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Idea Generation Compared between Children With and Without Learning Disabilities

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Abstract. The purposes of this quasi-experimental study were to: (a) compile a solution set of ideas and idea categories that could be used to measure ideational fluency, flexibility, and originality of ideas for future research studies, and (b) measure and compare the ideational performance of students with and without learning disabilities (LD). The idea generation performance of 13 students with LD and 11 children without LD was measured using 22 idea generation prompts modeled on the Torrance Tests of Creative Thinking (Torrance, 1974). Ideational fluency, flexibility, and originality was analyzed using hierarchical generalized linear modeling, and results indicated that for children with LD, fluency had a weaker positive association with originality (i.e., an interaction effect; F [1, 659] = 4.54, p = .03), indicating that students with LD utilized a more convergent thinking style approach to idea generation rather than a divergent thinking style approach employed by students without LD. A solution set for fluency, flexibility, and originality was compiled which could be used for scoring future studies investigating the effects of strategy instruction for idea generation performance in students who may demonstrate more difficulties in generating ideas for academic tasks than their similarly disabled peers.

Keywords: learning disability; idea generation; thinking style; hierarchical linear modeling.

1. Introduction

In many contexts, idea generation (ideation) is important. New ideas can be the basis for innovations in organizations and industry (Coskun, Brown, Paulus, & Sherwood, 2000). For companies and businesses, for example, idea generation is a vital component for developing new products and techniques to advertise those products (Coskun, 2005; Toubia, 2006). The ability to generate new ideas for content and problem solving is also regarded as crucial in many academic domains, including writing, mathematics, and reading (Graham & Harris, 2003; Passolunghi & Siegel, 2004; Poch & Lembke, 2017; Swanson & Siegel, 2001). Collectively, problems with long-term memory (LTM), working memory (WM), and metacognition can pose problems in idea generation

Research shows that idea generation is a complex process, and that students with LD often have difficulty with that process (Graham & Harris, 1993; Swanson, 1987). Further, research suggests problems with idea generation for students with LD may be due to memory deficits which impact the ability of the individual to store, retrieve, manipulate, and/or reorganize information/knowledge into new knowledge (Baughman & Mumford, 1995; Englert & Raphael, 1988; Mobley, Doares, & Mumford, 1992). Other research postulates that difficulties with idea generation can be due to an inability to access prior knowledge and use it to formulate new knowledge (Nijstad & Stroeb, 2006; Rietzschel, Nijstad, & Stroebe, 2007). Idea generation literature from the fields of information processing and creative cognition indicate that deficiencies or deficits in retrieval of information from long term memory (LTM) and manipulation of information in working memory (WM) are problematic in idea generation for students with LD (Gathercol, Pickering, Ambridge, & Wearing, 2006; Swanson, Ashbaker, & Lee, 1996; Swanson & Saez, 2003).

Whatever the reason, it is well known that for some students with LD, difficulties with generating ideas or content across academic content areas negatively impacts academic achievement. Researchers also suggest that some less skilled writers may need more help than other writers (Graham & Harris, 2003; Graham & Perrin, 2007). It would seem logical, then, that some students with learning disabilities are less responsive to interventions than their similarly disabled peers. For these less responsive children, it is important to develop interventions based on individual needs of the students (McMaster, Fuchs, Fuchs, & Compton, 2005). If, as the research suggests, some students are less responsive to interventions used to address academic difficulties (e.g., writing) where idea generation is required, it might be prudent to develop specific strategies which could enhance the idea generation performance of these students.

In this study, the idea generation performance of students with and without LD was measured using ideational fluency, flexibility, and originality. The purposes of this study were to: (a) compile a solution set of ideas and idea categories that could be used to measure ideational fluency, flexibility, and originality of ideas for future research studies, and (b) measure and compare the ideational performance of students without disabilities and students with LD.

2. Theoretical Framework for Idea Generation

The theoretical framework guiding the present study is comprised of information processing theory and creative thinking, which itself is informed by research on memory in three academic areas: mathematics, reading, and writing. Each of these concepts is discussed in the following paragraphs.

Information Processing Theory

Information processing theory compares the human mind and the way it stores and retrieves information to a computer in the way it stores and retrieves information. Information Processing Systems theory (IPS) states that human information processing is controlled by a system of rules and regulations (Newell & Simon, 1972). In general, information is stored in a system of nodes, schemata, or frames. A stimulus initiates a cue to construct a retrieval probe to long term memory (LTM). Information selected by strength of association is brought back to working memory (WM), where it is manipulated and used to construct new knowledge (ideas). This knowledge construction is restricted due to limited capacity of WM to store five to nine information units or symbols (Miller, 1956). LTM on the other hand has unlimited capacity and is organized associatively.

Creative Thinking

Creative thinking considers idea generation an active process involving active participation and divergent thinking by the individual (Amabile, 2012). Divergent thinking is a form of thinking used when the individual faces an open-ended problem, and may need to produce numerous and diverse ideas. Individuals proficient in ideation are able to use divergent thinking, produce numerous ideas (fluency), switch idea categories easily (flexibility), and produce useful, novel (originality) ideas (Crossley, Muldner, & McNamara, 2016; Runco, 2014; Skalicky, Crossley, McNamara, & Muldner, 2017).

The ability to retrieve information from LTM, manipulate it, and reorganize it in WM is vital to constructing new ideas (Baughman & Mumford, 1995). Research has shown that new ideas cannot be generated if prior knowledge cannot be retrieved from LTM, and used to reconstruct that knowledge in WM (Baughman & Mumford; Mobley, Doares, & Mumford, 1992). If information retrieved from LTM cannot contribute to new ideas or insights unless it is manipulated, there must be a type of transformational process that reorganizes and combines information (Mobley, et al., 1992; Runco & Chand, 1995). When there are deficits in WM, integration of information retrieved from LTM with other information is impeded, and further cognitive processes are inhibited (Gathercole, et al., 2006).

Swanson and Saez (2003) found that individuals with LD may be deficient in memory skills, and thus face problems with a variety of academic and cognitive tasks. WM deficits in children with LD can reflect problems in the executive system, and are primary contributors to difficulties in math, reading, and writing. These deficits place students with LD at a clear disadvantage when involved in activities requiring high demands on a limited capacity system, such as WM (Swanson, 1987; Swanson & Saez, 2003). Deficits in WM impede integration of information retrieved from LTM with other information, and inhibit further cognitive processes. Gathercole et al. (2006) suggest that deficits in WM promote an information bottleneck in the system that hinders learning, and impedes incremental knowledge acquisition.

