

# EXPLORATION OF THE PSYCHOMETRIC QUALITIES OF THE WCR CREATIVITY TEST

FOR CREATIVE HIGHER VOCATIONAL EDUCATION IN THE NETHERLANDS

Master thesis

Katja Schilte  
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Educational Science and Technology  
Faculty of Behavioral, Management and Social Sciences  
University of Twente

Supervision:  
Dr. Bas Kollöffel  
Stijn de Laat

## Abstract

In order to keep up with the rapid changing environments, companies need to constantly innovate and demand employees that are able to think creatively. Therefore, it is important that universities encourage students to think creatively. Creativity tests can provide insight into students creative thinking level and could substantiate decisions that are made regarding the curriculum. One of these tests, the WCR-test, is suitable for educational purposes because it measures three mental operations of creative thinking (Widening, Connecting and Reorganizing) and is easy to score. However, it is not yet clear whether the WCR-test is a valid and reliable measurement instrument that measures creative thinking for students in higher vocational education.

This quantitative, cross-sectional research is set up to explore the reliability and validity of the WCR-test for higher vocational education. 519 Dutch students that attend a creative bachelor participated in this research, that consists of 2 studies. The first study investigates the WCR-test, and reports low reliability and validity. The second study further investigates the validity of the WCR-test and a possible solution to bring the validity and reliability to an acceptable level. It was concluded that different scoring methods and lengthening the tests positively influences reliability, but not to acceptable standards. Moreover, a correlation of sections of the WCR-test and corresponding creativity test (Guilford's Alternative uses, 1967; RAT, 1968) was not found. However, an explorative factor analysis confirms the presence of the cognitive mental operations *Widening*, *Connecting* and *Reorganizing* in the WCR-test and further underlines the theory of the WCR-model. Further improvements of the WCR-test are discussed.

*Key words:* Measurement of creativity, WCR-test, higher vocational education

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Exploration of the WCR creativity test  
for creative higher vocational education in the Netherlands

Ideally, education focusses on teaching students the knowledge and skills that they will need in their future life. Needless to say, it is difficult to determine what these skills and competencies will be. What we do know is that technologies change the world at an unprecedented pace, and together with the transition from an industrial to a knowledge economy, the problems that companies and their employees face have gained complexity. These often multidisciplinary problems demand the collaboration of multiple disciplines to get solved. Companies need to constantly innovate and be highly flexible in order to survive the ongoing changing environment, and therefore demand flexible and innovative employees (Schreyögg & Sydow, 2010).

Creativity is often mentioned as one of the necessary 21<sup>st</sup> century skills (Voogt & Pareja Roblin, 2010) to deal with the changing environment such as ICT-skills, collaboration and critical thinking. Back in 1967, Guilford already stated that “creativity is the key to education in its fullest sense and to the solution of mankind’s most serious problems” (p. 13) and to this day creativity remains a prominent topic amongst scholars (e.g. Antonietti, Colombo & Pizzingrilli, 2011; Cropley, 2001, 2009; Fasko, 2001; Harris, 2016). Schools in particular are places where creativity can be fostered, since they are full of situations where creativity can be applied to, and teachers can stimulate students creative reasoning (Cropley, 2009). Along with research on creativity, tests were developed to measure creative thinking, from which Guilford’s Alternative Uses Test (1967), the Torrance Creative Thinking Test (Torrance, 1968) and Mednick’s Remote Associates Test (Mednick, 1968) are the most well-known. In education, testing creativity can give insight into students’ creative potential (Cropley, 2000) and can result in well-founded decisions on multiple educational levels, such as policy, curriculum changes or individual assignments. Unfortunately, most creativity tests are not feasible for use in education. The testing procedure takes a lot of time, that is often scarce in education, and for most tests a professional is required to administer and analyse the test (Stubbé, Jetten, Paradies & Veldhuis, 2015). As a solution Antonietti, Colombo and Pizzingrilli (2011) designed the ‘WCR-test’, a short and easy to score test, that measures creative thinking of students. The test is in line with the WCR-model (Antonietti, Pizzingrilli & Colombo, 2011; Antonietti & Colombo, 2013), a theory about creative thinking that derives three cognitive mental operations of creativity: Widening (W), Connecting (C) and Reorganizing (R). The WCR-test gives teachers and educational designers insight into the creative thinking level of their students, specified on the three cognitive mental operations W, C, and R.

The WCR-test has been tested only on primary and secondary schools in Italy (Pizzingrilli, Valenti, Cerioli & Antonietti, 2015) but not yet on higher vocational education. This particular target group are of interest as they will join the labour market in the near future, where being creative is considered to be a useful skill (Sternberg & Lubart, 1996).

The aim of this research is to test the reliability and validity of the WCR-test for higher vocational education in The Netherlands. A sound test can give insight in the creativity level of students and the use of a creativity test can help teachers, school leaders and policymakers in making well-founded decisions when it comes to teaching students’ creativity.

## Creativity

In 1950, Guilford was one of the first to study creativity as an element that was separated from intelligence (IQ). He studied soldiers of the air force during the second World War and noticed that in difficult situations (e.g. when dodging an attack) the ability to find out-of-the-box solutions seemed to be a highly effective skill. Guilford noticed that it was not necessarily the most intelligent soldiers that survived difficult situations, but that another factor was of influence too: creativity. Highly creative pilots found obscure solutions to complex problems, which could positively affect their chance of survival (Guilford, 1950). After Guilford's discovery, others followed his footsteps and have been studying creativity since.

Over the years, the definition of creativity is a highly debated topic in literature (Treffinger, Young, Selby & Shepardson, 2002; Runco & Jaeger 2012). Nevertheless, Runco and Jaeger (2012) speak of a standard definition that is used in literature, wherefore the foundation lays in the 1950's. This standard definition entails that creativity consists of two parts: creativity requires both originality and effectiveness. Notable is that many definitions in literature describe the *production* of something, meaning that creativity conducts into a product. Mumford (2003) describes a consensus in literature and concludes that there is a "general agreement amongst scholars that creativity involves the production of novel, useful products" (p. 110). The term product is widely interpretable and can reflect to an actual product such as a work of art, or to something less tangible like a creative idea. Rhodes (1961) refers to creative products as 'artefacts of thoughts' (p. 309). Sternberg (2011) uses a definition that is bipartite as well, and describes creativity as "the production of something original and worthwhile" (p. 479). This definition is short, easy to understand and entails both elements of the standard definition, and will therefore be used in this study to define creativity.

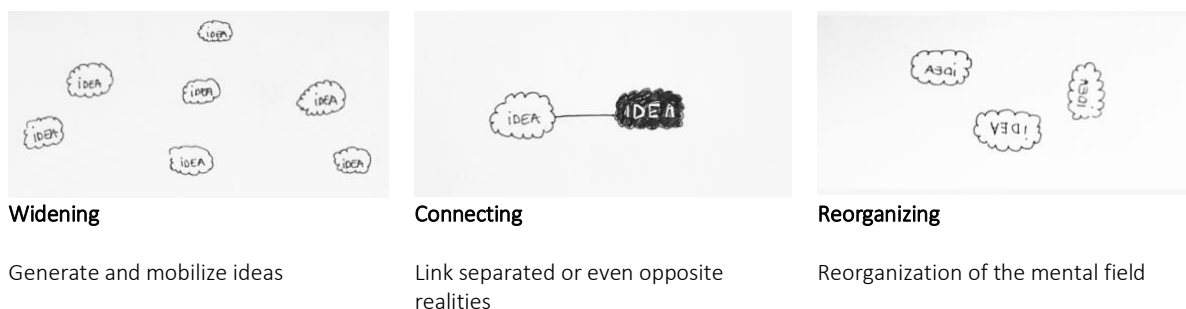
Creative thinking is a term that is closely linked with the term creativity. Where creativity is the production of something original and worthwhile, creative thinking is specifically about the production of original and worthwhile thoughts.

## Creative thinking and the WCR-model

Over the years many theories have been written about creative thinking, written from different perspectives. Antonietti et al. (2011; 2013) synthesizes and connects the main theoretical positions about creative thinking in a theoretical model: the WCR-model.

Antonietti et al. (2011; 2013) distinguish three main perspectives about creativity in the literature and relates them to three cognitive mental operations labelled as Widening (W), Connecting (C) and Reorganizing (R) (Figure 1).

Figure 1. Illustrative display of the WCR-model



Widening is described by Antonietti et al. (2011) as 'coming out from the limited conceptual framework ... and breaking all the thinking bonds that often restrain them' (p. 81). The Widening of the mental field will mobilize ideas, that results into new directions of thinking, which is necessary to produce something new and original. An example is given by the authors about the design of tennis rackets, that were produced with the same size for centuries. Although there were no restrictions about the size, no manufacturer thought of the possibility to change it. Then a sporting goods company came up with a 'big racket', a tennis racket with a bigger tailpiece that increased the chance of hitting the ball. The designer managed to widen the mental field which resulted in an improved product. The perspective in literature that Widening is derived from is in line with Guilford's divergent thinking theory (1950) that states that a creative person is able to produce numerous ideas to a stimulus. A creative person has a rich thinking flow and is open to follow new directions that result in original and uncommon ideas. However, not all ideas have value or are useful, which means that a process of selection takes place. This process of selection has resemblance with the evolution process (Campbell, 1960), because only the best ideas have a chance of survival.

Connecting is described by Antonietti et al. (2011) as the ability to link separated or even opposite realities. This is illustrated by multiple examples of scientists in history who discovered a new phenomenon almost by chance. For example, Wilhelm Röntgen, who saw a green luminescence next to the table where he was working on and brought this light in connection with the experiments he was conducting, leading to the discovery of x-rays.

Connecting is in line with the ideas of scholars like Vygotsky, Mednick Koestler and Rothenburg, who state that combining existing knowledge is part of the creative process. Creative ideas can emerge when a relationship is seen between different or even opposite realities. A far-fetched association can lead scientists and artists to brilliant original ideas.

Reorganizing, the third element of the WCR-model, is based on the idea that creativity occurs when there is a reorganization of the mental field. As an example, Antonietti et al. (2011) give the measurement of the volume of a small rock. As the volume of a ball or a cube can be calculated, there is no formula to calculate the volume of a rock without a consistent shape. The volume can be measured by putting it into a jug filled with water and checking the difference of the water level. Using a jug instead of a formula is a different approach to a problem and is an example of Reorganizing.

