



The roles of rarity and organization of stimulus material in divergent thinking



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ABSTRACT

This study examines the effects of rarity and organization of stimulus material on divergent thinking. Divergent thinking was assessed by the Unusual Uses test, in which participants had to generate as many uses as possible for a wooden ruler. Participants were primed with either rare or common ideas which were presented either in three consequent sets, or simultaneously in one set. We found a significant effect of rarity on originality. With regard to originality, participants primed with rare stimuli significantly outperformed their counterparts primed with common stimuli. We also found a significant effect of organization on fluency. With regard to this parameter, participants primed with the distributed stimulus set significantly outperformed their counterparts primed with the simultaneous set. Finally, we found marginally significant interactive effect of rarity and organization on fluency and originality. Participants who were primed with rare stimuli in distributed sets tended to obtain higher fluency and originality scores than participants in other groups.

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1. Introduction

The importance of introducing creativity to a school curriculum has long been recognized by the academic community (e.g., [Beghetto, 2010](#); [Runco, 2004](#); [Torrance, 1968](#); [Vygotsky, 1967/2004](#)). Since [Guilford, 1950's](#) presidential address to the American Psychological Association, numerous studies have been aimed at identifying and studying creativity. The primary concern of these studies has been focused on methods and techniques to enhance creativity in young children, adolescents and adults alike. Many models designed to analyze creative education look at specific factors stimulating an individual's creative performance (see [Moseley et al., 2005](#)). The present study focuses on two factors, namely, rarity of the stimulus material and the organization of procedures used to introduce this material.

1.1. Divergent thinking

In the psychometric tradition, creative thinking is perceived as an ability to initiate multiple cycles of divergent and convergent thinking (). The combined effort of these two types of thinking creates an active, attention-demanding process that allows generation of ideas satisfying the defining characteristics of a creative product. These characteristics include novelty (i.e., original or unexpected) and utility (i.e., useful or meeting task constraints) (see [Sternberg, 1999](#), for an overview).

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Over the last half century, numerous studies have provided evidence for the ability of divergent thinking tests to predict certain aspects of creative problem-solving performance and real world creative achievement (e.g., Kim, 2008; Kuhn & Holling, 2009). For example, Kim performed a meta-analysis of 27 studies (with 47,197 participants) that established the correlation coefficients between divergent thinking test scores and creative achievement. Despite the differences in divergent thinking tests, creative achievement types, predicted time periods, and creativity subscales, she found a significant relationship between divergent thinking performance and creative achievement ($r = 0.22$). Nevertheless, there is a meaningful argument that questions this relationship. For example, some researchers argue that the validity of divergent thinking tests may depend, in part, on the scoring procedures being applied (e.g. Runco & Mraz, 1992; Silvia, 2011). Other researchers argue that divergent thinking tests are weakly related to other kinds of creativity ratings and therefore measure only a small portion of creativity (Hocevar, 1981). Still others question the nature of divergent thinking tests as the measures of creativity at all. They argue that this relationship is rather between divergent thinking and other types of cognitive capacities such as intelligence (Sternberg & O'Hara, 1999). The concept of divergent thinking has been also criticized as not including motivational and affecting components (Sternberg & Grigorenko, 2000/2001). In a broader sense, Barron and Harrington (1981) criticized the idea that eminent creative performance can be explained by mundane cognitive processing such as divergent thinking. They noted that there was remarkably little evidence revealing divergent thinking abilities in highly creative people.

This skepticism however, is answered by researchers identifying the traces of divergent thinking in eminent individuals. For example, Stokes (2000: 279) notes:

Matisse, Picasso, and Calder displayed divergent thinking in using a multiplicity of styles and media. Think of the innovative paper sculptures made by Picasso during his Cubist period; of Matisse's late, great cut-outs, the culmination of his pursuit of an art of pure line and pure color; of Calder's whimsical, wire-constructed contour 'drawings' in three dimensions.