Memory and mathematics. Passolunghi and Siegel (2004) found that children with LD had a generalized and persistent deficit in WM. Passolunghi and Siegel suggested that WM deficits in students with difficulties in mathematics might be related to an inability to reduce irrelevant information. In addition, some children with math disabilities have a persistent deficit in their ability to store or retrieve number combinations from LTM. This may be related to a deficit in the ability to retrieve facts from semantic long-term memory (Geary, 2005), or an inability to inhibit retrieval of irrelevant information (Jordan, Hanich, & Kaplan, 2003).

Memory and reading. Difficulties in mathematics and difficulties with reading often are comorbid conditions that go hand in hand (Lewis, O'Donnell, Freebairn, & Taylor, 1998), and are related to deficits in working memory (Schuchardt, Maehler, & Hasselhorn, 2008; Swanson & Saez, 2003). For both mathematics and reading, deficits in working memory impede integration of information retrieved from long-term memory with other information, and may actually promote an information bottleneck that inhibits further cognitive processes (e.g., Shin & Bryant, 2017). If working memory capacity is overloaded, task failure may result. This may further impact both incremental knowledge acquisition and skill acquisition in these content areas (Gathercole et al., 2006).

Research has shown that some of these difficulties are related to deficits or deficiencies in the working memory structure. Swanson, Ashbaker, and Lee (1996) found that students with a reading learning disability show major deficits in working memory tasks when compared to normally achieving peers (Swanson et al., 1996). Gathercol et al. (2006) investigated the impact of working memory deficits on the mathematics and reading performance of students with reading disabilities. Siegel (2003) found individuals with a reading disability exhibited deficits in short term memory and WM. Schuchardt et al. (2008) found that specific reading disorders were due to a disorder in the phonological subsystem of WM rather than a deficit in central executive functioning (Baddeley, 1992). Data from these studies suggest that working memory may limit skill and knowledge acquisition of mathematics and reading, and hinder idea generation.

Memory and writing. It is well established that students with learning disabilities (LD) commonly have problems generating ideas for problem solving and developing content for written compositions across a variety of academic areas (Englert & Raphael, 1998; Englert et al., 1988; Graham, 1990; Nodine, Barenbaum, & Newcomer, 1985; Swanson & Saez, 2003). Of particular concern are apparent deficiencies or deficits in memory retrieval and manipulation of information. Searching and integrating knowledge is a critical skill in writing (Williams, 2003). Poor writers have difficulty generating subordinate ideas or categories of related information (Swanson, 1987).

Students with LD are less able to employ strategies to help them sustain memory searches (Englert & Raphael, 1998). Englert and Raphael noted that students with LD had difficulty producing multiple statements about topics, and that many students, when prompted, had much more knowledge about a topic than their written compositions. This indicated a problem with "retrieval and use of relevant schemas from memory that might sustain their thinking and writing in a generative way" (Englert & Raphael, p. 514). These researchers concluded that memory searches of students with LD were not effective in retrieving all of the information these students had in memory. Further, this suggests that these students lacked an ability to activate and sustain memory searches, and that they had difficulty activating new or deeper knowledge searches. As stated previously, memory deficits can affect performance in idea generation

In addition to difficulties with knowledge integration, children with LD typically use a knowledge telling approach (Scardamalia & Bereiter, 1987) to writing as compared to a knowledge transforming approach. Knowledge telling is a convergent "think-say" process of composing that continues until the search results in depletion of ideas. Students with LD typically spend less time planning, have difficulties generating ideas and editing compositions, and produce compositions of shorter length with more mechanical errors than their non-disabled peers (Graham & Harris, 1996). The knowledge-transforming model (a divergent thinking style) employed by more mature writers reflects a more thorough search of memory that results in increased idea or content generation and better compositions (Scardamalia & Bereiter, 1987). It is logical to assume that convergent thinking style would inhibit production of numerous, diverse, and unique ideas. Students who do not think in a divergent thinking style would not be as fluent, flexible, or creative as students who did use a divergent thinking style.

3. Method

Three variables that are the most straight forward to score and most commonly used to assess the creative ability of an individual during the process of idea generation are fluency, flexibility, and originality (Guilford, 1950; Runco, 1990). In response to an open-ended question, individuals are prompted to generate ideas that can then be scored in terms of fluency (quantity), flexibility (adaptability), and originality (novelty). Responses are then scored by simply counting the number of distinct, relevant ideas, and by counting the number of categories used to generate appropriate ideas in response to the prompt. Originality is scored by calculating the relative frequency of occurrence of a particular response.

Sample

A sample of 24 seventh-grade students from a suburban Midwest middle school were selected to participate in this study. To control for potential school and context variables, we purposefully constrained the study to one school, and worked with the district to identify a school that would have adequate numbers of students for both the disability and control groups. When contacted, the special education director informed us they had an inclusive classroom made up of equal numbers of students with and without disabilities. Disabilities included students with intellectual disabilities, students identified as "other health impaired," and students with learning disabilities. The classroom was co-taught by a general education teacher and a special education teacher. Study participants included 12 students with specific learning disabilities (LD) and 12 students with no specific learning disability. All students attended school in the inclusive classroom.

The two groups appeared to be similar in terms of gender, ethnicity, and socio-economic status. The LD group consisted of four female students (33%), and the non-LD group consisted of five female students (42%). However, the difference between the groups was not statistically significant (χ^2 [1] = 0.18, *p* = .67). In the LD group, nine participants were White (75%), as were eight participants in the non-LD group (80%, we were missing ethnicity data on two participants), but the difference between the groups was, again, not statistically significant (χ^2 [1] = 0.08, *p* = .78). We categorized participants as qualifying for free school lunch, reduced-price lunch, or non-qualifying. Eight LD participants qualified for free lunch (67%), and one for reduced-price lunch (8%), whereas three non-LD participants qualified for free lunch (30%, we were missing data for two participants), and three for reduced-price lunch (30%). However, the differences between the groups were not statistically significant (χ^2 [2] = 3.26, *p* = .20).

The groups also appeared to be similar in terms of reading ability and overall intelligence. Participants in the LD group ranged in state reading achievement score from 312 to 874 with a mean of 643.58 (*SD* = 221.68). We only had data for three of the non-LD students, whose scores ranged from 209 to 650 with a mean of 453.67 (*SD* = 224.44). A comparison of means revealed no statistically significant difference (*t* [13] = 1.33, *p* = .21). In terms of
WISC-IV Full Scale IQ score, LD participants ranged from 83 to 112 with a mean of 94.08 (*SD* = 8.07), whereas non-LD participants (again, we only had data for three) ranged from 78 to 103 with a mean of 90.00 (*SD* = 12.53). Again, no statistically significant difference was found between the means (*t* [13] = 0.88, *p* = .39). In accordance with school district policies, more detailed information about present levels of performance and students' formal educational and cognitive testing was not made available for researchers.

