Organizational Behavior and Human Decision Processes 138 (2017) 15–27

Contents lists available at ScienceDirect

Organizational Behavior and Human Decision Processes

journal homepage: www.elsevier.com/locate/obhdp

Ideas rise from chaos: Information structure and creativity

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ARTICLE INFO

Article history:
Received 30 July 2015
Revised 29 September 2016
Accepted 27 October 2016

Keywords:
Information structure
Creativity
Cognitive flexibility
Dual pathway to creativity model

ABSTRACT

Is structure good or bad for creativity? When it comes to organizing information, management scholars have long advocated for a hierarchical information structure (information organized around higher-order categories as opposed to a flat information structure where there is no higher-order category) to reduce complexity of information processing and increase efficiency of work. However, a hierarchical information structure can be a double-edged sword that may reduce creativity, defined as novel and useful combination of existing information. This is because a hierarchical information structure might obstruct combining information from distal conceptual categories. Thus, the current research investigates whether information structure influences creativity. We theorize that a hierarchical information structure, compared to a flat information structure, will reduce creativity because it reduces cognitive flexibility. Three experiments using a sentence construction task and a LEGO task supported our prediction.

1. Introduction

Organizations are complex systems with hierarchical structures, consisting of distinct subsystems that are subordinated by higher-level systems. Such structures arise because the existence of stable intermediary units (subsystems) is a superior form in the evolution of systems (Simon, 1962). In the Herbert Simon's (1962) example of watchmaking, suppose a watch contains 1000 components, a watchmaker could either piece all of them together at once, or assemble relatively stable subparts first and then integrate the subparts. Further assuming that the watchmaking process is frequently interrupted by external forces (e.g., phone calls) and every time that happens the watchmaker has to start from the beginning, the former flat system is hugely inefficient compared to the latter hierarchical system because the cost of interruption is much higher.

Hierarchical structures underlie many organizational activities.[1] For example, production management systems, such as the lean manufacturing system, categorize all components into clearly defined categories so that workers can easily and rapidly distinguish and use necessary components in manufacturing lines (Krafcik, 1988). The importance of structure on production efficiency is best illustrated in the fast-food industry, where ingredients and raw materials are neatly categorized in separate containers and can be quickly assembled on demand rather than making everything from scratch. Similarly, organizational information is highly structured as well. Since employees are clustered around jobs and roles, both explicit (e.g., job manual) and implicit information (e.g., embedded information) are categorized by job function. Generally speaking, it is advantageous for companies to organize information or materials by higher order categories due to the gain on efficiency in learning and production.

Without disputing the benefits of having such hierarchical structure, the current research asks whether structure might come with the cost of reduced creativity. In the example of watchmaking, suppose the goal is not to make a watch as quickly as possible but to create a novel watch, is the final product likely to be more or less creative if the components are organized into distinct categories as opposed to when there is no structure? Thus, in this paper we investigate the effects of hierarchical structure on creativity. We do so by focusing on the simplest form of hierarchical structure – the presence of high-order category that is just one level up.

Creativity is one of the defining features that separate humans from other species (Csikszentmihalyi, 1997; Nijstad, De Dreu, Rietzschel, & Baas, 2010). In the current research, creativity refers to novel and useful combinations of information (Koestler, 1964; Ward, 1994). We use the term information broadly, consistent with the concept of declarative information, which refers to "chunks," including objects, symbols, or facts that possess distin-

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[1] By hierarchy we do not imply authority-ranking relationships but it simply refers to the presence of subsystems and higher order categories or systems following Simon (1962). In the watchmaking example the process that involve subparts is a hierarchical system as contrasting to a "flat" system where everything is assembled at once.

http://dx.doi.org/10.1016/j.obhdp.2016.10.001
0749-5978/

guishable attributes[2] (Anderson, 1996, 2013). For example, a chair typically contains at least three pieces of declarative information including *seat, legs, and back*, each of which refers to a specific object with unique attributes that are distinguishable from other objects. In this sense, both components in the watchmaking example and raw materials in the production example can be considered declarative information.

