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# Understanding Fluency and Originality: A latent variable perspective

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ABSTRACT

Divergent thinking tasks, which require participants to generate multiple original ideas, are perhaps the most widely used measures in the creativity literature. Participant performance on divergent thinking tasks is often interpreted in terms of multiple factors, with Fluency and Originality being two of the most commonly utilized. Fluency refers to the quantity of ideas a participant generates, and Originality refers to the relative novelty of each of those ideas. In this study, the Uses of Objects Task is employed, and a comparison of three confirmatory factor models is undertaken on the resulting data to ascertain the nature of the constructs of Fluency and Originality as well as the relation between them. Moreover, Originality is operationalized in this investigation in terms of semantic distance, and calculated via latent semantic analysis (LSA). Results suggest that Fluency and Originality are best conceptualized as distinct but positively correlated constructs, and that Originality, when derived through LSA, can exhibit greater construct reliability than Fluency.



## 1. Introduction

Since at least the middle of the 20th century, creativity has been touted in scholarly literature as a critical capacity of the human mind (Guilford, 1950; Hudson, 1968; Runco & Albert, 2010). Throughout the history of creativity research, measuring the creative abilities of individuals, and using those measurements to understand the nature of creativity, has been a widely held goal (Plucker and Runco, 2001; Sternberg & Lubart, 1992). In the literature on creativity, divergent thinking tasks, which require participants to generate multiple original ideas, are perhaps the most widely used measure (Hudson, 1968; Lewis & Lovatt, 2013; Plucker & Makel, 2010). While divergent thinking tasks are not generally considered to tap creativity per se, the potential usefulness of divergent thinking tasks in understanding the creative potential of an individual is attested to by the large body of work pertaining to their predictive validity, which can be as good as the predictive validity associated with some tests of intelligence (e.g., Carson, Peterson, & Higgins, 2005; Runco, Millar, Acar, & Cramond, 2010). For example, scores on divergent thinking tasks can be predictive of creative achievements and activities, and remain somewhat stable over the lifespan (Millar, 2002; Torrance, 1972; Torrance & Safter, 1989).

Importantly, performance on divergent thinking tasks is often assessed in terms of multiple components or factors, based on the way responses are scored (Silvia, Martin, & Nusbaum, 2009). Two of the most often used, and potentially most important factors of divergent thinking are Fluency and Originality, where Fluency refers to the ease at which a participant

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can generate a large quantity of ideas, and Originality to the comparative novelty of those generated ideas (Hocevar, 1979; Runco & Mraz, 1992; Silvia, 2008). Because these two components of divergent thinking are often derived and utilized in research, the relation between Originality and Fluency has been a central question in creativity research (e.g., Hocevar, 1980; Silvia, 2008), with wider relevance to diverse pursuits such as applicant selection for jobs (e.g., Batey, Rawles, & Furnham, 2009) and educational interventions (Alfonso-Benlliure, Meléndez, & García-Ballesteros, 2013). However, little consensus exists as to the direction and strength of this relation (Runco, 2010). For example, some scholars (e.g., Benedek, Fink, & Neubauer, 2006) have found that Fluency and Originality are highly separable, or even come at the expense of one another. In contrast, others (e.g., Silvia, 2008) have argued that Fluency and Originality are strongly positively related constructs, and that individuals who generate highly original ideas are also likely to be highly fluent at idea generation. In this investigation, a latent variable perspective is adopted to better understand the nature of Fluency, Originality, and the relation between them.

In psychometrics, the distinction is made between observed variables, which are raw measurements taken from a test or task and have unaccounted-for measurement error within them, and latent variables, which are derived via latent variable models (e.g., confirmatory factor analysis, structural equation modeling) that account for measurement error (Hancock & Mueller, 2006). This is highly relevant to research on divergent thinking and creativity because the measurement error associated with divergent thinking tasks can at times be substantial (Piffer, 2012). This measurement error can cause relations between observed variables to be falsely attenuated or augmented, depending on the situation (Cole & Preacher, 2013). However, if a latent variable model is used, the measurement error associated with each observed or indicator variable is accounted for, and therefore does not affect the constructs being investigated (Hancock & Mueller, 2006). In the literature on divergent thinking and creativity, the relation between observed variables representing Originality and Fluency has been examined (Alliger, 1988; Benedek et al., 2006; Hocevar, 1979; Runco & Okuda, 1991). However, latent variable models of Fluency, Originality, and divergent thinking have appeared much less often (e.g., Silvia, 2008, 2011).

### 1.1. Fluency

In research pertaining to divergent thinking and creativity, tasks are most often scored and operationalized in terms of Fluency (Guilford, 1967; Plucker & Makel, 2010). Indeed, Fluency scores have often solely been used to represent divergent thinking, or even creativity in general (e.g., Turner, 1999). This trend may have arisen because Fluency can be operationalized objectively and easily by counting the number of ideas that a participant generates. These count scores can be further analyzed using a variety of statistical procedures, and have demonstrated their usefulness in testing hypotheses related to divergent thinking and creativity (Benedek et al., 2006; Torrance, 1972). However, while Fluency scores account for the quantity of ideas that a participant generates on a divergent thinking task, they do not account for the original quality of those ideas.

