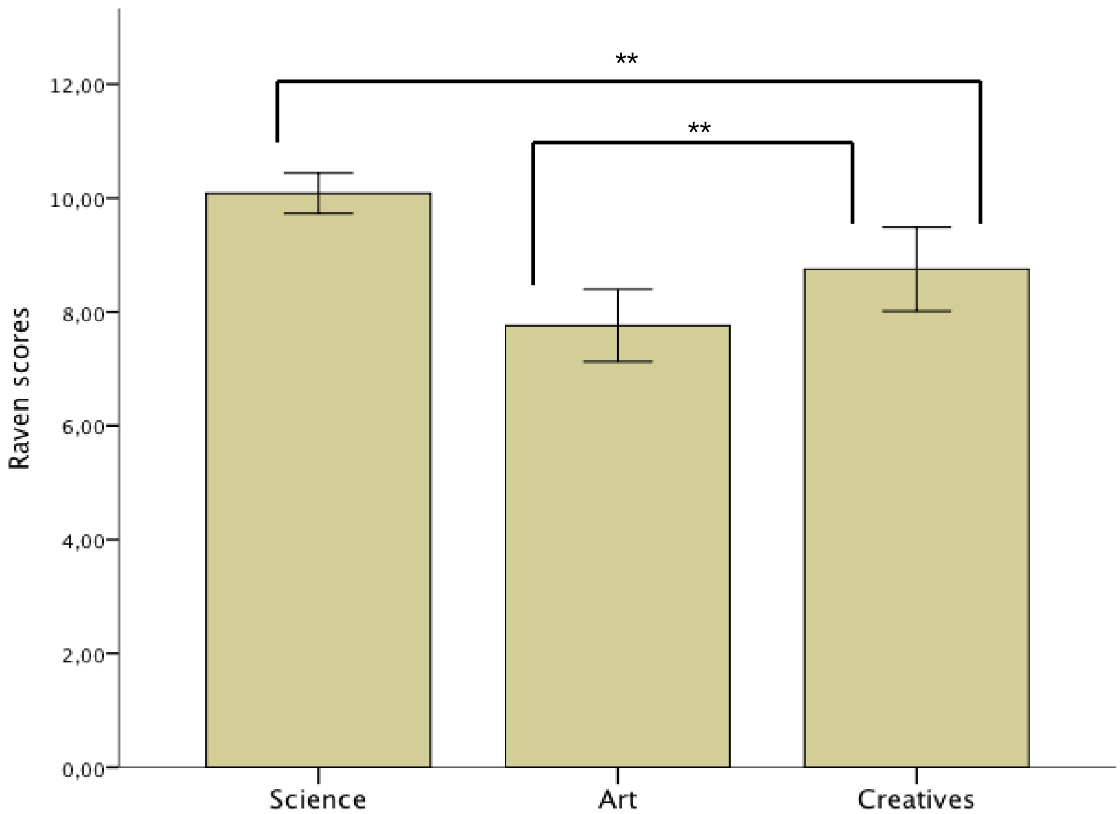
Figure 8. Self-efficacy scores in the scientific, artistic and creative industry domains. Significant differences in self-efficacy between the three domains are depicted in the Figure (** α ≤ 0.01; * α ≤ 0.05).



5.8.2 Science vs. Art vs. Creative domains: intelligence

A second analysis explores the differences between the three domains in intelligence, as measured through the Raven test (Figure 9). A univariate ANOVA demonstrates that a difference in intelligence exists between the three domains, $F(2,188)=23.453$, $p<.001$, $\eta^2_p=.200$. Post hoc analyses in particular show that scientific domain is characterized by a higher intelligence level than both artistic ($p=.001$) and creative industry ($p=.002$) domain, while artistic and creative industry domain are characterized by similar (non statistically different) intelligence level. Consistently with the results of the previous section highlighting that higher intelligence is associated with a higher scientific creative achievement, these results seem to confirm that the scientific domain is characterized by higher cognitive abilities in comparison with the other two domains, which creative achievement is on the contrary associated with lower intelligence scores.

Figure 9. Intelligence, as measured through the Raven test, in the scientific, artistic and creative industry domains. Significant differences in Raven test scores between the three domains are depicted in the Figure (** $\alpha \leq 0.01$; * $\alpha \leq 0.05$).



5.8.3 Science vs. Art vs. Creative domains: creative abilities

In this section the differences and similarities in creative abilities between the three domains are explored. First, the analyses on the convergent tasks (RAT and insight problems) are reported, then the analyses on divergent thinking abilities (fluency and frequency) in the three tasks (Figures, Realistic Problems, and Titles) are exposed, and finally the analysis on assessment ability (Judgment task) is presented.

Starting from the analyses on convergent thinking, a first univariate ANOVA highlights significant differences in RAT scores between the three domains,