In the same fashion, Runco (1986) explored the relationship between divergent thinking test scores and creative performance in 96 gifted and 116 non-gifted children. The criterion of creative performance was a self-report that estimated the quantity and quality of extracurricular activity in different domains (e.g., writing, art, music, science). He found that divergent thinking and creative performance scores were moderately related in the gifted sample but unrelated in the non-gifted sample. In a more recent study, Vincent, Decker, and Mumford (2002) examined the relationships among intelligence, expertise, and divergent thinking as they influence creative problem-solving and performance in a sample of 110 military leaders. Divergent thinking was measured using Christensen, Merrifield, and Guilford's (1953) consequences test known to capture aspects of divergent thinking relevant to leaders' problem-solving efforts (Mumford, Marks, Connelly, Zaccaro, & Johnson, 1998). In this study, divergent thinking correlated with idea generation and idea implementation more strongly than intelligence and expertise. The study suggested that divergent thinking has unique effects on creative problem solving that could not be attributed to the other cognitive capacities.

Thus, although as Runco (1991) argues, "Divergent thinking is not synonymous with creative thinking" (p. ix), many researchers believe that divergent thinking is an important component of the creative process (see also Lubart, 2000). Therefore, a close scrutiny of individuals' divergent thinking performance may at least partially illuminate their creative functioning.

Guilford (1967) associated the properties of divergent thinking with four main characteristics: fluency (the ability to rapidly produce a large number of ideas or solutions to a problem); flexibility (the capacity to consider a variety of approaches to a problem simultaneously); elaboration (the ability to think through the details of an idea and carry it out); and originality (the tendency to produce ideas different from those of most other people).

1.2. Organization of stimulus material

The present study assumes the organization of the presentation of stimulus material in terms of the structure of a stimulus set. Numerous studies investigating the role of the structure of stimulus sets in creativity stimulation focus on task decomposition. Dennis, Valacich, Connolly, and Wynne (1996) reported that individuals who brainstormed on a problem that was presented to them in three discrete sets generated more ideas than those who brainstormed on the same problem presented in one set. Similarly, Coskun, Paulus, Brown, and Sherwood (2000) demonstrated that distributed (sequential) presentation of stimuli leads to higher creative performance. In their experiment, participants were required to produce ideas on how to improve their university life along 10 categories. Participants in the distributed group had to generate ideas in each category one after the other. Participants in the simultaneous group had to generate ideas in all ten categories simultaneously. The first group produced a significantly higher number of ideas. However, this conclusion was not supported in some other studies. For example, Rastogi and Sharma (2010) reported that participants involved in a simultaneous task displayed significantly higher creative performance than their counterparts involved in a distributed task.

The positive effect of distributed presentation of stimulus material can be explained by memory effects. The role of memory in stimulus organization has been emphasized in studies on the spacing effect on learning. These studies revealed that spaced (distributed) presentations lead to better retention than massed (simultaneous) presentations (cf. Dempster, 1988; Seabrook, Brown, & Solity, 2005). Memory appears to play an important role in creative process as well. The Matrix model (Brown, Tumeo, Larey, & Paulus, 1998) focuses on the role of long-term memory in idea generation. This model considers memory as a number of interconnected nodes. The strength of the connection between two nodes stipulates the associative link between them. Each cell in this matrix contains information with probability of producing a next idea

from the same or a different semantic category. The probability of generating the next idea corresponds to the ability to generate a large overall number of ideas; that is, fluency. Fluency in divergent thinking therefore, is related to within- and between-category transition probabilities. Similarly, the Search for Ideas in Associative Memory (SIAM) model considers both long-term and working memory as factors in idea generation (Nijstad & Stroebe, 2006). According to this model, working memory is an active component of long-term memory, and activated elements from long-term memory are temporarily stored in working memory. The temporarily stored elements can be used for the subsequent transformation of knowledge and generation of new associations in long-term memory, which can in turn lead to the production of new ideas.