Setting

The study took place in an inclusive classroom consisting of equal numbers of students with and without disabilities. All participants received instruction in the general education classroom and received instruction for reading, math, and/or writing in the classroom. The general and special education teachers co-taught in the classroom. All prompts were administered in the participants' classroom.

Instrumentation

Assessment prompts. The Alternative Uses method (Wallach & Kogan, 1966) asks a student to generate as many uses for a specified object as possible. Alternate Uses prompts used in this study utilized in or modeled after prompts used in previous creativity studies (e.g., Torrance, 1974; Wallach & Kogan).

Questions provided by or similar to the ones used by Wallach and Kogan were:

1. Tell me all the different ways you could use a newspaper.
2. Tell me all the different ways you could use a screwdriver.
3. Tell me all the different ways you could use an automobile tire.
4. Tell me all the different ways you could use a cork.
5. Tell me all the different ways you could use a shoe.
6. Tell me all the different ways you could use a chair.
7. Tell me all the different ways you could use a key – the kind used in doors.
8. Tell me all the different ways you could use a button – the kind that is used on clothing.
9. Tell me all the different ways you could use a pencil.
10. Tell me all the different ways you could use a string.
11. Tell me all the different ways you could use a card board box.
12. Tell me all the different ways you could use an aluminum can.
13. Tell me all the different ways you can use a net.
14. Tell me all the different ways you can use a toothbrush.
15. Tell me all the different ways you could use a string.
16. Tell me all the different ways you could use a water hose.
17. Tell me all the different ways you could use an aluminum can.
18. Tell me all the different ways you can use a paperclip.
19. Tell me all the different ways you can use a brick.
20. Tell me all the different ways you can use a blanket.
21. Tell me all the different ways you could use a card board box.

Assessment procedures. Administration of Alternate Uses prompts was modeled after procedures suggested by Torrance (1974) and Wallach and Kogan (1966). The middle school service coordinator delivered all assessment prompts to the students as a group. Assessment sessions took place in the student's classroom at a time designated by the service coordinator when there was the least possibility of distraction for the students. Assessment prompts were administered for five days, five prompts per day, until all prompts were completed. Prompt administration did not exceed 10 minutes on any day. The service coordinator read the following protocol to the students: "I am going to ask you to tell me all of the different ways that an object can be used. I want you to think of as many ideas as you can. There are no wrong ideas. You have three minutes to write down your ideas. You can use as many of the items as you need and any size. Think of as many ideas as you can. When you are finished, please turn over your paper." The prompt was read out loud to the student two times for each prompt. No additional prompting was provided to the students and there was no time limit for writing down their ideas. When the students indicated they were finished they turned over their papers and the service coordinator collected the completed responses.

Variables. As mentioned earlier, three aspects of divergent thinking were examined: fluency, flexibility, and originality. Fluency was defined as the total number of relevant ideas produced in response to an open-ended alternate uses prompt during the ideation process (Guilford, 1951; Runco, 1986, 1990). An idea had to be a valid, distinct, and appropriate use for the object, not something that could be done to the object (Torrance, 1974). Fantastic or impossible ideas beyond reality (Torrance) were not counted. For example, a response of "chair" to the "aluminum can" prompt was counted as *irrelevant*. Both relevant and irrelevant ideas were tracked, as well as *redundant* ideas. Redundant ideas were defined as a string of responses that did not represent a new idea. For example, one respondent answered the "shovel" prompt with "hit a mole, hit a cat, hit a rat, hit a mouse," but the response was counted as just one relevant idea and three redundant ideas. Flexibility was operationalized as the total number of diverse sets of responses, themes, or categories represented by a participant's relevant responses to a particular prompt (Guilford, 1951; Runco, 1986; 1990). The third aspect, originality, was defined as the relative frequency of the occurrence of an individual relevant response among the entire set of relevant participant responses for a particular prompt. For example, "paper hat" was used as an answer to the prompt "newspaper" by 90% of the participants, and was considered less original than the response "origami swan", which was used by 10%.

Scoring protocol and reliability. According to a study by Shrout and Fleiss (1989), when judges were asked to rate the quality of the problem restatement, an interrater agreement coefficient of .66 was obtained. The interrater agreement for originality was .64. These interrater reliabilities are sufficient for research purposes and are similar to those obtained in other studies using the similar measures and procedures (Mobley et al., 1992; Runco & Chand, 1992). Problem construction ability was defined as both quality and originality of the problem restatement. The scoring protocol in this study was modeled after the Unusual Uses of Tin Cans activity found in the Torrance Tests of Creative Thinking (Torrance, 1974). The fluency score is the number of relevant ideas produced. Any idea generated that expressed a use for an object in a prompt was counted as one idea, unless the scorers judged the idea to be irrelevant or redundant. Judgments of relevancy and redundancy were cross-checked between scorers. Disagreements were discussed until a consensus was reached.

This scoring protocol has been used as a valid method for scoring quality and originality (Runco & Chand, 1982; Runco & Okuda, 1988). The quality and originality of the problem restatements were assessed using a procedure adapted from Hennessey and Amabile's (1988) consensual rating technique. These researchers used three judges familiar with relevant research in creativity, cognition, and problem solving were asked to rate the quality and originality of problem restatements obtained from 10 sample problems. These judges were then brought together for a panel meeting to discuss discrepancies in the ratings. Quality was defined as providing a plausible and viable restatement of the problem presented. Originality was defined as a novel response that was not structured by the stimulus context. These rating scales were then applied to actual data collected for this study. The trained judges were then given the stimulus material and the problem restatements generated by the participants and were asked to evaluate the quality and originality of each set of problem restatement. Raters were not given information about the hypotheses, experimental conditions, or expected outcomes.

The flexibility score for a given response was determined by counting the number of idea categories in which relevant ideas fell. Idea categories were determined using a consensus between two scorers. Typically, for creative thinking assessments, idea categories are predetermined. However, there were no predetermined idea categories for any of the alternate uses prompts that were used in the study other than the tin can and cardboard box prompts. Therefore, it was necessary to use a consensus method of determining idea categories for all prompts including the tin can and cardboard box prompts. First, both scorers independently determined the idea category for each relevant idea generated for each response. After independently determining an idea category for each relevant idea, scorers reviewed each idea category together by prompt to determine a consensus category for each relevant idea, and an idea category list was created. This idea category list (solution set) was then used to score total idea categories generated for a particular prompt. Scorers agreed on all idea categories.