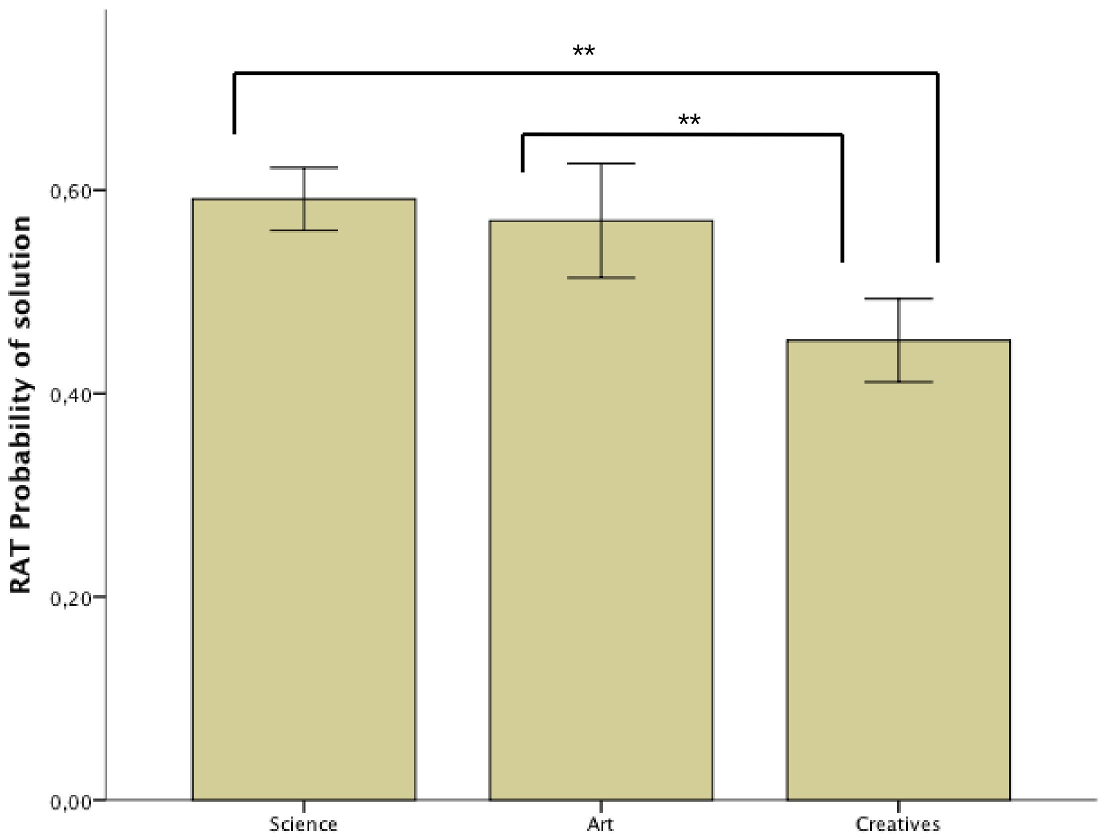


Figure 10. RAT probability of solution (from 0 to 1, corresponding to the 0% and to the 100% of solutions, respectively) in the scientific, artistic and creative industry domains. Significant differences between the three domains are depicted in the Figure (** α ≤ 0.01; * α ≤ 0.05).

$F(2,187)=10.094$, $p<.001$, $\eta^2_p=.097$ (Figure 10). Post hoc analyses in particular reveal that both scientific and artistic domains reached higher RAT scores than the creative industry domain ($p\leq .004$). This result should be further explored, since it could be determined by cultural differences between the scientific and artistic samples (mostly Italian students) and the creative sample (British creative professionals). Even if all solutions to the triplets used in the RAT task are based on semantic associations, that should reduce the effects produced by linguistic differences, further analyses will be provided after the recruitment of further participants to understand this result.

A second analysis explored differences and similitudes in insight problems solutions in the three domains. A MANOVA analysis, with the probability of solutions in the three insight problems as dependent variable, shows a significant difference in the solutions probability in the three domains, $F(6,374)=20.204$, $p<.001$, $\eta^2_p=.245$ (Figure 11). Univariate ANOVAs highlight that differences between the three domains emerged both in mathematical problems, $F(2,188)=21.815$, $p<.001$, $\eta^2_p=.188$, in verbal problems, $F(2,188)=20.037$, $p<.001$, $\eta^2_p=.176$, and in spatial problems, $F(2, 188)=38.365$, $p<.001$, $\eta^2_p=.290$. Post-hoc analyses show that science students are characterized by a higher percentage of solution in the mathematical insight problems than the art students ($p<.001$) and the creative professionals ($p=.008$), who show a higher solution percentage than the art students ($p=.043$). A similar data trend emerged in the insight spatial problems, where science students are characterized by a higher percentage of solution than the art students ($p<.001$) and the creative professionals ($p=.001$), who at the same time show a higher solution percentage than the art students ($p=.001$). Finally, post-hoc analyses highlighted that creative professionals showed significant higher percentage of solution in the verbal insight problems than the science ($p=.001$) and the art students ($p=.001$), who, in turn, showed lower percentages of solution than science students (<.001).

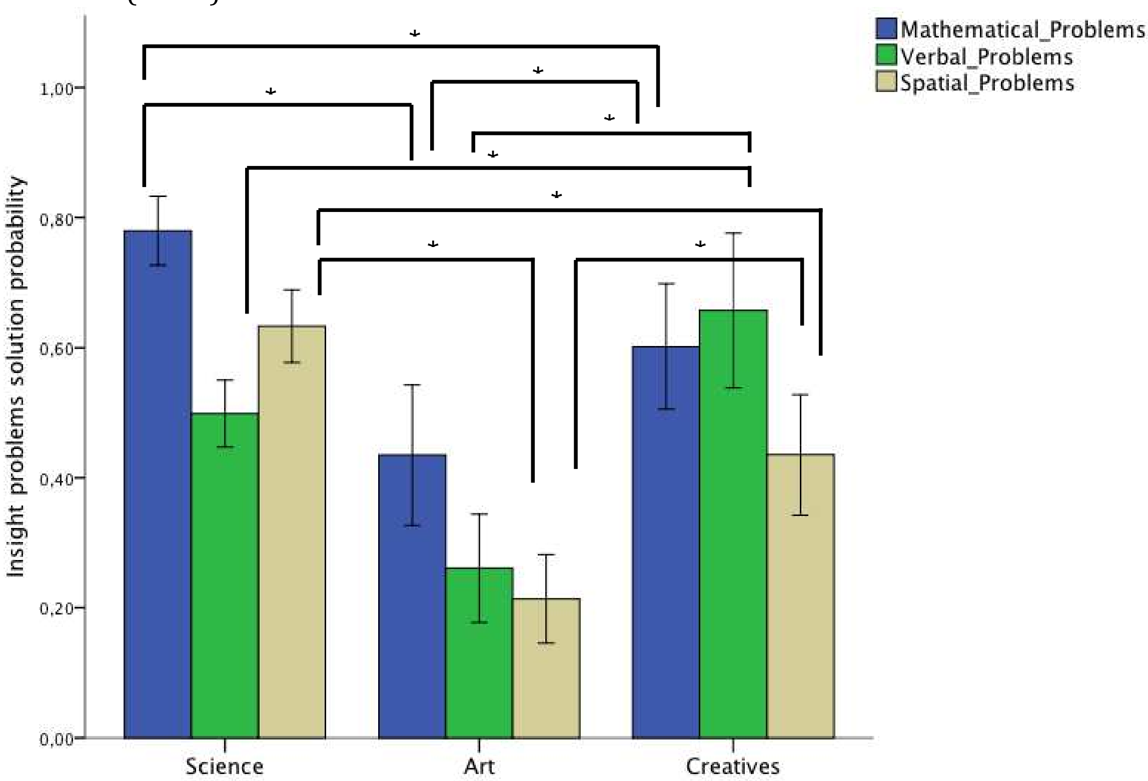


Figure 11. Insight problems probability of solution (from 0 to 1, corresponding to the 0% and to the 100% of solutions, respectively) in the scientific, artistic and creative industry domains. Significant differences in insight problems solutions between the three domains are depicted in the Figure (** α ≤ 0.01; * α ≤ 0.05). For more information on the significant differences within each domain please refer to the text.

