Vividness of Object and Spatial Imagery

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Abstract
Vividness is one of the fundamental characteristics of visual mental imagery. The first research goal was to examine whether vividness that refer to imagery of pictorial object (color, texture, or shape) versus spatial (three dimensional structure, location, or mechanism) properties constitute separate vividness dimensions. The second goal was to develop a vividness questionnaire separately assessing dimensions of imagery vividness. In Study 1, 111 students (M age = 21.8 years, SD = 1.3) evaluated the vividness of imagery evoked by nine object and nine spatial items from the pilot version of the new Vividness of Object and Spatial Imagery (VOSI) questionnaire, completed a self-report assessment of object and spatial imagery, and rated their aptitudes in art and science. Analysis indicated that imagery vividness comprised object and spatial dimensions. Object vividness items were positively associated with the self-report measure and ratings of artistic abilities, whereas spatial vividness items were positively associated with self-report measure and ratings of science abilities. In Study 2, an independent sample of 205 students (M age = 21 years, SD = 1.7) completed the second version of the VOSI, art and science aptitude ratings, and a number of self-report and performance measures assessing object and spatial imagery. Object and spatial imagery vividness items loaded on factors with 28 retained items; this two-factor vividness model fit the data better than a unidimensional vividness model. The questionnaire had satisfactory Cronbach’s α for object vividness scale (.88) and for spatial vividness scale (.85). Correlational analyses supported convergent and discriminative validity of the VOSI. While object imagery vividness and spatial imagery vividness share some underlying vividness variance, they are dissociated into separate dimensions.

Keywords
vividness, object imagery, spatial imagery

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Introduction

Visual imagery is a quasi-perceptual experience of “seeing in the mind’s eye” in the absence of relevant sensory input (Kosslyn, 1994). Vividness has been traditionally considered a fundamental characteristic of visual imagery (Richardson, 1994). Vividness of imagery refers to the quality of the subjective imagery experiences in terms of their clarity and richness, sense of reality, and resemblance of actual perceptual experiences (Marks, 1973; Richardson, 1994). The variability in reports of subjective imagery vividness was quantified by a significant relationship with early visual cortex activity measured via functional magnetic resonance imaging (Amedi, Malach, & Pascual-Leone, 2005; Cui, Jeter, Yang, Montague, & Eagleman, 2007).

Self-reported vividness has been widely used as a measure of individual differences in visual imagery ability (e.g., the ability to form mental visual images). The first assessment of imagery vividness was Galton’s (1880) Breakfast Table Questionnaire. The majority of the subsequent vividness measures have been derived from this instrument (e.g., Questionnaire upon Mental Imagery by Betts, 1909; Vividness of Visual Imagery Questionnaire, VVIQ, by Marks, 1973; VVIQ-Prosopagnosia by Grüter, Grüter, Bell, & Carbon, 2009; The Plymouth Sensory Imagery Questionnaire by Andrade, May, Deeprose, Baugh, & Ganis, 2014). In all these questionnaires, participants had to imagine specific items (e.g., breakfast table or familiar face) and to rate the subjective vividness of the evoked images on a Likert scale.

The majority of imagery questionnaires have been criticized for their nonsatisfactory psychometric properties. Despite relatively high internal consistency reliability, they often lacked criterion validity and had inconsistent correlations with performance imagery tests (Hiscock, 1978; for review and discussion, see Blajenkova, Kozhevnikov, & Motes, 2006; Dean & Morris, 2003; McAvinue & Robertson, 2007). For instance, high vividness scores were found to be associated with better performance on some tasks, such as detecting salient changes in pictures (Rodway, Gillies, & Schepman, 2006) or color photograph recall (Marks, 1973), but not others, such as performing mental rotations and spatial transformations (Durdell & Wetherick, 1976; Poltrock & Brown, 1984). Additionally, vividness self-reports loaded on orthogonal factors with spatial imagery tests (DiVesta, Ingersoll, & Sunshine, 1971; Lorenz & Neisser, 1985). This puzzling lack of relationship between imagery vividness and performance on spatial tests (which are supposed to involve mental imagery) is consistent with the surprising findings of Galton’s (1880) original work. To his astonishment, Galton did not find scientists to be high imagers as measured by his Breakfast Table Questionnaire and concluded that the ability to form vivid and clear mental pictures is antagonistic to abstract thought. Another popular explanation for the lack of criterion validity of imagery questionnaires refers to the subjective nature of self-reports. It suggests that subjective imagery experiences are per se unrelated to imagery performance measures (for review, see Dean & Morris, 2003).
Alternatively, these puzzling findings were recently explained (Blajenkova et al., 2006) by a new approach that challenged the view of imagery as a single ability and distinguished between object and spatial visual imagery on the individual differences level (Kozhevnikov & Blazhenkova, 2013; Kozhevnikov, Kosslyn, & Shepard, 2005). This research approach was based on evidence from neuroscience and neuropsychology that supports the existence of two distinct pathways in the brain (ventral “visual-object” and dorsal “visual-spatial”), underpinning processing of different aspects of visual information (Farah, Hammond, Levine, & Calvano, 1988; Kosslyn & Koenig, 1992; Mazard, Tzourio-Mazoyer, Crivello, Mazoyer, & Mellet, 2004; Ungerleider & Mishkin, 1982). In particular, Kozhevnikov et al. (2005) provided evidence of individual differences in visual-object imagery (visualizing pictorial appearances of objects and scenes in terms of their shape, color, brightness, and texture) and visual-spatial imagery (visualizing spatial relations and movements of objects and their parts, and spatial transformations). This research identified two types of individuals: object visualizers and spatial visualizers (or imagers). Object visualizers were found to use imagery primarily for constructing vivid and colorful images of individual objects and to excel in tasks that require object visualization (e.g., recognizing degraded objects). In contrast, spatial visualizers were found to use imagery predominantly for representing spatial relations and transformations and to excel in tasks that require spatial visualization (e.g., mental rotation).

