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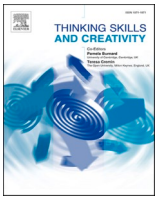

The effect of example abstraction on creativity from the perspectives of example modality and generality

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ABSTRACT

Examples can be beneficial or even detrimental to creativity under certain scenario. Presenting examples properly and stimulate the ability of creative idea generation matters to many fields including education, science, engineering, design, and the arts. Examples differing in abstract levels have been investigated in creativity literature, but it has not yet been demonstrated which abstraction level is most effective for boosting creativity. This study examined the effect of example abstraction in terms of example modality (i.e., pictorial or textual) and generality (i.e., categorical or specific) on creativity. Examples varying in modality (Experiment 1) or generality (Experiment 2) were presented to participants before a creativity task. In Experiment 1, 176 senior high school students were randomly assigned to textual-example (more abstract), pictorial-example (less abstract), and control (i.e., no example) groups. The results showed that idea fluency, originality, and flexibility were higher in the textual example group than in the pictorial example group. In Experiment 2, 165 senior high school students were randomly assigned to categorical-example (i.e., more abstract), specific-example (i.e., less abstract), and control groups. The results demonstrated no significant difference in idea fluency, originality, or flexibility between categorical and specific example groups. Moreover, idea originality, rather than fluency or flexibility, was higher in both example groups than in the control group. These findings indicate that example modality, rather than generality, can affect creativity. In comparison with pictorial examples, textual examples may activate a broader range of knowledge and contribute to creativity.

1. Introduction

Creativity is defined as the ability to generate original and useful ideas, insights, or problem solutions (Amabile, 1983; Sternberg & Lubart, 1999). Providing stimuli to inspire new ideas, such as example solutions, is one approach to facilitate creativity. It is generally accepted that scientists, artists, and different type of designers search for various types of external stimuli to develop new ideas (Goldschmidt & Sever, 2010; Wang & Nickerson, 2019). This phenomenon, in which prior knowledge or experience affects creative

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idea generation, is known as knowledge transfer or analogy (Chrysikou & Weisberg, 2005; Lambert et al., 2019). However, knowledge transfer can improve or impair creative performance, depending on various factors such as example features (Vasconcelos & Crilly, 2016).

The abstraction of an example is one of the key features that influences knowledge transfer. Abstract examples refer to examples without clear indications about their features, whereas less abstract examples have a clear specification of the features (Ezzat et al., 2020). Trope and Liberman (2010) pointed out in their review that modality (words vs. pictures) and categorization induce different levels of abstract thinking. Owing to the varied manipulation of example abstraction and other possible confounding variables, evidence about the role of example abstraction in creativity is mixed. Some studies have found that common abstract examples (i.e., categories of ideas) mitigated the negative effect of examples rather than common, less abstract ones (i.e., specific examples pertaining to some category; Ezzat et al., 2020). Other studies have shown that abstract examples (i.e., textual examples), rather than less abstract examples (i.e., pictorial examples), increased the repetition of example features or decreased idea rarity (Borgianni et al., 2020; Cardoso et al., 2012).

Example modalities include text, pictures, and drawings (Sio et al., 2015; Viswanathan et al., 2016). Researchers have reported that symbol-like texts are more abstract than corresponding physical artifacts or meanings that they convey (Viola & Isenberg, 2018). Research has shown mixed results when directly comparing the effects of pictorial examples with those of textual ones (Borgianni et al., 2020; Cardoso et al., 2012). For example, Cardoso et al. (2012) required participants to sketch ideas for future human transportation while referring to a pictorial or textual example solution. Creativity was measured through idea fluency, originality (assessed by the consensus assessment technique), flexibility, and repetition of example elements (i.e., fixation). The textual example group showed increased repetition of example elements (i.e., fixation), but had no difference in idea fluency, originality, or flexibility as compared to the pictorial example group. In another study, Borgianni et al. (2020) asked participants to generate new ideas for new-born outfits after considering five examples in one of the modalities (picture, text, or a juxtaposition of the two). Creativity was measured using idea fluency, rarity, originality, and flexibility. The pictorial example group performed better in idea rarity, but not in quantity (i.e., fluency), flexibility, or originality as compared to the textual example group.

