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Associative Abilities Underlying Creativity

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Empirical approaches to cognitive ability claim that divergent thinking represents a useful estimate for the potential of creative thought. According to associative approaches, the ability to fluently retrieve and combine remote associations was suggested to facilitate creative solutions. Taken together, these approaches suggest a close relationship of associative processes and divergent thinking, which so far, however, has not been properly tested. Therefore, the present study examines the validity of associative abilities with respect to divergent thinking, and also, on a more general level, with respect to creativity and intelligence. Four different word-association tasks were employed to assess associative fluency, associative flexibility, dissociative ability, and the ability of associative combination. The sample comprised 150 students from studies with varying amount of creativity-related demands. Associative abilities were found to explain about half of the variance of divergent thinking ability. Latent variable modeling confirmed the significance of dissociation and associative combination for creativity, but also substantiates the relevance of basic associative retrieval processes for intelligence. It is concluded that associative abilities represent valid elementary cognitive abilities underlying creativity.

Keywords: word association, divergent thinking, creativity, intelligence

It is one of the oldest ideas of creativity research that specific associative processes are crucial to creative ideation (Mednick, 1962; Koestler, 1964). Nevertheless, it appears that this notion has never been directly tested. Creativity research rather tends to sort into two poles, either focusing on high-level cognitive abilities, or focusing on low-level associative abilities. The study of high-level creative cognition often involves the construct of divergent thinking. Divergent thinking can be defined in contrast to convergent thinking (Guilford, 1968): While convergent thinking denotes the process of finding a single correct solution to a problem, in divergent thinking there are many possible solutions, which, however, may differ in their quality. As early as 1950, Guilford proposed that facets of divergent thinking, such as the fluency, flexibility, or originality of ideation, may represent useful indicators of creativity. Since then, the assessment of divergent thinking has established as the dominant psychometric approach in creativity research (Kaufman, Plucker, & Baer, 2008). Many psychometric creativity tests such as the Torrance tests of creative thinking (TTCT; Torrance, 1974) essentially are divergent thinking tests.

Divergent thinking requires the generation of novel and appropriate solutions to open ill-defined problems (Runco & Charles, 1993; Sternberg & Lubart, 1996). Recent research has approached the question of what cognitive strategies and processes are involved in divergent thinking. Gilhooly, Fioratou, Anthony, and Wynn (2007) were able to identify a number of cognitive strategies prevalent in different stages of the idea generation process by means of a verbal protocol analysis of the task performance in the alternate uses tasks (i.e., a typical divergent thinking task which requires participants to generate novel, unusual uses for given everyday objects), They showed that initial responses are usually based on the retrieval of preknown uses from long-term memory, whereas for later responses different strategies are adopted such as *property use* (i.e., generating alternate uses that require specific properties of the object), *broad use* (i.e., scanning broad use categories, e.g., *weapon*, for application to the object), or *disassembly use* (i.e., recombination of parts of the object). Moreover, the production of novel uses was found to be related to letter fluency but not to category fluency, while the production of preknown uses was related to category fluency but not to letter fluency. As letter fluency can be viewed as a more executively loading task, the authors concluded that the fluent generation of new ideas in divergent thinking is facilitated by greater executive capacity possibly involving cognitive inhibition and switching, whereas the fluent retrieval of ideas from long-term memory is rather related to more automatic retrieval processes. This is in line with studies reporting positive correlations of divergent thinking

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and performance in the Stroop task (Golden, 1975; Groborz & Nęcka, 2003), or with switching of categories during divergent thinking performance (Nusbaum & Silvia, 2011).

Other studies focusing on ideational fluency as an index of divergent thinking reported positive correlations with information processing speed in tasks involving no cognitive interference, but inverse correlations when tasks do involve cognitive interference (Dorfman, Martindale, Gassimova, & Vartanian, 2008; Kwiatkowski, Vartanian, & Martindale, 1999; Vartanian, Martindale, & Kwiatkowski, 2007). These results are usually discussed in terms of creativity being characterized by cognitive disinhibition (Eysenck, 1995) or by flexible attention (Martindale, 1999). The latter interpretation may be viewed in line with recent evidence suggesting that creativity is related to a flexible cognitive control (Zabelina & Robinson, 2010).

Associative Ability and Creativity

A quite distinct approach to creativity is related to the study of associative processes. Word-association behavior has been used to study normal and abnormal thinking early on. Word-association tests usually ask for the first association that comes to mind to a set of given words (Jenkins, 1970; Kent & Rosanoff, 1910). For example, manic individuals typically show higher associative fluency (Giehm, 1933). As another robust finding, schizotypy and psychoticism were found to be related to more uncommon word associations (Merten, 1992, 1993, 1995; Nestor et al., 2006). There is evidence that creative people also show more uncommon associative responses when uncommonness is asked for by the task, but at the same time, in contrast to schizophrenics, they hardly differ from controls when asked for common associative behavior (Merten & Fischer, 1999).