4. Results

Preliminary *t*-test comparisons were run between the LD and non-LD groups on each of the outcome variables (i.e., fluency, flexibility, originality, irrelevant ideas, and redundant ideas) for each of the prompts, but no significant differences were found. However, the *t*-test for redundant ideas on the "plate" prompt resulted in a $p = .053$ ($t[11.00] = 2.17$) for a mean difference of 0.50 more redundant ideas on average in the LD group, a moderate-to-large effect ($d = 0.76$). See Table 1 for means and standard deviations of each prompt for each group.

This result suggested a lack of statistical power, and one solution was to take advantage of the dependent within-subjects nature of the data; prompts were nested within individual. In addition, examination of the distributions of fluency (i.e., the number of ideas generated), and flexibility (i.e., the number of idea categories represented), and the count nature of the variables themselves, suggested that the variables should be modeled with the Poisson distribution. Originality (i.e., the relative frequency of an idea) was recorded as a percentage, and was modeled with the lognormal distribution.

Intraclass correlations, ρ, supported the treatment of the data as clustered (i.e., $\rho > .05$). For fluency, $\rho = .12$, and for flexibility, $\rho = .10$. For originality, the data had a three-level structure: idea nested within prompt nested within individual. However, after accounting for variability within individuals, there was not enough variability left within prompt to allow for computation of a three-level model (i.e., three-level models would not converge because the variance component for prompt was very small). Therefore, we used a two-level model for originality as with the other two outcome variables (i.e., prompt nested within individual), and $\rho = .05$.

Fluency

For the first outcome variable, fluency, a generalized multilevel model with a Poisson distribution and a log link function was run using PROC GLIMMIX in SAS v9.2, and robust standard errors were calculated. The linear mixed model was:

$$(1)\ Y_{ij} = \gamma_{00} + \gamma_{01} SLD + U_{0j} + R_{ij}$$

where γ represents the Level 2 regression coefficients, *U* the Level 2 residuals, and *R* the Level 1 residuals.

Table 1. Means and Standard Deviations of Learning Disabled and Non-Learning Disabled Groups

	Number of categories		Number of ideas		Mean proportion		Number of irrelevant ideas		Number of redundant ideas	
	LD	Non-LD	LD	Non-LD	LD	Non-LD	LD	Non-LD	LD	Non-LD
t	*M(n, SD)*	*M(n, SD)*	*M(n, SD)*	*M(n, SD)*	*M(n, SD)*	*M(n, SD)*	*M(n, SD)*	*M(n, SD)*	*M(n, SD)*	*M(n, SD)*
1.	1.83(12, 1.47)	1.78(9, 0.97)	2.17(12, 1.59)	2.11(9, 1.05)	.02(12, .02)	.02(9, .01)	0.00(11, .000)	0.00(8, 0.00)	0.82(11, 1.17)	0.38(8, 0.74)
2.	1.75(12, 1.06)	2.11(9, 0.93)	2.17(12, 1.85)	2.67(9, 1.00)	.04(12, .03)	.04(9, .02)	0.18(11, 0.40)	0.25(8, 0.46)	0.09(11, 0.30)	0.13(8, 0.35)
3.	2.50(12, 1.24)	2.33(9, 0.87)	2.75(12, 1.60)	2.33(9, 0.87)	.06(12, .04)	.06(9, .04)	0.58(12, 1.24)	0.14(7, 0.38)	1.92(12, 3.37)	0.86(7, 1.21)
4.	2.17(12, 1.59)	1.33(9, 0.50)	2.42(12, 1.56)	1.56(9, 0.73)	.03(12, .03)	.06(9, .04)	1.18(11, 1.72)	0.38(8, 0.74)	0.27(11, 0.65)	0.38(8, 0.52)
5.	1.58(12, 1.16)	2.33(9, 1.00)	2.00(12, 1.48)	2.56(9, 1.24)	.02(12, .02)	.03(9, .02)	1.25(12, 1.66)	0.43(7, 0.79)	1.75(12, 2.53)	0.71(7, 0.95)
6.	2.08(12, 1.38)	2.00(9, 0.87)	2.25(12, 1.54)	2.44(9, 1.33)	.02(12, .02)	.03(9, .02)	0.45(11, 0.52)	0.50(8, 0.76)	0.55(11, 1.29)	0.00(8, 0.00)
7.	2.25(12, 1.06)	1.89(9, 0.93)	2.67(12, 1.37)	2.33(9, 1.41)	.07(12, .03)	.10(9, .05)	1.09(11, 1.70)	0.50(8, 1.07)	1.00(11, 1.41)	0.38(8, 1.06)
8.	1.58(12, 0.79)	1.88(8, 1.13)	2.00(12, 1.04)	1.88(8, 1.13)	.06(12, .05)	.08(8, .05)	1.17(12, 1.75)	0.43(7, 0.53)	0.42(12, 1.16)	0.43(7, 0.53)
9.	1.92(12, 1.16)	1.88(8, 0.83)	2.25(12, 1.54)	2.00(8, 0.93)	.04(12, .03)	.05(8, .03)	0.08(12, 0.29)	0.00(7, 0.00)	1.00(12, 1.71)	0.43(7, 0.53)
10.	2.08(12, 1.16)	1.75(8, 0.71)	2.67(12, 1.67)	2.88(8, 1.25)	.07(12, .04)	.07(8, .04)	0.83(12, 2.29)	0.00(7, 0.00)	0.42(12, 0.90)	0.43(7, 0.79)
11.	1.64(11, 1.50)	1.75(8, 0.71)	1.64(11, 1.50)	1.88(8, 0.99)	.06(11, .05)	.08(8, .05)	0.82(11, 0.87)	1.00(8, 0.93)	0.45(11, 0.82)	0.63(8, 1.06)
12.	3.00(11, 1.48)	2.75(8, 1.58)	3.36(11, 1.96)	2.88(8, 1.73)	.03(11, .01)	.04(8, .04)	1.45(11, 2.11)	1.00(8, 1.07)	1.09(11, 1.38)	0.38(8, 0.52)
13.	1.36(11, 1.12)	1.50(8, 0.76)	1.64(11, 1.50)	2.50(8, 1.07)	.04(11, .04)	.03(8, .02)	0.27(11, 0.47)	0.38(8, 0.52)	0.55(11, 1.29)	0.38(8, 0.74)
14.	1.82(11, 1.25)	2.25(8, 0.71)	2.27(11, 1.62)	2.63(8, 0.92)	.05(11, .04)	.07(8, .03)	0.27(11, 0.47)	0.63(8, 0.92)	0.36(11, 0.92)	0.25(8, 0.46)
15.	2.45(11, 0.93)	2.00(8, 0.76)	2.73(11, 1.27)	2.25(8, 0.71)	.08(11, .02)	.07(8, .04)	0.50(12, 0.80)	0.00(7, 0.00)	1.00(12, 1.71)	0.43(7, 1.13)
16.	2.00(11, 0.89)	2.14(7, 2.04)	2.36(11, 1.03)	2.43(7, 2.30)	.01(11, .01)	.02(7, .01)	1.00(1, 0.00)	0.00(0, 0.00)	0.00(1, 0.00)	0.00(0, 0.00)
17.	2.45(11, 1.51)	1.83(6, 0.41)	2.45(11, 1.51)	1.83(6, 0.41)	.03(11, .02)	.04(6, .02)	1.00(11, 2.37)	1.13(8, 1.36)	0.64(11, 0.81)	1.50(8, 2.78)
18.	1.27(11, 0.65)	1.33(6, 0.52)	2.00(11, 1.26)	1.83(6, 0.75)	.05(11, .03)	.06(6, .02)	1.08(12, 1.56)	0.57(7, 0.79)	0.42(12, 0.90)	0.43(7, 0.79)
19.	1.50(10, 1.27)	1.67(6, 0.82)	1.9(10, 1.52)	1.83(6, 0.75)	.02(10, .02)	.03(6, .02)	0.36(11, 0.92)	0.71(7, 1.50)	0.09(11, 0.30)	0.14(7, 0.38)
20.	2.40(10, 1.07)	2.33(6, 1.03)	3.40(10, 0.97)	3.50(6, 1.52)	.04(10, .01)	.04(6, .02)	1.00(11, 1.79)	0.38(8, 1.06)	1.18(11, 1.66)	0.38(8, 0.74)
21.	1.70(10, 0.82)	2.17(6, 0.75)	2.00(10, 1.15)	2.17(6, 0.75)	.06(10, .04)	.06(6, .01)	0.55(11, 0.82)	0.50(8, 0.76)	0.09(11, 0.30)	0.00(8, 0.00)
22.	2.20(10, 1.48)	2.40(5, 0.55)	2.30(10, 1.57)	2.60(5, 0.89)	.02(10, .02)	.03(5, .01)	0.45(11, 0.69)	0.75(8, 1.16)	0.09(11, 0.30)	0.00(8, 0.00)