1.3. *Rarity of stimulating material*

The rarity of stimulus material is also hypothesized to have a positive impact on an individual's creativity. Individuals may perceive rare stimuli as an exemplar of someone else's creative activity, which in turn stimulates their creative thinking. When they try to come up with a novel idea, their imagination is generally limited by a particular set of properties characterizing a category to which this innovation should belong (Ward, 1994). They tend to select the most common set of properties of a category as a starting point for their creations (Ward, Smith, & Vaid, 1997). A number of studies on various domains of creative production show that the semantic structure of a category has a substantial influence on what people produce (Ward, Patterson, Sifonis, Dodds, & Saunders, 2002). "Structured imagination" (cf. Ward, 1994) limits individuals' "thinking outside the box"; that is, people have difficulties violating the conceptual boundaries of a standard category when creating a new exemplar of that category.

Several studies have tapped into this problem and obtained rather controversial results. Dugosh and Paulus (2005) asked participants to list the advantages and disadvantages of having an extra thumb on a hand. Participants generated a larger number of unique ideas when primed by a set of rare ideas than when primed by a set of common ideas. However, the effect was found only for a small set of stimuli (eight ideas). When primed with a large set (40 ideas), a common group in this study generated a larger number of unique ideas than did a rare group. Similar findings were obtained by Connolly, Routhieaux, and Schneider (1993) who presented participants with either common or rare ideas for balancing a college budget. Rare ideas were those proposed only once by participants in a preliminary study. Common ideas were those generated by at least five different participants in that preliminary study. Both rare and common groups were found to produce a comparable number of solutions to a problem. Fink et al., (2012), in a manner similar to that of the present study, examined the influence of the rarity of stimulus material on idea generation. They presented participants with either common or rare words, or meaningless pseudowords (a control condition). Then participants were asked to think up alternative uses of conventional everyday objects (e.g., umbrella). Participants exposed to common and to rare groups demonstrated insignificant differences in performance.

1.4. *Present study*

The purpose of the present study is to investigate the influence of organization and rarity of stimulus material on divergent thinking performance. We hypothesize that (a) priming with rare stimulus material influences divergent thinking, (b) priming with distributed stimulus material influences divergent thinking, and (c) an interaction of priming with rare and distributed stimulating materials influences divergent thinking. With regard to (c), we anticipate that participants who were stimulated with distributed sets of rare ideas will demonstrate greater divergent thinking than their counterparts.

2. **Method**

2.1. *Participants*

Participants were 129 undergraduate students of the Higher School of Economics (84 male and 45 female) aged between 17 and 20 ($M=18.13$, $SD=0.59$). They provided a consent to participate in the study and received a course credit for participation.

2.2. *Divergent thinking assessment*

Divergent thinking was assessed by Guilford's Unusual Uses test adopted by Averina and Shcheblanova (1996) for Russian speakers. The standard verbal procedure involved generating as many unusual and original uses as possible for a common object (in this case, a wooden ruler). Results were scored for fluency (the total number of uses generated for the object), flexibility (the total number of categories from which the uses were drawn), and originality (the statistical rarity of the uses). The fluency score was obtained by counting a number of relevant responses. The flexibility score was obtained by counting the number of categories of relevant responses identified by Averina and Scheblanova. The originality score was obtained by comparing participants' responses with a list of responses generated by 500 participants in Averina and Scheblanova's sample. This list consists of a response and the frequency of occurrence of this response. If the response occurred in more than 10% of participants, the originality score is 1; 6–10% – 2; 3–6% – 3; 1–3% – 4; less than 1% – 5. That is, the more original

Table 1
Means and standard deviations (in parentheses) of fluency, flexibility, and originality scores for all five groups.