Further repeated-measures ANOVAs divided for the three domains explore possible differences in the three insight problems within each domain. The first analysis shows a significant difference in the percentage of solution between the three insight problems in the scientific domain, $F(2,216)=36.438$, $p<.001$, $\eta^2_p=.252$, highlighting that the higher solution percentages are reached in the mathematical problems ($p<.001$) and the lower in the verbal problems ($p<.001$). In the same way, ANOVA highlights a difference in solutions between the three kinds of problems also in the artistic domain, $F(2,90)=8.566$, $p<.001$, $\eta^2_p=.160$, where mathematical problems show higher percentages of solution than verbal and spatial problems ($ps\leq .003$). Finally, a difference emerge also in the solution percentages of the creative industry domain, $F(2,70)=9.286$, $p<.001$, $\eta^2_p=.210$, where mathematical and verbal problems solutions result significantly higher than the special problems solution ($ps\leq .001$).

A second series of analyses explore the divergent thinking abilities differences in the

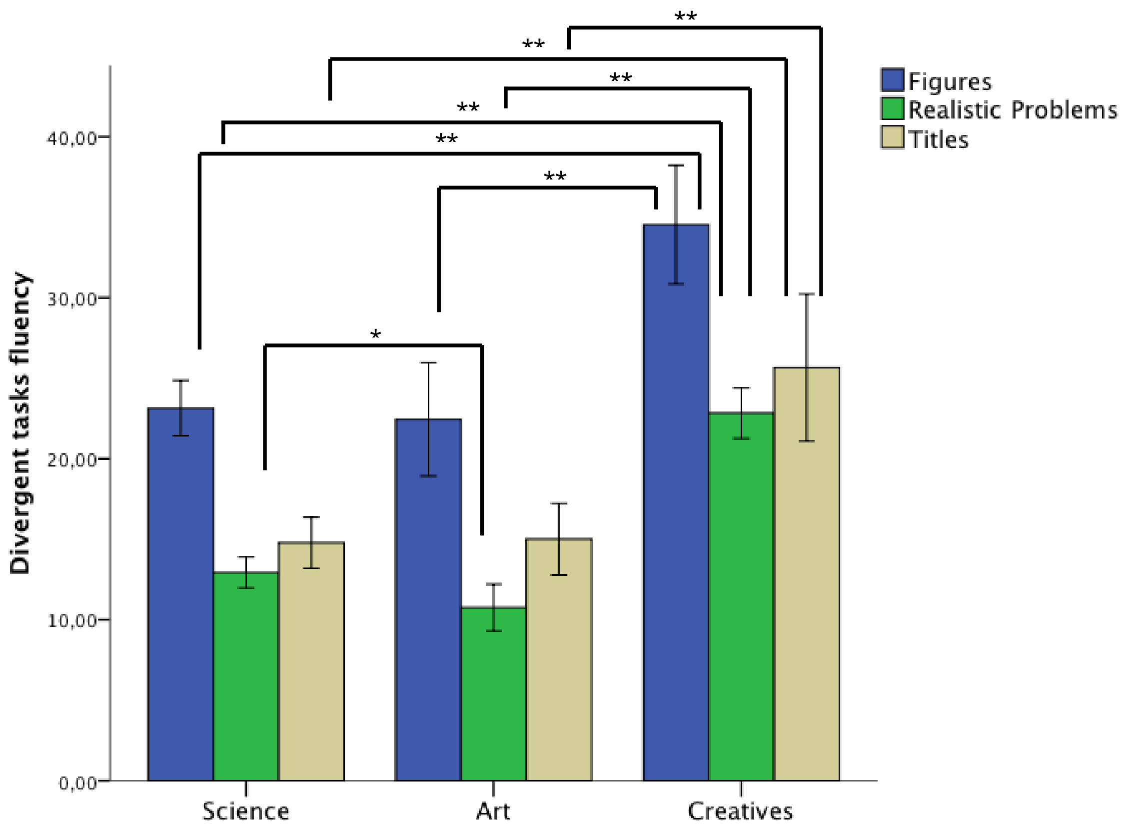


Figure 12. Fluency of produced solutions in the three divergent tasks (Figures, Realistic Problems, Titles) in the scientific, artistic and creative industry domains. Significant differences in divergent tasks fluency between the three domains are depicted in the Figure (** $\alpha \leq 0.01$; * $\alpha \leq 0.05$).

three domains. Starting with the analysis of the fluency in the three divergent tasks (Figure 12), a MANOVA analysis highlighted as fluency is significantly different in the three domains, $F(6,350)=17.859$, $p<.001$, $\eta^2_p=.232$. Further univariate ANOVAs show that this difference in the production of solutions is significant both in the Figures task, $F(2,176)=19.474$, $p<.001$, $\eta^2_p=.181$, in the Realistic Problems task, $F(2,176)=72.431$, $p<.001$, $\eta^2_p=.451$, and in the Titles task, $F(2,176)=19.801$, $p<.001$, $\eta^2_p=.184$. While scientific and artistic domain do not differ in fluency, except for a slight but significant difference in the realistic problems fluency (where art students show a lower fluency than science students, $p=.036$), creative professionals outperform scientific and artistic performance in all three tasks, always showing a significant higher production fluency ($ps <.001$). These results show that while art and science students are characterized by a similar solutions fluency in the divergent tasks, creative professionals are characterized by a significantly higher fluency ability than the other two tested samples, probability due to the higher expertise and to the nature of the creative professionals' work, that is strictly concerned with the production of always new alternatives.

A further analysis concerns the exploration of solutions frequency in the three divergent tasks across the three domains. Frequency is here expressed as the mean frequency of appearance of the solutions produced by all participants in the three knowledge domains (see Figure 13); this frequency score ranges from 0 (solutions produced by all participants) to 1 (solutions produced only one time within all participants). A MANOVA analysis highlighted as frequency is significantly different in the three domains, $F(6,336)=5.021$, $p<.001$, $\eta^2_p=.082$. Univariate ANOVAs showed that this difference is significant in particular in the Figures, $F(2,169)=11.177$, $p<.001$, $\eta^2_p=.117$, and Titles, $F(2,169)=9.093$, $p<.001$, $\eta^2_p=.097$ tasks. No significant difference emerged therefore in the frequency of the solutions produced in the Realistic Problems tasks between the three domains. Moreover, post-hoc analyses show that no difference emerged between scientific and artistic domains in the frequency of the solutions produced in the divergent tasks. However, post-hoc analyses also highlight that creative professionals are characterized by a better performance in frequency in the Figures and Titles tasks than science and art students ($p\leq .036$). These analyses therefore suggest that scientific and artistic domains are characterized by a similar performance in frequency in divergent tasks, while creative professionals outperform their performance.