### 1.2. Originality

Potentially more closely tied theoretically to creativity than Fluency; Originality has been considered a critical factor of divergent thinking for decades (Sternberg & Lubart, 1992; Torrance, 1972; Wilson, Guilford, & Christensen, 1953). Throughout that time, Originality has been operationalized and scored in a variety of ways, with the most common being through the use of a panel of raters (e.g., Sternberg, 2006a). Sometimes, the participants themselves are also asked to rate the Originality of their generated ideas (e.g., Silvia, 2011). However, the highly subjective nature of these scoring methods for Originality has led to problems. Specifically, Originality scores of the same idea from different raters can differ widely, even when the raters are explicitly trained (Sternberg, 2006b). This compromises measure reliability, and makes it very difficult to fruitfully use Originality scores to predict creative performance outside the laboratory (Forster & Dunbar, 2009).

In response to this problem, researchers have turned to some more objective measures of Originality. One such method is the use of algorithms that produce Originality scores based on the number of participants in a given sample that produced the same idea (e.g., Vargas Hernandez, Schmidt, & Okudan, 2013). Thus, if a participant is the only one in a sample to have generated a particular idea, that idea will receive the maximum score, while ideas that are more common will receive lower scores. While this method is more objective than using raters, it is still highly sample dependent. Indeed, the same idea, generated by different participants in different samples, can receive vastly different originality scores.

Another more recently formulated method of scoring the originality of verbal ideas, is through the use of semantic networks (e.g., Acar & Runco, 2014; Bossomaier, Harré, Knittel, & Snyder, 2009). This method uses the semantic structure of a given language (e.g., English) to operationalize Originality. Specifically, the more semantically distant a generated idea is from a prompt, the higher originality score it will receive. While this concept has existed in the creativity literature for some time (Mednick, 1962), the empirical usage of automated, computerized, semantic networks to operationalize Originality is a more recent endeavor (Bossomaier et al., 2009). This semantic-network based method is more objective, and potentially more useful, than algorithms for Originality based on participant responses in a given sample, because semantically derived Originality scores are not sample dependent and can therefore be compared across samples or studies. Interestingly, among those researchers who use semantic networks to operationalize Originality, multiple methods have been used, with most researchers using measures of semantic distance derived from word co-occurrence or word associations based on human raters (e.g., Acar & Runco, 2014; Mednick, 1962). However, these techniques may hold some of the same pitfalls as previously used methods for operationalizing Originality, in that they are heavily dependent on the sample of raters used to produce

the associations through which semantic distance is calculated. In response to this issue, some researchers (e.g., Dumas & Dunbar, 2014; Forster & Dunbar, 2009; Green, Kraemer, Fugelsang, Gray, & Dunbar, 2010) have extended the use of latent variable models to semantic distance through the use of latent semantic analysis (LSA).

LSA is a technique for quantifying the latent semantic relation between words or phrases through the analysis of a very large body of text, called a corpus (Deerwester, Dumais, Furnas, Landauer, & Harshman, 1990). In LSA, the frequency of words within the corpus are represented in the form of a multi-dimensional matrix, similar to what might be used in other multivariate procedures, such as factor analysis. In this multi-dimensional semantic space, vectors associated with specific words or phrases are identified. Taking the cosine of the angle between two word vectors produces a semantic similarity-score ranging between −1 and 1. Indeed, geometrically, a correlation can always be thought of as the cosine of the angle between variable vectors in a multivariate space. Importantly, these semantic correlations produced by LSA are at the latent variable level, meaning they are relatively free from unwanted attenuation or augmentation associated with measurement error. This means that, while semantic similarity scores between the same two words can potentially differ across corpora, they will always be highly similar, as long as each corpus is sufficiently large. Another potential advantage of LSA for research on creativity and divergent thinking is that it allows for multiple interpretations of linguistically presented stimuli (i.e., homonyms), meaning that participants who interpret prompts on divergent thinking tasks differently can have their responses scored relatively objectively, with neither interpretation being given preference because of the cultural context in which the measures were created, or the data was collected and analyzed.

Importantly, LSA has been shown to approximate human thinking in terms of category membership (Lanham, 1997), word to word priming (Landauer, Foltz, & Laham, 1998), and metaphor comprehension (Kintsch, 2000). LSA is also currently being used as an efficient, automated way, to score essays (Foltz, Streeter, Lochbaum, & Landauer, 2013). In creativity research, capturing this efficient, automated aspect of LSA for the scoring of Originality, whose measurement has perennially been time-consuming and expensive, is a potentially very helpful. In addition, LSA has been shown to be a more reliable means of scoring the Originality of participant responses on divergent thinking tasks, at the measured variable level, than human raters (Forster & Dunbar, 2009). Given each of these potentially advantageous elements, LSA was selected as the method by which Originality was operationalized in this investigation.

### 1.3. The relation between Fluency and Originality

Over the years, many theoretical relations between Fluency and Originality have been posited. For example, some have argued these constructs must be highly positively related, in that individuals who are highly fluent are likely to be highly original (e.g., Silvia, 2008). Others see Fluency and Originality as highly separable constructs, in that Originality likely suffers when the quantity of ideas becomes a main focus (e.g., Benedek et al., 2006; Hocevar, 1980). Interestingly, while calculating Fluency and Originality scores separately is common practice in the field, many researchers combine these scores by summing or averaging. These kinds of combinatorial decisions implicitly represent a single-factor conceptualization of divergent thinking, in which Fluency and Originality are practically the same. In contrast, when Originality and Fluency scores are calculated, and then entirely separated in analysis, an orthogonal conceptualization, in which the constructs are unrelated, is implicitly present.