Stimulus type	Common		Rare		Control
	Simultaneous	Distributed	Simultaneous	Distributed	
Fluency	12.31 (3.04)	12.65 (4.04)	11.54 (2.83)	14.38 (4.12)	10.28 (3.90)
Flexibility	10.00 (2.81)	10.31 (3.06)	9.50 (2.34)	11.19 (2.90)	8.48 (2.47)
Originality	3.07 (.63)	2.72 (.70)	3.26 (.41)	3.33 (.36)	2.90 (.61)

a response is comparing with the responses of other participants, the higher the score. An average originality score was calculated for each participant.

2.3. Procedure

The stimuli were selected from the list of original responses in [Averina and Shcheblanova \(1996\)](#) mentioned earlier. Fifteen uses of a wooden ruler that received a score of 5 (the most uncommon; e.g., to make a sole for an old shoe) were selected as rare stimuli; 15 uses of a wooden ruler that received a score of 1 (the most common; e.g. make a cross) were selected as common stimuli (see [Appendix A](#)). Selected stimuli were printed on sheets of paper and presented to participants as ideas produced by other participants.

Participants were randomly divided in five groups. Two distributed stimulation groups received stimuli in three consequent sets (5 stimuli printed on separate sheets of paper in each set). They had 20 s to familiarize themselves with each set. Then, they were given two minutes to produce and write down their own ideas. The procedure was repeated for each set. The first set of stimuli was presented to participants in the very beginning of the experiment and just before they started to produce their own applications of a wooden ruler. The *distributed rare stimulation* group received rare stimuli, whereas the *distributed common stimulation* group received common stimuli. Two simultaneous stimulation groups received all 15 stimuli at once. They had one minute to familiarize themselves with the stimuli. Then, they were given six minutes to produce and write down their own ideas. The *simultaneous rare stimulation* group received rare stimuli, whereas the *simultaneous common stimulation* group received common stimuli. The *control group* received no stimulation. They were given six minutes to produce their own ideas.

The test was preceded with the instruction, which explicitly prompted participants from all groups to produce as many uncommon uses of a wooden ruler as they could. It also explicitly stated that these uses should have some practical value.

3. Results

The means and standard deviations of originality, flexibility, and fluency scores for each group (rare distributed stimulation, rare simultaneous stimulation, common distributed stimulation, common simultaneous stimulation, and control) are reported in [Table 1](#).

We performed a multivariate ANOVA with rarity (rare, common) and organization (distributed, simultaneous) as independent factors and creativity traits (fluency, flexibility, and originality) as dependent variables. We found a significant main effect of rarity ($F(3, 98) = 4.61$; $p < 0.01$; $\eta^2 = 0.12$), and marginally significant effects of organization ($F(3, 98) = 2.56$; $p = 0.06$; $\eta^2 = 0.07$) and the interaction between rarity and organization ($F(3, 98) = 2.24$; $p = 0.09$; $\eta^2 = 0.06$). The results indicated evident influence of the rarity on the creativity traits. The organization of the stimulus set and the interaction of this factor and rarity of stimuli showed a tendency to influence creativity. The subsequent univariate ANOVAs revealed the results described below.

3.1. The effect of rarity of stimulus material on originality

We found a significant effect of rarity on originality ($F(1, 100) = 13.58$; $p < 0.001$; $\eta^2 = 0.12$). Participants primed with rare stimuli significantly outperformed their counterparts primed with common stimuli on the originality score ($\Delta M = 0.39$, $SE = 0.11$, $p < 0.01$). This finding confirmed our first hypothesis, namely, that priming with rare stimuli influences divergent thinking.

3.2. The effect of organization of stimulus material on fluency

We also found a significant effect of organization on fluency ($F(1, 100) = 5.24$; $p < 0.05$; $\eta^2 = 0.05$). Participants primed with the distributed stimulus set significantly outperformed their counterparts primed with simultaneous stimulus set on the fluency score ($\Delta M = 1.60$, $SE = 0.72$, $p < 0.05$). This finding confirmed our second hypothesis, namely, that priming with distributed stimuli influences divergent thinking.