A very influential theory on the relation of associative ability and creativity was put forward by Mednick (1962). He defined creative thinking "as the forming of associative elements into new combinations which either meet specified requirements or are in some way useful" (p. 221). He further concluded that "any ability or tendency which serves to bring otherwise mutually remote ideas into contiguity will facilitate a creative solution" (p. 222). Based on this theory, Mednick proposed some individual-differences variables that should be related to creativity. Most important, he assumed individual differences in the organization of associations. Low creative people should show steep associative hierarchies (i.e., the gradient of associative response strength for available associations to a given concept is steep, with only few associations showing high associative response strength), while high creative people should show flat associative hierarchies. Moreover, he predicted that in a free word-association task, creative people should initially respond more slowly but also more steadily and eventually emit responses of higher quantity and higher unusualness. Mednick developed the Remote Associates Test (RAT; 1962, 1968), which aims at assessing associative abilities required for creative thought. This test presents sets of three mutually unrelated words (e.g., rat—blue—cottage), and the participant is asked to find a solution word (cheese), which serves as a mediating link by complementing the three test words to meaningful compound nouns. Unlike most other tasks of creative thinking, this task hence asks people to find one of few correct solutions rather than finding many different original or creative answers. Mednick (1962, 1968) reports evidence for the validity of this test with respect to creativity. Later studies tried to directly test the predictions of his theory. There is strong support that high creative people show higher associative fluency (Levin, 1978; Mednick, Mednick, & Jung, 1964; Piers & Kirchner, 1971), which may hold true from the beginning of the task and not only in the long run as previously assumed (Mednick et al., 1964). Considering the commonality of associative responses, the literature reports mixed evidence. In some studies, high creative people were found to generate first associations of higher variability (Riegel, Riegel, & Levine, 1966), or higher uncommonness (Merten & Fischer, 1995); other studies, however, report no interindividual differences in the commonness of word associations (Coney & Sema, 1995; Olczak & Kaplan, 1969; Rothenberg, 1973). Gough (1976) reported that creativity was stronger related to moderately infrequent responses rather than to extreme commonness or remoteness.

The Present Study

Research on creativity and cognitive abilities tends to focus either on low-level creativity-related associative processes or on high-level creativity-related abilities. Therefore, the main aim of the present study is to link these two approaches in order to examine whether associative abilities can be conceived as relevant elementary cognitive processes involved in the more complex cognitive process of creative ideation. To this end, four different timed word-association tasks were devised, which aim at capturing different facets of associative ability. The validity of these association measures is examined with respect to various creativity-related criteria including divergent thinking, which is believed to more or less adequately reflect the complex cognitive process of creative idea generation. The validity of specific associative abilities is also analyzed on a more general level with respect to creativity and intelligence by means of latent variable modeling. Intelligence is included in this analysis, as intelligence is known to be related to both associative retrieval processes (e.g., Carroll, 1993) as well as creativity (e.g., Kim, 2005). Finally, predictive validity of associative abilities also will be examined.

Method

Participants

A total of 150 undergraduate students (42% females) from the Karl-Franzens University of Graz and the University of Applied Science Graz (Fachhochschule Joanneum) participated in this study. The average age was 22 years (SD = 2.7). In order to cover a wide range of creative ability, the total sample on the one hand included two groups of students from design studies with high creativity-related demands (63 students of information design, and 38 students of industrial design); on the other hand, it included 49 students from studies with no specific creativity-related demands such as industrial engineering (51%), psychology (14%), mechanical engineering (10%), or medical science (10%). The design students had passed a rigorous admission process including a personal interview, expert assessments of samples of their recent creative work, as well as a self-developed creativity test, and only the most creative candidates were admitted to the studies. As compensation for participation, the participants were offered individual feedback on personality structure and creativity. All participants gave written informed consent.

Psychometric Tests

Association tasks. Four word association tasks were devised in order to measure different aspects of associative ability considered relevant for creative idea generation. These aspects include the fluency and flexibility of association, the ability of semantic dissociation, and that of associative combination (a detailed description follows below). The tasks were designed to show high face validity. Each task comprised six items and participants worked 1 minute on each item. The employed item words were taken from the German translation of the Kent-Rosanoff word-association test (Kent & Rosanoff, 1910; Russel, 1970). No item was used in more than one task. Participants were told that association responses should always be single words but not phrases or sentences. An analysis of the reliability and validity of these tasks is provided in the results section.