The above research first shed light on the understanding of vividness in the context of object-spatial dissociation. In particular, object visualizers were found to score higher than spatial visualizers on the VVIQ, a popular instrument for measuring imagery vividness (Marks, 1973). Further found that visual artists scored high on VVIQ and other object imagery tests but were low in spatial imagery, whereas scientists scored low on VVIQ and other object imagery tests but instead excelled in spatial imagery tasks (Blajenkova et al., 2006; Blazhenkova & Kozhevnikov, 2009, 2010; Kozhevnikov, Blazhenkova, & Becker, 2010). These findings suggest that vividness (as assessed by VVIQ) is a property of object but not spatial visual imagery. Therefore, given that object and spatial imagery are different dimensions of imagery, it is not surprising that imagery vividness measures (e.g., VVIQ) commonly were found to be unrelated to spatial ability tests. Furthermore, the approach distinguishing between object and spatial imagery explained Galton’s (1880) puzzling findings (Blajenkova et al., 2006). It suggested that scientists are not generally deficient in mental imagery but may lack only one kind of imagery (object), and not the other (spatial). Indeed, scientists and other members of science, technology, engineering, and mathematics domains were found to excel in a spatial imagery that involves visualization of schematic representations and spatial transformations but does not require vivid visualization of pictorial properties (Ferguson, 1977; Kozhevnikov, Motes, & Hegarty, 2007; Wai, Lubinski, & Benbow, 2009).
Overall, the approach dissociating between object and spatial imagery provides a plausible explanation for the perplexing lack of relationship between imagery vividness ratings and visual-spatial imagery ability.

Furthermore, the approach discriminating between object and spatial visual imagery provided a theoretically guided background for the development of valid and reliable self-report imagery instruments. Based on this approach, Blajenkova et al. (2006) developed the Object-Spatial Imagery Questionnaire (OSIQ), which consisted of two independent scales that separately assessed object and spatial imagery (i.e., imagery abilities, experiences, and preferences). Unlike many previous imagery questionnaires that had lacked criterion validity, the object imagery scale of the OSIQ significantly correlated with performance on object imagery tasks and predicted interest and membership in artistic specializations, while the spatial imagery scale significantly correlated with performance on spatial imagery tasks ($r$'s ranged from .2 to .5) and predicted interest and membership in artistic specializations. This research suggested that imagery self-reports may be valid measures correlated with performance tests; however, only when different dimensions of self-report imagery were associated with corresponding types of imagery required for the performance tasks.

In contrast to the OSIQ, traditional assessments of imagery vividness carry the implicit assumption that imagery is a single ability (Richardson, 1994); thus, people can be classified as being “good” or “poor” imagers. Imagery vividness ratings were often assumed to characterize people as “high” or “low” in overall imagery ability (Marks, 1973). However, while assuming that imagery is a single general skill, most popular instruments of imagery vividness usually assessed only one dimension of visual imagery (i.e., object) while ignoring the possible other (spatial) dimension. Indeed, all of the VVIQ items refer to real-world objects and scenes (e.g., a friend or relative, a familiar store, a country scene) primarily evoking pictorial colorful representations but excluding items describing visual-spatial properties (spatial relationships and transformations). Notably, research by Blazhenkova and Kozhevnikov (2009, 2010) demonstrated that the VVIQ correlated significantly with the object scale of the OSIQ ($r$’s ranged from .41 to .66) but was unrelated or even negatively correlated with the spatial scale of OSIQ ($r$’s ranged from -.02 to -.22). These findings suggest that VVIQ assesses object imagery, not spatial imagery.