Reorganizing is later described as 'Reversing' by Antonietti & Colombo (2013). However, in this document the term 'Reorganizing' is used to describe the concept, because this term is used in the WCR-test. Reorganizing is a derivative from the ideas from the Gestalt psychologists (i.e. Wertheimer, Gruber and De Bono). This group of psychologist do not mention creativity, but describe the concept as 'productive thinking'. They believe that creativity takes place when the mental field is reorganized, which entails thinking about a concept or a problem from different perspectives or roles. A famous example are the 'thinking hats' of De Bono (1985), each hat is assigned to a different role and it is suggested to look at a problem with different hats on (i.e. from different roles or perspectives).

Creative thinking, the cognitive process that is closely linked with creativity, consists of the 3 mental operations Widening, Connecting and Reorganizing. As Guilford noticed in 1950, creativity is a useful skill that can be very advantageous in many situations. The measurement of creativity gives insight into someone's creativity level and can register possible changes. In education measuring creativity can help to make meaningful changes in the curriculum, in order to increase the creativity skills of students.

### Creativity tests

Stubbé, Jetten, Paradies and Veldhuis (2015) describe amongst others 4 characteristics of creativity that justifies the testing of creativity in education.

First, they state that creativity is a necessary skill to be successful. It is a useful skill in schools, but also later in the work field. This idea was already stated in 1950 by Guilford, and has been confirmed by scholars over the years.

Second, creativity can be developed and educated. Being creative is not a set skill, someone can learn to be more creative. Schools are undoubtedly places where creativity can be enhanced because schools provide multiple situations where creativity can be applied to and children can get support from their teachers to develop creative skills (Cropley, 2009). The contrary is also possible, Robinson (2016) emphasizes that schools can kill creativity as well. He states that children of a young age are all highly creative geniuses that lose their creativity over the years because of education. From this point of view, education should focus on maintaining creativity instead of teaching it.

Third, creativity can be present on different levels. This means that people are not either creative or not, one can also be a little creative or highly creative. Treffinger, Young, Selby and Shepardson (2002) state that creativity characteristics can be found on different levels that range from *not yet evident* to *excelling*. Finally, creative skills and characteristics can be observed. The many creativity tests that have been developed over the years (e.g. Besemer & O'Quin, 1986; Guilford, 1967; Mednick, 1968; Taylor & Ellison, 1968; Torrance, 1968) illustrate this.

Over the years many tests have been developed to measure creativity, the tests vary in focus (what is measured) and method (how it's measured). Cropley (2000) makes the distinction between tests that measure *creative products*, the *creative person* and the *creative process*.

Tests that measure the creative product investigate the level of creativity in, for example, a painting or a musical work. An example of a test that measures the creative characteristics of *products* is the Creative Product Semantic Scale (Besemer & O'Quin, 1986). This test measures novelty (the product is original), resolution (the product is valuable, understandable and useful), and elaboration and synthesis (the product is elegant, complex and well-crafted).

Tests that measure *creative person* focus on personality. An example is the Alpha Biographical Inventory (ABI), which measures family background, intellectual and cultural orientation (for example hobbies and interests), motivation, breadth of interest and drive towards novelty and diversity (Taylor & Ellison, 1968). A more recent test that focusses on the measurement of the creative person is the Creative ability test, which measures among other things curiosity, ingenuity and perseverance, and the environmental support of creative behaviour (Stubbé, Jetten, Paradies & Veldhuis, 2015).

Tests that measure creative thinking focus on the *creative process*. The WCR-test, that is used in this research, focusses on the cognitive aspects of creative thinking and therefore belongs to the category creative process. Therefore the main focus in this research is on tests that measure the creative process. Besides the WCR-test, there are other tests that focus on the creative process as well, such as the Alternative uses test, the TTCT and the RAT.

The *Alternative Uses test* that is a part of the Structure of Intellect test (SI) by Guilford (1967) that measures intellectual processes. The Alternative Uses test measures divergent thinking and asks participants to come up with as many alternative uses for an object they can think of and scores the answers on fluency, originality, flexibility and elaboration. The SI test and it's corresponding model has been criticized by researchers over the years (e.g. Carroll, 1993), but the alternative uses test is still in use for the measurement of divergent thinking (e.g. Dippo & Kudrowits, 2013).

The *Torrance Test of Creative Thinking* (TTCT) by Torrance (1968) was revised in 1999 and is nowadays still considered to be a valid and reliable test. The test measures creative thinking in a verbal section 'Thinking creatively with words' and a figural section 'Thinking creatively with pictures'. Categories that are scored



are fluency, flexibility, originality, elaboration, abstractness and resistance to premature closure. The interrater reliability is in most cases over .90 and the test retest commonly lie between .60 and .70 (Cropley, 2000).

Another well-known creativity test that measures creative thinking is the *Remote Associates Test* (RAT) by Mednick (1968). The 30-item tests that measures convergent thinking, consists of stimulus words (for example room, blood, salt) and the task is to find the word that links the three stimulus words (in this case: bath). The test is based on the idea that the more words a person finds, the more creative this person is. Mednick reported internal consistency coefficient of .91 and .92, and a correlation with an instructor's rating on a design course of .70.

The Alternative uses test, the TTCT and the RAT all have an overall similar scoring approach. The answers are checked on accuracy and are then compared to answers of others; answers that are frequently given are considered to be less creative than answers that are less frequently given. This means that the answers are scored to be effective and on originality, which are the key elements of creativity (Runco and Jeager, 2012).

The aforementioned tests that measure the creative process can be used in education, but their characteristics do not make them ideal. They have open ended questions (e.g. Alternative uses test, TTCT, RAT) and some have figural assignments (e.g. TTCT) that make the tests difficult and timely to score and often elaborative guidelines are necessary for scoring (e.g. Alternative uses test, TTCT). Moreover, these tests measure either divergent thinking (Alternative uses test), convergent thinking (RAT) or both (TTCT), which correspond with the cognitive mental operations Widening and Connecting of the WCR-model, but the tests do not measure the third element Reorganizing.

The WCR-test by Pizzingrilli et al. (2015) was specifically designed for use in education and measures all three mental operations (W, C and R). The goal of the test is to assess student's creative thinking abilities, in order to adjust education (classes, individual or group assignments, curriculum or policy) accordingly. The test was originally designed for elementary and secondary education and aims to function as a practical measurement instrument in order to help teachers get insight into the creative thinking skills of their students.

The character of the test is different from other tests that measure creative thinking, instead of open ended questions, the WCR-test uses multiple choice questions. This makes it very easy to score, since the answers can only be interpreted in one way. Moreover, interrater reliability is not an issue.

The scoring methods of the WCR-test is very simple, the answers that are given are compared to the answers given by others. The level of creativity is determined by the frequency of the given answer. For example, if 75% of the respondents give answer A and 25% chooses answer B, answer B is considered to be more creative than answer A. It can be argued whether this test measures the whole construct of creativity (i.e. the production of something original and worthwhile). The tests seems to measure originality by scoring the answers on frequency, however, due to the multiple choice character of the test participants can simply pick an answer and do not have to come up with a worthwhile idea.

### **The present study**

This study is set up to examine whether the WCR-test is a suitable measurement instrument for higher vocational education.

The WCR-test has been tested on primary and secondary schools in Italy and results show that the test measures creative thinking and the three corresponding mental operations of creative thinking. The results also show significant differences between age levels, but a developmental trend was not found (Pizzingrilli et al., 2015).

Besides, the test was administered by Italian students from higher vocational education by Antonietti and colleagues and the unpublished data is available. This data is not yet further analysed.

An easy to use test for the measurement of creativity is not yet available in higher vocational education.

This is remarkable, since the labour market where the students will enrol in demands innovative employees that can think creatively.

The WCR-test may be a suitable test for the measurement of creative thinking in higher vocational education, but the validity and reliability of the test are not yet confirmed. This study aims to explore the reliability and validity of the WCR-test for higher vocational education. In study 1 the reliability and validity are investigated and compared to the Italian dataset. Study 2 further investigates the outcomes and explores potential improvements for the test.

## Study 1

In study 1 the WCR-test is evaluated for the measurement of creative thinking among Dutch higher vocational education students. The WCR-test seems suitable for use in educational settings because of its simple nature: the test does not take a lot of time to fill in, it is easy for teachers to administer the test, and the multiple-choice character makes the test easy to score. Moreover, the test measures the three cognitive mental operations of creativity. However, it is unclear whether the WCR-test is sufficiently reliable and valid.

Students from higher vocational education, with a creative bachelor study such as Building Environment and Art Teacher participated in the research. Educators in these specific types of studies are likely to be interested in their students' level of creative thinking and are expected to use the creativity test in the future.

This quantitative, cross-sectional study aims to determine whether the WCR-test is a valid and reliable measurement instrument for Dutch students

The following research question and corresponding hypothesis are central in this study:

*Can creative thinking among (Dutch) higher vocational education students with a creative bachelor be measured in a reliable and valid way, when using the WCR-test?*

Hypothesis 1.1 The WCR-test is a valid and reliable measurement instrument that measures creative thinking.

Hypothesis 1.2 The reliability of the WCR-test conducted in the Netherlands with Dutch students is comparable to the WCR-test conducted in Italy with Italian students.

Hypothesis 1.3 The WCR-test measures the cognitive mental operations of creative thinking Widening, Connecting and Reorganizing.

## Method

### Participants

Data was collected from 6 higher vocational education universities. All students are currently undertaking a bachelor with a creative character, such as building environment, fashion textile technologies, and various bachelor studies of art academies. The universities are spread over different regions in the Netherlands, some of them are in the highly populated Randstad (Hogeschool Rotterdam, Koninklijke Academie voor Beeldende Kunsten Den Haag) and some of them are located in a more rural area (Hanzehogeschool Groningen, Saxion Enschede and Hogeschool Arnhem-Nijmegen). The students ( $N = 519$ ) have an average age of 20 years old. Table 1 shows the number of students per university, gender and study year. Students participated from all 4 study years, the first year students  $N = 269$  are the largest group, followed by the second ( $N = 144$ ), the third ( $N = 94$ ) and the fourth year students ( $N = 12$ ). Fourth year students were found to have less time available and were less often present in a class setting, and are therefore less present in the dataset.

Table 1.