Associative fluency. In the free-association task, participants were asked to freely generate as many associations as possible to the presented concept (e.g., summer: "beach, seaside, holidays, . . ."). This is a standard task for assessing typical unrestricted association behavior. The number of responses to a given concept can be considered as an indicator of associative fluency.

Associative flexibility. An association-chain task was employed that required the participants to generate long and diversified chains of associations. That is, only the first association should relate to the presented concept, whereas all following associations had to relate to the respectively last associative response (e.g., summer: "beach, sand, castle, knight, horse, race, . . ."). The number of discriminable concepts included in the generated word association chains was conceived to index spontaneous associational flexibility (cf. Guilford, 1967). The scoring of the number of concepts was performed by three experienced independent raters for the first two items (item 1: $n = 2{,}353$ responses, $ICC = .92$; item 2: $n = 2{,}238$ responses, $ICC = .90$). The number of concepts was found to be highly correlated with the total number of responses in this task ($r = .82$). Therefore, the average number of responses to all six items of the association-chain task was conceived as an adequate and economic index of associational flexibility.

Dissociative ability. A dissociation task required the participants to generate lists of unrelated concepts. The first response should be semantically unrelated to the presented concept and all further responses should be semantically unrelated to the presented concept and all responses so far (e.g., summer: "computer, banana, bicycle, . . ."). For every single response, this task thus requires an active dissociation from all salient concepts. This task can be assumed to assess a much more deliberate variant of associative flexibility as compared to the association-chain task. The scoring of the number of unrelated concepts was performed by three experienced independent raters for the first two items (item 1: $n = 1{,}659$ responses, $ICC = .99$; item 2: $n = 1{,}545$ responses, $ICC = .99$). The number of unrelated concepts was again found to be highly correlated with the total number of responses in this task ($r = .92$). Therefore, the average number of responses to all six items of the dissociation task was conceived as an adequate and economic index of dissociative ability.

Associative combination. In this task, a pair of unrelated words was presented and the participants were required to generate associations that relate to both stimulus concepts at the same time (e.g., summer—high: "airplane, temperature, expenses, . . ."). This task shows some similarity to the Remote Associates Test (Mednick, 1962), which actually employed three seemingly unrelated words and asked for one correct solution word linking them. In this task, two remote associate elements have to be combined in a process of *conceptual combination* (Ward, Smith, & Vaid, 1997) or *bisociation* (Koestler, 1964). Accordingly, the number of adequate responses in this task was conceived to index the ability of *associative combination*. The adequacy of all single responses was rated by three independent experienced raters for the first two items (item 1: $n = 1{,}401$ responses, $ICC = .92$; item 2: $n = 1{,}140$ responses, $ICC = .92$). The number of adequate responses was highly correlated with the total number of responses in this task ($r = .92$). Therefore, the average number of responses in all six items of the associative combination task was considered as an adequate and economic index of associative combination.

Creativity tasks. *Divergent thinking* was assessed by means of the alternate uses task. This task is a common measure of creative potential and is included in many creativity tests (Kaufman et al., 2008). In this task, the participants were presented with an everyday object and were asked to generate many different and original uses for this object. Two items were presented (wine bottle and CD) and the task duration was 2 minutes for each item. The originality of all responses was scored by four independent experienced raters on a 4-point Likert scale ranging from 0 (*not original*) to 3 (*highly original*) (ICC = .88 and .86 for item 1 and item 2, respectively). According to common procedures (e.g., Torrance, 1974), the originality scores of all ideas within a task were added up to compute the total original score. This summative originality score showed an expectedly high correlation ($r = .83$) with the ideational fluency (i.e., simple scoring of the total number of ideas in the task), which does not support an independent interpretation of these scores (Hocevar, 1979; Silvia et al., 2008). The resulting score thus represents a compound of ideational fluency and ideational originality, and will be referred to as divergent thinking ability. The two items of this score showed good internal consistency (Cronbach's alpha = .84).

Self-reported creative ideational behavior was assessed by means of a German translation of the Runco Ideational Behavior Scale (RIBS; Runco, Plucker, & Lim, 2000) employing the 17 first-factor items (e.g., "I have many wild ideas."). This scale showed a high internal consistency (Cronbach's alpha = .87).

Self-reported creativity was assessed on a 6-point Likert scale. Additionally, creativity-related demands of the participant's university studies were assessed with a short questionnaire (e.g., "My studies require verbal creativity.") using a 4-point Likert scale ranging from *little* to *a lot*. This scale showed moderate internal consistency (Cronbach's alpha = .69).

General cognitive and psychomotor ability. *Intelligence* was assessed by means of a verbal subtest (analogies [Analogien]), and a figural subtest (figure selection [Figuren Auswahl]) of a well-known German intelligence test (Intelligenz-Strukur-Test; I-S-T 2000-R; Amthauer, Brocke, Liepmann, & Beauducel, 2001). Each subtest consisted of 20 items and took 7 min.