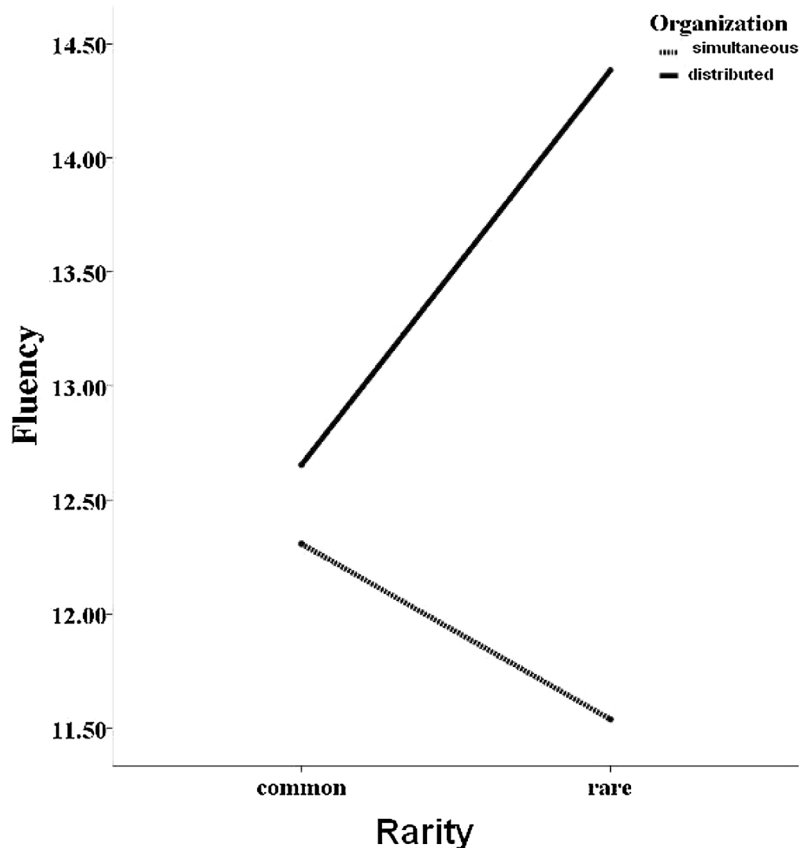


Fig. 1. The interactive effect of novelty and organization on fluency, $N = 104$.

3.3. The effect of interaction on fluency and originality

Finally, we found a marginally significant interactive effect of rarity and organization on fluency ($F(1, 100) = 3.21$; $p = 0.08$; $\eta^2 = 0.03$) and originality ($F(1, 100) = 3.93$; $p = 0.05$; $\eta^2 = 0.04$). As Fig. 1 illustrates, participants who received rare stimuli in distributed sets tended to obtain higher fluency scores than participants in other groups ($\Delta M = 2.85$, $SE = 0.99$, $p < 0.01$, with rare simultaneous; $\Delta M = 2.08$, $SE = 0.99$, $p < 0.05$, with common simultaneous; and $\Delta M = 1.73$, $SE = 0.99$, $p = 0.08$, with common distributed). Evidently, this kind of stimuli positively influences participants' fluency. Similarly, as Fig. 2 illustrates, participants who received rare stimuli in distributed sets tended to obtain higher originality scores than participants in other groups, although this difference became significant only in comparison with those participants who received common stimuli in distributed sets ($\Delta M = 0.60$, $SE = 0.15$, $p < 0.001$). The results revealed the greatest difference on originality between the rare distributed and the common distributed group.

4. Discussion

The purpose of the present study was to examine effects of rarity and organization of stimulus material on divergent thinking performance.