We expect that a hierarchical structure of declarative information may be a double-edged sword. On the one hand, it clearly increases efficiency; on the other hand, it may reduce the generation of creative ideas because the presence of higher-order categories reduces distal associations. For example, to design a wheelchair one needs to connect two distal pieces of declarative information: *wheel*, which typically belongs to the vehicle category, and *chair*, which is subordinate to furniture (Goldenberg & Mazursky, 2002). We argue that this association is less likely to take place if the set of declarative information is structured by higher order categories. In what follows, we define two types of information structures and explain why structures of declarative information (hereafter information structures) influence creativity via cognitive flexibility.

1.1. Information structure and creativity

Information structure, which refers to the way in which units of information are associated with one another within a set of information, can be hierarchical or flat. In a hierarchical information structure, a set of information is organized by higher-order categories, where units of information within a category have strong conceptual relationships but those between categories have weak conceptual relationships. In a flat information structure, a set of information is presented without higher-order categories and units of information have weak conceptual relationships with each other. For instance, a set of information that includes "cat", "dog", "cow", "mouse", and "tiger" is hierarchically organized under the higher-order category of "animal". On the other hand, a set of information such as "pudding", "Ukraine", "check", "mouse", and "symphony" has a flat information structure because they do not have an obvious and coherent higher-order category.

We suggest that a flat information structure will lead to higher levels of creativity compared to a hierarchical information structure mainly due to cognitive flexibility. Cognitive flexibility refers to the extent to which individuals can easily switch their focus between different categories or perspectives, making it more likely to integrate distal information in unique ways (George, 2007; Guilford, 1967; Mednick, 1962, 1968; Shalley, Zhou, & Oldham, 2004; Ward, 1994). Many previous studies have found a positive relationship between cognitive flexibility and creativity (De Dreu, Baas, & Nijstad, 2008; De Dreu, Nijstad, Baas, Wolsink, & Roskes, 2012; Mehta & Zhu, 2015; Miron-Spektor & Beenen, 2015; Miron-Spektor, Gino, & Argote, 2011). For example, De Dreu et al. (2008) showed that an increased level of cognitive flexibility induced by positive mood enhanced creativity, which was measured by both fluency and originality. Similarly, Miron-Spektor and Beenen (2015) found that simultaneous inducement of learning and performance goals increased creativity via cognitive flexibility.

A flat information structure, compared to a hierarchical information structure, increases cognitive flexibility for two reasons. First, the presence of higher-order categories in a hierarchical information structure anchors sense making because individuals interpret the focal information in relation to adjacent information. According to the Adaptive Character of Thought theory, a focal declarative information can belong to many higher-order categories and the interpretations of the information depend on which categories are activated (Anderson, 1996). Category activation is determined by both base-level activation and contextual-priming. Base-level activation refers to individual differences in how people categorize declarative information. For instance, an individual may frequently associate the word "star" with celebrity rather than a celestial body compared with others. Contextual-priming refers to the activation of higher-order categories induced by the conceptual associations between the focal information and adjacent information. The stronger the conceptual overlap, the stronger the influence of contextual-priming on the categorization of the focal information. For example, if "star" is presented along with words like "galaxy", "rocket", "meteor", "satellite", an individual is likely to interpret the word "star" as a celestial body because the contiguous information activates a higher-order category, "cosmic."

Asch (1946) showed that conceptual overlap between the focal and contiguous information could change the interpretation of the focal information. He presented one of two sets of information to participants and observed whether the meaning of the focal word (e.g., calm) changed in relation to adjacent words. In one condition, the information set consisted of "kind-wise-honest-*calm*-strong" while the other consisted of "cruel-shrewd-unscrupulous-*calm*-strong." Participants were then asked to come up with synonyms of the word "calm". In the first condition, participants generated neutral or positive word such as "serene", "poised", and "reserved." However, in the latter condition, the frequently reported synonyms were "cold", "frigid", and "icy". Thus, the interpretation of the focal concept changed as a function of its relations to adjacent concepts through conceptual priming.

We thus argue that a hierarchical information structure might reduce cognitive flexibility through contextual-priming. In a hierarchical information structure, the presence of a higher-order category primes the interpretation of the information in that category, reducing the possibility for alternative uses of the information. In a flat information structure, the absence of higher-order category allows individuals to discover alternative interpretations of the information and increases cognitive flexibility.

