Visual Imagery and Creativity: The Polish Version of Vividness of Visual Imagery
Questionnaire and Its Links with Creativity

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Abstract

Although mental imagery is crucial for creativity in many domains, its links with creative abilities are ambiguous. This paper, based on five studies (total $N > 3,600$), reports the development of the Polish version of the VVIQ-2 (VVIQ-PL), examines its validity and reliability, as well as tests the relationships between mental imagery and creativity. Based on the results of the confirmatory factor analyses, we demonstrated the single-dimensional structure of VVIQ-PL and measurement invariance concerning participants' gender. The VVIQ-PL showed excellent test-retest reliability, high internal consistency reliability, and adequate construct validity. As expected, art students were characterized by a higher level of mental imagery than 'non-artist' groups. Finally, however, although the vividness of visual imagery turned out to be positively correlated with creativity (creative abilities, creative imagery, and creative self-concept), the strength of these correlations was weak-to-moderate. We discuss these findings alongside future research directions.

Keywords: mental imagery; the Vividness of Visual Imagery Questionnaire; psychological assessment; vividness of visual imagery; creativity

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Visual Imagery and Creativity: The Polish Version of the Vividness of Visual Imagery Questionnaire and Its Links with Creativity

Imagine your breakfast table this morning. Try to see with the mind's eye all the details of this image. It's relatively easy, isn't it? But when you visualized this scene, was the mental picture clear and vivid or vague and dim? As it turns out, the vividness of mental visualization might vary substantially across individuals and situations.

Historically, the first empirical evidence of individual differences in detail and clarity of mental imagery was provided by Galton in a classic 'Statistics of Mental Imagery' paper (Galton, 1880). Galton described the results of the famous 'breakfast table study,' which asked many eminent individuals, including Galton's cousin, Charles Darwin, to describe, among other things, the vividness and clarity of their visual images of the breakfast table. Nowadays, many researchers discuss the limitations of this research (e.g., Burbridge, 1994; Karwowski & Jankowska, 2019), but they agree that it had an enormous impact on the history of research on mental imagery. For example, Galton's approach to the measure of imagery vividness served as an inspiration for the first fully quantitative questionnaire for measuring mental imagery: The Questionnaire upon Mental Imagery (Betts, 1909).

What is Mental Imagery?

In the psychological literature, the term 'mental imagery' is usually used in two ways: first, as the experience of sensory information without a direct external stimulus ('seeing with the mind's eye,' 'hearing with the mind's ear,' or 'feeling with the mind's skin'), and second, as 'an internal representation that gives rise to the experience of perception in the absence of the appropriate sensory input' (Wraga & Kosslyn, 2002, p. 466).

The nature of internal representations that underlie the experience of mental imagery is the main theme of one central debate in cognitive science, the so-called 'imagery debate'

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(Tye, 1991). Some scholars perceive mental images as a kind of picture-like (i.e., depictive) representation, a position that links imagery to visual perception (e.g., Brogaard & Gatzia, 2017; Kosslyn et al., 2006). Others perceive mental images as descriptive representations that correspond to abstract symbols also used in language (e.g., Pylyshyn, 1973, 2003). And although this has been the subject of a heated debate among scholars since the late 1970s, it still seems to be open within the frame of the embodied cognition approach (Palmiero et al., 2019).

Mental imagery can relate to any of the sensory modalities' stimuli, but visual mental imagery (i.e., *seeing with the mind's eye*) has been most frequently investigated to-date. Numerous studies have assessed visual imagery ability, defined as the quality of an individual's visual mental imagery, which is measured in terms of the abilities to generate and control mental images, preference, as well as by vividness of mental representations (e.g., McAvinue & Robertson, 2007). Since Galton (1880), vividness of visual mental imagery is probably the most commonly measured dimension of imagery ability (Kihlstrom et al., 1991). It is related to preservation of perceptual information and defined both as clarity and liveliness of a mental image, as well as the degree of similarity between subjective experience of visual imagery and corresponding perceptual experience (D'Angiulli & Reeves, 2007; Marks, 1973; McAvinue & Robertson, 2007). Clarity of mental images is associated with brightness of colors and sharpness of the outline and details, whereas liveliness reflects how dynamic, vigorous, and alive the image is (Marks, 1999).

Although the internal nature of visual mental imagery makes its assessment a challenge, this topic attracts considerable interest of researchers in various areas of psychology, including cognitive psychologists, neuroscientists, sports scientists, as well as learning and creativity researchers.