Repeated-measures ANOVAs separately executed in the three domains highlight differences in the frequency of solutions across the three tasks both in the scientific domain, $F(2,186)=158.567$, $p<.001$, $\eta^2_p=.630$, in the artistic domain, $F(2,86)=77.946$, $p<.001$, $\eta^2_p=.644$, and in the creative industry domain, $F(2,66)=68.159$, $p<.001$, $\eta^2_p=.674$. In the scientific domain the better performance is obtained in the realistic problems ($ps\leq .006$) and the worst in the figures task ($ps<.001$). In the same way in the artistic domain the worst performance is obtained in the Figures task ($p<.001$) and the better in the Realistic Problems and in the Titles tasks. This result, however, does not mean that the responses produced within Figures task are less original than the responses produced within the other two tasks, as frequency and originality are two clearly distinct measures. Originality measures will be included in the analyses in the next period of the project, after a further recruitment campaign.

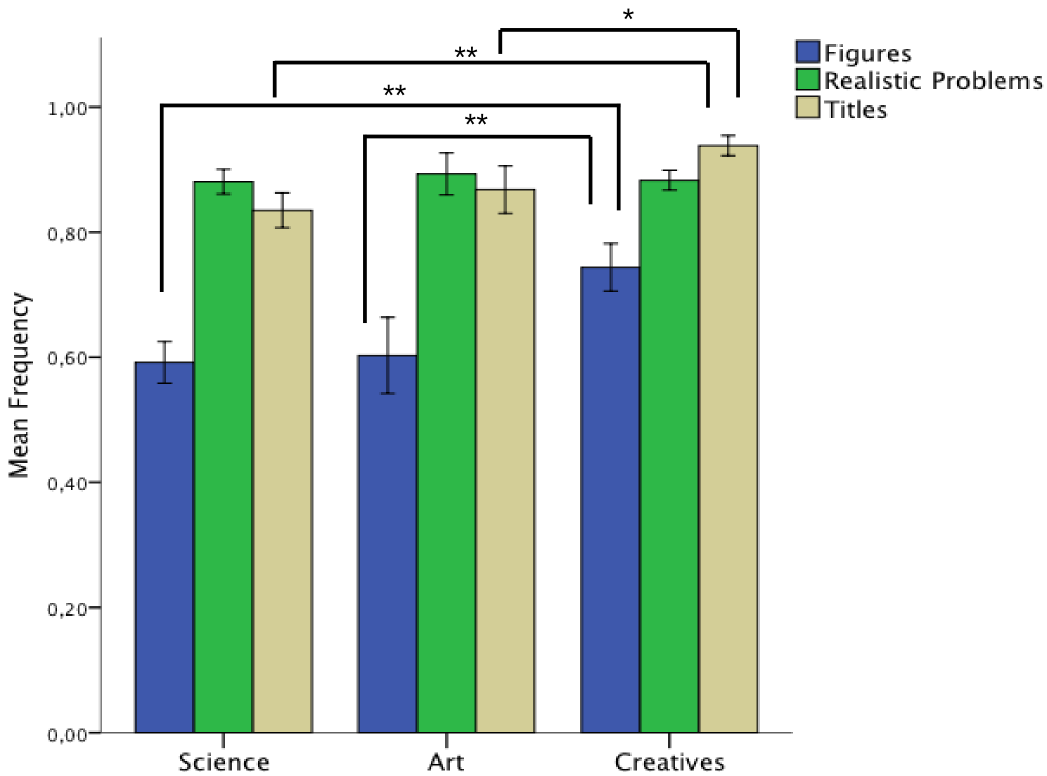
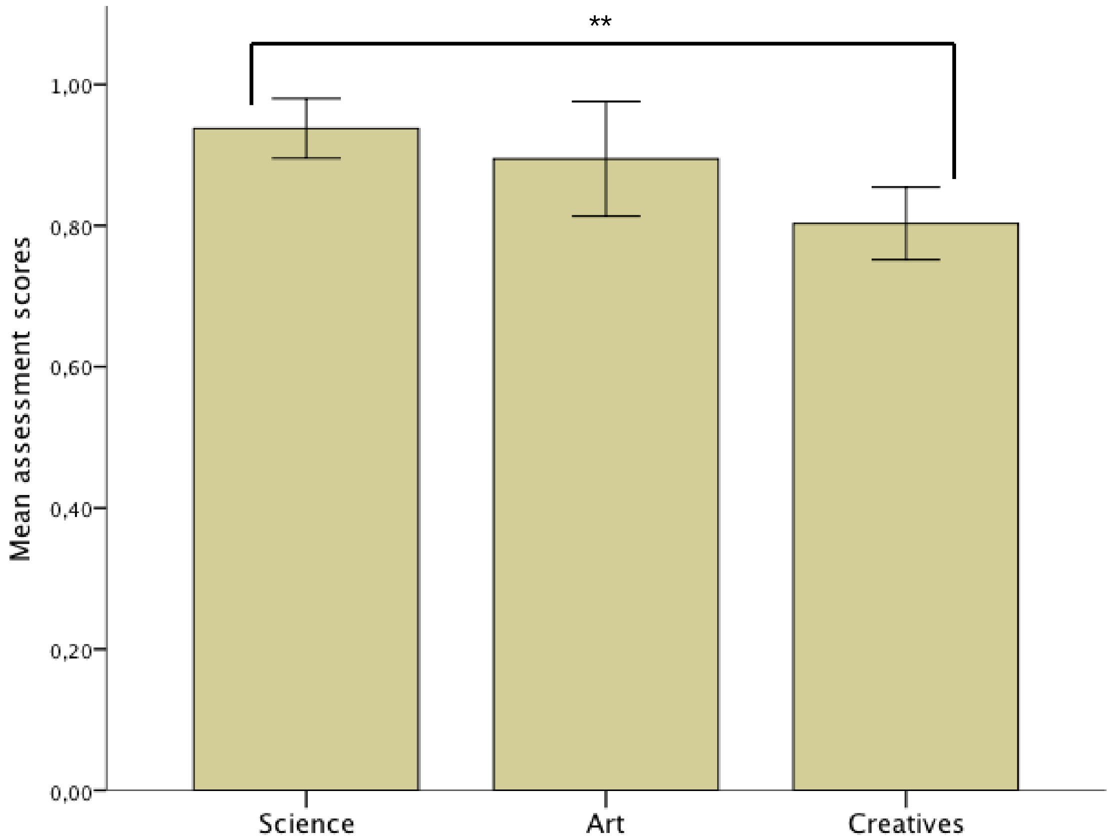


Figure 13. Mean frequency of appearance of the produced solutions (from 0 = produced by all participants, to 1 = unique solution) in the three divergent tasks (Figures, Realistic Problems, Titles) in the scientific, artistic and creative industry domains. Significant differences in frequency between the three domains are depicted in the Figure (** $\alpha \leq 0.01$; * $\alpha \leq 0.05$). For more information on the significant differences within each domain please refer to the text.