However, the question remains whether vividness is a property of solely object imagery. It may be the case that traditional assessments of vividness simply ignored the spatial imagery dimension. Dean and Morris (2003) proposed that the lack of relationship between vividness reports and spatial performance measures may be due to the VVIQ’s composition of items. They developed a research tool called the Shapes Questionnaire. This questionnaire asked respondents to visualize spatial shapes, similar to those used in spatial tests of imagery such as Mental Rotation Test (MRT; Vandenberg & Kuse, 1978). The Shapes Questionnaire measured many different aspects of the imagery
process (i.e., formation, maintenance, and transformation as identified by Kosslyn’s (1994) model of the imagery system) and included few vividness questions. Dean and Morris found that vividness ratings of schematic shapes weakly but significantly correlated with proficiency in mental rotation of schematic shapes, while the VVIQ (Marks, 1973) did not. This study provided preliminary evidence that vividness of spatial forms may be related to performance measures. However, the Shapes Questionnaire did not specifically focus on vividness; it asked respondents to visualize only two spatial shapes and did not include parallel questions for object imagery items. The current study aimed to examine the possibility of vividness assessment in both, object and spatial, imagery dimensions.

Overall, the previous mainstream research considered vividness as a general imagery property. In practice, however, it assessed vividness as a characteristic of object but not spatial visualization. The question remains whether spatial imagery may involve vivid representations separate from object imagery representations. Since the majority of instruments assessing vividness contain predominantly object imagery items, there is a need for an assessment of vividness, which distinguishes between spatial and object imagery vividness dimensions. First, the current research aimed to test whether object and spatial vividness are dissociated in separate dimensions. The other intent was to develop a vividness questionnaire that would separately assess object and spatial imagery vividness and to examine internal consistency reliability and criterion validity (relationship with object vs. spatial imagery measures as well as artistic vs. scientific specialization preferences) for each vividness scale.

**Study 1**

**Method**

**Participants.** Sabanci University students (53 men, 58 women), 19 to 26 years old (\(M_{\text{age}} = 21.8, SD = 1.3\)), participated in the study. They were reimbursed with either course credits or chocolate bars. Participants received individual links to the study (by email) and completed the surveys via online Qualtrics Software (Qualtrics, Provo, UT).

**Measures**

*Pilot version of the Vividness of Object and Spatial Imagery (VOSI) questionnaire.* Based on the descriptions of object and spatial imagery properties (Blajenkova et al., 2006), nine items assessing object imagery vividness and nine items assessing spatial imagery vividness were created (see items in Table 1). Participants were asked to imagine each of these items and rate the vividness of their evoked mental images. The rating scale was adopted from the classical VVIQ (Marks, 1973), with scale descriptions as follows: 5 (*perfectly clear and as*
OSIQ is a self-report measure assessing individual differences in visual-object and visual-spatial imagery (Blajenkova et al., 2006). The OSIQ consists of 15 items assessing object visualization (e.g., “My images are very colorful and bright”) and 15 items assessing spatial visualization (e.g., “My images are more like schematic representations of things and events”). Notably, vividness is not deliberately measured in OSIQ; however, some of the object imagery scale items refer to vivid imagery experiences. Participants rated each statement on a five-point scale ranging from 5 (total agreement) and 1 (total disagreement).

Table 1. Principal component analysis of vividness ratings (VOSI pilot version) and their correlations with criterion measures.