Regarding the decreased repetition of example features and increased idea rarity of pictorial example groups, researchers have argued that pictorial stimuli could induce different interpretations and facilitate more semantically distant and unexpected ideas than textual stimuli (Borgianni et al., 2020; Cardoso et al., 2012). However, this explanation might obscure the effect of example abstraction because of possible confounding variables that may affect the effect of the example modality. One possible confounding variable is example complexity, which may result in the excessive repetition of example features rather than example abstraction (Cardoso et al., 2012). This may occur because participants have to spend more effort reading the written materials so that they can understand their meaning (Cardoso et al., 2012). Another possible confounding variable is generality. The inconsistency of generality may be partly due to the difficulty in corresponding the abstract concepts depicted by textual examples to that pictorial examples. In addition, the prepared pictures were not obtained from a picture pool with solid reliability and validity (Borgianni et al., 2020). Other possible confounding variables were task requirements (i.e., sketching vs. writing) and the number of examples (i.e., five vs. one).

The effect of example modality on creativity may reveal a different pattern after controlling for these possible confounding variables. According to the dual coding theory (DCT) postulated by Paivio (1968, 1991), pictures are easier to memorize than text. The timing and duration of examples have varied across studies; the current study used a timing design in which examples were presented once and then disappeared (Sio et al., 2015; Yuan et al., 2021). In this case, participants can easily sustain clearer mental imagery of the entity after seeing pictorial examples rather than textual ones. According to the path-of-least-resistance theory, however, the easy-to-memorize features of pictures would bind individuals to the pictorial stimuli and make them cognitively fixated as a result (Finke et al., 1992; Rietzschel et al., 2014). Therefore, in accordance with the DCT and the path-of-least-resistance theory, it seemed appropriate to assume that pictorial examples would constrain creativity, including idea fluency, originality, and flexibility. Thus far, research on the impact of example modality on idea generation has predominantly focused on the design field. Moreover, owing to the aforementioned possible confounding variables, its effect still remains unclear.

Examples within the same modality may differ in abstraction because of their varying generalities (e.g., categorical vs. specific examples). Ezzat et al. (2020) manipulated abstraction by presenting categorical (abstract) or specific (less abstract) examples in text form. Participants had to generate original solutions to "*ensure that a hen's egg dropped from a height of ten meters does not break*" after seeing categorical examples such as "*Damping the shock*" or specific examples such as "*Place a mattress at the reception*." The researchers found that participants who were instructed to avoid using specific, common examples showed more fixation, whereas those who were instructed to avoid using categorial, common examples showed less fixation and generated double the number of creative ideas. These two conditions merely differed in the level of abstraction of examples that should be avoided (i.e., specific or categorical examples). They explained that specific, common examples led participants to follow the path of least resistance more easily, which induced fixation. However, the influence of text abstraction has only been explored in the case of cognitive fixation caused by common examples (Ezzat et al., 2020). The effect of the abstraction of novel textual examples on creativity warrants further exploration.

Accordingly, we proposed that example abstraction in terms of example modality and generality may involve different levels of abstract thinking, which further affects creativity. Huang et al. (2015) summarized that abstract thinking can increase creativity by promoting diverse and novel ideas or leading to ideas that were not there before. It is possible that individuals exposed to abstract examples will produce ideas with higher fluency and flexibility. It is worth noting that previous studies on example modality have shown variance in the match of complexity, task requirements, and example number. Moreover, studies on example generality have only explored the case of cognitive fixation caused by common examples (Ezzat et al., 2020). How the abstraction of novel examples affects creativity has received little attention.

Therefore, the present study aimed to investigate the influence of the abstraction of novel examples on creative idea generation.

Specifically, we tested the effect of abstraction by manipulating example modality (Experiment 1) and generality (Experiment 2). The participants' creative performance was measured using independent ratings of fluency, originality, and flexibility. As above-mentioned, the effect of example abstraction on creative idea generation could be obscured by confounding variables such as example complexity and generality (Borgianni et al., 2020; Cardoso et al., 2012). Researchers suggest that less abstract examples may follow the path of least resistance and constrain the thinking of other possible new ideas (Finke et al., 1992; Rietzschel et al., 2014). Thus, in contrast to previous findings on the effect of example modality on creative idea generation, we predicted that idea fluency, originality, and flexibility would benefit from abstract examples rather than less abstract ones. The hypotheses were as follows:

- H1: Textual, novel examples (i.e., abstract examples) stimulate higher creativity (idea fluency, originality, and flexibility) than pictorial novel examples (i.e., less abstract examples).
- H2: Categorical, novel examples (i.e., abstract examples) stimulate higher creativity (idea fluency, originality, and flexibility) than specific novel examples (i.e., less abstract examples).