A final analysis explores the differences in the assessment ability between the three domains (Figure 14). The univariate ANOVA shows a significant difference in the assessment ability between the three domains, $F(2,188)=4.869$, $p=.009$, $\eta^2_p=.049$. Post-hoc analyses do not show significant differences between creative professionals and art students or between science and art students, but highlight a significant differences between creative professionals and science students ($p=.006$). This result shows that creative industry and artistic domains do not differ in their assessment ability, but, on the contrary, that creative professionals are more able to evaluate than science students. This findings could highlight that assessment ability could be enhanced by expertise. A correlation analysis indeed highlights that assessment ability is, even slightly, significantly negatively associated with age ($r=-.150$, $p=.038$), showing that at the increase of age, the ability to assess accordingly to the norm increases.

Figure 14. Mean assessment scores (0 means a total correspondence with the norm, i.e., the assessment provided by expert raters) in the scientific, artistic and creative industry domains. Significant differences in the assessment ability between the three domains are depicted in the Figure (** α ≤ 0.01; * α ≤ 0.05).



5.8.4 Science vs. Art vs. Creative domains: creative achievement

The final analysis of the present deliverable explores differences and similitudes in creative achievement between the three domains. Starting from creative achievement as measured by CAQ, a univariate ANOVA shows that differences exist between domains in creative achievement, $F(2,188)=14.101$, $p<.001$, $\eta^2_p=.130$ (Figure 15). In particular, post-hoc analyses show that while science and art students do not differ in creative achievement, creative professionals (even if characterized by a high variability in CAQ scores) show a high creative achievement than the two students' samples ($ps \leq .001$). This difference can be imputed to the fact that creative professionals involved in the CREAM test battery administration are professionals with years of expertise in the creative work; therefore, their higher creative success could be mainly related to their higher expertise and to their higher past experience.

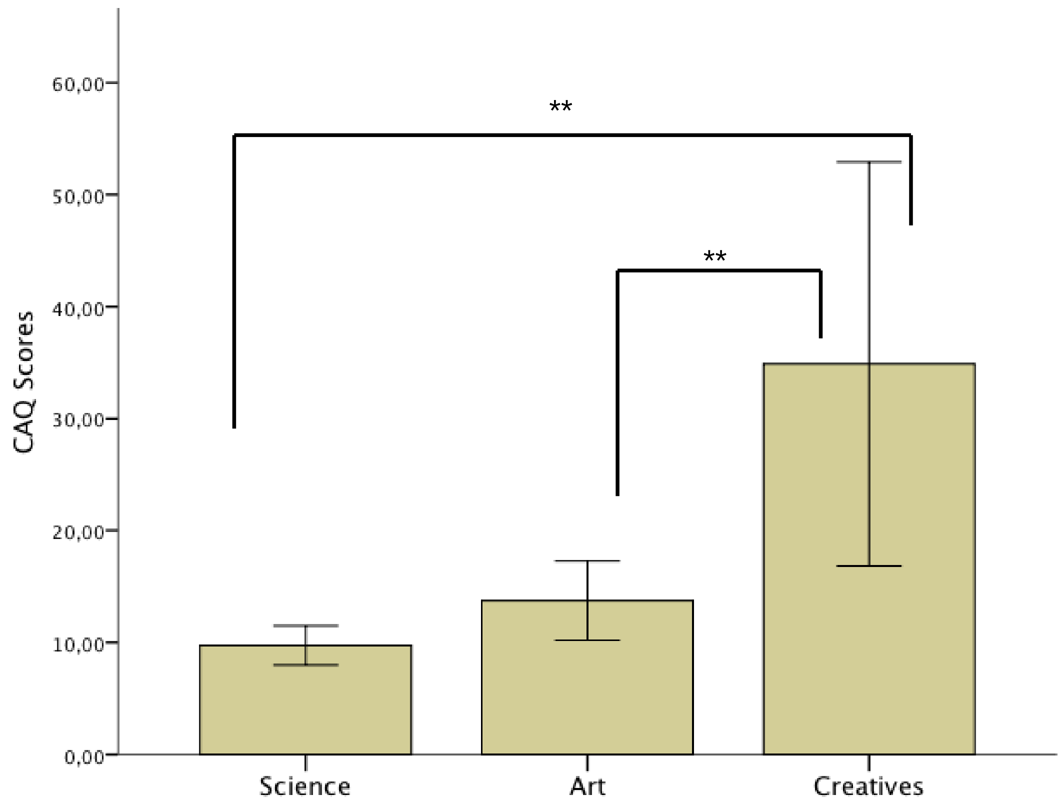


Figure 15. CAQ total scores in the scientific, artistic and creative industry domains. Significant differences in CAQ scores between the three domains are depicted in the Figure (** $\alpha \leq 0.01$; * $\alpha \leq 0.05$).

A second analysis explores differences in creative achievement on the basis of the more specific scores provided by CAAC. A MANOVA with the scores of the six subscales of CAAC as dependent variables shows that differences in creative achievements between the three domains exist, $F(12,366)=10.891$, $p<.001$, $\eta^2_p=.263$. In particular, univariate analyses reveal that these differences are significant in the scientific achievement within the scholastic/working environment, $F(2,187)=32.244$, $p<.001$, $\eta^2_p=.256$, in the artistic creative achievement within the scholastic/working environment, $F(2,187)=22.102$, $p<.001$, $\eta^2_p=.191$, in the everyday creative achievement within the scholastic/working environment, $F(2,187)=12.178$, $p<.001$, $\eta^2_p=.115$, in the scientific creative achievement outside the scholastic/working environment, $F(2,187)=13.056$, $p<.001$, $\eta^2_p=.123$, in the artistic creative achievement outside the scholastic/working environment, $F(2,187)=21.742$, $p<.001$, $\eta^2_p=.189$, but not in the everyday creative achievement outside the scholastic/working environment, where the three domains show a similar high achievement level (Figure 16).