<table>
<thead>
<tr>
<th>Item</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
<th>F5</th>
<th>FII</th>
<th>FI</th>
<th>OS</th>
<th>SS</th>
<th>Art</th>
<th>Sci</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1. Schema (plan) of a computer connecting to a printer</td>
<td>.80</td>
<td>-.06</td>
<td>-.02</td>
<td>.13</td>
<td>.09</td>
<td>.77</td>
<td>.04</td>
<td>.06</td>
<td>.44†</td>
<td>.09</td>
<td>.20‡</td>
</tr>
<tr>
<td>S2. Movement of bicycle parts (motion mechanism)</td>
<td>.75</td>
<td>.22</td>
<td>.20</td>
<td>.07</td>
<td>.05</td>
<td>.68</td>
<td>.12</td>
<td>.18</td>
<td>.43†</td>
<td>.11</td>
<td>.26†</td>
</tr>
<tr>
<td>S3. Blueprint (schematic plan) of the first floor in your school</td>
<td>.64</td>
<td>.21</td>
<td>.25</td>
<td>.21</td>
<td>.03</td>
<td>.68</td>
<td>.02</td>
<td>.06</td>
<td>.44†</td>
<td>.15</td>
<td>.15</td>
</tr>
<tr>
<td>S4. Location of your house on a map of your city</td>
<td>.59</td>
<td>.06</td>
<td>-.05</td>
<td>.10</td>
<td>.55</td>
<td>.67</td>
<td>-.01</td>
<td>-.06</td>
<td>.38†</td>
<td>.03</td>
<td>.18</td>
</tr>
<tr>
<td>S5. Mechanism of door handle</td>
<td>.50</td>
<td>.24</td>
<td>-.24</td>
<td>-.04</td>
<td>.61</td>
<td>-.02</td>
<td>-.01</td>
<td>.36†</td>
<td>.10</td>
<td>.23‡</td>
<td></td>
</tr>
<tr>
<td>S6. Motion plan of parallel parking</td>
<td>-.09</td>
<td>.80</td>
<td>.23</td>
<td>.12</td>
<td>.15</td>
<td>.60</td>
<td>.23</td>
<td>.21†</td>
<td>.36†</td>
<td>.16</td>
<td>.12</td>
</tr>
<tr>
<td>S7. Schema for putting some furniture pieces together (like in IKEA)</td>
<td>.20</td>
<td>.75</td>
<td>.07</td>
<td>-.06</td>
<td>.11</td>
<td>.59</td>
<td>.36</td>
<td>.26†</td>
<td>.39†</td>
<td>.18</td>
<td>.12</td>
</tr>
<tr>
<td>S8. Schematic plan of your room</td>
<td>.10</td>
<td>.74</td>
<td>.31</td>
<td>.12</td>
<td>.04</td>
<td>.59</td>
<td>.34</td>
<td>.27†</td>
<td>.31†</td>
<td>.12</td>
<td>.01</td>
</tr>
<tr>
<td>S9. Motion of the planets in our solar system on a model</td>
<td>.17</td>
<td>.57</td>
<td>.12</td>
<td>.04</td>
<td>-.04</td>
<td>.57</td>
<td>.24</td>
<td>.13</td>
<td>.29†</td>
<td>.04</td>
<td>.18</td>
</tr>
<tr>
<td>O1. Colors of ocean as if you were inside</td>
<td>.14</td>
<td>.15</td>
<td>.75</td>
<td>-.08</td>
<td>-.13</td>
<td>.15</td>
<td>.74</td>
<td>.36†</td>
<td>.10</td>
<td>.11</td>
<td>-.13</td>
</tr>
<tr>
<td>O2. Candle fire</td>
<td>-.07</td>
<td>-.01</td>
<td>.70</td>
<td>.11</td>
<td>.44</td>
<td>.05</td>
<td>.70</td>
<td>.32†</td>
<td>.04</td>
<td>-.01</td>
<td>-.11</td>
</tr>
<tr>
<td>O3. Fine details of zebra’s skin</td>
<td>.04</td>
<td>.32</td>
<td>.62</td>
<td>-.00</td>
<td>.16</td>
<td>.01</td>
<td>.65</td>
<td>.34†</td>
<td>-.06</td>
<td>.14</td>
<td>-.29†</td>
</tr>
<tr>
<td>O4. Shape of cloud in the sky</td>
<td>.19</td>
<td>.16</td>
<td>.57</td>
<td>.20</td>
<td>-.39</td>
<td>.09</td>
<td>.64</td>
<td>.32†</td>
<td>-.06</td>
<td>.18</td>
<td>-.12</td>
</tr>
<tr>
<td>O5. Texture of your favorite clothes</td>
<td>.27</td>
<td>.25</td>
<td>.56</td>
<td>.12</td>
<td>.01</td>
<td>.13</td>
<td>.60</td>
<td>.36†</td>
<td>-.04</td>
<td>.13</td>
<td>-.21†</td>
</tr>
<tr>
<td>O6. Combination of three colors that would match with sunset</td>
<td>.16</td>
<td>-.00</td>
<td>-.01</td>
<td>.86</td>
<td>-.06</td>
<td>.27</td>
<td>.58</td>
<td>.40†</td>
<td>.17</td>
<td>.23‡</td>
<td>-.11</td>
</tr>
<tr>
<td>O7. Shape of a grasshopper</td>
<td>.14</td>
<td>.16</td>
<td>.07</td>
<td>.82</td>
<td>.25</td>
<td>.11</td>
<td>.55</td>
<td>.42†</td>
<td>.06</td>
<td>.22‡</td>
<td>-.11</td>
</tr>
<tr>
<td>O8. Details of the best friend’s face</td>
<td>.44</td>
<td>.01</td>
<td>.08</td>
<td>.51</td>
<td>-.42</td>
<td>-.02</td>
<td>.54</td>
<td>.28†</td>
<td>-.00</td>
<td>-.01</td>
<td>-.15</td>
</tr>
</tbody>
</table>