4.1. The effect of rarity of stimulus material on divergent thinking

We found that priming with rare stimulus material leads to an increase of originality in thinking. This finding is consistent with the simple matching perspective, which argues that exposure to rare stimulus material may lead to generation of rare ideas; and conversely, that exposure to common stimulus material leads to generation of common ideas (Dugosh & Paulus, 2005). This finding also replicates that in Fink et al.'s (2012) study, in which participants were asked to produce unusual uses for 20 different everyday objects. Participants were presented with each object name accompanied by two examples from one of three categories: common uses, original uses, or meaningless words. After inspecting these words for four seconds, participants were given 12 s to generate their own uses of the given objects. The selected objects were semantically different, which could have reduced the semantic bias in the stimulus set. At the same time, this procedure required participants to

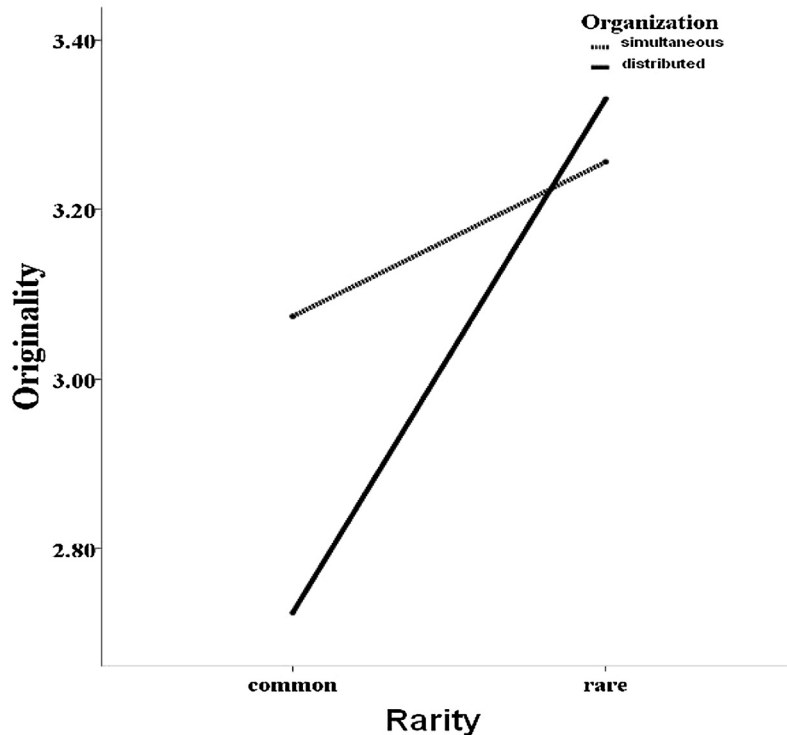


Fig. 2. The interactive effect of novelty and organization on originality, $N = 104$.

rapidly switch their attention from one object to another. Participants in our study, on the other hand, received more time to inspect the stimuli and produce their responses, which potentially allowed them to focus their attention to a greater extent. The degree of focused attention could explain why Fink et al.'s study found no effect of the rarity of the stimulus material, while the present study found a positive effect of this factor.

4.2. The effect of organization of stimulus material on divergent thinking

We also found that priming with distributed stimulus material influences fluency in thinking. This finding overlaps with that reported by in Dennis et al. (1996) and Coskun et al. (2000) discussed in the introduction. A possible explanation of the increase in fluency when stimulus material is presented in distributed sets is rooted in the task alternation. This effect occurs when work on a target activity is interrupted by an alternative activity. Dijksterhuis and Meurs (2006) demonstrated that distraction can stimulate individual creativity. In the distributed groups in our study, participants had to switch back and forth between perception and production of alternative uses of a ruler being periodically distracted from the target task. This task switching may stimulate production of new ideas, that is, fluency.

Another explanation refers to the decay of activated knowledge structures in working memory, as was elaborated by a revised Matrix model (Coskun et al., 2000). Previous ideas have less influence on idea generation because subsequent ideas have more weight and subsequently activate related associations more intensively. Simultaneously presented stimulus material contains a larger proportion of old ideas that could have less activation compared with distributed stimulating material.