Word fluency was assessed by means of the word-endings task, which requires participants to find many different words ending with a given syllable (e.g., "-der"). Two items taken from the Verbaler Kreativitäts-Test ([Verbal Creativity Test]; Schoppe, 1975; for an analysis of the validity of this task, see Benedek, Fink, & Neubauer, 2006) were administered for 2 minutes each.

Speed of information processing was assessed by means of Posner's letter-matching task applying the physical identity condition (Posner, Boies, Eichelmann, & Taylor, 1969; Posner & Mitchell, 1967). Participants were presented with a list of items, each consisting of an arbitrary combination of the letters *a* and *b*, depicted either in lower or upper case. The number of correct solutions within 25 seconds was scored.

Writing speed was assessed by means of a self-developed task that required the participants to write down as many words as possible from a simple list of numbers (ascending from one to 10 and descending to one again). Each word (i.e., "one, two, three, . . .") had to be written in a column one below the other. The numbers of words written within 20 seconds was used as an index of writing speed. Writing speed may represent a possible confounding factor of speeded tests which require written responses. Therefore, correlation analyses were planned to be controlled for individual differences in writing speed.

Personality. The structure of personality was assessed by means of the German version of the NEO-Five Factor Inventory (NEO-FFI; Borkenau & Ostendorf, 1993). The NEO-FFI comprises 60 items and was administered without time restriction.

Procedure

The participants were tested in groups of 3 to 10 students. All task instructions were presented via video projector. The participants received a booklet containing the response sheets for all tasks. The tests were administered in a fixed sequence, starting with some sociodemographic questions, followed by the test of self-reported creative ideational behavior, the intelligence test, the test of information processing speed, the test of writing speed, the free-association task, and the associative combination task. After a break of about 10 minutes, participants completed the association-chain task, the dissociation task, the word fluency task, the divergent thinking task, and finally the personality inventory. In the speeded tasks, the experimenter informed the participants when half of the task time had elapsed. The total duration of the test session was about 90 minutes.

Results

Analysis of the Association Tasks

Descriptive statistics for the four association tasks are presented in Table 1. In the free-association task (measuring associative fluency [A-Flu], i.e., the ability to fluently retrieve associative elements related to a given concept) and in the association-chain task (measuring associative flexibility [A-Flx], i.e., the ability to fluently switch between related concepts), participants generated on average about 15 responses within the given task time of 1 minute per item. The dissociation task (measuring dissociative ability [Diss], i.e., the ability to fluently switch between unrelated concepts) and the associative combination task (measuring the ability of associative combination [A-Comb], i.e., the ability to fluently combine unrelated concepts) appeared to be more challenging and resulted in only 9 to 10 responses per minute. The four association measures showed high intercorrelations; at this, the intercorrelations with dissociative ability were somewhat lower. A principal axis factoring with oblimin rotation and Kaiser normalization was performed for all 24 items of the four association tasks in order to test for the number of discriminable factors. This exploratory factor analysis extracted four factors (according to the Kaiser criterion as well as according to the Scree test; K-M-O = .96), explaining 78.2% of total variance. In this solution, all task items loaded on task-specific factors and showed only small unspecific loadings of < .25. Further evidence for a four-factor solution comes from the minimum average partial test (MAP test; Velicer, Eaton, & Fava, 2000), which returned four components as the number of factors to extract from the 24 association measures. Therefore, it seems adequate to assume that the data represents four discriminable associative abilities and use four separate measures in all subsequent analyses.

Table 1
Descriptive Statistics, Intercorrelations, and Reliability of the Association Measures

			Intercorrelation			
	M	*SD*	A-Flex	Diss	A-Comb	r_{tt} (α)
A-Flu	14.55	2.88	.72	.48	.76	.92
A-Flex	14.52	3.64		.53	.72	.94
Diss	10.15	3.20			.61	.96
A-Comb	9.47	3.33				.94

Note. A-Flu = Associative fluency; A-Flex = Associative flexibility; Diss = Dissociative ability; A-Comb = Associative combination.

Table 2 presents the correlations of the four association measures and divergent thinking with the available cognitive and personality measures. The association scores show strong significant positive correlations with divergent thinking, but also with self-reported creative ideational behavior, self-reported creativity, and word fluency. They also show substantial positive correlations with openness, but with none of the other personality factors. For associative fluency and flexibility there are minor significant correlations with verbal and figural intelligence and information processing speed. The correlation pattern of divergent thinking with the available cognitive and personality measures was quite similar to that of the association measures. Controlling for writing speed did not result in any significant change of any of the correlation coefficients.