In the existing empirical investigations of the relation between Fluency and Originality, a positive relation is typically found (e.g., Runco, 2010). However, the strength of that positive relation may be subject to change based on the scoring technique used. For example, one recent investigation of the relation between Originality and Fluency at the latent variable level (i.e., Silvia, 2008) uncovered a very strong positive correlation (i.e., .89) between the factors. However, the method used to score the Originality of ideas (i.e., whether or not an idea was unique to the sample) may have caused the correlation to be higher than it otherwise would have been. This observation opens the door for continued investigations of the relation between Originality and Fluency at the latent variable level. To our knowledge, this study is the first to investigate the relation between Fluency and Originality when Originality was scored using a latent semantic-network.

### 1.4. Construct reliability

Since the advent of psychometric research on creativity, the reliability of measures, such as divergent thinking tasks, has been of importance (Torrance & Safter, 1989). However, only recently has the *construct reliability* of latent variables associated with creativity and divergent thinking been formerly investigated in the field (Silvia, 2011). Especially in creativity research, in which the constructs of interest are deeply complex, the reliability of the variables measured, including those at the latent variable level, is critical to assess. However, some potentially meaningful questions remain about the construct reliability of creative Fluency and Originality. For example, no study of which we are aware has examined the construct reliability of Originality assessed via a semantic network (e.g., LSA). Further, because the inclusion of Originality and Fluency in structural equation models pertaining to the relations among creativity and other constructs (e.g., intelligence; Silvia, 2008) is of interest in the field, the differential construct reliability between Fluency and Originality is of importance. This is because differences in construct reliability can have potentially adverse effects on the fit of structural equation models (Raykov & Hancock, 2005). As such, when formulating a structural equation model, researchers would like to know what level of construct reliability they could expect from a given latent variable. In this investigation, the construct reliability of

Fluency and Originality will be formally examined. Specifically, we examined two related research questions. First, how can Fluency, Originality, and the relation between them, best be conceptualized at the latent variable level? Second, given the conceptualization of the constructs chosen previously, what is the construct reliability of Fluency and Originality?

## 2. Method

### 2.1. Participants

Two hundred and one undergraduate students at a large mid-Atlantic American university (131 female; 65.17%) participated in this study. Participants were recruited for this study via the introductory psychology participant pool, in which students taking introductory psychology classes are required to participate, and from recruitment posters displayed around the university campus and digital postings to university listservs. In exchange for their participation, students were entered into a lottery where they could win an iPad. Participants ranged in age from 17 to 27, with a mean age of 19.77 ($SD = 1.55$). The sample was highly diverse with a small White majority ($n = 119$; 59.201%), 6.96% of students reporting their ethnicity as African American ($n = 14$); 12.44% students reporting their ethnicity as Hispanic/Latino ($n = 25$); and 23.38% reporting their ethnicity as Asian ($n = 47$). The vast majority (89.55%) of the sample reported their first language as English ($n = 180$), and participants reported a mean grade point average (GPA) of 3.42 ($SD = .50$) with GPAs ranging from 2.00 to 4.00.

### 2.2. Measures

This study utilized the Uses of Objects Task (UOT). The UOT is a psychometric measure in which participants are asked to produce as many novel uses for a given object as possible. The UOT has been used for assessing participants' divergent thinking and creative ability for many years (Guilford, 1967; Hudson, 1968; Torrance, 1972).

On the UOT, 10 different object names were presented to participants in a random order. The ten objects that were used on the UOT were chosen based on the results of an empirical norming study, which identified them as objects that U.S. undergraduate students were generally very familiar with (Van Overschelde, Rawson, & Dunlosky, 2006). The object names that were presented to participants were as follows: book, fork, table, hammer, pants, trumpet, truck, carrot, shovel, and sandals.

### 2.3. Procedure

The UOT was administered to participants online, through the Qualtrics© (2013) online platform. For this investigation, participation on the UOT outside the laboratory and online was considered beneficial, because participants could complete the UOT from any computer connected to the Internet, allowing for a potentially advantageous level of flexibility and privacy. In order to access the UOT, participants were sent a link to the study website via email. On the study website, participants completed an informed consent form, and provided demographic information. Then, participants were asked to take the UOT with minimal distractions. Specifically, participants were prompted to turn off the TV, music, and close other websites or programs on their computer. Because the UOT requires a significant amount of typing, participation required a traditional keyboard, and taking the UOT on a smartphone or tablet was not permitted. Participants were given two minutes to provide uses for each object before they were automatically advanced to the next object in the task. After a participant had completed each of the ten objects (i.e., after 20 min), they were informed that the task was complete, thanked for their participation, and were automatically logged out of the study website.

While Internet-based measures and tasks are rapidly becoming the norm in psychometrics (e.g., Björnsdotter, Enebrink, & Ghaderi, 2013; DeBoer et al., 2014) their potential effects on participants' creativity is worth considering. For one, it does increase the likelihood (as compared to laboratory-based studies) that participants are distracted while engaged with the study, although participants were explicitly instructed in this case to focus on the task, and not on other websites or other potential distractors. Moreover, it also adds a level of privacy that is potentially important for creativity research. For instance, early methodologies utilized to capture the divergent thinking of students (e.g., Hudson, 1968) emphasized the need for participants to have as much privacy from authority figures as possible, so that they would feel comfortable expressing original ideas. Because participants in this research participated in a private setting, participants may have felt more comfortable thinking divergently than they would have if a researcher was present. With these observations in mind, data from the online UOT was collected and analyzed.