Second, a flat information structure may increase cognitive flexibility because it introduces higher probabilities of making distal connections among concepts. By definition, the flat information structure has a flat associative hierarchy, meaning that each unit of information has approximately equal probabilities of being next to any other units of information in the set (Eysenck, 1993; Mednick, 1962; Simonton, 2003). Compared to those in the hierarchical information structure condition, individuals presented with a flat information structure may be more likely to discover serendipitous associations between distal information. Scholars in the creativity literature have long argued that variations in the idea generations can be due to serendipity (Campbell, 1960; Simonton, 1999a, 1999b, 2003). Given that human conscious imagination is bounded and our ability to associate distal categories (i.e., cognitive flexibility) is limited (Ward, 1994), serendipity can refresh habitual thinking and opens up new possible associations. History provides numerous instances where serendipitous discoveries, such as the Archimedes principle or the X-ray, have enriched our lives. Thus, a flat information structure, relative to a hierarchical information structure, may increase serendipitous, flexible uses of information because a flat information structure is more likely to

[2] Anderson also defined procedural information as abstract rules of using and combining declarative information. There are some studies that compared absence and existence of procedural information in predicting creativity, showing that having procedural information has an inconsistent but generally positive effect on creativity. Since our research is primarily interested in structure in declarative information in terms of its hierarchical form or flatness, the relationship between procedural information and creativity is not relevant for our paper. We included an appendix that summarizes the role of procedural information on creativity (see Appendix A).

present conceptually distant information next to one another. For these reasons, we expect that a flat information structure condition will increase cognitive flexibility, which in turn enhances creativity.

Hypothesis 1. A flat information structure increases creativity compared to a hierarchical information structure.

Hypothesis 2. Cognitive flexibility mediates the effect of information structure on creativity.

We test these predictions in three experiments using a sentence construction task (Study 1 and 2) and a LEGO task (Study 3). In the sentence construction task, participants are given a set of words and are asked to construct meaningful sentences out of the words. In the LEGO task, participants are asked to construct an alien figure from a set of LEGO bricks. Both of these tasks involve assembling components like the watchmaking example. The only difference is that in the sentence construction task and the LEGO task there is no "correct" way of doing things and hence efficiency is not a relevant criterion. The three experiments systematically investigate the hypotheses that presenting declarative information (i.e., words or LEGO pieces) in a structured (hierarchical) as opposed to unstructured (flat) ways will reduce creativity via cognitive flexibility.

2. Study 1: sentence construction task

2.1. Method

2.1.1. Participants

One hundred sixty-two undergraduate students voluntarily participated in this experiment in exchange for one course credit (56 males, 106 females). Since our task involved English language ability, we recruited native English speakers or non-native English speakers who have lived in English speaking countries for more than 5 years. We excluded two participants because they did not generate any sentence. Thus, the final analyses included 160 participants (55 males, 105 females). The participants were 20.53 years old on average. The majority of the participants' ethnicity was East Asian (N = 79, 49.4%) followed by Caucasian (N = 40, 25%), South Asian (N = 28, 17.5%), Native American (N = 2, 1.3%), Hispanic (N = 2, 1.3%), and others (N = 18, 11.3%). There were more non-native speakers in English (N = 91, 56.9%) than native speakers (N = 69, 43.1%). The non-native speakers in our sample have lived in English-speaking countries for 7.66 years on average.[3]

2.1.2. Procedure

Upon arrival, participants were randomly assigned to either the hierarchical or flat information structure condition. Each participant received two sheets of letter-size paper with a pencil. The first sheet contains 100 nouns, and the other sheet was for writing down sentences. In the hierarchical information structure condition, participants were provided with a sheet of letter-size paper containing the 100 English nouns organized by 20 categories. Each category contained five nouns that are conceptually related. Note that we did not provide specific names of the category (see Appendix B). In the flat information structure condition, the same 100 English nouns were presented in a sheet of letter-size paper without categories (see Appendix B). The font and size of nouns were the same between the conditions. Participants were instructed to generate as many sentences as they want by combining the nouns and could take as much time as they need within the time limit of the experimental session (60 min). After the sentence construction task, participants completed a questionnaire asking about their demographic information and three manipulation check items that tap into the extent to which the set of nouns seem organized (e.g., "The list of nouns looks disorganized"; $\alpha = 0.86$). Since nouns in the hierarchical information structure are organized around higher-order categories we expect that participants will perceive the hierarchical information structure to be better organized than the flat information structure.