Columns F-1 – FII show factor loadings: F1 to F5: Factors 1 to 5; FII: Forced Factor II; Columns OS – Sci show correlations: OS: object scale; SS: spatial scale; Art: artistic ability rating; Sci: scientific ability rating.

* † p < .05. ‡ p < .01.

vivid as normal vision), 4 (clear and reasonably vivid), 3 (moderately clear and vivid), 2 (vague and dim), 1 (no image at all, you only “know” that you are thinking of the object).
Separate object and spatial imagery scores were calculated by averaging the corresponding 15 ratings. Cronbach’s αs of the object and spatial scales were .83 and .79, respectively (Blajenkova et al., 2006).

**Aptitudes in different specialization areas.** Participants were asked to rate on a scale from 1 (lowest) to 7 (highest), their abilities in the following specialization fields: visual arts (visual art, design, realistic drawing with color) and natural sciences (physics, math, computer programming, engineering).

**Analysis.** First, to examine the factorial structure for the construct of vividness, principal component analysis (PCA) was conducted with all object and spatial vividness ratings. PCA was implemented since it is a commonly used exploratory tool and a recommended method of factor extraction, allowing reduction of the number of related variables while accounting for the most of the variance within the original variables (Conway & Huffcutt, 2003). Next, the relationships of object and spatial vividness ratings with criterion measures (object and spatial scores of the OSIQ, as well as artistic and scientific aptitude ratings) were examined using Pearson’s correlation.

**Results**

**Principal component analysis.** The value for Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was .786. The results of the PCA with Varimax rotation indicated five factors with eigenvalues above 1, cumulatively explaining 63% of variance. In particular, the first and second factors had spatial vividness items with high loadings, whereas the last three factors had highly loaded object vividness items (Table 1). Thus, all spatial vividness items loaded on different factors than did object vividness items. Since the eigenvalues-greater-than-one rule does not always result in reliable components (Cliff, 1988), subsequent considerations determining the optimal number of components to retain were made. A two-factor solution was preferred, based on the results of parallel analysis (O’Connor, 2000), which identifies the number of components that account for more variance than the components derived from randomly generated data. Consistently, the scree test (Cattell, 1966) identified “leveling off” of eigenvalues on the scree plot after the second factor. Finally, the two-factor structure corresponded to the theoretically and physiologically based expectations: the object and spatial items that were initially formulated to discriminately assess different vividness dimensions loaded on separate components (this was also true for the initial nonforced PCA output). Thus, an additional PCA with forced two-factor solution was conducted, cumulatively explaining 42% of the variance. In this solution, the basic factor structure remained the same, consistently separating object and spatial imagery vividness items into different factors (Table 1). These results suggest that vividness is not a single construct and that object and spatial vividness constitute distinct dimensions.
**Pearson's correlations.** The results of correlational analysis indicated that all object vividness items significantly and positively correlated with the object imagery scale of OSIQ, whereas all spatial vividness items significantly and positively correlated with the spatial imagery scale of OSIQ (Table 1). However, while all object vividness items exclusively correlated with the object imagery scale of OSIQ but not the spatial imagery scale, the three of the spatial vividness items (S6, S7, and S8, as indicated in Table 1) also correlated with object OSIQ, though these correlations were smaller than with spatial OSIQ. Possibly, these items may have encouraged some object visualization. Furthermore, object vividness items tended to positively correlate with ratings of artistic abilities, while spatial ability items tended to positively correlate with scientific abilities ratings.

**Study 2**

**Method**

**Participants.** Sabanci University students (95 men, 110 women), 18 to 26 years old (\(M_{\text{age}} = 21.0, SD = 1.7\)), participated in the study. They were reimbursed with course credits. Participants completed the study via online Qualtrics Software (Qualtrics, Provo, UT).