## 3. Results

### 3.1. Scoring of the UOT

Reflecting this investigation's dual foci (i.e., Fluency and Originality) participant responses to each of the 10 objects on the UOT were scored in two different ways, yielding a total of 20 indicator variables for later analysis. The first scoring method was counting the generated uses (Fluency), and the second was LSA (Originality). Table 1 presents descriptive statistics for each of these indicators.

**Table 1**
Descriptive statistics of indicator variables.

| Latent variable | Scoring method | Indicator variable | Mean | Standard deviation |
|---|---|---|---|---|
| Fluency | Counts | Book | 8.63 | 4.28 |
| | | Fork | 7.11 | 3.96 |
| | | Table | 8.31 | 4.68 |
| | | Hammer | 6.75 | 3.48 |
| | | Pants | 7.39 | 4.50 |
| | | Trumpet | 5.92 | 3.94 |
| | | Truck | 6.18 | 3.56 |
| | | Carrot | 6.64 | 4.41 |
| | | Shovel | 6.18 | 3.74 |
| | | Sandals | 6.12 | 3.76 |
| Originality | Latent semantic analysis | Book | .752 | .168 |
| | | Fork | .806 | .105 |
| | | Table | .755 | .151 |
| | | Hammer | .721 | .127 |
| | | Pants | .681 | .118 |
| | | Trumpet | .761 | .142 |
| | | Truck | .734 | .121 |
| | | Carrot | .760 | .113 |
| | | Shovel | .738 | .135 |
| | | Sandals | .731 | .146 |

*Fluency*. First, the number of uses generated by each participant for each object was tallied, producing a count variable. As was explained earlier in this paper, counts such as these are the principle way in which Fluency has been operationalized in the extant research literature (Plucker & Makel, 2010). The mean number of uses generated by participants across all 10 objects on the UOT was 69.28 ($SD$ = 32.54). Mean numbers of generated uses for each of the individual objects are available in Table 2.

*Originality*. Originality was assessed using latent semantic analysis. As mentioned earlier, LSA is a latent variable statistical technique that can be fruitfully used to quantitatively operationalize the Originality of an idea (Deerwester et al., 1990; Kintsch, 2000). In this investigation, semantic similarity measures were calculated using a very large corpus (i.e., 37,651 included documents and more than 11 million included words) built to approximate the expected reading experience of the average college student (*general-reading-up-to-the-first-year-in-college:* Landauer et al., 1998). Using LSA, a measure of semantic similarity ranging from −1 (extremely dissimilar) and 1 (extremely similar) of each generated use from the original object was produced. Then, in order to convert this measure of semantic similarity into one of semantic distance, and therefore of Originality, these values were subtracted from 1, yielding measures of Originality which ranged from 0 (not original at all) to 2 (very original). This operationalization of Originality as semantic distance is consistent with theoretical accounts of creativity, which consider highly original ideas to depart in important ways from what is typically or generally done (Guilford, 1967; Sternberg, 2006b), as well as recent empirical investigations that have measured Originality through the use of semantic-networks (e.g., Bossomaier et al., 2009). These scores were then averaged across each of an individual participant's generated uses for a given object on the UOT, yielding their Originality score for that particular object. Table 1 depicts mean Originality scores in our sample for each of the objects on the UOT. Importantly, Fluency and Originality scores were derived from the same raw participant data, making a nonconfounded comparison of these two variables possible.

### 3.2. Examining Fluency and Originality

Because our research questions in this analysis focused on the nature of two particular, theoretically-derived latent variables (i.e., Fluency and Originality) and the relation between them, a model-comparison methodology was utilized in this investigation. This method allows for the empirical testing of various theoretical conceptualizations of Fluency and Originality and the relation between them. As such, this method can potentially provide statistical and empirical support to ideas existing within the literature. Specifically, we used confirmatory factor analysis (CFA) to compare three theoretically defensible models of Fluency and Originality, and compare their fit.

A theoretical depiction of each of the models is displayed in Fig. 1. Model A was a single-factor model, with one latent variable loading on all 20 indicator variables. This single factor may be termed *divergent thinking*, because it represents performance on the UOT, a quintessential divergent thinking task. A parallel to this model exists in the intelligence literature, in which intelligence has been described as being underlain by a single general-intelligence or "g" factor (Spearman, 1927). Indeed, if Model A were to fit best of the models being tested here, creativity may be conceptualized in similar way, with a general factor underlying divergent thinking performance.