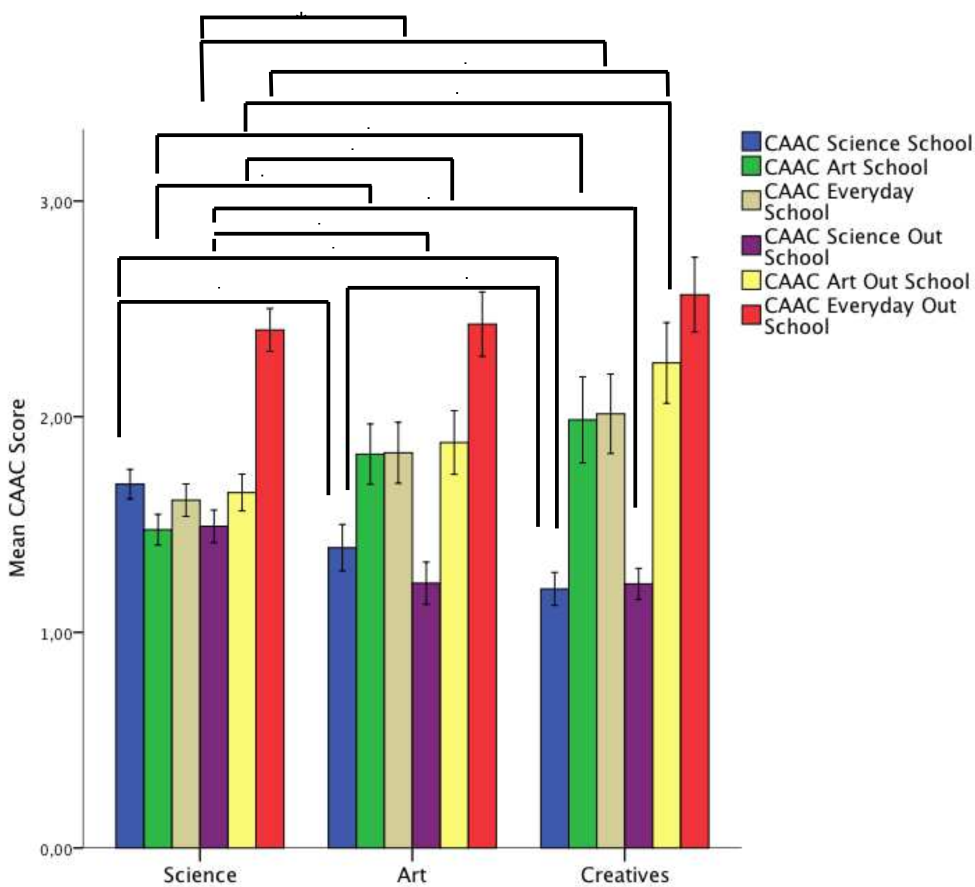


Figure 16. Creative achievement as measured by the CAAC in the scientific, artistic and creative industry domains. Significant differences in creative achievement between the three domains are depicted in the Figure (** $\alpha \leq 0.01$; * $\alpha \leq 0.05$). For more information on the significant differences within each domain please refer to the text.

Post-hoc analyses show that scientific creative achievement within school/work is higher in science students than in art students ($p<.001$), who in turn are characterized by higher creative achievement than creative professionals ($p=0.038$). This result could in part be related to the different demands of the environments where students and creative professionals mainly operate; while students (in particular science students) in university must face scientific subjects, creative professionals within their working environment mainly face artistic issues. This interpretation finds a possible validation from the outside of the school/work results; post-hoc analyses indeed show that science students are characterized by a higher scientific creative achievement outside school/work than art students and creative professionals ($ps<.001$), and that the last two participants' samples are characterized by a similar low level of scientific creative achievement. As for artistic creative achievement, artistic domain always shows (both within and outside school) a higher achievement than scientific domain ($ps<.021$). In the same way, creative professionals always show a higher artistic creative achievement than science students ($ps<.001$), while they show a higher artistic creative achievement than art students only outside the scholastic/working environment ($p=.002$). While everyday creative achievement do not show differences between the three domains outside the scholastic/working environment, within the scholastic/working environment creative professionals show higher everyday creative achievement than science students ($p<.001$), but not than art students, who in turn show higher achievement levels than science students ($p=.018$). Summarizing, these results highlight that the scientific domain is characterized by a higher scientific creative achievement than artistic and creative industry domains, but at the same time that it is characterized by lower levels of artistic and everyday creative achievement, especially within the scholastic/working environment. Finally, we can observe that creative professionals are characterized (as already highlighted by the CAQ results) by higher levels of creative achievement than the other two domains (except for the scientific creative achievement).

Finally, repeated-measures ANOVAs were conducted separately for the three domains. In the three domains, differences in the achievement measured by the six subscales emerged (Scientific domain: $F(5,540)=126.144$, $p<.001$, $\eta^2_p=.539$; artistic domain: $F(5,220)=68,908$, $p<.001$, $\eta^2_p=.610$; creative industry domain: $F(5,175)=98.800$, $p<.001$, $\eta^2_p=.738$). In all three domains everyday creative achievement outside the scholastic/working environment presents the higher scores ($ps<.001$), but while in the scientific domain scientific creative achievement results to have higher scores than artistic creativity, in the artistic and creative industry domains artistic creative achievement is higher than scientific creative achievement.

6. Concluding section

First of all, some general considerations on the CREAM battery administration can be drawn. The test battery emerged as a cognitive demanding measurement method, which required several efforts from the participants. More participants than the 200 subjects foreseen in the planned activity have been involved in the battery administration; however, not all participants completed the entire test battery. From the 235 participants involved in the administration, 192 completed at least the 80% of the battery. The administration campaign will therefore continue also during the second year of the CREAM project. The recruitment of other participants will in particular allow balancing the sample across the three domains (the campaign will be in particular devoted to the recruitment of participants in the artistic and in the creative industry domains).

Moreover, some general conclusions from the results emerged from the analyses presented in the previous sections can be drawn. First of all, the results confirm a good reliability of the measurement methods adopted within the CREAM test battery. More specifically, these show a good reliability in the particular participants' sample recruited within the CREAM project. The analyses on the CAAC method demonstrated, in particular, a good reliability of all six subscales measuring creative achievement in scientific, artistic and everyday areas both within and outside the school/working environment.

In addition, the correlational analyses strengthen the evidences on the discriminant and convergent validity of some tasks used within the battery. The results, for example, confirm that convergent and divergent tasks measure two distinct constructs, i.e., convergent thinking and divergent thinking, respectively. At the same time, the high associations between divergent thinking measures (as well as the high associations between the different kinds of insight problems) confirm that these tasks measure a unique construct. Moreover, the associations between the two measures of creative achievement, CAQ and CAAC, confirm that both methods converge on the measurement of the same construct, but, at the same time, specify that CAQ is mainly concerned with the measurement of artistic creative achievement. Finally, the positive associations between intrinsic motivation and the outside school/work creative achievement scores of CAAC seem to suggest that the measurement of creative achievement outside school/work is related to higher levels of intrinsic motivation, exactly as hypothesized in the development of the CAAC checklist.