Assessing Individual Differences in Visual Mental Imagery

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The Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973) and its updated versions, the Visual Imagery Questionnaire-Version 2 and Vividness of Visual Imagery Questionnaire-Revised Version (VVIQ-RV; Campos, 2011; Campos & Pérez-Fabello, 2009; Marks, 1995; McKelvie, 1995) are the best-known and the most widely used questionnaires that provide a global assessment of imagery's vividness. Marks developed VVIQ on the basis of the Questionnaire Upon Mental Imagery (QMI; Betts, 1909), which assesses vividness of imagery across seven sensory modalities. In its original form, the VVIQ consists of 16 items in four groups of 4 items each, in which the participant is asked to consider the mental image of specific scenes and situations (e.g., *Visualize a rising sun. Consider carefully the picture that comes before your mind's eye*). For each image, participants indicate how vivid the four items relating to that image are (e.g., *The sun rising above the horizon into a hazy sky*) by providing a rating on a scale from one (*Perfectly clear and vivid as real seeing*) to five (*No image at all, you only "know" that you are thinking of the object*). Therefore, participants have to introspect on their imagery experience and assess the vividness of their mental imagery. In 1995, Marks published a revised version of this instrument: the VVIQ-2, with a doubled number of items and reversing the numerical values on the scale so that higher scores reflected higher vividness. On the VVIQ-2, mental imagery is formed with eyes closed. The VVIQ-RV (Marks, 1995; McKelvie, 1995) consists of the same 32 items that were used in the VVIQ-2, but vividness is rated on a 7-point scale proposed by Marks (1995), and the procedure is undertaken with the eyes open.

A large body of evidence confirms that the VVIQ is a valid and reliable psychometric instrument to assess vividness of visual mental imagery. Internal consistency of the VVIQ (e.g., Burton, 2003; Campos & Pérez-Fabello, 2009;), the VVIQ-2, and the VVIQ-RV (e.g., Campos, 2011; Campos & Pérez-Fabello, 2009) is high, usually with Cronbach's α s around .90. Also, the test-retest reliability is satisfactory ($.67 \leq r \leq .86$; Parrott & Strongman, 1985).

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Factor analyses tend to indicate a single underlying dimension (Campos et al., 2002; LeBoutillier & Marks, 2001). Construct validity is supported by statistically significant correlations—usually within the range of .30-.50—with different self-reported measures of imagery ability, e.g., Betts' Questionnaire Upon Mental Imagery (Campos, 2011), Test of Visual Imagery Control (Burton, 2003), Gordon Test of Visual Imagery Control (Burton & Fogarty, 2003; Pérez-Fabello & Campos, 2004), or The Plymouth Sensory Imagery Questionnaire (Andrade et al., 2013). It also has been reported that vividness of mental imagery assessed by VVIQ corresponds to the tendency to use visual mental imagery in daily life (Nelis et al., 2014; Reisberg et al., 2003). Recent studies have found that individual differences in VVIQ scores may be used to predict changes in a person's brain activity (for a summary, see Fulford et al., 2018). For example, it has been demonstrated that vividness of mental imagery reported in VVIQ positively correlates with objective measures of early visual cortex activity assessed using fMRI (Amedi et al., 2005; Cui et al., 2007). On the whole, the current findings indicate that both original versions of the VVIQ and its revisions (i.e., the VVIQ-2 and the VVIQ-RV) are valid psychometric instruments for measuring image vividness (see Campos, 2011).

A controversial issue in the studies on mental imagery concerns possible gender differences (Richardson, 1991, 1995). While early works reported that female participants show more vivid mental imagery than male ones, the evidence to support this claim was found insufficient (see, e.g., Ashton & White, 1980). Still, however, more recent investigations tend to confirm that females outscore males in self-reported visual mental imagery (Campos & Sueiro, 1993; Campos & Pérez, 1988; Narchal & Broota, 1988). We emphasize, however, that there are many other studies that report null effects of gender (Campos, 2014; McKelvie, 1995). Indeed, while McKelvie (1995), in a review of the literature, revealed no significant gender difference on the VVIQ, Richardson's meta-analysis

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(1995) has shown a slight but reliable tendency for female participants to report more vivid mental images than male ones. Interestingly, none of the studies that applied the VVIQ-2 found gender differences (see Campos, 2014).

Mental Imagery and Creativity

There are both theoretical and empirical arguments to consider mental imagery important for creativity. Surprisingly, however, the links between these constructs were overlooked and creativity and mental imagery literatures develop quite independently from each other. It was not always the case: historically, these relationships have been quite intensively explored in correlational studies since the 1960s (Schmeidler, 1965), supplemented by anecdotal reports of the mental imagery of prominent scientists, inventors, and artists. It has been proposed that mental imagery played a crucial role in the development of history-making ideas, such as Galileo's thought experiments on inertia, Einstein's Special and General Theory of Relativity, Kekule's structure of the benzene ring, or in the creation of masterpieces of prominent visual artists such as Kandinsky, Moore or Dali (Miller, 2000; Rosenberg, 1987; Rothenberg, 1995). Recent research based on reports of professional artists and scientists tends to provide an empirical confirmation of these findings (e.g., Blazhenkova & Kozhevnikov, 2009; Kozhevnikov et al., 2007; Pérez-Fabello & Campos, 2011).