*Percentage of students per university of higher vocational education, gender and study year.*

University	N	Gender		Study year			
		Male ( $n = 298$ ) (%)	Female ( $n = 221$ ) (%)	Year 1 ( $n = 269$ ) (%)	Year 2 ( $n = 144$ ) (%)	Year 3 ( $n = 94$ ) (%)	Year 4 ( $n = 12$ ) (%)
Hogeschool Arnhem/Nijmegen	47	68.1	31.9			100	
Hanze Hogeschool	243	73.7	26.3	54.7	34.2	10.3	.8
KABK Den Haag	37	24.3	75.7	37.8	8.1	40.5	13.6
WdKA Rotterdam	12	8.3	91.7		100		
Haagse Hogeschool	120	56.7	43.3	52.5	37.5	5.8	4.2
Saxion Enschede	60	15	85	98.3	1.7		
Total	519	57.4	42.6	51.8	27.7	18.1	2.3

### Procedures

The students were asked during their class to fill in the WCR-questionnaire. In advance, the students were informed by the researcher about the purpose of the test (testing creative thinking) and the length of the test (9 items). The students were asked to fill in the test individually, without discussing answers with other students, and during the test the researcher was present to keep an eye on this. The students received a hyperlink to a webpage with the online questionnaire. Students could administer the test in the browser of their phone or laptop, and were free to choose their most suitable device. Students were asked to fill in the test during their classes and it was made clear that participating was not mandatory. At the first page, prior to the questionnaire, students were asked for consent to approve the use of the (anonymous) data. On the end of the questionnaire students could leave their email address in order to win a gift card, it was made clear to the students that the data would then lose its anonymity.

**Instrumentation**

The WCR-test (Appendix A) that was used in this study is specifically designed for students by Antonietti et al. (n.d.) and measures creative thinking and the three cognitive processes (Widening, Connecting and Reorganizing) regarding to creative thinking.

The test was available in English and was translated to Dutch. Both versions of the test (English and Dutch) were uploaded to the online questionnaire, so students could choose their preferred language.

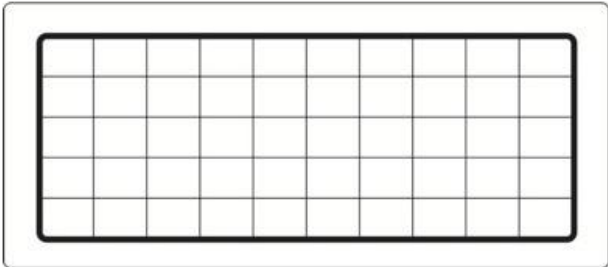
The test consisted of 9 questions that were divided over three sections W, C and R. The Widening process (section W) reflects the tendency to generate ideas. An example of a question in section W is shown in Figure 2.

The Connecting process (section C) refers to the capacity to combine different elements in unusual ways. An example of a question from section C is: ‘Think of the colour “black”. Which of the words listed below does “black” make you think of? (Choose 3 answers)’. Possible answers are: Night, Ink, Batman, Hearse (funeral car), Zorro, Coal, Panther, Elegance and Mulberry.

The Reorganizing process (section R) consists of changing the perspective and inverting relationships among elements. An example question of section C is ‘What would happen if people slept during the day and were awake at night?’. ‘Safety helmets would include lights’, or ‘Sunglasses would not be sold’ are examples of possible answers.

Figure 2. Example question of section Widening of the WCR-test

**W1 – What may this picture represent? (choose 1 answer)**



A rectangle with many small squares inside

A food grill

A chocolate bar

A calendar

In order to score the items of the multiple-choice test, the same method was used as the method in the research of Pizzingrilli, Valenti, Cerioli & Antonietti (2015), where the score is based on the frequencies of the answers. Answers that are least frequent chosen are scored as the most creative answers and answers that are given by many students are scored as the least creative. A score is given to an answer by subtracting the frequency percentage from the total percentage.

Example: For item X, 10% of the students choose option a, 40% option b, 25% option c and 25% option d. This means that option a gets a score of 90 ( $100 - 10$ ) and option b a score of 60 ( $100 - 40$ ), option c and d score 75 ( $100 - 25$ ). Option a is the least frequently chosen and is considered to be most creative, and therefore gets the highest score.

The sum of the scores divided by the number of questions of the section (W, C or R) result in an average total score per section. The total score (W, C and R) was calculated as the sum of the three sections divided by three.

### **Data collection and analysis**

The data will be analysed to check the validity and the reliability of the WCR-test. First, the reliability of the three sections (W, C and R) is analysed by using Cronbachs' Alpha interitem test, that measures consistency within the sections. The rules of thumb of George and Mallery (2003) are taken into account where Cronbach's alpha of  $>.7$  is acceptable and  $<.5$  is unacceptable (p.231). Gliem and Gliem (2003) add that Cronbach's alpha of  $.8$  is a reasonable goal (p. 87). Moreover, it is examined whether a different scoring method (taking one school as a reference to extract a score, versus taking all schools as a scoring reference) has an effect on the reliability.

Cronbach's alpha of the test that was administered with Dutch students, will be compared with Cronbach's alpha of data that was gathered in a similar explorative research amongst Italian students by Antonietti et al. (n.d.).

Furthermore, a factor analysis was conducted in order to determine construct validity. It was expected that the items show correlation with the intended factors (W, C, and R).

## Results

The purpose of this study was to determine the reliability and validity of the WCR-test. First, descriptive statistics are given of the study. Secondly, the reliability was explored by determining Cronbach's Alpha and deleting items to increase the latter. Third, a factor analysis was conducted to confirm the presence of the three thinking processes Widening, Connecting and Reorganizing are present in the WCR-test.

### Descriptives

Descriptive statistics of the WCR-test and its sections (Widening, Connecting and Reorganizing) are shown in Table 2. Connecting has the lowest average score ( $M = 55.61$ ;  $SD = 5.81$ ) and Reorganizing the highest average score ( $M = 75.90$ ;  $SD = 55.58$ ). Pearson's correlation analysis reveals that all three sections have a positive correlation with the total score on the WCR test. Furthermore, this analysis shows a positive correlation between Widening and Reorganizing ( $r = .14$ ). Table 3 shows the percentages of the frequencies per answer option and the corresponding score.

Table 2

*Pearson Correlations and Descriptive Statistics of Study Variables*

	1.	2.	3.	4.
1. Widening				
2. Connecting	.06			
3. Reorganizing	.14*	.07		
4. Total Score WCR	.81*	.48*	.53*	
<i>Mean</i>	62.52	55.61	75.90	64.68
<i>SD</i>	10.41	5.81	5.58	4.74

\*  $p < .01$

Table 3

*Percentages and scores per item of the WCR-test*

Item	Answer option	Percentage	Score
<b>Widening</b>			
W1 What may this picture represent?	a A rectangle with many small squares inside	39.5	60.5
	b A food grill	19.7	80.3
	c A chocolate bar	16.4	83.6
	d A calendar	24.5	75.5
W2 How many triangles are in this picture?	a 144	11	89
	b 192	7.5	92.5
	c 312	15.6	84.4
	d More than 312	65.9	34.1
W3 A paper sheet can be used to ...	a Write	51.8	48.2
	b Construct a paper boat	16.8	83.2
	c Build a fan	5.6	94.4
	d Fold under a moving table leg	25.8	74.2

THE PSYCHOMETRIC QUALITIES OF THE WCR CREATIVITY TEST

Connecting

C1 Which of the words listed below does "black" make you think of?	a	Night	78.2	21.8
	b	Ink	59.3	40.7
	c	Batman	31.2	68.8
	d	Hearse (funeral car)	16.8	83.2
	e	Zorro	12.3	87.7
	f	Coal	47.2	52.8
	g	Panther	22	78
	h	Elegance	28.5	71.5
	i	Mulberry	4.4	95.6

C2 Which of the words listed below does a cell phone make you think of?	a	A touch screen	41.6	58.4
	b	Energy	10.6	89.4
	c	Amusement	37.8	62.2
	d	SMS	13.1	86.9
	e	Being connected	69	31
	f	Time	24.5	75.5
	g	Communication	75.3	24.7
	h	A battery charger	23.9	76.1
	i	Protection	4.2	95.8

C3 Which of the things listed below would you insert into the painting?	a	Person from a different ethnic background	27.2	72.8
	b	Horse	53.9	46.1
	c	Tree	42	58
	d	Sun	18.7	81.3
	e	Oxcart	27	73
	f	Basket	28.5	71.5
	g	Bow with arrows	37.2	62.8
	h	Cloak	30.3	69.7
	i	Notebook	11.4	88.6
	j	Julius Caesar	23.9	76.1

Reorganizing

R1 What would happen if people slept during the day and were awake at night?	a	Electricity bills would be more expensive	29.5	70.5
	b	People would use more often flash when taking pictures	8.3	91.7
	c	Brunch will not exist	9.8	90.2
	d	People would work at night	35.3	64.7
	e	Sunglasses would not be sold	11.9	88.1
	f	Safety helmets would include lights	5.2	94.8

R2 What would happen if it was always summer and there were no seasons?	a	Fashion designers would propose a unique collection of clothes per year	7.3	92.7
	b	There would be more cases of sunburn and skin allergies	15	85
	c	Fireplaces and heaters would disappear from homes	20	80
	d	There would be drought	30.3	69.7
	e	People would ski only on artificial snow	14.5	85.5
	f	People would not make the change of seasonal clothes	12.9	87.1

R3 How might the plot continue?	a	Picture 1	33.3	66.7
	b	Picture 2	11.2	88.8
	c	Picture 3	33.5	66.5
	d	Picture 4	22	78



### Reliability of the WCR-test

Reliability was analysed by calculating Cronbach's Alpha interitem consistency. Cronbach's Alpha of the WCR-test and the sections are shown in Table 4. The complete test has a Cronbach's  $\alpha = .19$ , which is unacceptable according to George and Mallery (2003).

Deleting items from the test can increase Cronbach's Alpha. Table 3 reveals that Cronbach's Alpha can be raised to  $\alpha = .37$  if item W2 is deleted from the test. Despite an increase, the number is still not at the acceptable level of .70.

A similar study was conducted with Italian students ( $N = 450$ ). Analysis of this data shows that the Cronbach's alpha is  $\alpha = .40$ . Similar to the Dutch dataset, deleting item W2 leads to a higher Cronbach's alpha of  $\alpha = .46$ .

Table 4

*Cronbach's alpha of the WCR-test per section and for the total test.*

Test	N of Items	Cronbach's Alpha	
		Dutch students	Italian students
WCR Total	9	.19	.40
Widening	3	-.54	.09
Connecting	3	.23	.21
Reorganizing	3	.19	.21

### The effect of a different scoring method to the reliability of the WCR-test

For the scoring of an answer the frame of reference is important, because this categorizes whether an answer is creative or not. The reference group can be the total of respondents or for example the respondents per university.