The associations emerged from the correlation analyses allow to draw some considerations also on the relationships between creative tasks and tendencies measured within the CREAM test battery. A first consideration concerns the different data trends characterizing assessment ability and ideational abilities. The results emerging from these analyses seem to highlight that assessment ability is a clearly distinct ability from ideational abilities, in particular from divergent thinking. However, some significant associations emerged between assessment ability and convergent abilities highlighting that these two abilities are somewhat related. We hypothesize that they could be associated by a similar ability to converge to the norm, in the case of convergent ability to converge to the right answer, in the case of assessment ability to converge to recognized and shared norms.

Moreover, general trends emerged from the associations of convergent and divergent abilities with intelligence and personality. While, indeed, convergent abilities are mainly related to intelligence, divergent abilities are mainly associated with personality traits and tendencies, in particular with Extraversion and Openness traits, and with higher levels of intrinsic motivation and self-efficacy. These associative trends seem to suggest that convergent abilities are cognitive-related abilities, while divergent abilities are personality-related abilities.

Convergent thinking abilities and divergent thinking abilities are also differently associated with creative achievement in scientific, artistic and everyday creative achievement. Convergent abilities are mainly related to scientific creative achievement, while divergent abilities are mainly related to artistic and everyday creative achievement. At the same time, intelligence resulted more related to scientific creative achievement, while Openness, Extraversion, and Intrinsic motivation resulted more related to artistic and everyday creative achievement.

Further considerations are devoted to the differences and similarities emerged from the analyses between the three explored knowledge domains. As for personality traits and tendencies, the participants from the scientific domain and the participants from the artistic domains seem to be characterized by similar personality trends. However, creative professionals seem to be characterized by differences in personality compared to science students, in particular they show higher levels of Extraversion, Emotional Stability, and Openness. Furthermore, art students did not show differences in personality from creative professionals, highlighting that the creative industry domain is characterized by a personality structure more similar to the artistic domain than to the scientific domain. Also the results on intelligence highlighted a similar trend, with science students performing better in cognitive tasks than art students and creative professionals. Creative professionals moreover are characterized by a higher level of divergent abilities (in particular fluency) than science and art students, which are characterized by a similar data trend in divergent tasks. In the same way, creative professionals exhibited higher levels of creative achievement in artistic and everyday areas than artistic and scientific domains. Science students are obviously characterized by higher levels of scientific creative achievement than art students and creative, whereas art students are characterized by higher levels of artistic creative achievement than science students.

Finally, these data seem to indicate that creative achievement in scientific, artistic, and everyday areas are associated with different creative abilities, personality traits and tendencies, and cognitive abilities (intelligence). At the same time, scientific and artistic domains seem to be characterized by similar structures in personality and divergent thinking abilities (even if scientific domain is characterized by higher convergent thinking abilities and intelligence than artistic domain). On the contrary the professionals of the creative industry domain show high levels of creative achievement and of creative abilities (both divergent thinking and assessment abilities) than the other two domains, especially of scientific domain.

These data will be further deepened during the second year activities. Thanks to the increase of participants' number, further indexes will be introduced (for example originality in the divergent thinking tasks) in the analyses and more in depth analyses will be provided to understand the significant predictors of creative achievement in the different areas and across the different domains.

6.1. Bibliography

Agnoli, S., Franchin, L., Rubaltelli, E., & Corazza, G. E. (in press). An eye-tracker analysis of the moderating effect of irrelevance processing between Openness and creative outcomes. Creativity Research Journal.

Agnoli, S., & Corazza, G. E. (2013). “TRIZ as seen through the DIMAI creative thinking model”. TRIZ Future Conference 2013 Proceedings, pp. 23-33.

Amabile, T. (1983). The social psychology of creativity. New York. NY: Springer-Verlag.

Amabile, T. M., Hill, K. G., Hennessey, B. A., & Tighe, E. (1994). The work preference inventory: Assessing intrinsic and extrinsic motivational orientations. Journal of Personality and Social Psychology, 66, 950–967.

Arden, R., Chavez, R. S., Grazioplene, R., & Jung, R. E. (2010). Neuroimaging creativity: A psychometric view.Behavioural Brain Research, 214, 143–156

Arthur, W., & Day, D. (1994). Development of a short form for the Raven Advanced Progressive Matrices test. Educational and Psychological Measurement, 54, 395–403.

Bandura, A. (1984). Recycling misconceptions of perceived self-efficacy. Cognitive Therapy and Research, 8, 213–229.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1997). Self-efficacy: The exercise of control. New York: Freeman.

Beghetto, R. A., & Kaufman, J. C. (2007). Toward a broader conception of creativity: A case for “mini-c” creativity. Psychology of Aesthetics, Creativity, and the Arts, 1, 73–79.

Batey, M., & Furnham, A. (2006). Creativity, Intelligence, and Personality: A Critical Review of the Scattered Literature. Genetic, Social, and General Psychology Monographs, 132, 355-429.

Bhattacharya, J., & Petsche, H. (2005). Drawing on mind’s canvas: Differences in cortical integration patterns between artists and non-artists. Human Brain Mapping, 26, 1–14.

Bowden, E.M, & Jung-Beeman, M. (2003) One hundred forty-four Compound Remote Associate Problems: Short insight-like problems with one-word solutions. Behavioral Research, Methods, Instruments, and Computers, 35, 634-639.

Carson, S. H., Peterson, J. B., & Higgins, D. M. (2005). Reliability, validity, and factor structure of the Creative Achievement Questionnaire. Creativity Research Journal, 17, 37–50.

Chiesi, F., Ciancaleoni, M., Galli, S., Morsanyi, K., & Primi, C. (2012). Item Response Theory analysis and Differential Item Functioning across age, gender and country of a short form of the Advanced Progressive Matrices. Learning and Individual Differences, 22, 390-396.

Corazza, G.E., Agnoli, S. “DIMAI: An universal model for creative thinking”, 2013, Marconi Institute for Creativity Internal Report, 1.

Csikszentmihalyi, M. (1996). Society. culture. person: A systems view of creativity. In R. J. Sternberg (Ed.), The nature of creativity, pp. 325-339. Cambridge: Cambridge University Press.

Dietrich, A. (2004). The cognitive neuroscience of creativity. Psychonomic Bulletin & Review, 11, 1011–1026.