Note. None of the mean differences between groups was significant at the .05 level. LD = learning disabled. 1 = aluminum can. 2 = Blanket. 3 = book. 4 = brick. 5 = button. 6 = card board box. 7 = chair. 8 = door key. 9 = feather. 10 = hairdryer. 11 = net. 12 = newspaper. 13 = paper clip. 14 = pillow. 15 = plate. 16 = screw driver. 17 = shoe. 18 = Shovel. 19 = string. 20 = tire. 21 = tooth brush. 22 = water hose.

The independent variable, LD group, was found to have no effect: $t(460) = -0.11$, $p = .90$ (see Table 2, Model 2). Using the modeling process recommended by Snijders and Boskin (2004), we tested fixed effects and random slopes for Level 1 covariates (i.e., irrelevant ideas and redundant ideas), fixed effects for Level 2 covariates (i.e., mean number of irrelevant ideas per individual, and mean number of redundant ideas), cross-level interactions (e.g., irrelevant ideas X LD group), and Level 2 interactions (e.g., mean irrelevant ideas X LD group). We found significance for mean irrelevant ideas, mean redundant ideas, and an interaction between mean irrelevant ideas and LD group. The final mixed marginal model was as follows:

$$(2)\ Y_{ij} = \gamma_{00} + \gamma_{01} SLD + \gamma_{02}\left(\overline{irrelevant}\right) + \gamma_{03}\left(\overline{redundant}\right) + \gamma_{04}\left(\overline{irrelevant}\ x\ SLD\right) + U_{0j} + R_{ij}$$

In this model, the mean number of redundant ideas was significantly and positively associated with fluency ($t[460] = 5.73$, $p < .001$). However, the association of the mean number of irrelevant ideas with fluency was moderated by LD group ($t[460] = -3.26$, $p < .01$; see Table 2, Model 3).

Table 2. Hierarchical Generalized Linear Models of Number of Ideas on SLD[a] Group, Mean Irrelevant Ideas and Mean Redundant Ideas (N = 484 [24 Individuals, 22 Prompts])

	Model 1		Model 2		Model 3	
Variable	*B (SE)*	β	*B (SE)*	β	*B (SE)*	β
Fixed effect						
Intercept, γ_{00}	0.81 (0.06)‡	2.25	0.81 (0.08)‡	2.25	0.37 (0.13)†	1.45
SLD[a] group, γ_{01}			-0.01 (0.13)	0.90	0.05 (0.11)	1.05
Mean redundant ideas, γ_{02}					0.73 (0.13)‡	2.08
Mean irrelevant ideas, γ_{03}					0.36 (0.14)†	1.43
SLD group x Mean irrelevant ideas, γ_{04}					-0.57 (0.18)†	0.57
Random effect						
τ_0^2	0.08 (0.03)		0.09 (0.03)		0.05 (0.02)	
σ_0^2	0.60 (0.04)		0.60 (0.04)		0.60 (0.04)	
-2 res. log pseudo-likelihood	792.62		795.48		783.77	
Generalized χ^2	291.52		291.18		287.57	
Generalized χ^2/df	0.60		0.60		0.60	

Note. The data were modelled with a Poisson distribution and log link. Standard errors were empirically adjusted.
[a]Students with learning disabilities.
**p* < .05. †*p* < .01. ‡*p* < .001.

The significant interaction coefficient indicated that the slope of mean irrelevancy for each LD group was significantly different. For the LD group, the association was negative and significant ($\gamma_{02} = -0.27$, $t[237] = -2.50$, $p = .01$), whereas for the non-LD group, the effect was positive and significant ($\gamma_{02} = 0.32$, $t[223] = 2.30$, $p = .02$; see Figure 1). It is important to note that both the main and interaction effects were significant even when all other Level 1 and Level 2 variables were controlled in prior model building steps.