2. Experiment 1

Experiment 1 manipulated the abstraction of examples through example modality (i.e., pictorial and textual examples). Hypothesis 1 was examined by presenting pictorial (i.e., less abstract) or textual (i.e., abstract) examples with high novelty before the creativity task.

2.1. Materials and methods

2.1.1. Participants and design

A priori power analysis using G*power 3.1 (Faul et al., 2007) was conducted to estimate the sample size necessary for the main effect of an analysis of variance (ANOVA; fixed, omnibus, one-way) at 80% power ($\alpha = 0.05$). The between-participant effect size was set to Cohen's $f = 0.25$. Based on these results, the required sample size was 159. Due to the possibility of invalid data or participants dropping out, we recruited a total of 176 students from a senior high school for the study. A one-factor (example modality: pictorial example vs. textual example vs. control) between-subjects design was employed. Participants were randomly assigned to one of three groups.

Note that 9 participants were excluded because they failed to complete the experiment as requested. Thus, the final sample consisted of 167 participants (77 females, 90 males; age: 15.57 ± 0.70 years old). There were respectively 53, 54 and 60 participants in the pictorial, textual, and control groups. All participants were right-handed native Chinese speakers. Thus, the study was conducted in Chinese. They provided written informed consent prior to the experiment and voluntarily participated. The experimental protocol was approved by the institutional ethics committee of the university.

2.1.2. Task and procedure

The participants collectively completed this experiment in class using paper and pencils. Each participant would receive a booklet containing the instruction and other experimental materials before the experiment. During the experiment, the students were prohibited from talking to each other. They were required to complete the alternative uses task (AUT), a well-established test of creative potential, that requires participants to generate as many original uses as possible for common objects (Guilford, 1967; Runco & Mraz, 1992). Two AUT items (*tennis racket* and *zip-top can*) were presented in counterbalanced order on separate pieces of paper for each participant. In each example group, two examples were presented in the form of pictures or text in the example page before the task. After understanding the examples, the participants turned to the page of the AUT task. Examples for tennis rackets were "*Using the tennis racket as a basketball hoop after tearing out its net*" and "*Blowing bubbles with the net of the tennis racket.*" Examples for the zip-top

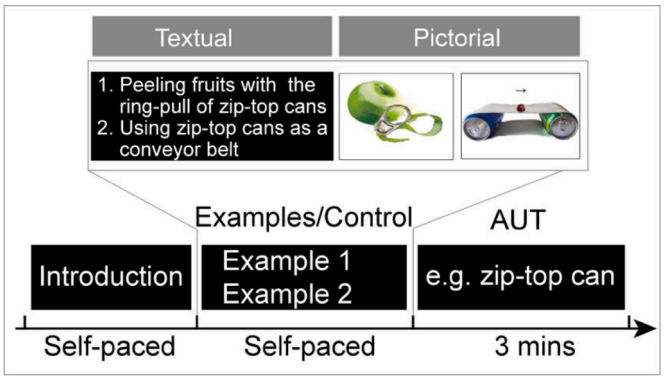

Fig. 1. Procedure overview of one of the two AUT items (i.e., a zip-top can). Note: After reading the introduction of the experiment, participants read two examples in the form of pictures or texts at their own pace. Then, they completed the AUT task (3 min).

can were *"Peeling fruits with the ring pull of the zip-top can"* and *"Using zip-top cans as a conveyor belt."* The participants in the control group received no examples. During each AUT task, participants were asked to generate and write down as many novel ideas as possible. Each AUT task lasted for three minutes (see Fig. 1)