Some creativity theories see mental imagery as a subset of creative cognition. Consider for example a generate model of creativity (Finke et al., 1992). Studies inspired by the creative cognition approach treat visual imagery as an essential component in creating new image combinations that represent original ideas and thoughts (e.g., Finke, 1990). Still, the open question is to what extent different abilities and skills engaged in creative processes, e.g., divergent thinking, ability to find remote associations or creative imagery, are related to the vividness of mental imagery. Even less attention was devoted to links between imagery and creative self-concept variables – e.g., creative self-efficacy or creative personal identity

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(see Karwowski et al., 2019). While examining VIVIQ-PL's properties, we also included these rarely studied variables into our investigations.

Within correlational studies, researchers primarily analyzed the relationship between self-reported mental imagery (vividness of images, among others) and divergent thinking, namely the ability to generate many (fluency), diverse (flexibility), and original solutions to a problem (e.g., Parrott & Strongman, 1985; Rhodes, 1981; Shaw & DeMers, 1986). Although this line of research established positive correlations between divergent thinking scores and self-reported visual imagery, the effects obtained were usually weak-to-moderate (r s between .2 and .4), and a meta-analytic summary (LeBoutillier & Marks, 2003) provides even smaller averaged point estimate ($r = .15$). Mental imagery tended to be slightly more strongly associated with figural ($r = .19$) than verbal ($r = .13$) modality of creativity (LeBoutillier & Marks, 2003). Therefore, in the studies presented below, we included verbal divergent thinking tasks (Study 1) as well as more figural tests of creative imagery (Study 2) and figural creative abilities (Study 3).

Overview of the Present Studies

This paper has two goals. First, across five studies (total $N = 3,660$), it assesses the psychometric quality of the Polish adaptation of VVIQ-2 (VIVIQ-PL). Second, apart from presenting the psychometrics behind the adaptation and the instrument's validity check, our particular focus is on the links between mental imagery and creativity. To this end, first, we compare the VIVIQ-PL scores obtained by fine arts students and a control group (Study 3). Then, across three studies, we examine the relationship between VIVIQ-PL scores with creative self-concept (Karwowski et al., 2019), creative imagery (Jankowska & Karwowski, 2015), remote associations (Mednick, 1962), and the Test of Creative Thinking-Drawing Production (Urban & Jellen, 1996).

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Large Studies 1 ($N = 1,328$) and 2 ($N = 1,576$) were devoted to assessing the internal consistency and factor structure of the VVIQ-PL and gender differences, including measurement invariance. Study 3 examined the test-retest reliability of VIVIQ-PL over three weeks. In the same study, we explored the links between VIVIQ-PL and Test for Creative Thinking-Drawing Production (TCT-DP; Urban & Jellen, 1996). Study 4 examined construct validity by estimating correlations between scores in VIVIQ-PL and the Test of Visual Imagery Control (TVIC; Richardson, 1969). In Study 5, our purpose was also to explore the possible differences in vividness of visual imagery between art students and social science students ('artist group' and 'non-artist group'). We hypothesized that art students should assess their mental images as more vivid than social science students ('artist group' vs. 'non-artist group').

We assumed a single-dimensional structure of VIVIQ-PL, as demonstrated by the author (Marks, 1973) and other researchers (e.g., Campos et al., 2002; LeBoutillier & Marks, 2001). Regarding evidence for validity, construct validity of the VVIQ-PL will be supported if the correlation of .30-.50 or above is found between it and the TVIC (Burton, 2003; Burton & Fogarty, 2003; Pérez-Fabello & Campos, 2004), and divergent validity will be supported if there is a lower correlation between VIVIQ-PL and the TCT-DP as a measure of figural creativity (LeBoutillier & Marks, 2003). Also, we hypothesized that female participants would report higher vividness of imagery than male ones (Campos & Sueiro, 1993; Campos & Pérez, 1988; Harshman & Paivio, 1987). As some authors (e.g., Ashton & White, 1980) emphasize that previously obtained differences might be artifactual, we put special effort to examine VIVIQ-PL measurement invariance among male and female participants, to exclude the possibility that the differences obtained are caused by differential item functioning.