The effect of two scoring methods on Cronbach's alpha were examined, one where the score of the test was calculated by taking all respondents from the Dutch dataset as a frame of reference, the other one with only the respondents from the same university as a frame of reference. Reliability analyses were conducted per university (Table 5). For example, the score of a KABK student can be calculated by taking the answers of the total dataset into account, or by taking the answers of the KABK students only.

The results show that the Cronbach's alpha shows a slight increase in all of the cases, except for Haagse Hogeschool where Cronbach's alpha drops from  $\alpha = .19$  to  $\alpha = .15$ . KABK shows the biggest difference in Cronbach's alpha, from  $\alpha = -.25$  to  $\alpha = .21$ .

Overall it can be concluded that calculating Cronbach's alpha within the universities in most cases causes a slight raise of the reliability statistic.

Table 5

*Influence of scoring method on Cronbach's alpha*

University	N	Cronbach's Alpha	
		Scoring based on data of all universities	Scoring based on data per university
Hogeschool Arnhem/Nijmegen	47	.21	.26
Hanze Hogeschool	243	.22	.23
KABK	37	-.25	.21
WdKA	12	.19	.25
Haagse Hogeschool	120	.19	.15
Saxion	60	-.05	-.01

**Exploratory factor analysis of the WCR-test**

In order to determine the validity of the WCR-test an exploratory factor analysis was conducted. An exploratory factor analysis (Table 6) with Varimax rotation confirms the presence of the sections Widening, Connecting and Reorganizing in the WCR-test and one other factor. 4 components were extracted from the dataset, all with Eigenvalues > 1.00, explaining 17% of the variance. Three items (W1, W3 and R1) load to one factor that was labelled Widening. Item R1 also loads onto another factor which includes R2 and R3 and was labelled Reorganizing. Three items were loaded for Connecting (C1, C2 and C3). Item W2 loads to a separate factor that is labelled as 'Other' as well as item C2 that loads negatively to this factor.

Table 6

*Rotated component matrix of exploratory factor analysis of the 9 items of the WCR-test*

Item	Widening	Connecting	Reorganizing	Other
W1 <i>What may this picture represent?</i>	<b>,67</b>	-,01	-,02	,13
W2 <i>How many triangles are in this picture</i>	-,09	,09	,17	<b>,78</b>
W3 <i>A paper sheet can be used to ...</i>	<b>,66</b>	,27	-,05	-,14
C1 <i>What does 'black' make you think of?</i>	,33	<b>,56</b>	-,23	,31
C2 <i>What does 'cell phone' make you think of?</i>	-,05	<b>,47</b>	,07	<b>-,55</b>
C3 <i>What would you insert into the painting?</i>	-,03	<b>,75</b>	,13	-,07
R1 <i>What would happen if people slept during the day and were awake at night?</i>	<b>,57</b>	-,04	<b>,44</b>	-,20
R2 <i>What would happen if it was always summer and there were no seasons?</i>	,17	-,06	<b>,67</b>	,02
R3 <i>How might the plot continue?</i>	-,19	,15	<b>,61</b>	,15

Note: Factor loadings over .4 appear in bold.

## Conclusion and Discussion Study 1

The aim of this study is to determine the reliability and validity of the WCR-test. It was expected that the reliability would be of an acceptable value, and would be comparable to the reliability of the Italian dataset. Moreover, it was expected to find proof for the three cognitive mental operations of creative thinking (Widening, Connecting and Reorganizing) according to the WCR-theory.

However, results show a low reliability of the WCR-test in the Dutch and the Italian dataset, the Cronbach's alpha would be considered to be unacceptable. Deleting item W2 increases reliability, but the raise is not enough to get the Cronbach's alpha to an acceptable level.

An explanation for the low reliability can be the length of the test, 3 items per section and only 9 items in total is very minimal to measure creative thinking and it is expected that the addition of extra items will increase Cronbach's alpha (Dooley, 2009). This might not be a suitable solution for the WCR-test for primary or secondary education, where the concentration span of children might be shorter, but for students of higher vocational education lengthening the test does not seem problematic. The effect of additional items to the reliability of the WCR-test is examined in study 2.

Notable was that the Italian dataset showed a slightly higher Cronbach's alpha compared to the Dutch dataset. A possible explanation for this could be the reference frame that is used for scoring. The students in the Italian study all come from the same university, and scoring the test with a homogeneous group as a reference might improve the reliability of the WCR-test. Therefore, it was examined whether the frame of reference that is used when scoring the answers is of influence. The score that an answer receives depends on the responses of the rest of the dataset: an answer that is often chosen is considered to be less creative than an item that is chosen by a small group. It can be argued that taking all the data as a frame of reference for scoring might lead to too much difference, because an answer can be creative for the students of Building Environment, but might not be creative for students of Art Teacher. Therefore, the scoring was calculated in two ways: by taking the answers of all students into account, and by taking answers per university into account. Taking the university as a frame of reference into results in a slightly higher reliability in 5 out of 6 cases.

In line with the WCR-model (Antonietti et al. 2011; 2013), the factor analysis revealed the presence of the cognitive mental operations Widening, Connecting and Reorganizing in the WCR-test. This further underlines the theory of the WCR-model about creative thinking.

However, the factor analysis shows 3 items that stand out. Widening item W2 'How many triangles are in this picture?' is the only item that appears as separate component. The item stands out between the other questions, because the answer needs to be calculated. Also, this item is the only item that has one correct answer, whereas the other items present answers that can all be considered correct (i.e. A paper sheet can be used to ... A; write, B; construct a paper boat, C; build a fan and D; fold under a moving table leg). It is likely that participants will try to find the correct answer, which would measure numeracy instead of the mental operation Widening. Nevertheless, it can be argued that one needs creativity to solve mathematical issues (e.g. Nadjafikhah, Yaftian & Bakhshalizadeh, 2012; Silver, 1997), which indicates that the ability of solving a difficult mathematical issue is linked to a high level of creativity. In that case the scoring method for this item is wrong, because the highest score would be the correct answer and not the answer that is the least frequently chosen. Moreover, the difficulty level of the mathematical problem should be precisely adjusted to the level of the participants, because questions that are too easy would result in highly creative scores and vice versa.

Reorganizing item R1 'What would happen if people slept during the day and were awake at night?' shows resemblance with both Reorganizing and Widening. The reason for this is unclear, because the character of the item is very similar to item R2 'What would happen if it was always summer and there were no seasons?' which shows resemblance with Reorganizing only. This might indicate that the sections Widening

and Reorganizing overlap. Although the division between the mental operations is theoretically clearly defined (Widening describes the generation and mobilization of ideas and Reorganizing entails thinking about a problem from different perspectives), it is plausible that in practice these mental operations are not that strictly separated, which explains the resemblance of item R1 to both Widening and Reorganizing.

Despite the confirmation of the presence of three sections in the test, it is unclear if these sections measure the three cognitive mental operations Widening, Connecting and Reorganizing. The students did the WCR-test only, so the results cannot be compared with another creativity test, which is one of the limitations of this study.

In conclusion, it is still unclear to determine whether the WCR-test is suitable for higher vocational education. Study 2 further explores the reliability issues and further investigates the validity of the constructs of creative thinking.

## Study 2

Study 2 is set out to further explore the outcome of study 1, that determined low reliability and validity. To increase reliability, lengthening a questionnaire is a well-known method (e.g. Dooley, 2009 p. 83). A balance must be considered between the length of a questionnaire and the reliability, a test that is too long might have a high reliability, but can be impractical for both researcher and participant. The WCR-test was originally designed for primary and secondary school, which explains its short character. Especially for primary education lengthening is unlikely to be a good solution since the concentration span of children is relatively short, but for students of higher vocational education lengthening the 9 item-test with additional items is not expected to be problematic.

The exploratory factor analysis of study 1 indicates the presence of the three cognitive processes of creativity present in the WCR-test. However, this does not confirm that the test measures creative thinking. To further investigate the validity of the WCR-test, it will be examined whether (sections of) the WCR-test shows correlation with two other creativity tests and the self-estimated creativity level of students.

Widening is extracted from the divergent thinking theory of Guilford (1950), and can be measured by Guilford's Alternative uses test (1967), which is a section of the Structure of Intelligence test (SI). In the test the participant is asked to think of as many alternative uses for an object, for example a brick. Items are scored on originality, fluency, flexibility and elaboration. Since the Alternative uses test and the Widening section of the WCR-test both claim to measure divergent thinking, it is expected that the scores of these two tests show correlation.

A similar comparison can be made with the Connecting section of the WCR-test and Mednick's Remote Associates Test (RAT, 1968), both tests measure convergent thinking and a correlation is expected between the scores of these tests.

Furthermore, a correlation is expected between the self-estimated creativity level and the overall score of the WCR-test. Studies show that students are able to self-estimate academic achievement (Ackerman, Chamorro-Premuzik & Furnham, 2011) and to estimate their own level of creativity (Putwain, Kearsley & Symes, 2012; Hughes, Furnham & Batey 2013). Therefore, it is expected that the total score of the WCR-test would show correlation with the answers on the question 'How would you estimate your own level of creativity?'

### Research questions and hypothesis

The following research questions and corresponding hypothesis are central in this quantitative, cross-sectional study:

*Does lengthening increase reliability of the WCR-test?*

Hypothesis 1 Lengthening the WCR-test will lead to a higher reliability.

*Is the WCR-test measuring creative thinking?*

Hypothesis 2.1 The Widening score of the WCR-test and the score of the Alternative Uses test shows resemblance.

Hypothesis 2.2 The Connecting score of the WCR-test and the score of the RAT shows resemblance.

Hypothesis 2.3 The self-assessed level of creative thinking of students shows resemblance with the total score of the WCR-test.

## Method

### Participants

Students from Fashion textile technologies of Enschede's university Saxion ( $N = 167$ ) participated in this study (Table 7). The first-year students (average age 20 years) consisted of two groups: a group of international students ( $N = 24$ ) and a group of Dutch students ( $N = 36$ ). Both groups did an additional creativity test on top of the WCR-test, the international students did Guilford's alternative uses test and the Dutch group of students did the RAT-test.

The second-year students ( $N = 107$ ) with an average age of 20 years did an extended version of the WCR-test, in Dutch ( $N = 81$ ) and in English ( $N = 26$ ).

Table 7

*Number of participants organized by study year, test type and gender.*

Study year	Student type	Creativity test	Male	Female
Year 1	International students	WCR-test + Alternative uses in English	5	19
	Dutch students	WCR-test + RAT in Dutch	4	32
Year 2	International students	Extended WCR in English	1	25
	Dutch students	Extended WCR in Dutch	9	72
			19	148

### Procedures

The students were asked during their class to fill in the WCR-questionnaire. In advance, the students were informed by the researcher about the purpose of the test (testing creative thinking), the length of the test and the time they had (about 15 minutes). The students were asked to fill in the test individually, without discussing answers with other students, and during the test the researcher was present to keep an eye on this.