Examples were obtained from the original data of a previous study (Yuan et al., 2018). According to the consensus assessment technique, which uses a 5-point Likert scale (1 = unoriginal, 5 = highly original), textual ideas with originality scores above three were selected as novel examples. The ideas were then sorted by the originality score. The two most original ideas were selected as final examples for each AUT prompt in Experiment 1. Based on these final textual examples, corresponding pictorial examples were drawn by a laboratory assistant. To ensure correspondence of meaning and interestingness between the textual and pictorial stimuli, six undergraduate students who had experience in creativity research rated the consistency of meaning (i.e., whether the text comprised the same semantic meaning as the corresponding picture) and interestingness (i.e., whether the idea itself depicted by a picture is as interesting as the text) on a 5-point Likert scale (1 = not consistent at all, 5 = very consistent). The rating consistency among the raters was satisfactory (meaning: $\alpha = 0.703$; interestingness: $\alpha = 0.814$), with the average score for each item being greater than four. In addition, as textual examples have been presented in long sentences in previous research, which makes them more complex than pictorial examples by requiring more attention to read, we used short phrases for textual examples. From the perspective of attention allocation, the attention paid to pictorial examples may be approximately similar to that paid to textual examples.

In addition, we used the Behavior Identification Form (BIF, Vallacher & Wegner, 1989) to assess participants' abstract thinking. However, considering that the BIF was inappropriately split into two halves without reasonable equivalence validation, data from BIF were not entered into analysis.

2.1.3. Task assessment

Participants' creative performance was measured based on fluency, originality, and flexibility. Fluency was scored as the total number of non-redundant ideas produced by participants. Originality was rated on a 5-point scale (1 = unoriginal, 5 = highly original) by four independent raters with satisfactory inter-rater reliability (tennis racket: $\alpha = 0.804$; zip-top can: $\alpha = 0.751$). These final originality scores for each participant were obtained by averaging the individual ratings from the raters. For flexibility, the responses for each AUT item were grouped into ten broad semantic categories by two raters. For instance, the response categories of *tennis rackets* included *hitting objects with the tennis racket, cutting or filtering objects with the net of tennis rackets,* etc. The response categories of *zip-top can* included *making handicrafts with zip-top cans, doing sports with zip-top cans,* etc. (see the appendix). Two trained raters independently coded a random subset of the response pool (25%), and inter-rater reliability (Cronbach's α) was satisfactory (tennis racket: $\alpha = 0.938$; zip-top can: $\alpha = 0.861$). The first rater scored the remaining responses. The final flexibility score for each participant was calculated by counting the number of explored categories. The raters of originality and flexibility were blinded to the experimental conditions.

2.2. Results

A one-way multivariate analysis of variance (MANOVA) with example modality (pictorial example vs. textual example vs. control) as the between-subjects factor was performed on AUT fluency, originality, and flexibility. The covariance matrices of the creative performance indices (fluency, originality, and flexibility) were not homogeneous (*Box's M* = 78.98, $p < 0.001$). The overall effects showed significant overall effects of example modality on AUT fluency, originality, and flexibility, $F(3, 163) = 20.59$, $p < 0.001$, $\eta_p^2 = 0.28$. Then, one-way ANOVAs using example modality as the between-group factor were conducted on AUT fluency, originality, and flexibility, respectively. All post hoc tests were corrected using the Scheffe correction.

Fluency differed significantly across groups, $F(2, 164) = 28.52$, $p < 0.001$, $\eta_p^2 = 0.26$. Participants in the textual example group showed higher fluency ($M = 9.74$, $SD = 3.97$) than those in the pictorial example group ($M = 6.66$, $SD = 3.44$, $p = 0.001$, Cohen's $d = 0.83$). Moreover, participants in the control group showed higher fluency ($M = 12.80$, $SD = 5.21$) than those in the pictorial ($p < 0.001$, Cohen's $d = 1.39$) and textual ($p = 0.001$, Cohen's $d = 0.66$) example groups (see Fig. 2 and Table 1).

Originality differed significantly across groups, $F(2, 164) = 6.49$, $p = 0.002$, $\eta_p^2 = 0.07$. Participants in the textual example group showed higher originality ($M = 2.05$, $SD = 0.23$) than those in the pictorial example ($M = 1.82$, $SD = 0.48$, $p = 0.006$, Cohen's $d = 0.61$) and control ($M = 1.85$, $SD = 0.34$, $p = 0.013$, Cohen's $d = 0.69$) groups. No significant difference was observed between the pictorial example and control groups ($p = 0.938$; see Fig. 2 and Table 1).