2.1.3. Evaluating creativity

Three undergraduates who are native English speakers from the linguistic department of at a North American university were recruited to evaluate levels of creativity of the sentences participants generated. They were blind to the hypotheses and conditions. They evaluated levels of creativity of each sentence ("how creative is this sentence?") ranging from 1 (*not at all creative*) to 7 (*extremely creative*). Given acceptable inter-rater reliability (ICC = 0.62), we collapsed ratings across the evaluators.[4] We operationalized creativity in the sentence construction task in two ways: *average* and *best creativity*. We measured *average creativity* by averaging creativity scores of all the sentences each participant generated, and *best creativity* by choosing the most creative sentence generated by a participant. We did not have a prediction regarding which of these measures best captures creativity in our task – just like it is debatable whether artists should be evaluated by their best work or average of their work.

2.1.4. Mediators

Since cognitive flexibility captures the extent to which individuals link concepts from different categories, we operationalized it as the number of categories from which participants chose nouns to construct the sentence. The higher the number, the more cognitive flexible participants were. For each sentence, the first author found the nouns from the sheet and coded which of the 20 predetermined categories (e.g., cloth, country, sport, animal; see Appendix B) they were from, and two research assistants verified the coding. We then averaged the number of categories used across all sentences. On average, participants used 2.69 categories ($SD = 1.11$) in each sentence.

2.2. Results

2.2.1. Manipulation check

We submitted the three-item measure for manipulation check to a one-way ANOVA with information structure as the independent variable. The result showed that perceived disorganization was higher in the flat information structure condition ($M = 5.15$, $SD = 1.23$), relative to the hierarchical information structure condition ($M = 2.60$, $SD = 1.17$), $F(1,158) = 178.57$, $p < 0.01$, $\eta^2 = 0.53$.

2.2.2. Creativity

We submitted the two measures of creativity to a one-way ANOVA with information structure as the independent variable. As expected, participants in the flat information structure condition showed higher levels of *average creativity* ($M = 4.08$, $SD = 0.95$), relative to those in the hierarchical information structure condition ($M = 3.31$, $SD = 0.95$), $F(1,158) = 26.65$, $p < 0.01$, $\eta^2 = 0.14$. Also, the

[3] English fluency did not predict *average creativity*, $F(1,158) = 3.11$, $p = 0.08$, $\eta^2 = 0.02$, but predicted *best creativity*, $F(1,158) = 4.60$, $p = 0.03$, $\eta^2 = 0.03$. However, all the results remained unchanged when we included English fluency as a covariate.

[4] We used ICC(1) which represents "an effect size estimate revealing the extent to which judges' ratings were affected by the target" (LeBreton & Senter, 2007, p. 823). Our ICC values across the three studies range from 0.46 to 0.65. Some of ICC values in our studies are lower than those generally obtained by scholars in the previous studies (e.g., De Dreu et al., 2008). However, according to the guideline offered by LeBreton and Senter (2007), ICC(1) = 0.25 is acceptable effect size. Based on this rule of thumb, we made the decisions on aggregations of the ratings.

Table 1
Means, standard deviations, and correlations in Study 1.

Variables	Mean	SD	1	2	3	4
1. Information structure (0 = hierarchical; 1 = flat)	0.51	0.50				
2. Cognitive flexibility	2.69	1.11	0.25**			
3. Average creativity	3.71	1.02	0.38**	0.76**		
4. Best creativity	4.75	1.18	0.49**	0.69**	0.92**	
5. Fluency	11.1	3.99	0.23**	−0.06	0.09	0.25**

Note. Effective sample size = 160. All tests 2-tailed.
* $p < 0.05$.
** $p < 0.01$.

former showed higher levels of *best creativity* ($M = 5.31$, $SD = 1.00$), compared to the latter ($M = 4.17$, $SD = 1.07$), $F(1,158) = 49.40$, $p < 0.01$, $\eta^2 = 0.24$. Therefore, Hypothesis 1 was supported.