**Measures.** Participants were administered the second version of VOSI, as well as self-report of aptitudes in different specialization areas (as in Study 1) and the OSIQ. The VOSI was revised based on the results of the first study. New items assessing object and spatial imagery vividness were created. Overall, 17 object vividness and 17 spatial vividness items were included. In addition, participants completed the assessments of object imagery (VVIQ, Fragmented Pictures, and Camouflage task) and spatial (Mental Rotation Task and Paper Folding Task).

**VVIQ** (Marks, 1973) is the most common assessment of imagery vividness. Participants rated the subjective vividness of the evoked visual images from 16 verbal descriptions of scenes (e.g., “The sun is rising above the horizon into a hazy sky”) on a five-point scale (same as in VOSI). VVIQ scores were created by averaging all ratings. Internal consistency reliability (Cronbach’s \(\alpha\)) for this questionnaire was .88 (McKelvie, 1995).

**Fragmented Pictures task.** Thirty-four pictures were taken from the stimulus set created by De Winter and Wagemans (2004). Participants had 5 min to recognize meaningful objects from fragmented outlines (created by deleting parts of their contours) and write down the names of the recognized objects. The final score was computed as the number of correctly identified objects. In the current sample, Cronbach’s \(\alpha\) for this task was .77.
**Camouflage Pictures task.** Thirty-six pictures of various nature scenes were presented. Half included a hidden living object (e.g., an insect in grass or an animal in the woods). Participants had 5 min to identify living objects in these scenes, and either write down the name of the recognized object, or indicate that there was no living object in the scene. The final score was computed as the sum of correct answers. In the current sample, Cronbach’s $\alpha$ for this task was .80.

**Paper Folding test.** (Part 2, Ekstrom, French, Harman, & Dermen, 1976). This test measures spatial visualization ability. Participants had to identify how a folded and punched paper would look when fully opened. Participants were given 3 min to complete 10 test items. Test scores were computed as the number of correct answers minus one-quarter of one point for each incorrect answer. The split-half reliability for this test was .75 (Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001).

**MRT** (Vandenberg & Kuse, 1978; redrawn by Peters et al., 1995) measures spatial transformation ability. Participants had to mentally rotate 3D geometric figures composed of cubes and to indicate which two of the four figures were rotated versions of the criterion figure. Participants had 3.5 min to complete 12 items (MRT, B). Test scores were calculated as the number of items in which both rotated images of the criterion figure were correctly identified. The Kuder–Richardson (KR20) internal consistency for this test was .88 (Vandenberg & Kuse, 1978).

**Analysis.** First, to examine the factorial structure for the construct of vividness, PCA was conducted with all object and spatial vividness ratings. Based on PCA, the final items for the VOSI questionnaire were selected. Next, confirmatory factor analysis (CFA) was used to evaluate two-factor versus unidimensional vividness models. Finally, the psychometric properties of the VOSI were examined using Scale Reliability (Cronbach’s $\alpha$) and Pearson’s correlation analyses.

**Results**

**Principal component analysis.** The value for KMO measure of sampling adequacy was .847. The initial 34 items were analyzed using PCA with Varimax rotation. As a check, Promax rotation ($k = 4$), assuming that the two vividness factors are correlated, was implemented. There was little difference between the Varimax and Promax solutions (see Table 2). Consistent with Study 1, the results supported separating object and spatial imagery vividness items into different factors. Based on loadings in the forced two-factor solution, cumulatively explaining 37% of the variance, 14 object imagery and 14 spatial items for the were retained for the final version of the VOSI (Table 2).

**Confirmatory factor analysis.** Comparative evaluation of the two-factor model (distinguishing between object and spatial vividness dimensions, see Figure 1) and
the unifactorial vividness model (Figure 2) was conducted using CFA. As can be seen from the estimated two-factor model, all object vividness items loaded above .45 on one factor, while all spatial vividness items loaded above .44 on the other factor. Object and spatial vividness factors appeared to be positivity
related. However, individual item loadings on each of the factors exceeded the strength of the relationship between the two vividness factors. In the unifactorial vividness model, all items appeared to load positivity on a single factor; however, the loadings were overall smaller than in the two-factor model (the lowest loading was .24).