Method

Participants, Measures, and Procedure

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Study 1. A total of 1,328 elementary (52%) and middle-school (48%) students (54% female) participated in Study 1. The study was longitudinal, with two measurement waves (T1 and T2) separated by nine months. VIVIQ-PL was filled during T2.

During T1 and T2 participants reported their domain-general creative self-efficacy (CSE, $\alpha_{T1} = .82$, $\alpha_{T2} = .83$) and creative personal identity (CPI, $\alpha_{T1} = .87$, $\alpha_{T2} = .88$) measured by the Short Scale of Creative Self (SSCS; Karwowski et al., 2018), as well as domain-specific creative self-efficacy in math ($\alpha_{T1} = .89$, $\alpha_{T2} = .89$) and language ($\alpha_{T1} = .87$, $\alpha_{T2} = .87$), using a brief (12 item) scale used in the previous research (Karwowski et al., 2015).

Additionally, during T1, participants solved the intelligence test (based on in the International Cognitive Ability Resource project, ICAR, Condon & Revelle, 2014, $\alpha = .84$), three divergent thinking tasks (providing unconventional uses of toothpaste, consequences of a situation where there would be no cell phones or the Internet, and similarities between a chocolate bar and a computer), and Creativity and Learning in School Achievement Test (CLISAT, Karwowski et al., 2020). Responses in divergent thinking tasks were scored for fluency (the number of ideas) and originality across tasks ($\alpha = .85$). The CLISAT measures academic achievement and creative-learning relevant processes in language and math. In the version of CLISAT used in this study, there are 24 tasks in total – 12 in language and 12 in math. In the language part, seven tasks have a closed-ended character, while five tasks are aimed at measuring creativity-relevant processes. All five language tasks were scored for fluency (i.e., number of appropriate ideas generated); two of them were also scored for originality (i.e., rated uniqueness of response), and three for flexibility (i.e., number of different categories that a response could be assigned to). In the math portion of the test, eight tasks are closed-ended, and four tasks measure aspects of creative thinking in math. All open-ended tasks were scored for fluency; two of them were additionally scored for originality, and two for flexibility (see Karwowski et al., 2020, for details of CLISAT scoring and validity

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information).

Study 2. A total of 1,576 elementary (48%) and middle-school (52%) students (55% female) participated in Study 2. Similarly, as Study 1, also Study 2 was longitudinal, with two measurement waves (T1 and T2) separated by 7 months. VIVIQ-PL was filled during T1. Additionally, during both waves they solved ICAR-based intelligence test ($\alpha_{T1} = .73$, $\alpha_{T2} = .78$), filled the SSCS allowing to measure their domain-general CSE ($\alpha_{T1} = .85$, $\alpha_{T2} = .82$) and the CPI ($\alpha_{T1} = .89$, $\alpha_{T2} = .87$), as well as reported their math-specific and language-specific CSE ($\alpha_{T1} = .89$, $\alpha_{T2} = .90$ and $\alpha_{T1} = .86$, $\alpha_{T2} = .88$, respectively). Additionally, during the T1 (together with VIVIQ-PL), they solved the Polish version of the Remote Associates Test (Sobków et al., 2016, $\alpha = .91$), and the Test of Creative Imagery Abilities (TCIA, Jankowska & Karwowski, 2015).

Study 3. Study 3 was carried out on a group of 254 participants, mostly female (94.5%), ranging in age from 19 to 29 years ($M = 20.28$, $SD = 1.17$). This group was composed of social science students pursuing their degrees primarily in education and special education. After three weeks, some of the participants ($N = 103$) who had taken part in the first stage of the study were asked to fill in the VVIQ-PL once again, and other ones were asked to complete the Test for Creative Thinking-Drawing Production (TCT-DP) ($N = 103$).

Internal consistency of the VVIQ-PL was assessed both on the data collected in the test and retest phase. The Cronbach's α coefficients were good: $\alpha = .92$ in the test phase and $\alpha = .85$ in the retest phase.

The Test for Creative Thinking-Drawing Production (TCT-DP) was used to measure figural creativity (Urban & Jellen, 1996). The participants are asked to complete the drawing, which initially had six elements placed asymmetrically on the test sheet. The TCT-DP was scored by an experienced coder according to the guidelines in the manual. Scores were obtained for 14 categories: (1) Continuations: any use of the test elements; (2) Completions:

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additions made to the elements; (3) New elements: each new element created; (4)

Connections made with a line: each linear connection between test elements; (5) Connections that contribute to a theme: each element related to a theme of the created picture; (6)

Fragment-dependent boundary-breaking: any use of an element outside the frame; (7)

Fragment-independent boundary-breaking: any drawing that breaks the boundary of the large square frame; (8) Perspective: any attempt to introduce the impression of three dimensions;

(9) Humor and affectivity; (10) Manipulation of the test material; (11) Surrealistic or abstract elements; (12) Use of symbols or signs; (13) Unconventional usage of the given elements; and

(14) Speed. The total score of the TCT-DP is obtained by summing the ratings of these 14 criteria (Urban & Jellen, 1996). Previous studies (e.g., Jankowska & Karwowski, 2018) confirmed TCT-DP's validity and reliability. Its reliability in this study was adequate ($\alpha = .73$).