Flexibility

The same process was used to model flexibility. In the model with just the simple main effect of LD group, no effect was found: $t(460) = -0.08$, $p = .99$ (see Table 3, Model 2). Again, using the modeling process recommended by Snijders and Boskin (2004), we tested fixed effects and random slopes for Level 1 covariates, fixed effects for Level 2 covariates, cross-level interactions, and Level 2 interactions. We arrived at the same set of explanatory variables as we did for fluency, namely mean irrelevant ideas, mean redundant ideas, and the interaction between mean irrelevant ideas and LD group. The mean number of redundant ideas was significantly and positively associated with flexibility ($t[460] = 4.88$, $p < .001$).

Table 3.Hierarchical Generalized Linear Models of Number of Idea Categories on SLD[a] Group, Mean Irrelevant Ideas and Mean Redundant Ideas (N = 484 [24 Individuals, 22 Prompts])

	Model 1			Model 2			Model 3		
Variable	*B (SE)*		β	*B (SE)*		β	*B (SE)*		β
Fixed effect									
Intercept, γ_{00}	0.65 (0.05)	‡	1.92	0.66 (0.07)	‡	1.93	0.28 (0.12)	*	1.33
SLD[a] group, γ_{01}				-0.01 (0.11)		0.99	0.08 (0.10)		1.08
Mean redundant ideas, γ_{02}							0.61 (0.13)	‡	1.85
Mean irrelevant ideas, γ_{03}							0.32 (0.14)	*	1.37
SLD group x Mean irrelevant ideas, γ_{04}							-0.54 (0.18)	†	0.58
Random effect									
τ_0^2	0.06 (0.02)			0.06 (0.02)			0.04 (0.02)		
σ_0^2	0.51 (0.03)			0.51 (0.03)			0.51 (0.04)		
-2 res. log pseudo-likelihood	782.45			785.55			777.97		
Generalized χ^2	248.26			247.94			245.32		
Generalized χ^2/df	0.51			0.510			0.51		

Note. The data were modelled with a Poisson distribution and log link. Standard errors were empirically adjusted.
[a]Students with learning disabilities.
*$p < .05$. †$p < .01$. ‡$p < .001$.

The effect of mean number of irrelevant ideas on flexibility was moderated by LD group ($t[460] = -2.95$, $p < .01$; see Table 3, Model 3), meaning that the slope of mean irrelevance for each LD group was significantly different. For the LD group, the association of mean irrelevance with flexibility was negative and significant ($\gamma_{03} = -0.29$, $t[237] = -2.83$, $p < .01$), whereas for the non-LD group, the effect was positive but nonsignificant ($\gamma_{03} = 0.27$, $t[223] = 1.79$, $p = .08$; see Figure 1).

Originality

For the third outcome variable, originality, a generalized multilevel model with a lognormal distribution and the identity link was run with robust standard errors. In the simple main effect model LD group was found to have no effect: $t(1091) = -0.07$, $p = .99$. We used the same modeling process as for the previous two outcome variables, but added some covariates. Because the originality of an idea may be associated with the number of ideas, and the number of categories of ideas, an individual may generate for a particular prompt or on average across all prompts, we included fluency, flexibility, mean fluency, and mean flexibility in our modeling. However, we ultimately arrived at a somewhat similar set of explanatory variables. There was a significant negative Level 1 fixed effect of fluency on originality ($t[1090] = -8.70$, $p < .001$); an increase in an individual's number of ideas generated for a particular prompt was associated with a decrease in the originality of any one particular idea. The effect of mean number of irrelevant ideas on originality was moderated by LD group ($t[1090] = 5.57$, $p < .001$; see Table 4, Model 3). For the LD group, the effect of mean irrelevant ideas on originality was negative and significant ($t[565] = -3.28$, $p < .01$), as it was for the non-LD group ($t[524] = -5.90$, $p < .001$). However, the effect for the non-LD group was more than five times larger ($\gamma_{03} = -0.10$ versus -0.53; see Figure 1).

5. Discussion

Our results indicate that as the average number of redundant ideas generated by each individual increases—whether LD or not—so do both the fluency and the flexibility of those ideas. However, the average number of irrelevant ideas generated by each individual has a different relationship with fluency and flexibility depending on whether the individual is LD. For the LD group, fluency and flexibility decrease as the average number of irrelevant ideas increases, whereas for the non-LD group, fluency and flexibility increase. This group difference may be a reflection of a difference in the quality of brainstorming for LD and non-LD students. Perhaps when LD students brainstorm, they have more difficulty getting out of a certain train of thought, or less ability to recognize clear qualitative differences in ideas. This is a matter for further investigation.

Our results also indicate that on a prompt-by-prompt basis, as the number of relevant ideas generated by each individual increases, the originality of the ideas decreases for both the LD and non-LD groups. We expected to find a difference between groups in this relationship, but we did not, perhaps because it is more difficult to come up with a unique idea as more and more ideas are generated (sort of like exhausting the supply). We also observed in both groups that as the average number of irrelevant ideas generated by each person increased, so did the originality of the ideas. However, the increase was more pronounced in the non-LD student group. Perhaps brainstorming itself has different types or purposes, and each has certain advantages. When generating irrelevant ideas as a part of brainstorming, there may be a positive effect on originality of ideas, but not on the number of (i.e., fluency) or the categories of ideas (i.e., flexibility). In either case, non-LD students seem to increase more in the originality, fluency, and flexibility with increasing numbers of irrelevant ideas, and LD students seem to increase much less, and in fact, have a negative association with number of relevant ideas.

Table 4.Hierarchical Generalized Linear Models of Originality on SLD[a] Group, Number of Ideas, and Mean Irrelevant Ideas (N = 1115 [24 Individuals, 22 Prompts])

	Model 1		Model 2		Model 3	
Variable	*B (SE)*	β	*B (SE)*	β	*B (SE)*	β
Fixed effect						
Intercept, γ_{00}	1.94 (0.06)‡	6.96	1.94 (0.10)‡	6.96	2.86 (0.10)‡	17.46
SLD[a] group, γ_{01}			-0.01 (0.12)	0.99	-0.07 (0.09)	0.93
Number of ideas, γ_{10}					-0.26 (0.03)‡	0.77
Mean irrelevant ideas, γ_{02}					-0.57 (0.09)‡	0.57
SLD group x Mean irrelevant ideas, γ_{03}					0.51 (0.09)‡	0.60
Random effect						
τ_0^2	0.06 (0.03)		0.07 (0.03)		0.005 (0.01)	
σ_0^2	1.21 (0.05)		1.21 (0.05)		1.11 (0.05)	
-2 res. log pseudo-likelihood	3406.64		3408.97		3303.85	
Generalized χ^2	1346.23		1345.01		1237.53	
Generalized χ^2/df	1.21		1.21		1.11	

Note. The data were modelled with a lognormal distribution and identity link. Standard errors were empirically adjusted.
[a]Students with learning disabilities.
$^*p < .05$. †$p < .01$. ‡$p < .001$.