The students received a hyperlink to a webpage with the online questionnaire. Students could administer the test in the browser of their phone or laptop, and were free to choose their most suitable device. At the first page, prior to the questionnaire, students were asked for consent to approve the use of the (anonymous) data.

At the end of the questionnaire students could leave their email address in order to win a gift card, it was made clear to the students that the data would then lose its anonymity.

### Instrumentation

The original 9 items WCR-test, that measures creative thinking out of the variables Widening, Connecting and Reorganizing, was done by the first-year students in English and Dutch (see paragraph 'Instrumentation' of Study 1).

The international group did the English version, followed by the Alternative uses test. The Alternative uses test consists of one question: 'List as many things you can do with a paperclip'. A text box was shown on screen where students could type their answers. A timer was added to the online webpage, that gave the students 5 minutes time to come up with as many alternative uses they could think of. After the 5 minutes passed, the webpage automatically submitted the answers and went on to the next page.

The Dutch first-year students did the WCR-test first, followed by Medick's RAT (Appendix B). The RAT test focusses on the Connecting element of creative thinking. Each item consists of 3 stimulus words, that should generate a fourth word. For example, the three stimulus words man / glue / star, would lead to the

fourth word 'super' (superman, superglue, superstar). A 22-item translated version to Dutch of Mednick's RAT-test, that was adapted by Chermahini, Hickendorff and Hommel (2012), was used. The students got a maximum of 10 minutes to do the RAT and could proceed whenever they were finished. The time was shown in a timer on the webpage, and when 10 minutes passed, the webpage automatically submitted the answers and went on to the next page. Some adjustments have been made to the translated test, because of some spelling issues ('pause' instead of 'pauze' in Dutch). All changes that have been made to the adjusted version of the RAT-test are shown in Appendix B.

The Extended WCR-test (Appendix C), consists of 27 items divided over the three sections Widening, Connecting and Reorganizing. 18 new items were developed, inspired by the 9 original items of the WCR-test were added to the Extended WCR-test. There was no time limit added to this test.

At the end of the creativity tests, all of the students were asked to estimate their own level of creative thinking, a Likert scale of 7 was used in which 1 = not creative at all and 7 = very creative.

### **Data collection and analysis**

The data was analysed to further explore the validity and reliability of the WCR-test and the Extended WCR-test.

First, the Extended WCR-test was scored in a similar way to the original WCR-test, and the Cronbach's alpha of the Extended WCR-test with 27 items was determined.

Second, paired correlations were calculated to check for correlation with the score of the Alternative uses test and the Widening section of the WCR-test. Also, paired correlations were calculated with Mednick's RAT and the section Connecting.

Last, paired correlations were calculated in order to see whether the students' estimation of their own creativity level is in line with the score on the 4 creativity tests.

## Results

### Descriptives

Descriptive statistics from the score of the 4 creativity tests (WCR-test, Alternative uses test, RAT and Extended WCR-test) are given in table 8.

The Alternative uses test and the RAT use a different method for scoring, therefore the scores cannot be compared 1 on 1 to the scores of the WCR-test and the Extended WCR-test, but it is possible to compare the score of one respondent of for example the Alternative uses test to the score of the WCR-test in respect to the test results of other respondents. That is to say, a high score of the Alternative uses test means a high score on the WCR-test.

Notable is the average score of the WCR ( $M = 63,81$ ) that is slightly higher than the score of the Extended WCR-test ( $M = 58.95$ ).

Table 8

#### *Descriptive statistics per creativity test*

Test type	N	Minimum	Maximum	Mean	Std. Deviation
Extended WCR-test	107	50.41	72.28	58.95	4.76
WCR-test	60	54.58	74.09	63.81	4.14
Alternative uses test	24	8.11	43.28	18.68	7.93
RAT	36	.00	9	3.5	2.93

### Correlation between the Alternative uses test and Widening

Paired correlations were calculated (Table 9) between the Alternative uses test and the different sections of the WCR-test. The Alternative uses test and the Widening section of the WCR-test are meant to measure the same construct, and therefore a positive correlation was expected.

Results are non-significant, the expected correlation with the Widening section did not show ( $r = -.59$ ), nor did it show correlation with the other sections or the total score. It can be concluded that the WCR-test, nor a section of the WCR-test measures the same construct as the Alternative uses test.

Table 9

#### *Paired correlations of Alternative uses test, different sections of the WCR-test and the total score*

Paired tests	Correlation	Sig.
Alternative uses Score & Widening	-.16	.46
Alternative uses Score & Connecting	.09	.67
Alternative uses Score & Reorganizing	.34	.10
Alternative uses Score & Total score WCR	.11	.61

### Correlation between RAT and Connecting

Mednick's RAT and the Connecting section of the WCR-test are meant to measure the same construct, which means that a positive correlation was expected.

In order to find out whether there is a positive correlation between Connecting and Mednick's RAT test paired correlations were calculated. The results of the paired correlations (Table 10) show no significant correlation for Mednick's RAT and Connecting ( $r = -.21$ ), nor with the other sections of the test or the total score. This means that Mednick's RAT is not measuring the same construct as the WCR-test, or sections of the WCR-test.



Table 10

*Paired correlations of Mednick's RAT, different sections of the WCR-test and the total score*

Paired tests	Correlation	Sig.
RAT & Widening	.14	.42
RAT & Connecting	-.21	.23
RAT Score & Reorganizing	-.28	.11
RAT & Total score WCR	-.11	.53

**Correlation between estimated creativity level and the WCR-test**

A correlation was expected with the self-estimate creativity level of students and the score of the 4 creativity tests (the WCR-test, the Extended WCR-test, the Alternative uses test and the RAT). Paired correlations are shown in Table 11.

No significant correlations are found between the self-estimated creativity level and the creativity tests.

Table 11

*Paired correlations of the self-estimated creativity level and creativity tests*

Paired tests	Correlation	Sig.
Self-estimated creativity level & WCR-test	.04	.77
Self-estimated creativity level & Extended WCR-test	.13	.17
Self-estimated creativity level & Alternative uses test	.10	.63
Self-estimated creativity level & RAT	.19	.26

**Reliability of the Extended WCR-test**

The reliability of the Extended WCR-test was conducted by calculating Cronbach's alpha as shown in Table 12. The addition of the 18 items to the original WCR-test leads to a Cronbach's alpha of  $\alpha = .62$ . This is a notable increase compared to the Cronbach's alpha that was measured in study 1 of  $\alpha = .19$ . Deleting items (W1B, W2A, W2B, W2C, R1B, R3A and R3C) will increase the reliability statistic. In line with the results of Study 1, the items derived from the original item W2 are of negative influence on the tests' reliability. Deleting items W2A, W2B and W2C (items that have only one correct answer) from the questionnaire result in  $\alpha = .66$ , which is 'questionable' according to the rule of thumb of George and Mallery (2003).

Table 12

*Cronbach's alpha for Widening, Connecting and Reorganizing and total score of the Extended WCR-test*

Section	Cronbach's Alpha	N of Items
WCR Total	.62	27
Widening	.49	9
Connecting	.54	9
Reorganizing	.02	9

**Validity of the Extended WCR-test**

In study 1, an exploratory factor analysis underlined the presence of the three cognitive mental operations of the WCR-theory in the WCR-test. It was expected that an exploratory factor analysis on the Extended WCR-test would show similar results as in study 1, because the questions that were added to the Extended WCR-test are of the same nature as the original questions in the WCR-test.

An exploratory factor analysis (Table 13) with Varimax rotation shows the presence of 12 components that were extracted, all with Eigenvalues of > 1.00, explaining 8% of the variance.

The results do not show a clear pattern of the three cognitive mental operations W, C and R of the Extended WCR-test.

Despite of the similarity that the additional questions show with the original questions, it cannot be concluded that they too measure Widening, Connecting and Reorganizing.

Table 13

*Rotated component matrix of exploratory factor analysis of the 27 items of the WCR-test*

	Component											
	1	2	3	4	5	6	7	8	9	10	11	12
W1	.16	.05	-.11	-.07	.19	.08	<b>.77</b>	-.00	.03	-.02	-.22	.00
W1A	.09	-.05	.04	.04	.01	-.07	.10	-.03	<b>.79</b>	-.12	.01	.02
W1B	.08	.07	.25	-.02	-.06	<b>.63</b>	.04	.07	.08	.32	.05	.32
W2	.14	.10	.10	-.07	.32	<b>.59</b>	.10	.02	-.13	-.22	.23	-.26
W2A	.02	-.07	.12	<b>.61</b>	-.13	-.11	.24	-.11	-.21	.15	-.18	-.19
W2B	.20	-.08	-.13	<b>.75</b>	.08	.11	-.09	.01	.03	-.19	-.09	.04
W3	<b>.46</b>	.06	.27	.06	.01	-.17	.40	.03	.12	.28	-.05	.15
W3A	<b>.75</b>	.08	.07	-.03	-.01	.14	.21	-.20	.03	-.13	-.02	.10
W3B	<b>.78</b>	.05	.16	.04	.14	-.12	-.07	.06	.12	.09	.14	.06
C1	.05	<b>.80</b>	.11	-.01	-.08	-.09	.12	-.11	.01	-.08	.04	.05
C1A	.30	-.32	.05	.03	<b>.65</b>	-.24	-.08	.00	.22	.10	-.05	.15
C1B	.22	.34	.15	-.08	.08	<b>-.64</b>	.03	.09	-.06	.03	.01	.03
C2	.15	.06	.25	-.08	-.01	.19	-.17	-.09	<b>.49</b>	-.06	-.22	-.29
C2A	<b>.40</b>	<b>.60</b>	-.10	.05	.27	-.05	<b>-.42</b>	.03	-.01	.19	-.21	-.05
C2B	.29	.08	<b>.51</b>	.25	.02	-.22	.29	.15	.07	-.09	.30	.09
C3	-.05	-.06	.21	.04	.16	.03	-.03	-.14	-.13	<b>.73</b>	.04	-.06
C3A	-.05	.31	<b>.66</b>	-.10	.22	-.02	-.17	.01	.07	.13	.05	-.01
C3B	.18	-.11	<b>.74</b>	-.00	.03	.13	.00	-.06	.04	.09	-.03	.07
R1	.22	.19	.07	-.04	-.23	-.01	.04	<b>-.66</b>	.12	.15	-.08	-.25
R1A	.09	-.01	.03	-.02	.01	.11	-.16	.01	-.05	.06	<b>.85</b>	-.04
R1B	.31	.13	-.23	-.05	-.36	.00	.09	.22	.00	<b>.50</b>	.11	.04
R2	.17	.05	.10	.01	.00	.01	.01	-.08	-.01	-.04	-.05	<b>.80</b>
R2A	-.18	.11	.02	<b>.68</b>	.06	-.03	-.08	.09	.10	.12	.20	.09
R2B	.02	.14	.13	.04	<b>.78</b>	.13	.24	.01	-.08	.05	.04	-.05
R3	.12	-.01	.39	-.28	-.07	-.01	-.39	.22	-.31	-.22	-.29	.06
R3A	.02	.39	-.09	-.00	.02	.15	.04	.35	<b>.47</b>	.21	.05	.26
R3B	.04	.03	.06	.00	-.14	-.04	.00	<b>.80</b>	.04	.02	-.04	-.24

Note: Factor loadings over .4 appear in bold.