2.2.3. Mediation analyses

Before we test mediation, we submitted cognitive flexibility to a one-way ANOVA with information structure as the independent variable. The results showed that participants in the flat information structure condition, relative to the hierarchical information structure condition, were more cognitively flexible ($M_{Flat} = 2.96$, $SD_{Flat} = 0.99$; $M_{Hierarchical} = 2.42$, $SD_{Hierarchical} = 1.16$; $F(1,158) = 10.13$, $p < 0.01$, $\eta^2 = 0.06$). The hypothesized indirect effect of information structure (1 = the hierarchical information structure condition, 2 = the flat information structure condition) on creativity via cognitive flexibility was tested using SPSS PROCESS macro, developed by Hayes (2013), with bootstrapped standard errors (N = 10,000). The result showed that the positive relationship between information structure and *average creativity* was indeed mediated by cognitive flexibility, *Indirect Effect* = 0.35, *Boot SE* = 0.12, 95% *CI* [0.13, 0.59]. Furthermore, the positive relationship between information structure and *best creativity* was also mediated by cognitive flexibility, *Indirect Effect* = 0.35, *Boot SE* = 0.11, 95% *CI* [0.13, 0.57]. Therefore, Hypotheses 2 was supported.

2.3. Additional analyses

We also looked at fluency or the number of sentences generated as an exploratory variable, given that some researchers have suggested that fluency may be a manifestation of creativity (Guilford, 1967). Participants on average generated 11.14 sentences ($SD = 3.99$). Those in the flat information structure condition generated more sentences ($M = 12.02$, $SD = 3.64$) than those in the hierarchical information structure condition ($M = 10.22$, $SD = 4.16$), $F(1,158) = 8.57$, $p = 0.004$, $\eta^2 = 0.05$. This is consistent with our hypothesis. However, fluency had inconsistent relationships with the two measures of creativity. Table 1 showed that fluency was positively correlated with best creativity ($r = 0.25$, $p = 0.002$) but not with average creativity ($r = 0.09$, $p = 0.272$). This is not inconsistent with prior studies that find a non-significant or negative correlation between fluency and creativity (for a review, Montag, Maertz, & Baer, 2012). Although fluency may be related to creativity in some ideation tasks, De Dreu and colleagues suggest that fluency and creativity are distinct constructs: "fluency may manifest itself in a relatively large number of solved insight or perception problems, with the solutions themselves not being particularly new or uncommon" (De Dreu et al., 2008, p. 740). Thus, even though our post hoc analyses on fluency seem to be consistent with our prediction, it is unclear to what extent fluency in this context captures creativity.

2.4. Discussion

In Study 1, participants presented with a set of disorganized information (flat information structure) were more creative than those presented with a set of information organized by higher categories in the sentence construction task. The beneficial effect of the flat information structure on creativity was mediated by cognitive flexibility. Using the same design, Study 2 further strengthened the validity of the creativity measure by recruiting three experts (PhDs in English literature) to evaluate sentences generated by participants (Kaufman, Baer, & Cole, 2009). In addition, in Study 2 we reduced the number of nouns from 100 to 45 to make sure that Study 1's results are not unique to the amount of information provided. It is possible that when presented with a high volume of information participants in the flat information structure condition might perceive the task to be more challenging than those in the hierarchical information structure condition because higher-order categories in the hierarchical condition help participants comprehend information. Given that task difficulty can increase creativity (Amabile, 1996a, 1996b; Amabile, Conti, Coon, Lazenby, & Herron, 1996), in Study 2 we test our hypotheses with fewer nouns.

3. Study 2: sentence construction task II

3.1. Method

3.1.1. Participants

One hundred and seventeen undergraduate students were recruited for this experiment in exchange for one course credit (57 males, 56 females, 4 missing gender information). As in Study 1, they were either native English speakers or non-native English speakers who have lived in English speaking countries for more than 5 years. The average age of the participants was 20.56. The ethnic majority was East Asian (N = 50, 42.7%) followed by Caucasian (N = 24, 20.5%), South Asian (N = 22, 18.8%), Native American (N = 1, 0.9%), African American (N = 2, 1.7%), Hispanic (N = 2, 1.7%), and others (N = 18, 15.4%). There were more native speakers in English (N = 65, 55.6%) than non-native speakers (N = 48, 41%, 4 missing information). The non-native speakers have lived in English-speaking countries for 10.65 years on average.[5]

3.1.2. Procedure

We used the same task as in Study 1. The only difference was that we provided 45 English nouns instead of 100 nouns in Study 2. Upon arrival, participants were randomly assigned to the conditions, and received a sheet of letter-size paper containing 45 nouns either organized by 9 categories or unorganized (see, Appendix C). They were asked to construct as many sentences as they want by combining provided nouns. Unlike Study 1 that used the paper-and-pencil survey, participants entered sentences in an online survey. Using a timer embedded in the online survey, we measured the total time they spent on the task. After the sentence construction task, participants completed three manipulation check items

[5] English fluency did not influence any of the four types of creativity, and all the results were the same when we controlled English fluency.

as in Study 1, (α = 0.84) and demographic information. At the end of sessions, participants were compensated and debriefed.