Study 4. Study 4 was conducted on a sample of 313 individuals (156 female, 157 male), aged 26-54 ($M = 38.97$, $SD = 6.37$). The participants were members of an online panel and completed the questionnaires along with other instruments. Participants' imagery ability was measured using the VVIQ-PL and the Test of Visual Imagery Control (TVIC) in the modified form provided by Richardson (1969). The TVIC (Richardson, 1969) was used to measure abilities to control mental images. It consists of 12 items and involves various modifications on the mental images of an automobile (e.g., stopped, lying upside down, falling off a bridge). They are rated on a 3-point scale where 0 = *No*, 1 = *Unsure* and 2 = *Yes*. Internal consistency was high, with the VVIQ-PL having a Cronbach's $\alpha = .96$ and the TVIC $\alpha = .87$.

Study 5. In total, 189 undergraduate and graduate students participated; the sample included 17% male and 83% female participants. The artist group contained 82 art students, while the non-artist group contained 98 social science students. The age of the artist group ranged from 20 to 28 years ($M = 23.02$, $SD = 3.40$), while the non-artist group age ranged from 19 to 40

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years ($M = 22.40$, $SD = 1.75$). Informed consent was obtained from every participant.

Participants were informed about the general aim of the study. The VVIQ-PL had good reliability in this study, with a Cronbach's $\alpha = .90$ for all participants.

Results

Given our research question and the focus of this paper, we organize our results section in two parts. First, we provide an overview of our findings on the VIVIQ-PL's psychometric quality: its reliability and validity. We start with basic descriptive statistics from the five studies to assess the VIVIQ-PL results' distributions and internal consistency. Then, we focus on this scale's factor structure (Studies 1 and 2), measurement invariance concerning participants' gender (Studies 1 and 2), and gender differences based on Study 1 and Study 2. We then examine the VIVIQ-PL's test-retest reliability (Study 3) and construct validity concerning the VIVIQ-PL and the TVIC (Study 4).

Part 2 explores the links between the VIVIQ-PL and creativity. More specifically, we analyze the differences between artists and a control group (Study 3), examine correlations (including correlates more distant in time) between the VIVIQ-PL and creative self-concept (Study 1 and Study 2), divergent thinking (Study 1), remote associations and creative imagery (Study 2), as well as the links between the VIVIQ-PL and more synthetic creative abilities as measured by a figural TCT-DP (Study 3).

Part I: Psychometric Properties of VIVIQ-PL

Descriptive statistics of the VIVIQ-PL's scores, along with internal consistency, are provided in Table 1. As illustrated, the mean scores were almost identical across 4 out of 5 studies (we emphasize that Study 5 involved artists, so higher overall scores were expected here) with a lack of clear signs of skewness and excellent internal consistency.

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Table 1. Descriptive Statistics and VIVIQ-PL Internal Consistency

	<i>N</i>	<i>M</i>	<i>SD</i>	α	Skewness	Kurtosis
Study 1	1328	3.75	0.80	.94	-0.72	0.70
Study 2	1576	3.74	0.77	.95	-0.52	0.19
Study 3						
3a	254	3.78	0.60	.92	-0.61	0.43
3b	103	3.73	0.47	.85	-0.66	1.14
Study 4	313	3.74	0.67	.96	-0.28	0.48
Study 5	189	3.97	0.54	.90	-1.04	1.02

Note. Study 3a = 1st measurement, 3b = 2nd measurement

In the second step, we aggregated the two largest studies, similar in terms of samples and design (Study 1 and Study 2), and conducted two confirmatory factor analyses (CFA). Although we expected a single-factor solution of the VIVIQ-PL, we note that the instrument holds a somehow complex structure. All 32 items are naturally clustered within eight situations participants are asked to imagine and assess. Thus, we estimated two models. Model A was a one-factor model loaded by all 32 items, but allowing correlations between errors of items from the same group. Model B was a model estimated on parcels, so items average across eight groups. As illustrated in Table 2, in both cases the model fit was good or excellent. That leads us to the conclusion that a one-factor structure of the VIVIQ-PL was indeed confirmed.