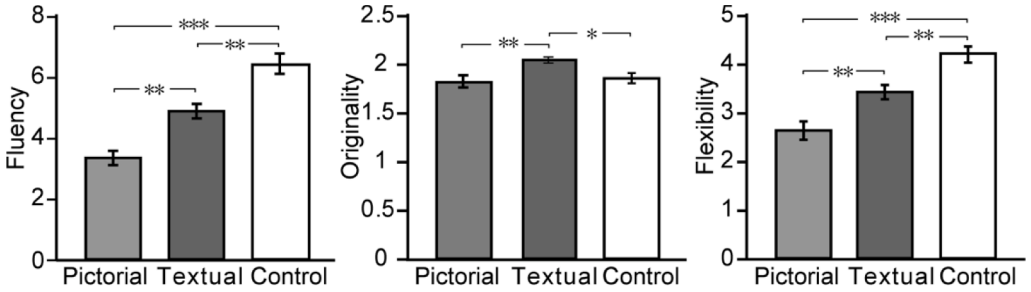

Fig. 2. Fluency, originality, and flexibility of responses in the pictorial, textual and control group. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 1
Fluency, originality, and flexibility in experiment 1 and 2.

	Condition	Fluency	Originality	Flexibility
Experiment1	Pictorial example	3.33 ± 1.72 [2.857, 3.803]	1.82 ± 0.48 [1.689, 1.952]	2.63 ± 1.23 [2.291, 2.973]
	Textual example	4.87 ± 1.98 [4.328, 5.413]	2.05 ± 0.23 [1.985, 2.111]	3.40 ± 1.12 [3.102, 3.713]
	Control	6.40 ± 2.61 [5.727, 7.073]	1.85 ± 0.34 [1.758, 1.932]	4.19 ± 1.16 [3.890, 4.494]
Experiment 2	Specific example	4.26 ± 1.99 [3.715, 4.813]	1.74 ± 0.19 [1.691, 1.793]	3.23 ± 1.12 [2.918, 3.535]
	Categorical example	4.85 ± 2.12 [4.281, 5.428]	1.72 ± 0.24 [1.657, 1.787]	3.30 ± 1.15 [2.989, 3.611]
	Control	4.95 ± 2.11 [4.386, 5.508]	1.55 ± 0.23 [1.491, 1.612]	3.29 ± 1.10 [2.997, 3.582]

Flexibility also differed significantly across groups, F (2, 164) = 24.80, $p < 0.001$, $\eta_p^2 = 0.23$. Participants in the textual example group showed higher flexibility ($M = 6.81$, $SD = 2.24$) than those in the pictorial example group ($M = 5.26$, $SD = 2.47$, $p = 0.004$, Cohen's $d = 1.11$). Moreover, flexibility in the control group ($M = 8.38$, $SD = 2.33$) was higher than that in the pictorial ($p < 0.001$, Cohen's $d = 1.30$) and textual ($p = 0.002$, Cohen's $d = 0.69$) example groups (see Fig. 2 and Table 1).

Pairwise correlations are presented in Table 2. The results showed that fluency was positively correlated with originality ($r = 0.15$, $p = 0.049$) and flexibility ($r = 0.87$, $p < 0.001$). Originality was also positively correlated with flexibility ($r = 0.26$, $p = 0.001$).

2.3. Interim discussion

The textual example group performed better in fluency, originality, and flexibility than the pictorial example group, supporting Hypothesis 1. As Paivio (1968) argued in the DCT, images are easier to memorize than text. Accordingly, pictorial examples may be more accessible to semantic memory than textual ones, thereby leading to more cognitive fixation (Finke et al., 1992; Rietzschel et al., 2014). In addition, the textual example may have activated more relative concepts than the pictorial one due to its high abstraction.

It must be noted that control group showed higher fluency and flexibility than the pictorial and textual example groups. This finding suggests that novel examples promote idea originality at the expense of idea fluency and flexibility. This is consistent with previous studies showing that examples enhance idea originality but impair idea fluency (Wang et al., 2018). According to the path-of-least-resistance theory (Finke et al., 1992; Ward, 1994; Rietzschel et al., 2014), presenting novel examples before a task can hinder the semantic activation of easily accessible knowledge. Therefore, novel examples may inhibit individuals from generating more ideas in the early stages of creativity.