As the sampling from a heterogeneous sample (design students and nondesign students) may cause an overestimation of some correlations, we recomputed correlations separately for both groups. The size of correlation coefficients, however, was only weakly affected by this procedure. Especially for the nondesign students, which represent the average university population, correlations of associative abilities and divergent thinking remained in the range of .51 to .63. For the quite homogeneous group of design students, correlations still ranged from .45 to .54. This suggests that the sampling procedure did not cause substantial overestimations of correlations.

Table 2
Correlation of Associative Abilities and Divergent Thinking With Cognitive and Noncognitive Measures

	DT	Crea-IB	Crea-SR[a]	W-Flu	Int-V	Int-F	Speed[a]	O	C	E	A	N
A-Flu	.55	.30	.29	.33	.16	.22	.19	.36	−.03	.00	−.05	.12
A-Flex	.57	.25	.24	.26	.16	.29	.23	.25	−.11	−.02	−.07	.03
Diss	.57	.17	.21	.28	.09	.13	.08	.23	−.12	.07	−.10	−.07
A-Comb	.62	.29	.30	.29	.12	.14	.21	.30	−.05	−.01	−.10	.11
DT	—	.32	.17	.33	.19	.17	.15	.26	−.10	−.03	−.02	−.06

Note. A-Flu = Associative fluency; A-Flex = Associative flexibility; Diss = Dissociative ability; A-Comb = Associative combination; DT = Divergent thinking; Crea-IB = self-reported creative ideational behavior; Crea-SR = self-reported creativity; W-Flu = Word fluency; Int-V = Verbal intelligence; Int-F = Figural intelligence; Speed = Information processing speed; O = Openness; C = Conscientiousness; E = Extraversion; A = Agreeableness; N = Neuroticism. $N = 150$: $p < .05$ for $r > .16$, and $p < .01$ for $r > .21$.
[a] $N = 148$.

Predicting Divergent Thinking Ability by Associative Ability

In order to examine to what extent divergent thinking ability can be explained by associative abilities, a linear regression was computed employing divergent thinking as criterion variable and the four association measures as predictors. Preliminary analyses indicate that no multicollinearity of measures is evident (Tolerance: .32 to .61; VIF: 1.64 to 3.13; Condition Index: 9.09 to 22.38, with no dimension having more than one variance proportion > .50; Rawlings, Pantula, & Dickey, 2001). The four association measures can explain as much as 47% of the variance of divergent thinking ability ($R^2 = .47$; $R^2_{adj} = .45$; $F(4, 145) = 31.91$, $p < .001$), which can be attributed to significant contributions by dissociative ability ($\beta = .28$, $p < .001$) and associative combination ($\beta = .26$, $p < .05$), but not to any further significant contributions by associative fluency ($\beta = .11$, $p = .28$) or by associative flexibility ($\beta = .15$, $p = .11$).

Modeling Associative Ability, Creativity, and Intelligence

A latent variable model was estimated in order to analyze the relationship between associative abilities, creativity, and intelligence without interfering measurement error. It was conducted with *Mplus* 5.2, using maximum likelihood (ML) estimation. As shown in Figure 1, creativity and intelligence were modeled as latent variables predicted by the four latent associative abilities.