In contrast to Model A, Model B fully separated the latent variables of Fluency and Originality. Specifically, the 10 counted indicator variables were set to load on Fluency, and the 10 LSA-derived indicators were set to load on Originality, and the covariance between these two latent variables was set to zero. This model may represent conceptualizations of creativity or divergent thinking found in the research literature, in which the construct is found to be composed of highly separable

**Table 2**
Correlations among indicator variables.

| | Fluency (Counts) | | | | | | | | | | | Originality (LSA) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Latent Variable | Indicator Variable | Book | Fork | Table | Hammer | Pants | Trumpet | Truck | Carrot | Shovel | Sandals | Book | Fork | Table | Hammer | Pants | Trumpet | Truck | Carrot | Shovel | Sandals |
| Fluency (Counts) | Book | 1.00 | | | | | | | | | | | | | | | | | | | |
| | Fork | .376 | 1.00 | | | | | | | | | | | | | | | | | | |
| | Table | .525 | .368 | 1.00 | | | | . | | | | | | | | | | | | | |
| | Hammer | .361 | .264 | .344 | 1.00 | | | | | | | | | | | | | | | | |
| | Pants | .325 | .213 | .395 | .145 | 1.00 | | | | | | | | | | | | | | | |
| | Trumpet | .192 | .077 | .139 | .340 | .071 | 1.00 | | | | | | | | | | | | | | |
| | Truck | .179 | .109 | .160 | .160 | .065 | .336 | 1.00 | | | | | | | | | | | | | |
| | Carrot | .471 | .247 | .364 | .317 | .240 | .186 | .106 | 1.00 | | | | | | | | | | | | |
| | Shovel | .293 | .196 | .273 | .409 | .284 | .376 | .134 | .377 | 1.00 | | | | | | | | | | | |
| | Sandals | .283 | .245 | .350 | .361 | .240 | .227 | .076 | .436 | .471 | 1.00 | | | | | | | | | | |
| Originality (LSA) | Book | .332 | .113 | .201 | .121 | .132 | .182 | .043 | .111 | .230 | .077 | 1.00 | | | | | | | | | |
| | Fork | .233 | .221 | .222 | .205 | .073 | .209 | .690 | .239 | .196 | .199 | .634 | 1.00 | | | | | | | | |
| | Table | .183 | .036 | .190 | .098 | .136 | .137 | -.102 | .112 | .151 | .119 | .699 | .739 | 1.00 | | | | | | | |
| | Hammer | .199 | .121 | .155 | .265 | .065 | .207 | -.100 | .192 | .257 | .215 | .661 | .737 | .678 | 1.00 | | | | | | |
| | Pants | .202 | .101 | .161 | .088 | .231 | .179 | -.094 | .169 | .165 | .182 | .680 | .707 | .667 | .716 | 1.00 | | | | | |
| | Trumpet | .155 | .090 | .121 | .161 | .141 | .352 | .133 | .216 | .297 | .235 | .589 | .558 | .550 | .558 | .573 | 1.00 | | | | |
| | Truck | .100 | .075 | .099 | .059 | .088 | .232 | .199 | .143 | .257 | .177 | .490 | .483 | .500 | .564 | .449 | .666 | 1.00 | | | |
| | Carrot | .048 | .044 | .089 | .049 | .100 | .082 | .064 | .232 | .236 | .156 | .521 | .514 | .551 | .579 | .516 | .706 | .757 | 1.00 | | |
| | Shovel | .167 | .195 | .154 | .158 | .157 | .258 | .090 | .177 | .378 | .230 | .529 | .531 | .487 | .563 | .515 | .644 | .728 | .713 | 1.00 | |
| | Sandals | .103 | .011 | .112 | .142 | .077 | .193 | .032 | .183 | .246 | .248 | .641 | .572 | .603 | .634 | .641 | .717 | .659 | .680 | .665 | 1.00 |