## Conclusion and Discussion Study 2

The goal of study 2 is to improve the reliability and validity of the WCR-test, that turned out to be very low in the previous study. First, the influence of lengthening the WCR-test on the interitem reliability is discussed. Furthermore, the correlation with the WCR-test, the Alternative uses test, the RAT and students' self-estimated creativity level is described.

Lengthening a questionnaire increases its reliability (Dooley, 2009 p. 83), therefore the WCR-test is extended by 18 additional items (27 items in total). For every item of the original WCR-test (9 items), two additional items of similar nature were added to the Extended WCR-test. For example, the original Widening item W3 'A paper sheet can be used to ...' was accompanied by 'A glass can be used to ...' and 'A ping-pong ball can be used to ...'.

As expected, the Extended WCR-test shows an increase in interitem reliability compared to the original WCR-test, and reaches a 'questionable' level according to the rules of thumb (George & Mallery, 2003). Despite the improvement from 'unacceptable' to 'questionable', the interitem reliability still does not qualify as acceptable.

This study further underlines the results that were found in study 1 about item W2 (How many triangles are in this picture?). Item W2 measures has a different character than the other questions and measures numeracy. The item causes a decrease in the interitem reliability, as shown in Study 1, and comparable questions in the Extended WCR-test in Study 2 showed the same negative result.

An exploratory factor analysis in Study 1 revealed the existence of three mental operations Widening, Connecting and Reorganizing in the WCR-test. An expected similar result of the Extended WCR-test in Study 2 stayed out, the analysis extracted 12 components and logical pattern cannot be found. This can indicate that the mental operations of creative thinking (Widening, Connecting and Reorganizing) show overlap which makes it difficult to measure them separately. On the other hand, it might be that the additional questions of the Extended WCR-test are inaccurate, since Study 1 did find proof for the existence of the three mental operations in the WCR-test.

The WCR-theory, that assumes that creative thinking consists of three cognitive processes Widening, Connecting and Reorganizing, is based on the same three categories that are found in literature about creativity (Antonietti 2011; 2013). Widening is based on the thoughts of Guilford, where divergent thinking is central. Therefore, a correlation with Guilford's Alternative uses test (1967) and the Widening section of the WCR-test was expected (students who obtain a high score on the Alternative uses test, would score high on the Widening section of the WCR-test) however, a correlation was not found. A similar analysis is done with Mednick's RAT (1968), a test that has in theory congruence with the element Connecting and was expected to show correlation, but no correlation was found either. Further analysis to explore other possible correlations of the Alternative uses test and the RAT with different sections of the WCR-test were carried out, but no significant results were found.

Since students are able to estimate their own creativity level (Putwain, Kearsley & Symes, 2012; Hughes, Furnham & Batey 2013), it was expected that the total score of the WCR-test would show correlation with the answers to the question 'How would you estimate your own level of creativity?'. No correlations were found with the total score on the WCR-test and the Extended WCR-test. On the other hand, no correlations were found between the self-estimate creativity and the established Alternative uses test and RAT either.

Bergkvist and Rossiter (2007) state that a single item measure can be sufficient for the measurement of a construct. They add as a condition that the construct should be narrowly defined, which might be the problem in this case because the term creativity might be too broadly interpretable.

## Overall Conclusion and Discussion

Creativity is a skill that gets more and more attention over the years and is one of the 21<sup>st</sup> Century skills (Voogt & Pereja Roblin, 2010) that are necessary to teach in order to deal with the changing environments that the future generation might face. In order to evaluate and improve creativity in education, testing students creativity is useful (Cropley, 2000).

The WCR-test (Antonietti, Colombo & Pizzingrili, 2011) was specifically designed for use in education, the test is short (9 items) and consists of multiple choice questions which make it easy to administer and score, which makes it very suitable for educational purposes, where time is often scarce and professionals to administer the test are not typically present in higher vocational education.

The test focusses on the creative process and measures three cognitive operations that are components of creative thinking: Widening, Connecting and Reorganizing. These three cognitive operations are derived from the perspectives in the literature that has been written over the years about creativity.

The aim of this study is to explore the use of the WCR-test for higher vocational education in the Netherlands. The WCR-test was not yet tested on students and the validity and reliability were not yet determined.

Study 1 revealed proof for the presence of the three cognitive processes Widening, Connecting and Reorganizing in the WCR-test, which consolidates the theoretical WCR-model (Antonietti 2011;2013). Study 2 further investigates validity by comparing Widening and Connecting to other creativity tests that ought to measure the same construct. Widening is compared with the Alternative uses test (Guilford, 1967) and Connecting to the Remote Associates Test (Mednick, 1968). In theory these test show similarities to the sections in the WCR-test, but the results do not show any significant correlations.

Although the theory behind the WCR-model is well substantiated, the results indicate that the WCR-test itself is less accurate. Study 1 revealed that the reliability of the WCR-test does not match to the acceptable standards. Different scoring methods and lengthening of the test increase the reliability statistics, but not to a convincing level.

For the analysis of the reliability Cronbach's alpha was used, which is a statistic that is commonly used to determine the (interitem) reliability and measures whether the given answers is consistent with the other answers that measure the same construct (Dooley, p. 83). Although this statistic is common in social research Sijtsma (2009) argues that Cronbach's alpha is often a misinterpreted measure that is not suitable for reliability. Cronbach's alpha is used to determine two different things that cannot be measured at the same time: the interitem consistency and the reliability of a test.

Interitem consistency is described by Sijtsma (2009) as the extent to which items in a test are linked together as sign of what they commonly measure, and he argues that interitem consistency can better be confirmed by a factor analysis.

Reliability is described as the correlation of test scores on parallel tests, which is not what Cronbach's alpha measures. Moreover, he argues that Cronbach's alpha systematically strongly underestimates the reliability of a test.

In this light, the results of this study regarding to the reliability are in favour of the WCR-test. After all, a factor analysis revealed a positive interitem consistency. To further determine the reliability a parallel test could be administered. The extra questions of the Extended WCR-test could function as a parallel test, but because the exploratory factor analysis did not show any resemblance with the items and the corresponding mental operations, the extra items of the Extended WCR-test are not a suitable parallel test.

An explanation for the low reliability and validity of the WCR-test is the use of multiple-choice questions. Although multiple-choice is practical for use in education, because it is easy to score, it is questionable whether it is suitable for the measurement of creative thinking. Creativity is about the production of something original and worthwhile (Sternberg, 2011). Scoring an item on the frequency that is given by the total dataset measures originality, but it does not measure the *production* of something original and worthwhile. This means that the WCR-test is measuring only one aspect of creativity (originality). Most well-known creativity tests (e.g. RAT, Alternative uses test, TTCT) do not use multiple-choice questions, but use open ended questions instead. Open ended questions force the participant to produce original and worthwhile ideas and are therefore more suitable for the measurement of creative thinking.

Two solutions are recommended to further improve the WCR-test. The first recommendation to increase reliability and validity is to remove item W2 from the test or to adjust the scoring method and adapt the difficulty of the question to the target audience. The first study showed an increase in interitem reliability when the item was deleted. The second study, where 2 extra versions of question W2 were added showed a similar result. Item W2 is an item where calculation is necessary in order to find the right solution, and is therefore more likely to measure numeracy instead of creativity. On the other hand, the ability to solve a mathematical problem can be an indication of creativity (e.g. Nadjafikhah, Yaftian & Bakhshalizadeh, 2012; Silver, 1997) and might therefore be kept in the WCR-test. In this case, the level of difficulty should be carefully adjusted to the target audience (the question should not be too difficult or too easy) and the scoring method for this item needs to be revised, because the correct answer should receive the highest score and not the most original answer.

The second recommendation is to use open ended questions instead of multiple choice. Although multiple-choice is convenient for educational purposes, it is not suitable for the measurement of creative thinking since it only measures originality.

Notable was that during the data collection some students complained about this aspect as well, some had come up with a creative answer by themselves, but were forced to choose an item from the list. The test does not give room for own interpretations or solutions and students are bound to the level of creativity of (the person that came up with) the listed answers.

Changing the format of the WCR-test to open ended questions is likely to improve the content validity (Assessing a test's validity by inspecting its content, Dooley, 2009, p. 90) that appeared to be low. 'Is this a serious test?' was a common comment made by students taking the test. The students did not feel like they were taken seriously, which in some cases led to frustration and disbelief. Removing the multiple-choice options will provoke students to think themselves, which is likely to improve the content validity. Open ended question need a different method for scoring, wherefore the scoring method of the Alternative uses test, where originality, fluency, flexibility and elaboration are scored (Guilford, 1967) seems to be applicable. A drawback of scoring open-ended questions is that the scoring process is more difficult and timely, which was one of the advantages of using the WCR-test in education. To solve this, a clear grading rubric that makes scoring easy seems to be essential.

If grading open ended questions is considered as problematic, an alternative test for the measurement of creativity in education is the Creative Ability test of Stubbé, Jetten, Paradies and Veldhuis (2015). This test has a different scope and does not measure the creative process as the WCR-test does, but focusses on the creative person (Cropley, 2000) and the environmental factors that influence creativity. The Creative Ability test is specifically designed for primary and secondary education in the Netherlands and uses multiple choice questions, but it is yet unclear whether the test is suitable for use in higher vocational education.

A limitation of this research is that the reliability was checked with Cronbach's alpha only and not with a parallel test, which is according to Sijtsma (2009) more accurate. Also, only Widening and Connecting were compared to a similar test (respectively the Alternative Uses test and the RAT), but there was no scientific test found that could be compared to Reorganizing. Another limitation has to do with the composition of the group of participants, that consists of students from bachelor studies with a creative focus such as Art Teacher or Building Environment. This was deliberately chosen because it was assumed that educators in these type of studies are particularly interested in their students creative abilities. However, it would be interesting to further explore the implementation of the WCR-test in studies with a different focus (for example Technical Engineering) and to check for differences between studies.