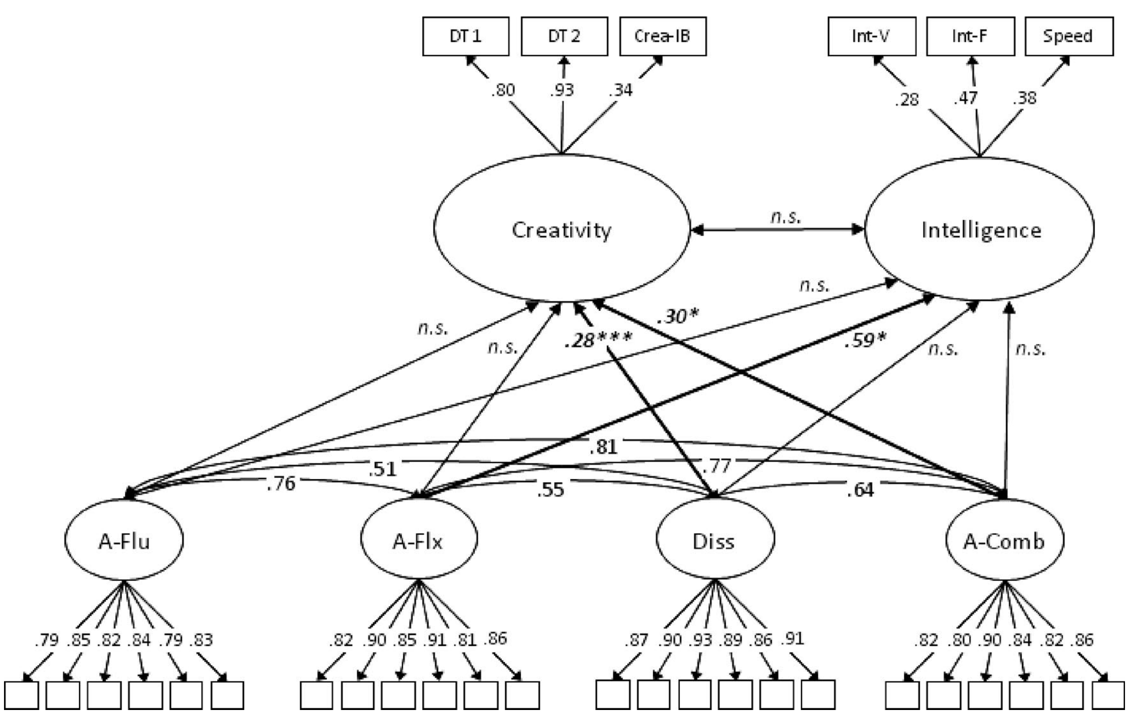

Figure 1. Latent variable model of creativity and intelligence predicted by associative abilities (A-Flu = Associative fluency; A-Flex = Associative flexibility; Diss = Dissociative ability; A-Comb = Associative combination; DT = Divergent thinking; Crea-IB = self-reported creative ideational behavior; Int-V = Verbal intelligence; Int-F = Figural intelligence; Speed = Information processing speed).

The model assumed intercorrelations of the latent associative abilities, as well as for creativity and intelligence. Each associative ability was indicated by six items of the accordant tasks. Creativity was measured with two divergent-thinking tasks and by self-reported creative ideational behavior; intelligence was indicated by verbal intelligence, figural intelligence, and information processing speed. Creativity and intelligence thus were captured in a multifaceted way, which, however, may also be reflected in lower factor loadings. All factor loadings in the model were statistically significant. For model-identification, the first factor loading of each latent variable was fixed to one, and the analysis turned out to be robust concerning different model-identification approaches. The model was evaluated with the χ^2-test, CFI, RMSEA, and SRMR (Beauducel & Wittmann, 2005; Hu & Bentler, 1998, 1999) and showed a close fit with $\chi^2(390\ df) = 522.57$, $p < .001$ ($\chi^2/df = 1.34$), CFI = .97, RMSEA = .05 (90% *CI* = .04–.06), and SRMR = .05.

In line with the regression analysis, the model reveals that associative combination and dissociative ability are significant predictors of creativity, whereas both have no significant relationship to intelligence. In contrast, intelligence is predicted by associative flexibility, which in turn has no significant relationship to creativity. The model thus suggests that the associative abilities have a differential meaning for creativity and intelligence. Despite their high intercorrelations, they involve distinct components with specific predictive value. The predictors account for 56% of the latent variance of creativity ($p < .001$), and explain 38% of the variance of intelligence ($p < .05$). In this model, creativity and intelligence showed a residual correlation of $r = .19$, which, however, was not statistically significant.

Additionally, a higher-order model was estimated, in which a higher-order factor of general associative ability was defined to represent the common variance of the four specific associative abilities. This model showed a marginally worse but still close fit with $\chi^2(398\ df) = 542.00$, $p < .001$ ($\chi^2/df = 1.36$), CFI = .96, RMSEA = .05 (90% *CI* = .04–.06), and SRMR = .05. In this model, general associative ability significantly predicts creativity (.76, $p < .001$) and intelligence (.54, $p < .001$). It accounts for 58% of the latent variance of creativity ($p < .001$); however, this model does not significantly explain the variance of intelligence ($R^2 = .29$, *ns*.). Furthermore, it would also have been interesting to model the specific association abilities together with a higher-order factor of general associative ability as separate predictors of creativity and intelligence. However, this was impossible due to underidentification of the higher-order factor.

Predicting Creativity Groups

Low-level associative abilities may do well in predicting creativity test scores, but will they also predict external creativity-related criteria? And how do they compare to divergent thinking ability? In order to examine these questions, the participants of this study were divided in two quasi-experimental groups: a creative group consisting of design students, who passed admission to the design school ($n = 101$), and a control group ($n = 49$) from other studies without creativity-related admission test. For further examination of the validity of this procedure, the two experimental groups were compared with respect to the self-reported creativity-related demands of their studies by means of an independent-sample *t* test. Students of the creative group reported much higher creativity-related demands as compared to the control group, $t(57.34) = 9.39$, $p < .001$. In a next step, individual differences of the two experimental groups in divergent thinking and the four association scores were analyzed by means of a MANOVA. The analysis revealed a highly significant multivariate effect ($F[5, 144] = 8.16$, $p < .001$, $\eta^2 = .22$), and also significant univariate effects for each dependent variable. The creative group showed higher ability in divergent thinking ($F[1, 149] = 16.65$, $p < .001$; $\eta^2 = .10$), associative fluency ($F[1, 149] = 27.36$, $p < .001$; $\eta^2 = .16$), associative flexibility ($F[1, 149] = 33.82$, $p < .001$; $\eta^2 = .19$), dissociative ability ($F[1, 149] = 10.40$, $p < .01$; $\eta^2 = .07$), and associative combination ($F[1, 149] = 33.76$, $p < .001$; $\eta^2 = .19$).