Dietrich, A., & Kanso. R. (2010). A review of EEG. ERP and neuroimaging studies of creativity and insight. Psychological Bulletin, 136. 822-848.

Dow, G. T., & Mayer, R. E. (2004): Teaching students to solve insight problems: Evidence for domain specificity in creativity training, Creativity Research Journal, 16, 389-398.

Feist, G. J. (1998). A Meta-Analysis of personality in scientific and artistic creativity. Personality and Social Psychology review, 2, 290-309.

Gosling, S. D., Rentfrow, P. J., & Swann Jr., W. B. (2003). A very brief measure of the Big-Five personality domains. Journal of Research in Personality, 37, 504–528.

Guilford, J. P. (1950). Creativity. American Psychologist, 5, 444-454.

Guilford, J. P. (1967). The nature of human intelligence. New York: McGraw-Hill.

Guilford, J. P. (1968). Creativity, intelligence and their educational implications. San Diego, CA: EDITS/Knapp.

Jung-Beeman. M.. Bowden. E. M.. Haberman. J.. Frymiare. J. L.. Arambel-Liu. S.. Greenblatt. R.. et al. (2004). Neural activity when people solve verbal problem with insight. Plos Biology. 2. 500-510.

Hocevar, D. (1981). Measurement of creativity: Review and critique. Journal of Personality Assessment, 45, 450-464.

Kauman, J. C. (2009). Creativity 101. New York: Springer.

Knoblich, G., Ohlsson, S., & Raney, G.E. (2001) An eye movement study of insight problem solving. Memory & Cognition 29, 1000-1007.

Kounios, J., Frymiare, J. L., Bowden, E. M., Fleck, J. I., Subramaniam, K., Parrish, T. B., & Jung-Beeman, M. (2006). The prepared mind: Neural activity prior to problem presentation predicts subsequent solution by sudden insight. Psychological Science, 17, 882–890.

Kozbelt, A., Beghetto, R. A., Runco, M. A. (2010). Theories of creativity. In J. C. Kaufman & R. J. Sternberg (Eds.), The Cambridge handbook of creativity, pp. 20-47. New York: Cambridge University Press.

Lubart, T. I. (1994). Creativity. In R. J. Sternberg (Ed.), Thinking and problem solving (pp. 289–332). San Diego, CA: Academic Press.

Mednick, S. A. (1962). The associative basis of the creative process. Psychological Review, 69, 220-232.

Milgram, R. M. & Hong, E. (1999). Creative out-of-school activities in intellectually gifted adolescents as predictors of their life accomplishments in young adults: A longitudinal study. Creativity Research Journal, 12, 77-88.

Nusbaum, E. C., & Silvia, P. J. (2011). Are intelligence and creativity really so different? Fluid intelligence, executive processes, and strategy use in divergent thinking. Intelligence, 39, 36-45.

Prabhu, V., Sutton, C., & Sauser, W. (2008) Creativity and Certain Personality Traits: Understanding the Mediating Effect of Intrinsic Motivation. Creativity Research Journal, 20, 53-66.

Raven, J. (2000). The Raven's Progressive Matrices: Change and Stability over Culture and Time. Cognitive Psychology, 41, 1-48.

Raven, J. C., & Raven, J. (Eds.). (2008). Uses and abuses of intelligence: Studies advancing Spearman and Raven's quest for non-arbitrary metrics. Unionville, New York: Royal Fireworks Press.

Raven, J., Raven, J. C., & Court, J. H. (1998). Raven manual section 4: Advanced Progressive Matrices. Oxford: Oxford Psychologists Press.

Runco, M. A. (2007). Creativity. San Diego, CA: Academic Press.

Runco, M. (2007). Creativity. Theories and themes: research, development and practice. Elsevier Academic Press.

Runco, M. A. (Ed.). (2013). Divergent thinking and creative potential. Cresskill, NJ: Hampton Press.

Runco, M. A., & Acar, S. (2012). Divergent thinking as an indicator of creative potential. Creativity Research Journal, 24, 66-75.

Runco, M. A., & Albert, R. S. (1985). The reliability and validity of ideational originality in the divergent thinking of academically gifted and nongifted children. Educational and Psychological Measurement, 45, 483–501.

Runco, M. A., & Chand, I. (1994). Problem finding, evaluative thinking, and creativity. In M. A. Runco (Ed.), Problem finding, problem solving, and creativity (pp. 40-76). Norwood, NJ: Ablex.

Runco, M. A., & Charles, R. (1993). Judgments of originality and appropriateness as predictors of creativity. Personality and Individual Differences, 15, 537-546.

Runco, M. A., Dow, G., & Smith, W. (2006). Information, Experience, and Divergent Thinking: An Empirical Test. Creativity Research Journal, 18, 269-277.

Runco, M. A., Illies, J. J., & Eisenman, R. (2005). Creativity, Originality, and Appropriateness: What do Explicit Instructions Tell Us About Their Relationships? Journal of Creative Behavior, 39 , 137 – 148.

Runco, M. A., Noble, E. P., & Luptak, Y. (1990). Agreement between mothers and sons on ratings of creative activity. Educational and Psychological Measurement, 50, 673-680.

Sandkühler, S., & Bhattacharya, J. (2008). Deconstructing Insight: EEG Correlates of Insightful Problem Solving. PLoS ONE 3(1).

Schwarzer. R. (1993). Measurement of perceived self-efficacy. Psychometric scales for cross-cultural research. Berlin, Germany: Freie Universitat Berlin.

Silvia, P. J., Wigert, B., Reiter-Palmon, R., & Kaufman, J. C. (2012). Assessing Creativity With Self-Report Scales: A Review and Empirical Evaluation. Psychology of Aesthetics, Creativity, and the Arts, 6, 19–34.

Simonton, D. K. (2012). Quantifying creativity: can measures span the spectrum? Dialogues Clin Neurosci, 14, 100-104.

Sternberg, R. J., & Lubart, T. I. (1995). An investment perspective on creative insight. In R. J. Sternberg & J. E. Davidson (Eds.). The nature of insight, pp. 386-426. Cambridge, MA: MIT Press.

Sternberg, R. J., & Lubart, T. I. (1999). The concept of creativity: Prospects and paradigms. In R. J. Sternberg (Ed.), Handbook of creativity, pp. 3-15. Cambridge: Cambridge University Press.

Torrance, E. P. (1974). Torrance test of creative thinking. Lexington. MA: Personal Press.

Ward, T. B., Smith, S. M., & Finke, R. A. (1999). Creative cognition. In R. J. Sternberg (Ed.), Handbook of creativity, pp. 189-212. Cambridge: Cambridge University Press.