Despite a thorough analysis of the WCR-test it is difficult to give a conclusive answer to the question whether the WCR-test in its current state is a suitable measurement instrument that measures creative thinking in higher vocational education. The presence of the cognitive mental operations Widening, Connecting and Reorganizing in the WCR-test is determined which contributes to the validity of the WCR-test. However, the lack of resemblance of the sections Widening and Connecting with other creativity tests that measure the same construct indicates the opposite. It is likely that open ended questions are more useful to measure creativity, since it forces the participant to actively come up with worthwhile ideas. Future research is necessary to explore the consequences of changing the WCR-test to a test with open ended questions and to develop a practical grading rubric. An increase of validity and reliability is desirable, but it must be kept in mind that the test keeps its practical character that is necessary for use in education.

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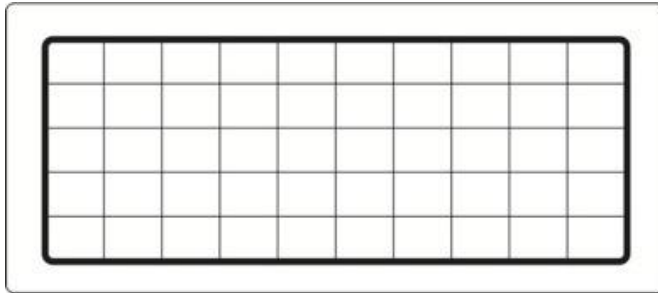
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Appendix A. WCR-test

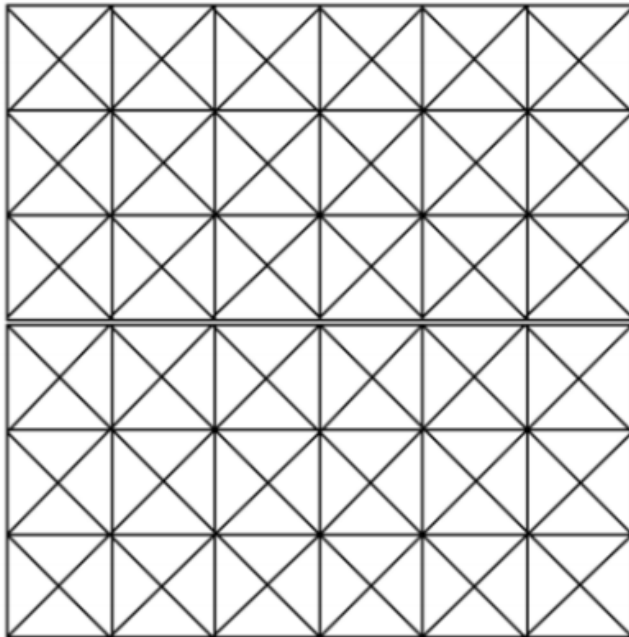
**Widening:**

W1 What may this picture represent? (Choose 1 answer)



- A rectangle with many small squares inside
- A food grill
- A chocolate bar
- A calendar

W2 How many triangles are in this picture? (Choose 1 answer)



- 144
- 192
- 312
- More than 312

## THE PSYCHOMETRIC QUALITIES OF THE WCR CREATIVITY TEST

W3 A paper sheet can be used to ... (Choose 1 answer)

- Write
- Construct a paper boat
- Build a fan
- Fold under a moving table leg

### Connecting:

C1 Think of the colour "black". Which of the words listed below does "black" make you think of? (Choose 3 answers)

- Night
- Ink
- Batman
- Hearse (funeral car)
- Zorro
- Coal
- Panther
- Elegance
- Mulberry

C2 Think about a cell phone. Which of the words listed below does a cell phone make you think of? (Choose 3 answers)

- A touch screen
- Energy
- Amusement
- SMS
- Being connected
- Time
- Communication
- A battery charger
- Protection



C3 Look at this picture. Which of the things listed below would you insert into the painting? (Choose 3 answers)

- Person from a different ethnic background
- Horse
- Tree
- Sun
- Oxcart
- Basket
- Bow with arrows
- Cloak
- Notebook
- Julius Caesar

**Reorganizing:**

R1 What would happen if people slept during the day and were awake at night? (Choose 1 answer)

- Electricity bills would be more expensive
- People would use more often flash when taking pictures
- Brunch will not exist
- People would work at night
- Sunglasses would not be sold
- Safety helmets would include lights

R2 What would happen if it was always summer and there were no seasons? (Choose 1 answer)

- Fashion designers would propose a unique collection of clothes per year
- There would be more cases of sunburn and skin allergies
- Fireplaces and heaters would disappear from homes
- There would be drought
- People would ski only on artificial snow
- People would not make the change of seasonal clothes

THE PSYCHOMETRIC QUALITIES OF THE WCR CREATIVITY TEST



R3 Look at this picture. How might the plot continue? (Choose 1 answer)

A



B



C



D



## Appendix B. RAT in Dutch

1. Bar / jurk / glas
2. Kop / boon / pauze
3. Vlokken / ketting / pret
4. Val / meloen / lelie
5. Vis / mijn / geel
6. Achter / kruk / mat
7. Worm / kast / legger
8. Water / schoorsteen / lucht
9. Trommel / beleg / mes
10. Hond / druk / band
11. Kaart / plaats / gewicht
12. Goot / kool / bak
13. Kolen / land / schacht
14. Schommel / klap / rol
15. Kamer / masker / explosie
16. Nacht / vet / licht
17. Arm / veld / stil
18. Olie / pak / meester
19. School / ontbijt / spel
20. Deur / werk / kamer
21. Strijkijzer / schip / trein
22. Man / lijm / ster

### **Adjustments:**

3 adjustments were made to the RAT that was translated by Chermahini, Hickendorff and Hommel (2012), because of incorrect translations.

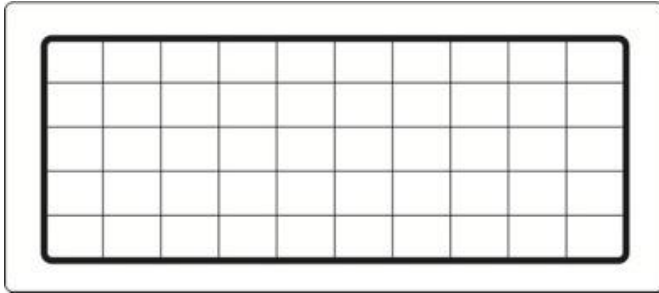
1. Item 2 was originally Kaas / land / huis (solution word: Boeren). In Dutch the combination of words 'Boeren kaas' has meaning, but 'Boeren land' and 'Boeren huis' do not. Therefore, this item was replaced with Kop / boon / pauze (solution word: Koffie).
2. In Dutch Item 3 was originally Vlokken / ketting / pet (solution word: Sneeuw), but 'Sneeuw pet' does not exist in Dutch, therefore 'pet' was replaced with 'pret'.
3. A similar error was found in item 11, Controle / plaats / gewicht (solution word: Geboorte), but 'Geboorte controle' is not a correct combination of words in Dutch, therefore the 'controle' was replaced with 'kaart'.

### Appendix C. Extended WCR-test

The Extended WCR-test consists of the original items of the WCR-test (e.g. W1), plus two extra items per original item (e.g. W1A and W1B).

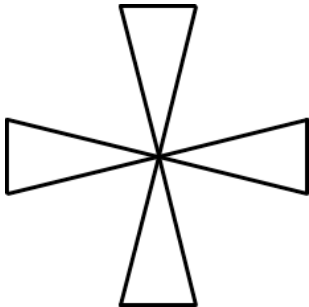
#### Widening:

W1 What may this picture represent? (Choose 1 answer)



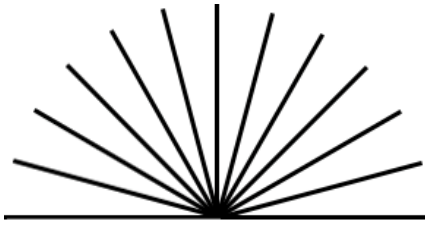
- A rectangle with many small squares inside
- A food grill
- A chocolate bar
- A calendar

W1A What may this picture represent? (Choose 1 answer)



- A mill
- 4 triangles
- A helicopter
- An award

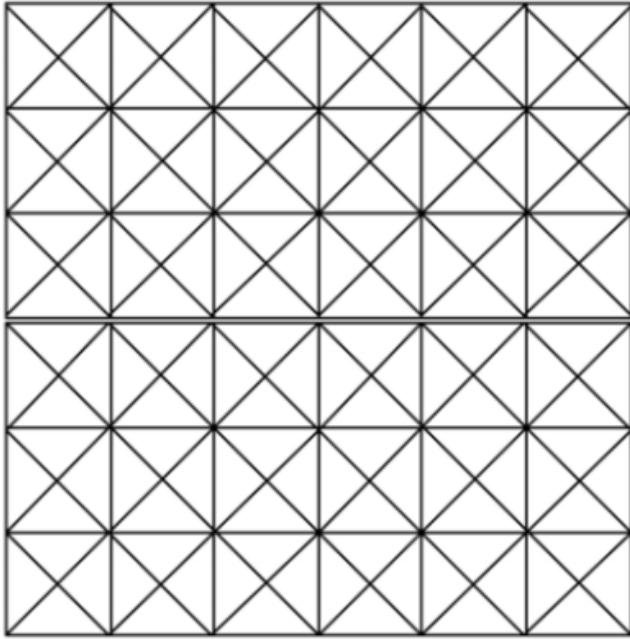
W1B What may this picture represent? (Choose 1 answer)



- A sunset
- An opened book
- A dandelion (flower)
- A peacock

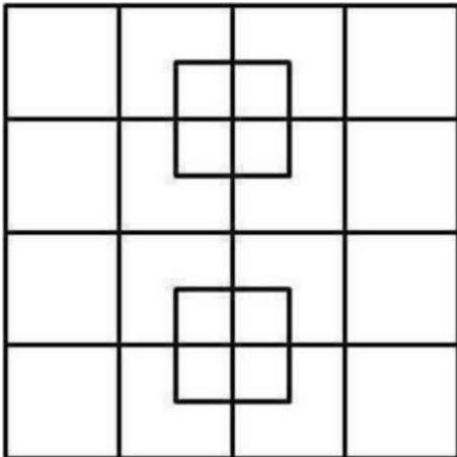


W2 How many triangles are in this picture? (Choose 1 answer)