Table 2. Confirmatory Factor Analyses Models' Fit (Studies 1-2 Aggregated)

	<i>CFI</i>	<i>TLI</i>	<i>RMSEA</i>	<i>SRMR</i>
Model A (32 items, correlated errors)	.962	.955	.034 (.032, .035)	.028
Model B (8 parcels, 4 items each)	.990	.987	.048 (.039, .058)	.017

Note. Model A was estimated with the Full Information Maximum Likelihood (FIML) estimator due to missing data. Model B was estimated with the Maximum Likelihood estimator with robust standard errors (MLR).

Following this analysis, we also examined whether the VIVIQ-PL measurement is invariant with regard to participants' gender. As illustrated in Table 3, the decrease in model fit when more restricted models were compared with more liberal ones (metric with configural and scalar with metric invariance models) was slight as compared to invariance criteria (Chen, 2007; Cheung & Rensvold, 2002), so a change of comparative fit index (*CFI*) of less than .01 ($\Delta CFI < .01$), a change of root mean square error of approximation (*RMSEA*) of less than .015 ($\Delta RMSEA < .015$). Therefore, we conclude that the VIVIQ-PL is a gender-

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fair instrument, therefore the average scores obtained among male and female participants could be compared.

Table 3. Measurement Invariance (Studies 1-2 aggregated)

Measurement Invariance	Model A		Model B	
	Model Fit	Comparisons	Model Fit	Comparisons
Configural	$CFI = .928$, $RMSEA = .051$		$CFI = .990$, $RMSEA = .051$	
Metric	$CFI = .926$, $RMSEA = .051$	$\Delta CFI = .002$, $\Delta RMSEA = .00$	$CFI = .990$, $RMSEA = .047$	$\Delta CFI = .000$, $\Delta RMSEA = .004$
Scalar	$CFI = .920$, $RMSEA = .052$	$\Delta CFI = .007$, $\Delta RMSEA = .001$	$CFI = .985$, $RMSEA = .052$	$\Delta CFI = .005$, $\Delta RMSEA = .006$

Model A = 32 items, correlated errors; Model B = 8 parcels, 4 items each

Having scalar invariance established, we compared the distributions and average scores obtained in the VIVIQ-PL by female and male participants (Figure 2). Our results are in line with previous findings – female participants outperformed the male ones (Welsch $t(2663.11) = 5.92, p < .001$), but the effect size of this difference was small: Cohen's $d = 0.22$ (95% CI : 0.15, 0.30).

Figure 2. Gender Differences in VIVIQ-PL (Studies 1-2 Aggregated)

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Test-Retest Reliability (Study 3)

The test-retest correlation of the VVIQ-PL scores with an interval of 3 weeks was strong and highly significant ($r = .89$; $p < .001$). When the intraclass correlation coefficient (ICC) was estimated as a mean-rating ($k = 2$), absolute-agreement, 2-way mixed-effects model, the ICC was .85 (95% *CI*: .79, .90), indicating high-to-excellent stability.

Construct Validity: VVIQ-PL vs. TVIC (Study 4)

The relationship between vividness of visual imagery (as measured by the VVIQ-PL) and control imagery (as measured by the TVIC) studied in Study 4 was both significant and robust in terms of the effect size ($r = .58$, $p < .001$; 95% *CI*: .49 to .67).

Part II: Vividness of Imagery and Creativity

Vividness of Imagery among Fine Artists and Controls (Study 5)

The independent samples Welch's t -test demonstrated the hypothesized difference between artist group and non-artist group on the total score on the VVIQ-PL (see Figure 2), $t(151.57) = 6.12$, $p < .001$; fine arts students ($M = 4.19$, $SD = 0.31$) scored higher than social science students ($M = 3.77$, $SD = 0.61$) and achieved a large effect size (Cohen's $d = 0.88$). This result confirms our expectation that individuals with formal artistic training tend to use visual imagery more vividly than 'non-artists.'

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Figure 2. Differences in VIVIQ-PL scores among fine arts students and control group

Creative Abilities, Creative Imagery and Creative Self-Concept (Studies 1, 2, 3)

Pearson's correlations between the VIVIQ-PL scores and different creativity measures applied across Studies 1-3 are summarized in Table 4. As illustrated, while in the majority of cases, the links were statistically significant, the size of these correlations was weak-to-moderate when performance measures are considered and moderate when self-report measures were applied.

More specifically, there were robust associations between the VIVIQ-PL and creative self-concept (domain-general CSE and CPI and creative self-efficacy in language and math), with r s between .13 and .39 – stronger when measured simultaneously and weaker when the measurement was deferred in time. The links between the VIVIQ-PL and performance measures of creative abilities were weaker. Fluency and originality were unrelated with the VIVIQ-PL. In contrast, in the case of creative imagery abilities (TCIA), there were significant, yet weak links with vividness and originality (both r s = .07), a null relationship with transformativeness (r = .03), and a weak link with the TCIA fluency (r = .12).