These effects may be expressed as differences in quality of brainstorming between the groups with and without LD and may be linked to deficits or deficiencies related to memory processes and lack of metacognitive abilities for the LD group. In a comprehensive review of studies, Swanson and Saez (2003) revealed that students with LD had difficulties in executive processing relative to encoding of information, use of retrieval strategies, and switching attention when manipulating information in working memory. These deficits are associated with problems related to information retrieval from LTM (Baughman & Mumford, 1995) and information processing in working WM (McCutchen, 1996; McLean & Hitch, 1999; Swanson, 1987; Swanson & Ashbaker, 2000). More specifically, students have been found to have difficulties in working memory associated with the central executive, phonological loop, and visuo-spatial sketchpad (Baddeley, 1992; Gathercole, Pickering, Ambridge, & Wearing, 2004) and problems with knowledge manipulation and reorganization (Baughman & Mumford; Mobley, et al., 1992).

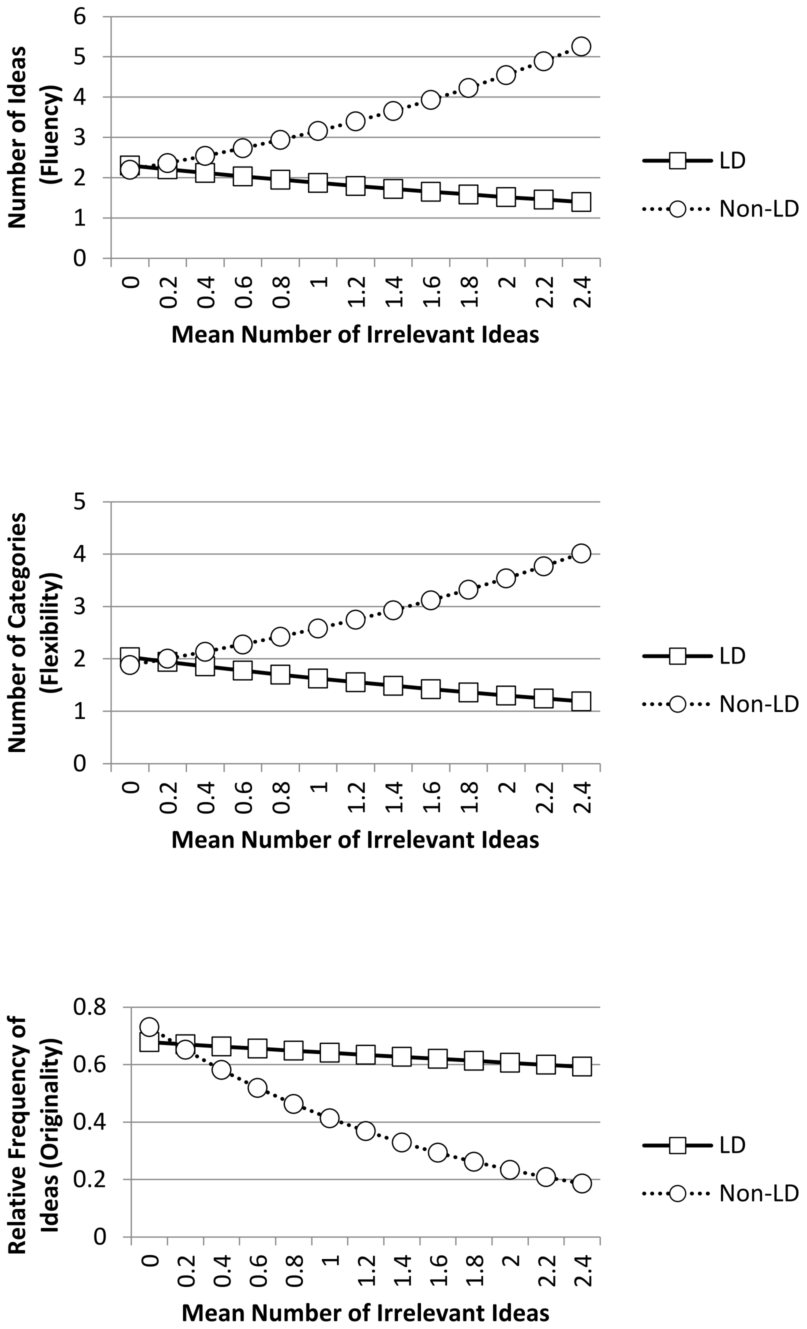

Figure 1. Three line charts illustrating the moderation effect of group—learning disabled (LD) and non-learning disabled (non-LD)—on the curvilinear relationships between each individual's mean number of irrelevant ideas and the total number of ideas generated (top), the number of different categories of ideas generated (middle), and the relative frequency of each idea (bottom).

Kolligan and Sternberg (1987) found that students with LD employed deficient cognitive strategies and had deficient knowledge in certain domains. This resulted in problems with encoding, evaluating, and combining information in order to form new knowledge representations. Williams (2003) states that cognitive processing problems such as difficulties in working memory and ineffective self-monitoring can result in reading comprehension problems. Benedek, Jauk, Somner, Arendasy, and Neubauer (2014) demonstrated that such executive functions are crucial for creativity, and given the fact that students with LD often have deficits, it is likely they would have problems with creativity. In fact, students with LD often lack spontaneity, flexibility, planning, monitoring, and checking their work (Brown & Palincsar, 1982; Englert et al., 1988).

Further, when considering idea generation from a creative cognition perspective, several points stand out: (a) ideation is a complex process that requires a family of skills, and processes (Armbruster, 1989; Mobley et al., 1992; Puryear, 2015; Runco, 1986, 2014; Runco & Chand, 1995); (b) ideation consists of fluency, originality, and flexibility (Guilford, 1950; Runco & Chand, 1995; Crossley et al., 2016); and (c) in order to construct new ideas, extant knowledge must be accessed, retrieved from long-term memory, and reorganized and combined into new knowledge structures that can be used to construct a product in fulfillment of a task requirement (Baughman & Mumford, 1995; Beaty, Silvia, Nusbaum, Jauk, & Benedek, 2014). It would seem logical that individuals who are less productive at generating ideas may have difficulty accessing a variety of information categories or knowledge structures, which could manifest as a deficiency in brainstorming as expressed by the LD group.