3. Experiment 2

The results of Experiment 1 showed that textual novel examples induced better creative performance than pictorial novel examples. Experiment 2 aimed to examine further how abstraction of textual and novel examples affects creative performance. In line with a previous study (Ezzat et al., 2020), the abstraction of textual examples was manipulated by presenting categorical examples or specific examples pertaining to certain categories.

3.1. Materials and methods

3.1.1. Participants and design

As in Experiment 1, the results of a priori power analysis using G*power 3.1 (Faul et al., 2007) showed a required sample size of 159 ($\alpha = 0.05$, 1-$\beta = 0.8$) for a fixed, omnibus, one-way ANOVA. One hundred and sixty-five students from a senior high school participated in Experiment 2 (82 females, 83 males; age: 15.48 ± 0.55 years old). A one-factor (example generality: specific examples vs. categorical examples vs. control) between-subjects design was employed. Participants were randomly assigned to one of three groups.

Table 2
Pairwise correlations for fluency, originality, and flexibility in experiment 1 and 2.

	Experiment 1			Experiment 2		
	1	2	3	1	2	3
1. Fluency	–			–		
2. Originality	0.15*	–		0.21**	–	
3. Flexibility	0.87***	0.26**	–	0.82***	0.27***	–

Note: *$p < 0.05$
** $p < 0.01$
*** $p < 0.001$.

There were 53, 55, and 57 participants in the specific, categorical, and control groups, respectively. All participants were right-handed native Chinese speakers. Thus, the study was conducted in Chinese. They provided written informed consent prior to the experiment and voluntarily participated. The experimental protocol was approved by the institutional ethics committee of the university.

3.1.2. Procedure

Similar to Experiment 1, participants collectively completed this paper-and-pencil-based experiment in class. They were asked to complete two AUT tasks (*sticky notes* and *paper clips*). Before each task, two examples (i.e., specific examples/categories of these examples) were presented in the example groups, whereas no examples were presented in the control group. After reading the examples, the participants were asked to generate and write down as many novel ideas as possible in the following three minutes.

Examples from prior research (Yuan et al., 2018) with originality > 3, using the same procedure as in Experiment 1, were assigned to the specific and categorical example groups. Based on the manipulation of example abstraction in a previous study (Ezzat et al., 2020), one laboratory assistant removed the specific features of the selected and novel examples to create categorical examples. Examples retaining specific features were considered specific examples. Specifically, the specific examples for sticky note included "*Burning the sticky note to ashes and dye the water black with the ashes*" and "*Sticking the sticky note on the racket to increase the friction*". The specific examples for paper clip included "*Using paper clips combined as a steel wool to wash dishes*" and "*Using the magnetized paper clip to indicate directions*". Correspondingly, the categorical examples for sticky note included "*Burning the sticky note to ashes for other uses*" and "*Sticking the sticky note on other objects to prevent them from slipping*". The categorical examples for paper clip included "*Cleaning objects with the paper clip*" and "*Magnetizing the paper clip for other uses*."

3.1.3. Task assessment

Similar to Experiment 1, AUT performance was evaluated in terms of fluency, originality, and flexibility. Originality was rated on a 5-point scale (1 = unoriginal, 5 = highly original) by four independent raters. Inter-rater reliability was satisfactory (sticky note: $\alpha = 0.751$; paper clip: $\alpha = 0.703$). The final originality score for each participant was obtained by averaging the individual ratings from the raters. AUT flexibility was scored in the same manner as in Experiment 1 (sticky note: $\alpha = 0.861$; paper clip: $\alpha = 0.861$). For flexibility, the responses for each AUT item were grouped into ten broad semantic categories by two raters. For instance, the response categories of *sticky notes* included *sticking the sticky notes to other objects, writing or drawing things on sticky notes,* etc. The response categories of *paper clips* included *fastening or clamping objects with paper clips* and *making handicrafts with paper clips.* The final flexibility score for each participant was calculated by counting the number of explored categories. The raters of originality and flexibility were blinded to the experimental conditions.