Finally, group affiliation was predicted by means of a binary logistic regression employing divergent thinking and the four association scores as predictors. In this analysis, correct classifications were obtained for 79% of the cases, and significant predictions were provided by associative combination (exp[B] = 1.36, $p < .05$) and associative flexibility by trend (exp[B] = 1.17, $p < .10$), but not by the other predictors. These two associative abilities thus are very relevant for predicting whether participants belonged to the creative group (i.e., design class) or not, and at this showed even higher predictive value than divergent thinking ability.

Discussion

Divergent thinking is conceived as a valid indicator for the potential of creative thought (Runco, 1999) and currently represents the predominant psychometric approach to creativity. However, the detailed cognitive processes underlying divergent thinking remain largely unclear. It was put forward that creativity requires the ability to fluently retrieve and recombine remote associative elements (Mednick, 1962). Following this notion, the present work sought to examine whether specific associative abilities are related to divergent thinking ability and creativity. Four different word-association tasks were employed in order to assess different facets of associative ability including indicators of associative fluency (i.e., the ability to fluently retrieve associative elements related to a given concept), associative flexibility (i.e., the ability to fluently switch between related concepts), dissociation ability (i.e., the ability to fluently switch between unrelated concepts), and associative combination (i.e., the ability to fluently combine unrelated concepts). An efficient quantitative scoring was found to show high correspondence with an alternative qualitative scoring of the tasks, and the four resulting association measures showed very high internal consistency. The association measures showed substantial intercorrelations but also clear factor analytic distinctness. Moreover, positive correlations with various indicators of creativity including divergent thinking, self-reported creative ideational behavior, self-reported creativity, and openness, indicate strong convergent validity of associative abilities with respect to creativity (Feist, 1998). Further analyses informed about the specificity and validity of the single association measures.

Regression analyses revealed that associative abilities can explain nearly half of the variance of divergent thinking ability. Specifically, high divergent thinking ability was significantly predicted by high ability of dissociation and associative combination. A similar result pattern was obtained in the latent variable model, which examined the validity of associative ability with respect to creativity and intelligence. The results again clearly point at the relevancy of dissociative ability and associative combination for creativity. Moreover, these abilities appear to be unrelated to cognitive intelligence and thus also show discriminant validity.

These results suggest that the abilities of dissociation and associative combination represent relevant elementary cognitive abilities involved in creative thinking. Dissociative ability reflects the ability to dissociate from salient concepts and ideas. This can be conceived to be of twofold importance for divergent thinking. First, it should facilitate the concurrent access to mutually remote concepts, which is believed to be a key aspect for the generation of creative thoughts (Martindale, 1999; Mednick, 1962). Second, since divergent thinking requires the individual to generate many different ideas, dissociative ability should be important in order not to get stuck with initial ideas. This is in line with recent evidence on the significance of switching of idea categories for divergent thinking (Nusbaum & Silvia, 2011). Gilhooly et al. (2007) pointed at the issue that divergent thinking may involve inhibition of dominant responses (i.e., typical, preknown solutions) as well as inhibition of proactive interference (i.e., interference of salient memory cues which might be induced by earlier responses in the process of idea generation; Friedman & Miyake, 2004). Following this terminology, dissociative ability could also be conceived to reflect a kind of semantic inhibition ability that facilitates the steady access to new and semantically remote concepts.

The significant predictor associative combination indicates that for creative thinking, besides being able to access mutually remote associative elements, it is also essential to be able to combine these remote concepts in an adequate way. This is in line with Mednick's (1962) idea that creative people are good at recombining remote associative elements. Moreover, it conforms to Koestler's (1964) fundamental idea that the creative act requires bisociation of apparently incompatible frames of thought. Quite similar ideas have been expressed when referring to Janusian thinking (Rothenberg, 1973) or to the process of conceptual combination (Ward et al., 1997).

These findings also complement the evidence of other studies employing unrelated word pairs. Vartanian, Martindale, and Matthews (2009) reported that creative people are faster in judging the relatedness of concepts. They proposed that higher speed of relatedness judgments might be advantageous for the fast identification of potentially useful conceptual relationships. Rossman and Fink (2010) showed that creative people judged the associative distance of unrelated words to be lower as compared to less creative people, which may point at their higher ability in noticing subtle associations between unrelated concepts. Taken together, these findings suggest that creative people show advantages in evaluating the relation of remote concepts, which may eventually facilitate the discovery of associative links and result in a high ability of associative combination.