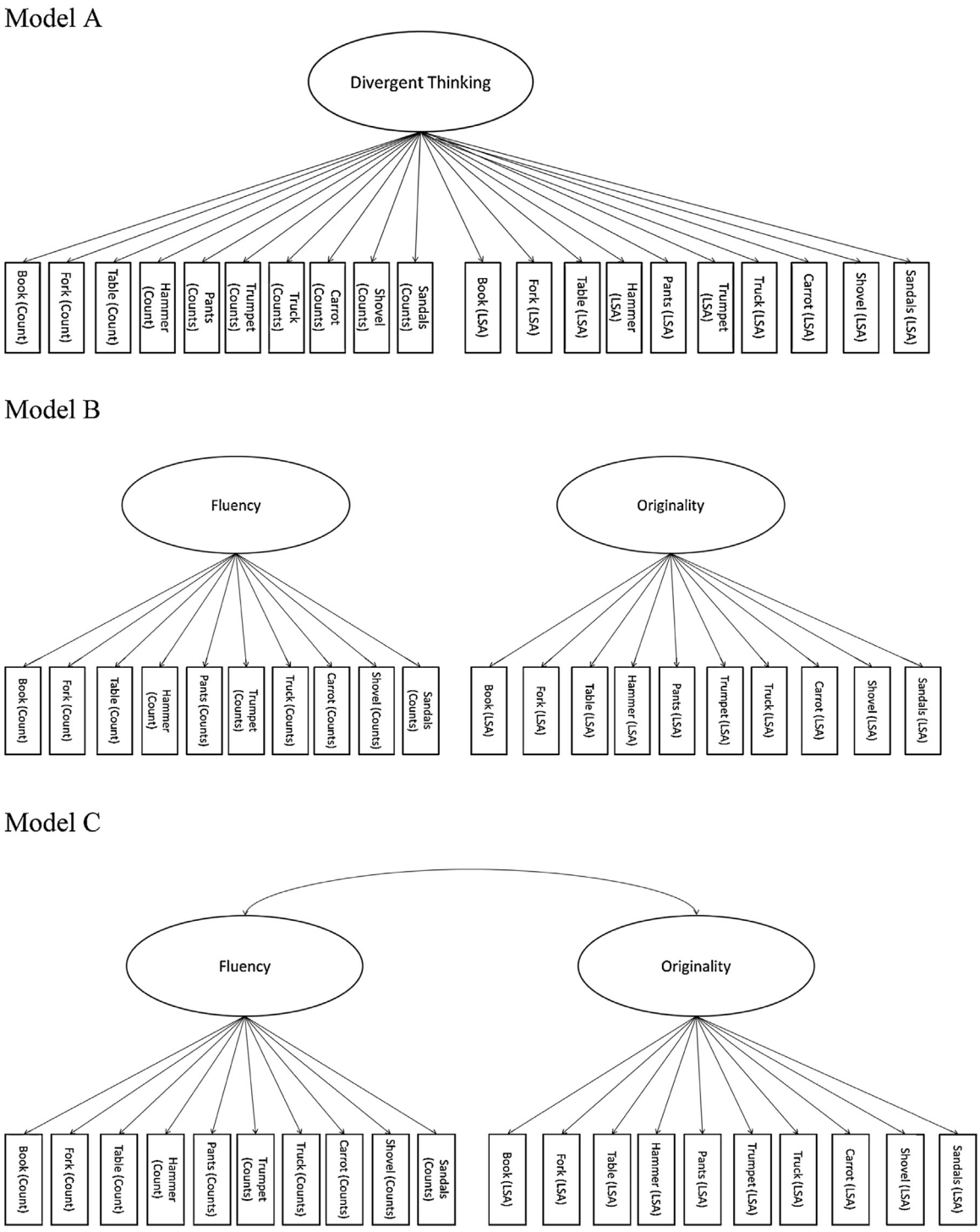


**Fig. 1.** Three theoretically viable models tested and compared via confirmatory factor analysis.

dimensions or factors (e.g., Benedek et al., 2006). If this model was found to be the best-fitting model, Fluency and Originality could be thought of as relatively unrelated constructs which are best examined separately from one another.

Finally, Model C included factors both for Fluency (which again loaded on the 10 counted indicator variables) and Originality (which loaded on the 10 LSA-derived indicator variables) and also allowed these two latent variables to covary. In this way, the direction and strength of the relation between Fluency and Originality could be empirically tested. This model may correspond to those in the research literature where Fluency and Originality are treated as distinct yet related

**Table 3**
Confirmatory factor analysis model fit statistics.

| | Statistics | | | | |
|---|---|---|---|---|---|
| Model | $\chi^2$ | *df* | RMSEA | CFI | SRMR |
| Model A | 227.86 | 170 | .041 | .991 | .065 |
| Model B | 119.22 | 170 | .009 | .995 | .069 |
| Model C | 105.16 | 169 | .001 | .999 | .042 |

variables and the relation between them is of interest, either in terms of their differential predictive power (e.g., Runco & Albert, 1985; Silvia, 2008), or their respective contribution to overarching constructs such as divergent thinking and creativity (e.g., Sternberg, 2006b). If this model was shown to fit best, then Fluency and Originality may be most appropriately conceptualized as separate but related constructs.

*Factor analysis*. Each of the CFA models were run using Lisrel software version 8.80 using maximum likelihood estimation (Jöreskog & Sörbom, 1993). Maximum likelihood estimation is the most commonly used method for estimating CFAs and structural equations, especially when the indicator variables are continuous, as they are here (Beauducel & Herzberg, 2006). In order to interpret the fit of each model, a combination of fit statistics that capture the absolute, incremental, and parsimonious fit were examined. Specifically, chi-square values, Root Mean Square Error of Approximation (RMSEA; values $\leq$.06), Comparative Fit Index (CFI; values $\geq$.96), and the Standardized Root Mean Square Residual (SRMR; values $\leq$.08) were identified a priori as guidelines for the interpretation of model fit (Hu & Bentler, 1999). These fit statistics, for each of our three models, are displayed in Table 3.

Based on these fit criteria, Model C was designated the model of best fit. Specifically, the Chi-square value, RMSEA, and SRMR values for Model C were the smallest among the models. Further, Model C's CFI value was the greatest among the models. Because Model C was the best-fitting model, its standardized model with standardized loadings and residuals, is depicted in Fig. 2. Importantly, Model C represents a conceptualization of Originality and Fluency in which the latent variables are distinct yet related. Specifically, Model C posits a moderate positive correlation between Fluency and Originality ($r$ = .38).