3.2. Results

A one-way MANOVA with example generality (specific example vs. categorical example vs. control group) as the between-subjects factor was performed on AUT performance (*Box's* $M = 10.55$, $p = 0.59$). The overall effect showed a significant main effect of example generality on AUT fluency, originality, and flexibility, $F(3, 161) = 11.21$, $p < 0.001$, $\eta_p^2 = 0.17$. Then, one-way ANOVAs using example generality as the between-group factor were conducted on AUT fluency, originality, and flexibility, respectively. All post hoc tests were corrected using the Scheffe correction.

The results revealed a significant main effect of originality, $F(2, 162) = 12.70$, $p < 0.001$, $\eta_p^2 = 0.14$. No significant difference was observed between the specific and categorical example groups ($p = 0.89$). Moreover, originality in the control group ($M = 1.55$, $SD = 0.23$) was lower than that in the specific ($M = 1.74$, $SD = 0.19$, $p < 0.001$, Cohen's $d = 0.90$) and categorical ($M = 1.72$, $SD = 0.24$, $p < 0.001$, Cohen's $d = 0.81$) example groups (see Fig. 3). For fluency and flexibility, no main effect of example generality was found, $F(2, 162) = 1.72$, $p = 0.18$; $F(2, 162) = 0.07$, $p = 0.94$ (see Fig. 3 and Table 1).

Pairwise correlations are presented in Table 2. The results showed that fluency was positively correlated with originality ($r = 0.20$, $p = 0.009$) and flexibility ($r = 0.82$, $p < 0.001$). Originality was also positively correlated with flexibility ($r = 0.27$, $p < 0.001$).

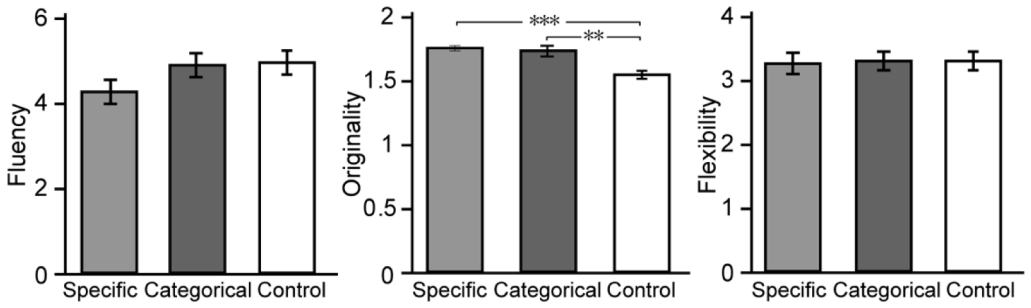

Fig. 3. Fluency, originality, and flexibility of responses in the specific, categorical, and control groups. $^{**}p < 0.01$, $^{***}p < 0.001$.

3.3. Interim discussion

The results of Experiment 2 showed that the categorical and specific example groups had higher originality than the control group. However, no difference was found between the two example groups; therefore, Hypothesis 2 was not supported. A possible reason is that novel examples were used in both groups, which might lead to the activation of remote associations in semantic memory and contribute to creative performance (Mednick, 1962). In this case, high example novelty may compromise the potential effect of the examples' generality abstraction on creativity. Another possible reason is that the difference in feature details between categorical and specific examples was limited to induce different levels of abstraction.

4. General discussion

The use of examples as supportive tools for creative idea generation is widespread in educational and design practices. Although psychological studies have examined the factors that determine the effect of examples on creativity, the role of example abstraction in the effect remains unclear. In this study, we investigated the effect of example abstraction by manipulating example modality (textual vs. pictorial examples) and generality (categorical vs. specific examples) to induce different levels of abstraction. Our results suggest that regarding modality, abstract (i.e., textual) examples facilitated creativity more than less abstract (i.e., pictorial) examples; regarding generality, abstract (i.e., categorical) and less abstract (i.e., specific) examples groups showed no difference in creativity.