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Performance-based creativity scores obtained in the CLISAT were unrelated to the VIVIQ-PL when language was considered ($r = .07$) and significantly linked with math scores ($r = .17$). The overall result in the RAT was weakly linked with the VIVIQ-PL ($r = .11$), while the relationship between the VIVIQ-PL and a figural TCT-DP was within weak-to-moderate range ($r = .21$).

Table 4. Correlations between VIVIQ-PL, intelligence, and creativity measures across Studies 1-3

Variables	Study 1		Study 2		Study 3
	Same moment	Nine months apart	Same moment	Seven months apart	
Intelligence	--	.14***	.15***	.12***	--
CSE	.32***	.18***	.29***	.20***	--
CPI	.33***	.15***	.33***	.23***	--
CSE language	.39***	.18***	.35***	.24***	--
CSE math	.23***	.13***	.20***	.13***	--
CLISAT language	--	.07	--	--	--
CLISAT math	--	.17***	--	--	--
DT fluency	--	.03	--	--	--
DT originality	--	.07	--	--	--
TCIA fluency	--	--	.12***	--	--
TCIA vividness	--	--	.07*	--	--
TCIA transformativeness	--	--	.03	--	--
TCIA originality	--	--	.07*	--	--
RAT	--	--	.11***	--	--
TCT-DP	--	--	--	--	.21*

Note. Study 1, $N = 1,328$, Study 2, $N = 1576$, Study 3, $N = 103$. CSE = creative self-efficacy; CPI = creative personal identity; CLISAT = Creativity and Learning in School Achievement Test; DT = divergent thinking; TCIA = Test of Creative Imagery Abilities; RAT = Remote Associates Test; TCT-DP = Test of Creative Thinking-Drawing Production.

* $p < .05$, ** $p < .01$, *** $p < .001$

Discussion

The findings of the five studies summarized in this paper attest to the psychometric quality of the Polish adaptation of the VVIQ-2. Results of the factor and reliability analyses show that the VVIQ-PL is unidimensional and holds excellent internal consistency. This is consistent with previous findings; for example, Campos and colleagues (2002) drew similar conclusions in applying a one-factor solution to the Spanish version of the VVIQ. Also, the test-retest reliability indicates that the Polish version of the VVIQ-2 holds an excellent level of repeatability of scores obtained by individuals within a relatively short time interval (3 weeks). In previous research, estimates of test-retest reliability of the VVIQ over a three to

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seven weeks have also been judged to be satisfactory (e.g., Marks, 1973; Parrott & Strongman, 1985). In line with previous studies (Burton, 2003; Burton & Fogarty, 2003; Pérez-Fabello & Campos, 2004), scores on the VVIQ-PL were robustly correlated with scores on the Test of Visual Imagery Control (TVIC), which provides the evidence for the construct validity of this questionnaire.

To the best of our knowledge, our project is the first study that reported measurement invariance of the VVIQ-2 across gender groups. The presented results suggest that the VVIQ-PL is gender-fair, and the mean scores could be statistically compared. Our findings replicate previous results by showing that female participants report more vivid visual imagery than males ones (e.g., Campos & Sueiro, 1993; Campos & Pérez, 1988; Harshman & Paivio, 1987).

How does mental imagery relate to creativity? This—more substantial than psychometric—question informed our second goal in this investigation. Although anecdotal reports are full of examples of creators who use their imagery to create, empirical evidence shows that differently operationalized creative abilities (e.g., divergent thinking, insight problem solving) is relatively independent from vividness of mental imagery. Our studies provide a somewhat complex picture.

On the one hand—replicating Pérez-Fabello and Campos (2011)—we found not only statistically significant, but also large differences in mental imagery between the ‘artist group’ and matched controls (see also De Pisapia et al., 2016). Indeed, classic studies have demonstrated that mental imagery is not only related to aesthetic participation (Leonard & Lindauer, 1973), but also to creative behavior (Morrison & Wallace, 2001). It might even be speculated that vivid visual imagery serves as a prerequisite of artistic activity.