Associative fluency and flexibility show high correlations with divergent thinking, but they fail to explain significant additional variance of divergent thinking next to dissociative ability and associative combination. This indicates that a substantial part of the variance of the former associative abilities may be covered by the latter. Apparently, the fluent generation of dissociations and associative combinations also draws on fluent and flexible association processes. This is supported by the high intercorrelations between these association scores at manifest and latent level. Therefore, associative fluency and flexibility can both be viewed as relevant associative abilities subserving divergent thinking.

Associative fluency and flexibility also showed significant correlations to intelligence (at latent level this was true for associative flexibility, but also for general associative ability). This suggests that associative fluency and especially associative flexibility explain unique variance of intelligence. This finding is in line with the conceptualization of the *broad retrieval ability* (Gr) in the three-stratum model of general intelligence (Carroll, 1993). In this model, broad retrieval ability represents a second-order factor of intelligence which is conceived to encompass various elementary speed factors related to fluent and flexible retrieval from memory. It can thus be concluded that basic retrieval functions, as reflected by associative fluency and flexibility, are essential for both creative and intelligent thinking. At this, high crystallized intelligence (Gc) could be assumed to specifically facilitate the fluent and flexible retrieval of ideas from long-term memory (cf., Gilhooly et al., 2007), whereas the generation of new and original ideas might more strongly involve executive processes and be more tightly related to fluid intelligence (Gf). These results hence point at possible common grounds of creativity and intelligence at an elementary cognitive level (cf., Nusbaum & Silvia, 2011). Moreover, the results also inform about the distinctness of these constructs. Associative retrieval which targets at the generation of unrelated concepts (i.e., dissociation) or associative combination (i.e., bisociation) appears to be more relevant for creative thinking than for convergent reasoning. Or, to put it in other words, creative ideation may not only draw on the basic process of association, but more specifically on that of dissociation and bisociation.

The results of this study clearly support Mednick's (1962) original conception on the associative basis of creativity, assuming that creativity requires the ability to fluently retrieve and recombine remote associative elements. His theory was based on the notion that creative people have rather flat associative hierarchies, which should enable them to generate more fluent and more unique associations. Subsequent tests of this theory showed that creative people generate associations more fluently, but, so far, there has been no robust evidence that they also generally show more unique associations. This could be explained by the fact that most of the relevant studies employed free-association tasks, which require the participants to simply generate the first associations that come to their mind. High creative people may not generally show deviant association behavior (this may still be true for schizophrenics), but they are perfectly able to retrieve common associations to given concepts (Merten & Fischer, 1999). However, when high creative people are explicitly asked for unique associations or dissociations, they may perform better at retrieving them. This conforms to a highly functioning retrieval ability which does not only involve convergent processing (i.e., scanning for related associative elements) but also divergent processing (i.e., scanning for unrelated associative elements). In high creative people, this is complemented by the ability to generate adequate associative relations of supposedly unrelated concepts.

Some limitations of this study should be mentioned. This study takes an explorative approach in devising four association tasks for assessing relevant associative processes underlying creative thought. We obtained evidence that these measures show factor analytic distinctness and validity with respect to creativity. However, there still may be further relevant associative processes that have been missed by the present research. Moreover, the scoring of associative abilities relied on a quantitative approach based on the number of responses. A qualitative evaluation of all responses is very laborious and entails certain subjectivity, but it might further increase the validity of the scores. More efficient and objective methods for scoring of responses would be needed to be able to fully account for this issue. For future studies, it might also be useful to realize a more differentiated assessment of divergent thinking (i.e., discriminating between facets of ideational fluency, flexibility, and originality), and of intelligence (e.g., separate assessment of fluid and crystallized intelligence) for obtaining an even more detailed picture of the interrelations of low-level associative abilities and high-level cognitive abilities.

Summing up, we conclude that specific associative abilities qualify as valid elementary cognitive abilities underlying creativity. They allow for an efficient and reliable assessment and thus might be considered useful as basic indicators of creative potential. We believe that further detailed study of the basic cognitive processes involved in creative thinking represents a fruitful approach for the investigation of the common ground and the differences of creativity and intelligence. Specifically, there is increasing evidence that creativity is related to executive processes (e.g., inhibition). Future studies might address this issue in more detail by including explicit measures of executive functioning. These approaches may help to eventually understand “creativity as an extraordinary result of ordinary [cognitive] processes” (Sternberg & Lubart, 1996, p. 681).

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