In contrast to earlier studies, experiment 1 found that textual examples led to an increase in idea fluency, originality, and flexibility after establishing the examples' meaning correspondence and complexity levels so that they were approximately the same. Contrary to Borgianni et al. (2020), our results suggest a facilitation effect of textual rather than pictorial examples. This is consistent with Hypothesis 1 and extends prior research by controlling for possible confounding variables, such as the correspondence of meaning. Ward et al. (2004) induced different levels of abstract thinking through task descriptions, and found that abstract thinking involved in problem structuring could produce greater creativity (i.e., more diverse and novel solutions) by reducing the dominance of any single solution. According to the DCT, memory retrieval of pictorial and textual examples may differentially influence responses in creative tasks (Paivio, 1968). This "attachment" to pictorial examples may constrain an individual's mind to the features of the example and make it hard to think of other ideas without these features. Moreover, according to the path-of-least-resistance theory, individuals tend to automatically have access to information that comes to mind easily, such as a specific solution (Finke et al., 1992; Ward, 1994; Rietzschel et al., 2014). Because of their easy memorization, pictures may lead individuals to follow the path of least resistance and constrain creative idea generation.

The results of Experiment 1 also revealed higher idea fluency and flexibility in the control group than in the pictorial or textual groups. A possible explanation for this is that novel examples associated with distant concepts in semantic memory undermine the activation and association of near concepts (Berg et al., 2014). This inhibition of near concepts will, in turn, impede the generation of more ideas and categories of ideas in the early stages of creative idea generation. Consequently, idea fluency and flexibility declined. This is consistent with the findings of Wang et al. (2018), who reported that a novel example, rather than a common one, increased idea originality and decreased idea fluency.

With reference to the perspective of example generality, the results of Experiment 2 indicated no differences in creative performance between categorical and specific example groups. These findings failed to support Hypothesis 2 and were inconsistent with previous studies (Ezzat and colleagues, 2020). It may be due to the fact that novel examples were used in the present study instead of common ones. Research has shown that common abstract examples (i.e., categories of these examples) mitigate fixation compared to common, less abstract ones (i.e., specific examples of a category; Ezzat et al., 2020). Moreover, highly novel examples activate remote semantic concepts, which further facilitates the generation of novel ideas (Mednick, 1962; Yuan et al., 2022). This facilitation effect of idea novelty may compromise the effect of example abstraction on creativity, according to the path-of-least-resistance theory. It may also be due to the limited difference in abstraction between categorical and specific examples. Although we manipulated this abstraction according to the conceptualization of abstract examples in prior research (Ezzat et al., 2020), we did not check the abstraction level of these two types of examples. It is necessary to ensure that the abstraction difference between categorical and specific examples is sufficiently strong in further research.

In summary, although the results regarding the effect of example abstraction from the perspective of example modality and generality were inconsistent, they still shed some light on the effect of abstraction of novel examples on creativity. In addition to the varied manipulation of abstraction in previous studies, the example number and novelty also varied across previous studies. The current study extends previous studies by providing two novel examples from the perspectives of example modality and generality. The finding that textual rather than pictorial novel examples presented prior to the task increased creativity suggests that teachers should adopt appropriate examples to inspire students before creative idea generation. In addition, designers might refer to abstract examples to retrieve and activate more information in semantic memory before designing a product or solving other design problems.

This study had some limitations. Firstly, experiment 1 did not control for the complexity between pictorial and textual examples. Although we used short phrased describing textual examples so that they were as approximately complex as pictorial examples, it is necessary for further study to ensure the consistency of complexity between pictorial and textual examples. Secondly, the effect of example novelty was not explored. Previous studies have shown that common and novel examples exert different effect on creativity (Pi et al., 2019). Future research should examine the interaction effect of example novelty and example abstraction on creative performance. Thirdly, the example abstraction was manipulated based on previous studies, but no manipulation check was conducted for example abstraction in this study. Further research should also include a manipulation check. Finally, the precise mechanism underlying the stimulation effect of abstract textual example on creative performance was not explored. Further research may examine

the mediation role of possible factors such as abstract thinking.

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Data availability statement

The data used to support the findings of this study is available from the corresponding author upon request. The data can only be for research use.

CRediT authorship contribution statement

Huan Yuan: Conceptualization, Methodology, Formal analysis, Writing – original draft. **Meng Liu:** Conceptualization, Validation, Investigation. **Kelong Lu:** Writing – review & editing. **Cuirong Yang:** Conceptualization, Supervision. **Ning Hao:** Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors have nothing to disclose.

Data availability

Data will be made available on request.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.tsc.2023.101234.

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