*Reliability of the latent variables*. Because the differing nature of the latent variables Fluency and Originality are of principal interest to this investigation, the reliability of the latent variables was calculated and compared. Here, reliability of the latent constructs is estimated via coefficient *H* (Hancock & Mueller, 2001). Coefficient *H* is a widely used measure of construct reliability, and can be conceptualized as the "extent to which the latent construct is reproducible from its own measured indicators" (Gagné & Hancock, 2010, p. 68). In fact, if a latent variable were regressed on each of its indicators, *H* would represent the proportion of variance in the latent variable that the indicators can account for, similar to an $R^2$ value (Hancock & Mueller, 2001). Besides being used in a variety of other contexts, coefficient *H* has been fruitfully utilized to calculate the

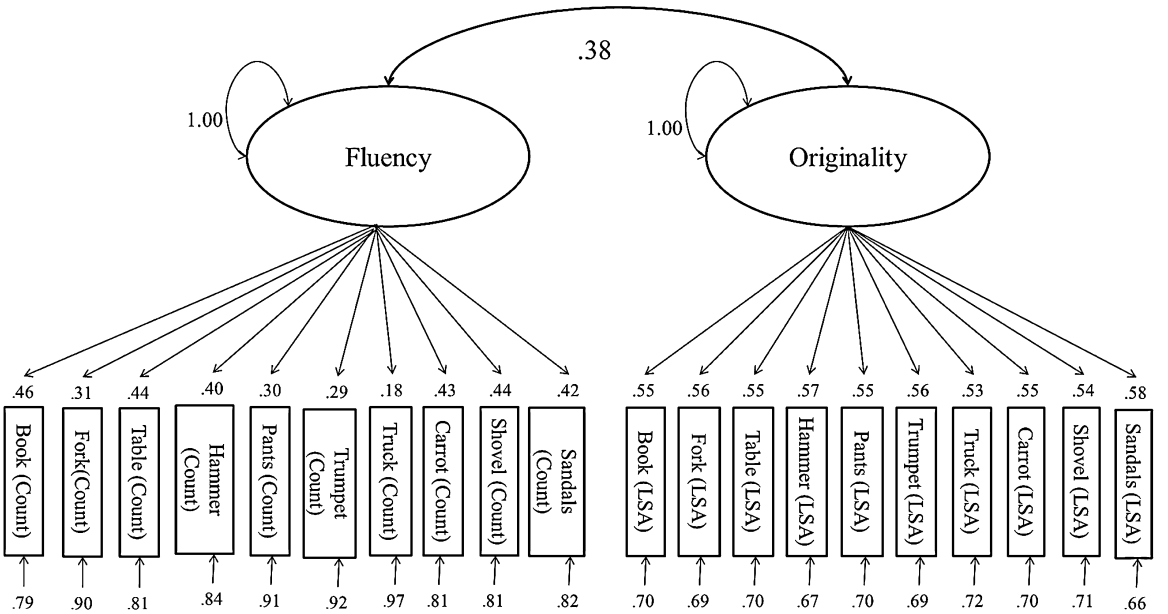


**Fig. 2.** Standardized model with loadings, residuals, and latent variable correlation for the best fitting model (Model C).

construct reliability of latent variables associated with divergent thinking and creativity (e.g., Silvia, 2011). Coefficient $H$ can be expressed for a latent factor with $k$ indicators and $a$ standardized loadings as follows:

$$H = \frac{\sum_{i=1}^{k} a_i^2/(1-a_i^2)}{1+\sum_{i=1}^{k} a_i^2/(1-a_i^2)}$$

Standardized loadings for each of our latent variables of interest are found in Fig. 2. For the Fluency latent variable produced in our model of best fit (Model C), coefficient $H = .631$. In contrast, the construct reliability of the Originality latent variable was $H = .816$. Importantly, the Originality latent variable, based on LSA-derived indicator variables, was found to be more reliable than the Fluency latent variable, which was based on counts. This finding implies that LSA, a fully automated, relatively objective procedure for scoring the Originality of ideas on divergent thinking tasks, is more capable than count-data at producing reliable latent constructs associated with divergent thinking and creativity.

## 4. Implications and conclusion

This study represents a systematic examination of Fluency and Originality in a divergent thinking task frequently used to measure creativity. Here, we measured these components of creativity at the latent variable level. As such, this investigation adds a potentially important empirical basis for the existing theoretical discussion pertaining to the nature of creativity, and the relations among its components. Indeed, while many scholars have posited relations between Originality and Fluency (Runco, 2010), the empirically derived relation between them has been less examined, especially at the latent variable level. Moreover, this study was one of the first to fruitfully use LSA to measure the Originality of ideas on the UOT. As such, this study has a number of implications for the understanding of Originality and Fluency in creativity research such as, (a) the conceptualization of Originality and Fluency as distinct but related constructs, (b) the productive use of LSA to measure Originality, and (c) the understanding that, through the use of LSA, latent variables of Originality can be more reliable than those of Fluency. Each of these implications will now be further discussed.

### 4.1. Originality and Fluency: distinct but related

In the literature on divergent thinking and creativity, many researchers have focused on Fluency (e.g., Turner, 1999), and used Fluency scores to operationalize divergent thinking or creativity in general, perhaps because of the lack of a reliable automated scoring method for assessing Originality. However, given the results of this investigation, in which it was found that Fluency and Originality can best be described as distinct but related constructs, that approach may not be appropriate. Importantly, the factor analytic methodology employed in this investigation offers information about the strength and direction of the relation between the factors of Fluency and Originality. As has been posited in the creativity literature (e.g., Hocevar, 1980), the two constructs were positively correlated. However, the correlation was only moderate in strength ($r = .38$), implying that the two constructs can be differentiated in important ways.