4.3. The interactive effect of rarity and organization of stimulus material on divergent thinking

Finally, we found an interactive effect of rarity and organization of stimulus material on fluency and originality in thinking. Specifically, participants who received rare stimuli in distributed sets tended to obtain higher scores on these measures in comparison to their counterparts in other groups. This effect can be explained in terms of the functioning of working and long-term memories.

We assume that stimulus ideas can either automatically activate related associations in long-term memory directly (similar to the Matrix model) or indirectly serving as components of a searching cue (similar to the SIAM model). Rare ideas present better exemplars relevant to the task demands (i.e., production of unusual and original uses of a given object) compared to common ideas. Hence, the rare ideas are more likely to be included into searching cues than are common ideas. If a stimulus idea is included in a searching cue, it can serve as a starting point for the activation of the relevant

associations in the long-term memory; that is, it activates relevant knowledge structures. In this case, recently generated ideas can match searching cues, which in turn may facilitate an individual's creative performance (Hao et al., 2016). When ideas are presented in a distributed manner, a larger number of rare ideas can become components of searching cues. At the same time, when ideas are presented simultaneously, the number of ideas included in the searching cue set is smaller due to the limited working memory capacity. As Coskun et al., (2000) stated, simultaneous presentation of stimuli set "may overwhelm the participants and prevent them from focusing their attention adequately on each of the primes presented" (p. 318). Assuming that the stimuli in the searching cues set may trigger idea generation, the increased number of included rare ideas could lead to increase in divergent thinking. Analysis of particular mechanisms of inclusion of an idea into a searching cue and the functioning of the searching cue may be a promising direction for future research.

5. Conclusion

This study demonstrated the influence of rarity and organization of stimulus material on divergent thinking. Thereby it contributes to a collection of empirical work investigating the effects of stimulus set decomposition on individual creativity. The results of the study suggest that an elaborately structured set of presented original (rare) ideas may facilitate overcoming barriers and stereotypes in divergent thinking. Previous studies demonstrated that creative verbal improvisation positively affects individual divergent thinking (Lewis & Lovatt, 2013). Presentation of others' verbal improvisation products to an individual appears to produce similar effect. It can provide teachers in a classroom with more flexibility in the use of creativity stimulation techniques. They can improve creative improvisation tasks by introducing original ideas generated by the others (preferably in distributed format).

At the same time, the study revealed complexity of interaction between the structure of a stimulus set and the degree of rarity stimuli exposed. This complexity may give a head start to future research in the area. Future research should elaborate on the findings of the current study by collecting more data to produce a stronger quantitative basis for experimental statistics. We can identify at least one limitation of the study stemming from the semantic diversity of presented stimuli, which was not controlled. It is entirely possible that the number of categories to which the stimulus ideas belong may modify the effect of stimulus set decomposition. The effect of semantic diversity of the stimulus material should be investigated in future research.

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Appendix A. A list of rare and common stimuli (translated from Russian)

A list of rare and common stimuli (translated from Russian)

	Rare	Common
1.	An ice-cream stick	Cut out shapes
2.	Make a hair roller	Make a cheat sheet
3.	An ice-hockey stick	Make a box
4.	A stand for items	Measure length or width
5.	A spatula for applying paint or plaster	Make a catapult
6.	Make a fan	Draw lines, shapes or select anything
7.	Make a propeller for a toy airplane	Make a sword
8.	Make blinds	A bar to lock the door
9.	A sole for an old shoe	An opener
10.	An electrical insulator	Make a toy raft
11.	A tennis racket	Make a cross
12.	A ladle	Material to burn
13.	Make a stretcher	Make a bird cage
14.	A float for fishing rod	Make furniture
15.	Make a water ski	A boomerang

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