For both models, chi-square was significant: two-factor model: $\chi^2(349) = 759.30, p < .001$; unifactorial model: $\chi^2(350) = 1180.09, p < .001$. However, chi-square is affected by the sample size, and large samples (over 200 in the current study) are likely to produce significant chi-squares (Barrett, 2007). The chi-square difference comparing the fit of two models indicated that the overall fit of the two-factor model is significantly greater than that of the unifactorial model, $\chi^2(1) = 420.80, p < .001$. The values of fit indices suggest that the

Figure 1. Path diagram for the confirmatory factor analysis of two-factor model. VOSI: Vividness of Object and Spatial Imagery.
two-factor model had a relatively better fit than the unifactorial model; however, the two-factor model did not describe the data well. For the two-factor model, the root mean square error of approximation (RMSEA) value of .076 was within the reasonable fit range of 0.05–0.08 (Browne & Cudeck, 1992). However, the goodness-of-fit index (GFI) value of .77 and the comparative fit index (CFI) value of .77 were far below the recommended threshold of .9 (Baumgartner & Homburg, 1996). For the unifactorial model, the RMSEA

![Figure 2. Path diagram for the confirmatory factor analysis of unifactorial model. VOSI: Vividness of Object and Spatial Imagery.]
value was .108, the GFI value was .60, and the CFI value was .53, suggesting that this model described the data poorly.

**VOSI questionnaire reliability and validity.** The two separate scale scores of VOSI were computed by averaging the corresponding 14 object and 14 spatial imagery vividness ratings. Internal reliability (Cronbach’s $\alpha$) for object vividness scale was .88 and for spatial vividness scale was .85, which meets McKelvie’s (1994) recommendations for psychometric properties of imagery questionnaires ($\alpha$ above .85).

The VOSI validity was examined by correlating the scale scores with the criterion measures. The results supported convergent and discriminative validity of VOSI. In particular, VOSI object vividness scale positively correlated with measures of object imagery (OSIQ object scale, VVIQ, Camouflage Pictures task, and Fragmented Pictures task) and artistic ability ratings, and even negatively with scientific ability ratings, but did not correlate with spatial imagery ability measures. In contrast, the VOSI spatial vividness scale positively correlated with measures of spatial imagery (spatial OSIQ scale, MRT, and Paper Folding test) and scientific ability ratings but did not correlate with performance object imagery measures and OSIQ object scale. However, the VOSI spatial vividness scale was moderately correlated with the VVIQ, though, more weakly than the object vividness scale correlated with the VVIQ (Table 3). Besides, the object and spatial vividness scales of the VOSI were correlated ($r = .31$), suggesting some common variance.

**Discussion**

The results of the current research provided evidence that visual imagery vividness is not a homogeneous single construct but comprises distinct object and

<table>
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<tr>
<th>Measure</th>
<th>VOSI Object scale</th>
<th>VOSI Spatial scale</th>
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</thead>
<tbody>
<tr>
<td>OSIQ object scale</td>
<td>.64†</td>
<td>.04</td>
</tr>
<tr>
<td>OSIQ spatial scale</td>
<td>-.03</td>
<td>.45†</td>
</tr>
<tr>
<td>Artistic ability rating</td>
<td>.37†</td>
<td>-.10</td>
</tr>
<tr>
<td>Scientific ability rating</td>
<td>-.21†</td>
<td>.33†</td>
</tr>
<tr>
<td>VVIQ</td>
<td>.65†</td>
<td>.29†</td>
</tr>
<tr>
<td>Camouflage Pictures</td>
<td>.23†</td>
<td>.11</td>
</tr>
<tr>
<td>Fragmented Pictures</td>
<td>.16*</td>
<td>.06</td>
</tr>
<tr>
<td>Paper Folding</td>
<td>.05</td>
<td>.18*</td>
</tr>
<tr>
<td>Mental Rotation</td>
<td>.10</td>
<td>.15*</td>
</tr>
</tbody>
</table>

VOSI: Vividness of Object and Spatial Imagery; OSIQ: Object-Spatial Imagery Questionnaire.

*p < .05. †p < .01.
spatial dimensions. PCA and CFA indicated that vividness ratings that refer to imagery of pictorial (color, texture, or shape) versus spatial (3D structure, location, or mechanism) properties constitute separate vividness dimensions. These findings challenge previous conceptions of vividness of imagery as an attribute of general imagery ability (Galton, 1880; Marks, 1973; Richardson, 1994) and extend the research that considered vividness as a property of object imagery ability (Blajenkova et al., 2006; Blazhenkova & Kozhevnikov, 2009, 2010). Furthermore, CFA demonstrated that although the overall fit of the two-factor vividness model was not perfect, it was significantly greater than that of the unifactorial vividness model, suggesting that the two-factor model is superior to the single-factor model. Probably, the structure of relationships between different vividness components is more complex than reflected in the two-factor model evaluated in the current study. Yet, current results showed that a unifactorial vividness model assuming vividness as a single unitary construct did not describe the data adequately.