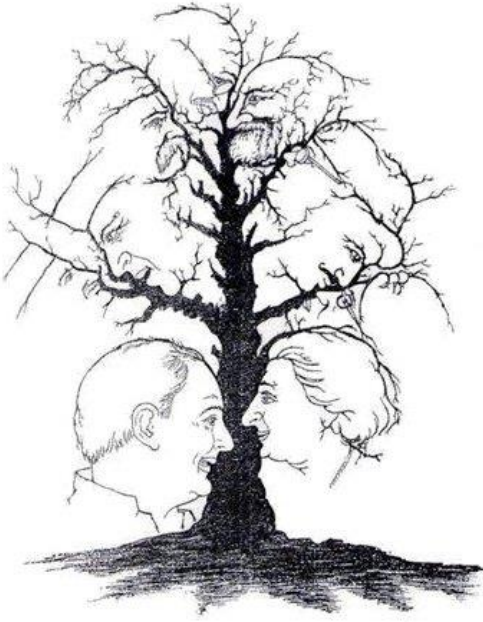
- 144
- 192
- 312
- More than 312

W2A How many squares do you see in this picture? (Choose 1 answer)



- 20
- 34
- 40
- More than 40

W2B How many faces do you see in this picture? (Choose 1 answer)



- 8
- 10
- 14
- More than 14

THE PSYCHOMETRIC QUALITIES OF THE WCR CREATIVITY TEST

W3 A paper sheet can be used to ... (Choose 1 answer)

- Write
- Construct a paper boat
- Build a fan
- Fold under a moving table leg

W3A A glass can be used to ... (Choose 1 answer)

- Listen through the wall to the neighbours
- Drink
- As a candle light
- Catch a wasp

W3B A ping-pong ball can be used to ... (Choose 1 answer)

- Play table tennis
- Use as decoration in a fish tank
- Play with a cat
- Check whether a surface is level (horizontal)

**Connecting:**

C1 Think of the colour “black”. Which of the words listed below does “black” make you think of? (Choose 3 answers)

- Night
- Ink
- Batman
- Hearse (funeral car)
- Zorro
- Coal
- Panther
- Elegance
- Mulberry

C1A Think of the term ‘large’. Which of the words listed below does ‘large’ make you think of? (Choose 3 answers)

- Giant
- Mega
- Universe
- Skyscraper
- Important
- Sun
- Stadium
- Powerful
- Adult

C1B Think of the term ‘shiny’. Which of the words listed below does ‘shiny’ make you think of? (Choose 3 answers)

## THE PSYCHOMETRIC QUALITIES OF THE WCR CREATIVITY TEST

- Successful
- Clean
- Luxury
- New
- Mirror
- Luminous
- Jewellery
- Crystal
- Chrome

THE PSYCHOMETRIC QUALITIES OF THE WCR CREATIVITY TEST

C2 Think about a cell phone. Which of the words listed below does a cell phone make you think of? (Choose 3 answers)

- A touch screen
- Energy
- Amusement
- SMS
- Being connected
- Time
- Communication
- A battery charger
- Protection

C2A Think about a dog. Which of the words listed below does a dog make you think of? (Choose 3 answers)

- Beast
- Collar
- Walking the dog
- Loyalty
- Tennis-ball
- Whistle
- Good sense of smell
- Tetanus injection
- Obedient

C2B Think about wool. Which of the words listed below does the word wool make you think of? (Choose 3 answers)

## THE PSYCHOMETRIC QUALITIES OF THE WCR CREATIVITY TEST

- Sheep
- Spinning wheel
- Knitting
- Sweater
- Warmth
- Static electricity
- Grandmother
- Winter
- Sock

THE PSYCHOMETRIC QUALITIES OF THE WCR CREATIVITY TEST

C3 Look at this picture. Which of the things listed below would you insert into the painting? (Choose 3 answers)

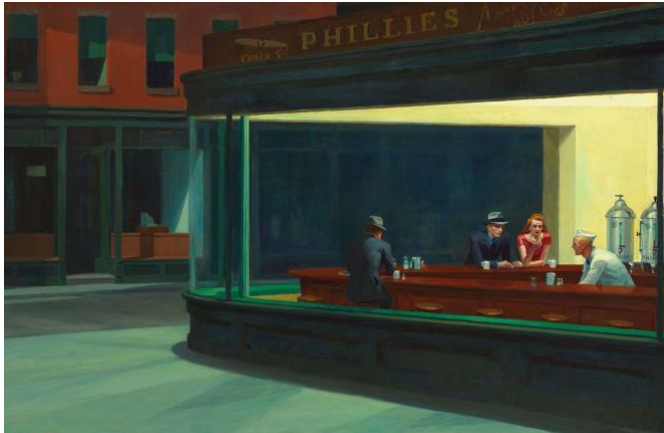


- Person from a different ethnic background
- Horse
- Tree
- Sun
- Oxcart
- Basket
- Bow with arrows
- Cloak
- Notebook
- Julius Caesar



THE PSYCHOMETRIC QUALITIES OF THE WCR CREATIVITY TEST

C3A Look at this picture. Which of the things listed below would you insert into the painting? (Choose 3 answers)



- A sportscar
- A drug dealer
- A street dog
- A lamppost
- A garbage truck
- A sniper
- A newspaper
- A ladder
- A hole in the ground

THE PSYCHOMETRIC QUALITIES OF THE WCR CREATIVITY TEST

C3B Look at this picture. Which of the things listed below would you insert into the photograph? (Choose 3 answers)



- A fata morgana
- A tent
- A snowman
- A camel
- An oasis
- A spider web
- A gerbil
- A container ship

**Reorganizing:**

R1 What would happen if people slept during the day and were awake at night? (Choose 1 answer)

- Electricity bills would be more expensive
- People would use more often flash when taking pictures
- Brunch will not exist
- People would work at night
- Sunglasses would not be sold
- Safety helmets would include lights

R1A What would happen if everything was green? (Choose 1 answer)

- You would not know when fruit is ripe
- Traffic lights would look different
- You could no longer see the horizon
- Your eye vision would become better
- You would not see whether food is rotten or toxic
- The planet looks like a green ball from space

R1B What would you do if you were invisible? (Choose 1 answer)

- You would avoid people in the streets, to prevent they bump into you
- You would be a superspy
- You would scare people
- You would travel around the world
- You would become a magician
- You would no longer go to school/work

## THE PSYCHOMETRIC QUALITIES OF THE WCR CREATIVITY TEST

R2 What would happen if it was always summer and there were no seasons? (Choose 1 answer)

- Fashion designers would propose a unique collection of clothes per year
- There would be more cases of sunburn and skin allergies
- Fireplaces and heaters would disappear from homes
- There would be drought
- People would ski only on artificial snow
- People would not make the change of seasonal clothes

R2A What would happen if people no longer had to eat? (Choose 1 answer)

- Restaurants and supermarkets would close
- No one would know how to cook
- Farmers will only grow crops for clothing
- Eating becomes a special hobby
- Cutlery and tableware will slowly disappear
- No one is overweight

R2B What would happen if it would constantly rain? (Choose 1 answer)

- Umbrellas will be free of charge
- Streets will get roofs, so you won't get wet when you go outside
- Boats would become most important way of transport
- Sewers would be made bigger to cope with all the water
- There will be special flights to view the sun above the clouds
- One would no longer go camping on vacations

THE PSYCHOMETRIC QUALITIES OF THE WCR CREATIVITY TEST

R3 – Look at this picture. How might the plot continue? (Choose 1 answer)



A



B



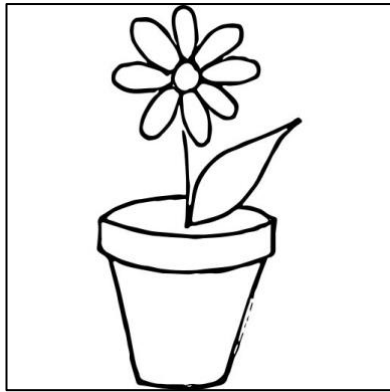
C



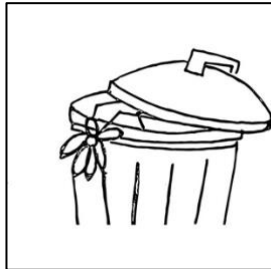
D



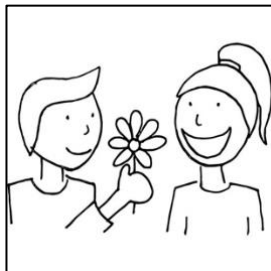
R3A Look at this picture. How might the plot continue? (Choose 1 answer)



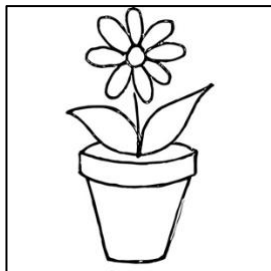
A



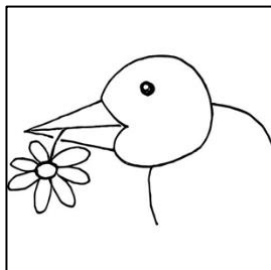
B



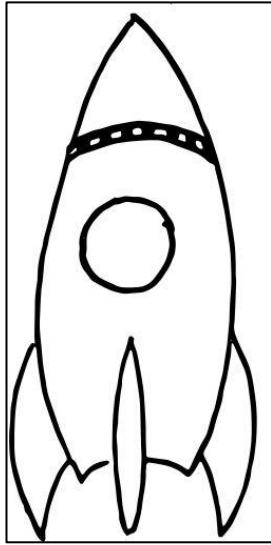
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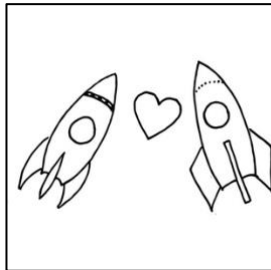
D



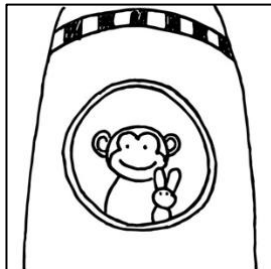
R3B Look at this picture. How might the plot continue? (Choose 1 answer)



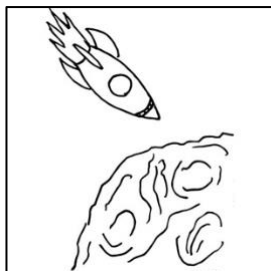
A



B



C



D