Finally, the data support previous research that suggest students with LD tend to think in a convergent thinking style. This convergent thinking style would present as less efficient and effective brainstorming. A convergent thinking style generates fewer ideas than a divergent thinking style, because fewer idea categories are searched during memory searches. Students with LD often have difficulty generating ideas for writing (Scardamalia & Bereiter, 1987), because they employ a convergent, less flexible, “think-say” or knowledge-telling process to writing. In a knowledge-telling approach, a memory search continues until ideas are exhausted. An inability to switch idea categories would limit idea generation to one idea theme or idea set. Also, students with LD might take the path of least resistance suggested by Ward (1994), and search only readily available information. This would limit memory searchers to a more superficial level rather than a thorough, deeper memory search of semantic categories. The final result would be less effective idea generation.

Implications for Teaching

Generating ideas for content and problem solving is fundamentally important in many academic environments (Graham & Harris, 2003; Passolunghi & Siegel, 2004) and is one area that is vital for students’ academic success (Collins & Gentner, 1980). It seems intuitive then that if idea generation is crucial to success across academic areas, children who have difficulties generating ideas will find academic tasks more difficult. Further, if constructing an idea depends on the ability to retrieve prior/extant knowledge and reorganize that knowledge into a new idea, then problems with memory processes would impact an individual’s ability to generate ideas (Baughman & Mumford; Mobley et al., 1992; Nijstad & Stroebe, 2006; Rietzschel et al., 2007).

Results from this study support the knowledge telling approach to writing utilized by many students with LD (Scardamalia & Bereiter, 1987). This may have important considerations for the classroom teacher. Difficulty generating ideas may be most obvious in the area of writing. If students with LD do have problems generating ideas it could be because they are using a knowledge telling approach for idea generation, which this study has shown would be a convergent thinking style confined by memory deficits. A convergent thinking style used by students with LD would limit both flexibility and fluency. Subsequent written products produced by these students would reflect these limitations.

While not all students with LD may have idea generation problems, there are some who will. By definition, students with LD are non-responsive to intervention. Within this group of students, there may be a subset of students who are less-responsive than their non-responsive peers, failing to respond to strategies normally employed by teachers who instruct students with LD. These students most likely would employ a convergent idea generation thinking process, and would need more direct and specific instruction in how to think more divergently. If a student does in fact have deficits in idea generation, then teachers may be asking them to complete assignments or tasks that they simply are not able to complete. These students would require even more specialized instruction specifically targeting idea generation. The idea that some students will not respond to all interventions is noted by Graham and Perrin (2007). In Writing Next, Graham and Perrin state that some students will require much more intense and direct instruction in order to write at acceptable levels of performance. They offer 11 key elements for writing instruction. One element is the use of writing strategies that teach planning, revising, and editing for compositions. One writing strategy, Self-Regulated Strategy Development (SRSD), is a strategy that has been proven effective and uses explicit and individualized teaching and instruction. Within the SRSD model students are taught idea generation as part of the instructional package (Graham & Harris, 1993). However, if such instruction does not work or promote sufficient results for a particular student, that student may need specific or dedicated idea generation instruction.

The SRSD model would provide a framework for developing an instructional model that would specifically teach the student to generate ideas using a divergent thinking style. After targeted idea generation instruction, the teacher could pair that instruction with a writing strategy. Research has shown that a sequential combination of intervention strategies can improve generalization of strategies over teaching interventions in isolation (Lovett, Barron, & Benson, 2003). Classroom teachers should consider the possibility that a less responsive student may need individualized instruction in idea generation beyond what is typically taught in the classroom, and then add strategies in writing instruction. Future studies that sequentially combine an idea generation strategy with a writing strategy might address idea generation problems.

Strengths and Limitations

Our study has a number of strengths. We employed 22 different idea-generating prompts, a large enough number to provide a reliable within-subjects measure. All students were selected from the same classroom, which mitigates potential teacher and classroom confounds found in studies sampling from more than one classroom. Students from both groups were similar in reading achievement, IQ, gender, ethnicity, and socio-economic status, mitigating some potential subject characteristics threats to internal validity. Two raters were used to judge each prompt response, and agreement was reached on all responses, which supports the reliability and validity of the ratings themselves. The main construct of interest, creativity, was measured in three different ways—number of relevant nonredundant ideas generated (i.e., fluency), number of idea categories used (i.e., flexibility), and the relative frequency of occurrence of each idea (i.e., uniqueness or originality)—which provides evidence of construct validity for our inferences. The nested structure of the data was accounted for in our analyses, and the number of irrelevant and redundant ideas was statistically controlled in all our models.

However, our study also has some limitations. Among them were a small sample size, which was limited by the feasibility of administering and scoring 22 prompts for each individual. Measures of reading achievement, IQ, and socio-economic status were unavailable for some students, and thus we could not use those variables in our statistical models. Although we used a large number of prompts, many had never been used before in published studies, and need to be evaluated by other researchers for content validity. In addition, the number of categories of ideas generated was highly correlated with number of ideas themselves (r = .88), which may be an indication that our decisions about what ideas belonged in which categories might have been uninformative (i.e., added little to our eventual inferences). Finally, the exact nature of the learning disabilities (i.e. reading, math, etc.) of the individuals was not taken into account in our analyses.

6. Conclusion

While it is recognized that idea generation is a critical component for academic success, few studies have examined and quantified the specific difficulties that students with disabilities have with idea generation, and the role that it may play in enhancing their ability to succeed in some content areas. Research shows that idea generation is a complex process, and that students with LD often have difficulty with that process. Further, research suggests problems with idea generation for students with LD are due to memory deficits, which impact the ability of the individual to store, retrieve, manipulate, and/or organize information/knowledge into new knowledge. Other research postulates that difficulties with idea generation can be due to an inability to access prior knowledge and use it to formulate new knowledge. Whatever the reason, it is well known that for some students with LD, difficulties with generating ideas or content across academic content areas negatively impact their academic achievement. This study is a first step in developing an instructional tool that might be used to ameliorate or limit the effect of memory deficits on the academic performance of students with LD who have trouble generating ideas. Given the importance of academics and the impact these deficits can have on this student population, it would seem appropriate to conduct further research in this area and to develop specific strategies to address the needs of those less responsive students with LD who express deficiencies in idea generation.

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