Furthermore, the results indicated that object and spatial imagery vividness are not fully independent and might share some common variance. Object and spatial vividness ratings of the VOSI appeared to be moderately associated, as demonstrated by correlation and CFA. Additionally, the spatial vividness scale of the VOSI was moderately correlated with the VVIQ, suggesting some connection between spatial and object vividness. This relationship may be partially explained by the format (adopted from the VVIQ rating scale), used for rating both object and spatial vividness items. Not surprisingly, since both content and format of questions are very similar for the VOSI object vividness scale and the VVIQ, these measures were correlated strongly.

While the current study supported the existence of distinct spatial imagery vividness construct, the conceptual understanding of spatial vividness needs further clarification. It should be noted that definition of imagery vividness has often referred to the resemblance of actual perceptual experiences (Marks, 1973). However, while this is fully relevant for visual-object imagery vividness (e.g., imagining pictorial details of a face or candle fire), in case of spatial vividness, mental visualization may not directly resemble perceptual experiences (e.g., imagining spatial schema or 3D structure) but still be vivid in a sense of being clear or rich in detail. Additionally, there is evidence that spatial representations may be not only visual but encoded in a modality-independent schematic spatial format (Lacey & Campbell, 2006; Thinus-Blanc & Gaunet, 1997). Thus, while estimating vividness of spatial items, participants may reinterpret the “vividness” as less visual than in case of object items. Research is needed to further examine these possibilities as well as for further refinement of the “vividness” concept in imagery research. Possibly, current VVIQ-like format of items is biased toward object imagery representations, and future assessments of visual vividness should use definitions of vividness that would equally apply to both object and spatial visual imagery experiences (e.g.,
Nevertheless, the current investigation demonstrated the distinctness of object and spatial vividness, suggesting that the items’ content was pertinent, despite all items being rated in the VVIQ-like format.

The second aim of the current study was to design a vividness questionnaire that would separately assess object and spatial imagery vividness and to examine its psychometric quality. As an outcome, a new instrument, the VOSI questionnaire, was developed. Both object and spatial VOSI vividness scales showed satisfactory internal consistency reliability. Furthermore, the results demonstrated criterion-related validity of both object and spatial vividness scales of the VOSI. In particular, the object vividness scale positively correlated with the measures of object imagery (object OSIQ scale, VVIQ, Camouflage Pictures task, and Fragmented Pictures task) and artistic ability ratings but not with spatial measures, and it correlated negatively with scientific ability ratings. The spatial vividness scale of the VOSI positively correlated with the measures of spatial imagery (spatial OSIQ scale, MRT, and Paper Folding test) and scientific ability ratings but not with object measures or artistic ability ratings. Overall, object and spatial vividness scales demonstrated significant relationships with a number of criterion measures, including both self-report and performance assessments. However, the strength of correlations with performance assessments was relatively weak. The VOSI needs further validation using additional samples and other criterion measures, and, possibly, further reconsideration of items (i.e., inclusion of items that better tap separate dimensions of vividness) or format (i.e., inclusion of more precise definitions of vividness applicable to both object and spatial visual imagery experiences). The current version of the VOSI can serve as a research tool to examine vividness in different imagery dimensions. The findings suggest that vividness should not be exclusively associated with pictorial object imagery but may also apply to spatial imagery representations. Furthermore, the associations found between vividness and performance measures indicate that both object and spatial imagery vividness may play functional role. This research opens the gates for future work examining the role of object and spatial vividness in performance on different kinds of tasks. Moreover, the present work showed that spatial and object vividness are associated with aptitudes in different specialization areas, suggesting that vividness may play role in both artistic and scientific thinking. There is substantial evidence for the functional role of visual imagery (Blazhenkova & Kozhevnikov, 2010; Kozhevnikov et al., 2007; Miller, 1996; Rosenberg, 1987) and in particular, vividness of imagery (Di Corrado, Guarnera, & Quartiroli, 2014; Morrison & Wallace, 2001) in multiple professional areas. However, since Galton’s research (1880), the role of imagery vividness in scientific thinking has been overlooked. Future research is invited to examine more thoroughly the role of imagery
vividness in mental processes of different professionals, whose work involves object and spatial visualization (e.g., artists, designers, architects, engineers, and scientists). Additionally, neural correlates of spatial vividness remain to be examined. The current finding that object and spatial vividness constitute separate dimensions brings new theoretical and applied perspectives in understanding one of the most fundamental imagery characteristics.

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References


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