Interestingly, the positive correlation found in this study, with Originality being operationalized through LSA, was lower than in a previous study (i.e., Silvia, 2008) where a very strong positive correlation ($r = .89$) between the latent variables was found. This difference likely stems from the method used to measure Originality, and implies that the use of LSA creates Fluency and Originality variables that are more independent from one another than previously used methods for scoring Originality. This may have a number of potentially beneficial effects on creativity research, including the reduction of collinearity in predictive models. Because collinearity among variables generally attenuates the predictive power of statistical models (e.g., regression), using LSA may boost the ability of creativity researchers to predict critical creative abilities from divergent thinking tasks.

### 4.2. Originality as semantic distance

In this investigation, the statistical technique used for scoring the Originality of participants' responses on the UOT was latent semantic analysis. At its core, LSA offers a relatively objective measurement of the semantic distance between two words or phrases (e.g., Landauer et al., 1998). In this case, the semantic distance between the object on the UOT (e.g., "book") and the idea produced by a participant (e.g., "throw like a Frisbee") was used as a quantification of the Originality of the produced idea. This operationalization of Originality as semantic distance is gaining popularity in the empirical literature on creativity (Acar & Runco, 2014), and is consistent with theoretical accounts of creativity, which consider highly original ideas to depart in important ways from what is typically or generally done (Guilford, 1967; Sternberg, 2006b). However, the results of this investigation illustrate that measures of semantic distance are not only theoretically compatible with Originality as conceived in the literature on divergent thinking and creativity, but can also be usefully employed to quantify the Originality of an idea in a highly objective, automated way. Indeed, the efficient quantification of Originality has remained a challenge for many researchers working in the field of creativity. As the results of this study imply, LSA may be able to function as a much needed way to operationalize Originality in creativity research without the need for the time-intensive, and highly subjective process of using human raters.

Importantly, because LSA uses a large representative corpus, and derives latent relations among words or phrases, it is able to approximate human raters on a variety of complex tasks including metaphor comprehension (Kintsch, 2000), and essay scoring (Foltz et al., 2013). While comparability of LSA scores to those of human raters in divergent thinking tasks has been established (Forster & Dunbar, 2009), to our knowledge, this is the first investigation to examine the relation of LSA-derived Originality scores to Fluency scores, especially at the latent variable level. Further, LSA may have benefits over other semantic-network techniques for scoring Originality, because it measures the latent relation between words or phrases, and does not rely on observed word co-occurrence or associations created by human raters. Of course, LSA, and other semantic-network scoring methods are inherently limited to verbal tasks, in which participants respond to divergent thinking prompts using spoken or written language. The creation of statistical techniques for operationalizing the Originality of creative ideas expressed nonverbally remains a potentially important future direction.

### 4.3. Reliability of Fluency and Originality

The assessment of reliability is a critical component of any rigorous attempt to measure cognitive variables (Cronbach, 1951). Creativity research is no exception to this rule, and investigations into the reliability of constructs associated with divergent thinking and creativity, be they observed or latent, have added important information to the body of scholarly work in the field of creativity (Silvia, 2011). Moreover, creativity research has been the subject of scrutiny both from within and without the field concerning the reliability and validity of our measurements (Kim, 2006). For these reasons, the construct reliability of latent Fluency and Originality, is of interest. Importantly, the factor analytic methodology used in this investigation offers information about the reliability of these latent variables. In this study, the construct reliability of the Fluency latent variable was $H = .631$ and the Originality latent variable was $H = .816$. Interestingly, the construct reliability of the LSA-derived Originality latent variable was higher than the count-based Fluency latent variable. This finding suggests that LSA is not only an efficient and highly objective method for operationalizing the Originality of ideas, but that it may do so in a more reliable way than counts are able to operationalize Fluency.

Importantly, divergent thinking tasks like the UOT measure a relatively domain-general creative ability (Guilford, 1950; Hudson, 1968; Runco & Albert, 2010). In this investigation, we have found a correlation of .38 between Fluency and Originality as elicited by the UOT. While the use of a latent variable model does ensure a degree of generalizability for this finding in domain-general contexts, the relation between these constructs may still differ from .38 in domain-specific contexts. For example, among expert mechanical engineers solving engineering problems, the quantity of their ideas may have a different relation to the relative originality of those ideas. Therefore, the systematic investigation of creative abilities across many domains of learning, and among experts and novices as well, remains an important endeavor in creativity research.

In the scholarly discourse on creativity and divergent thinking, the nature of certain components of creativity, such as Fluency and Originality, is of high importance. This study has been an empirical, latent variable examination of the nature of Fluency and Originality as well as the relation between them. Importantly, methodologies like the one employed by this study allow for theoretical questions about the conceptualization of creativity and associated constructs to be tested. Using CFA, the relative appropriateness of differing models of psychological constructs like divergent thinking can be an empirical question, and as such can be tested as statistical hypotheses. This approach minimizes the need for protracted theoretical arguments in the field, and allows for the formal assessment of theoretically derived models. Given recent calls for conceptual clarity from within the field of creativity research, (e.g., Runco & Jaeger, 2012) studies such as this one may be necessary. Further, with the increasing emphasis being placed on creativity and innovation both from the scholarly literature (e.g., Caniëls & Rietzschel, 2013) and governmental policy (e.g., Obama, 2011), creativity researchers may need now more than ever to hold an empirically based conceptualization of our constructs of interest. Indeed, without an empirically-based understanding of latent constructs underlying creativity, the field risks missing crucial aspects of creative thought, and losing-out on chances to support this critical ability in students—something that the 21st century simply cannot afford.

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