On the other hand, however, links between the VVIQ-PL and various measures of creativity we used across our studies might be considered disappointing. While positive and in

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most cases statistically significant, they rarely exceeded the value of $r = .30$: a benchmark for medium correlation (Cohen, 1988). In line with our assumptions, we obtained somewhat stronger relationships between the VVIQ-PL and the measures of figural creativity (TCT-DP, $r = .21$) than the verbal creativity (RAT, $r = .11$). In fact, however, what both of these correlations show is relative independence of mental imagery and creativity, rather than a robust association. While it seemed natural that the vividness mental images will relate more strongly to visual creativity as the same modality is being engaged, this pattern was not particularly consistent across our creativity measures. Take for example the Test of Creative Imagery Abilities (TCIA). Jankowska and Karwowski (2015), in one of their studies introducing the TCIA, reported robust correlations with the VIVIQ: $r = .42$ for vividness, $r = .36$ for originality, and $r = .31$ for transformativeness (all $ps < .001$). In our Study 2, the links obtained were marginal – from a correlation of $r = .03$ between the VIVIQ-PL and transformativeness (not significant) and $rs = .07$ in the case of VIVIQ-PL-originality and VIVIQ-PL-vividness links. This difference calls for further investigations that will go beyond a simple correlational analysis. One obvious explanation of these differences might focus on sample characteristics, as elementary and middle school students participated in our Study 2. Another possible reason might relate to the procedure. As participants in Study 2 solved a number of creativity and intelligence tasks, it is possible that they approached the TCIA in a way that focused on problem-solving rather than engaging imagery. Different strategies of approaching creativity tests result in different total scores obtained (Jankowska et al., 2018). Therefore, future studies should examine whether the links between the TCIA and the VIVIQ are stronger if the TCIA is solved when imagery is activated versus in a more problem-solving-oriented mode.

Regarding verbal creativity, we did not observe statistically significant correlations between the VIVIQ-PL and verbal fluency and originality as measured in divergent thinking

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tasks. Consequently, the connection between mental imagery and divergent thinking remains ambiguous as previous studies suggested; some studies, like ours, provide null effects, while others report weak-to-moderate effects (see LeBoutillier & Marks, 2003 for a review).

The obtained significant yet relatively weak correlations between vividness of mental imagery and intelligence replicate previous findings (see, e.g., Karwowski et al., 2016, Study 3). What seems particularly interesting, however, is the potential role of visual imagery not only for school achievement, but also for the so-called creative learning (Beghetto, 2016). In our Study 1, we applied the Creativity and Learning in School Achievement Test (CLISAT) that builds on the creative learning model (Beghetto, 2016; Beghetto & Karwowski, 2018; Karwowski et al., 2020). A recent longitudinal study on children (Guarnera et al., 2019) showed that generation and transformation of mental images predicts school achievement in early years of primary school. Therefore, we also expected that mental imagery might inform the processes of creative learning (see Beghetto & Karwowski, 2018), especially by allowing the students to more effectively build mental representations of the concept they learn about (see, e.g., Jankowska et al., 2019). Our findings, however, showed no relationship between vividness of mental imagery and ability to creatively use language for creative purposes ($r = .07$), and a significant (albeit weak) relationship with math scores in the CLISAT ($r = .17$), similar to an average score obtained in a recent meta-analysis on creativity-academic achievement links (Gajda et al., 2017, $r = .22$). Therefore, although it is too early to conclude that creative imagery does not inform creative learning, it seems fair to conclude that vividness of mental imagery alone is not sufficient to strengthen creative learning processes.

Finally, our studies demonstrated quite robust positive correlations between the VIVIQ-PL and creative self-concept, both domain-general creative self-efficacy and creative personal identity (Karwowski et al., 2019) and domain-specific creative self-efficacy in language and math (Karwowski et al., 2015). These correlations ranged from $r = .20$ to $r = .39$

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when creative self-concept and vividness of mental imagery were measured at the same time, and dropped to a correlation between $r = .13$ and $r = .24$ when the measurement was distant (seven-to-nine months apart). Although not impressive in absolute values, these correlations were systematic and illustrate a pattern that was not previously reported. More specifically, Study 1 and Study 2 showed that individuals who were more effective in seeing clear mental images were also those who believed in their creative abilities and tended to value creativity to a higher extent. While we emphasize that these links might partially stem from the common method variance—as both creative self-concept and mental imagery were measured by self-report instruments—this finding opens an interesting avenue for future research.

Conclusion

The conclusions that stem from the analyses presented in this paper are two-fold. First, the VIVIQ-PL we presented is a psychometrically sound instrument that allows for valid and reliable measurement of vividness of mental imagery. Second, however, although the role of mental imagery for creativity has been discussed for decades, while our studies were able to show strong differences in the vividness of mental imagery between artists and controls, correlations between the scores obtained in the VIVIQ-PL and different measures of creativity were weak-to-moderate at best. Thus, even if mental imagery plays an essential role in visual arts, its role for divergent thinking, creative learning, creative self-concept, or even creative imagery should not be taken for granted. Future studies, going beyond simple correlations, should integrate these links into a more comprehensive model of different creative abilities, including creative mental imagery.

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