3.1.3. Evaluating creativity

We recruited three independent experts (two PhD candidates and one PhD in English Literature), who were blind to the hypotheses and conditions, to evaluate the sentences. They evaluated two aspects of creativity: (1) creativity ("how creative is this sentence?"; ICC = 0.65) and (2) creative use of the provided nouns ("how creatively has the participant used the provided noun(s) in this sentence?"; ICC = 0.65). Note that in each sentence the provided nouns were highlighted with red so that the evaluators could recognize them easily. They were also shown all of the 45 nouns provided to participants. Before the evaluation, they were presented with the definition of creativity and asked to consider both novelty and usefulness (i.e., whether sentences make sense and whether they are grammatically correct) in their evaluation. The two measures were evaluated with 7-point Likert scale from 1 (*not at all creative*) to 7 (*extremely creative*). Afterward, we operationalized the two creativity measures in two ways just as we did Study 1. We calculated average creativity by collapsing creativity scores across all the sentences within person; best creativity was calculated by choosing the single most creative sentence within a person. Thus, we had four measures of creativity as dependent variables: *average creativity, best creativity, average creative use of the provided nouns, and best creative use of the provided nouns*.

3.1.4. Mediators

Two research assistants evaluated cognitive flexibility by counting the number of nine categories (e.g., occupation, animal, color, sport; see, Appendix B) from which nouns in each sentence came. We then averaged the number of categories across all sentences. On average, participants used 2.21 categories (SD = 0.84) in each sentence.

3.2. Results

3.2.1. Manipulation check

We conducted a one-way ANOVA with the manipulation check measure as the dependent variable and information structure as the independent variable. As intended, the flat information structure condition (M = 5.64, SD = 0.98) was seen as more disorganized than the hierarchical information structure condition (M = 3.37, SD = 1.02), $F(1,112) = 148.51$, $p < 0.01$, $\eta^2 = 0.57$.

3.2.2. Creativity

We submitted the four measures of creativity to a one-way ANOVA with information structure as the independent variable. We found that participants in the flat information structure condition (M = 2.70, SD = 0.76) showed higher levels of *average creativity* than those in the hierarchical information structure condition (M = 2.15, SD = 0.49), $F(1,115) = 21.81$, $p < 0.01$, $\eta^2 = 0.16$. The same pattern was found for *best creativity* (M_{Flat} = 4.02, SD_{Flat} = 1.01; $M_{Hierarchical}$ = 3.40, $SD_{Hierarchical}$ = 0.89; $F(1,115)$ = 12.43, $p < 0.01$, $\eta^2 = 0.10$), *average creative use of the provided nouns* (M_{Flat} = 2.41, SD_{Flat} = 0.79; $M_{Hierarchical}$ = 1.81, $SD_{Hierarchical}$ = 0.39; $F(1,115) = 26.93$, $p < 0.01$, $\eta^2 = 0.19$), and *best creative use of the provided nouns* (M_{Flat} = 3.62, SD_{Flat} = 0.98; $M_{Hierarchical}$ = 2.89, $SD_{Hierarchical}$ = 0.75; $F(1,115) = 20.28$, $p < 0.01$, $\eta^2 = 0.15$). Therefore, Hypothesis 1 was fully supported.

3.2.3. Mediation analyses

We submitted cognitive flexibility to a one-way ANOVA with information structure as an independent variable. We found that participants in the flat information structure condition, relative to the hierarchical information structure condition, were more flexible (M_{Flat} = 2.47, SD_{Flat} = 0.96; $M_{Hierarchical}$ = 1.95, $SD_{Hierarchical}$ = 0.60; $F(1,115) = 12.13$, $p < 0.01$, $\eta^2 = 0.10$). The hypothesized indirect effect of information structure (0 = the hierarchical information structure condition, 1 = the flat information structure condition) on creativity via cognitive flexibility was tested using SPSS PROCESS macro, developed by Hayes (2013), with bootstrapped standard errors (N = 10,000). For the mediation analyses, we used *average creativity* and *average creative use of the provided nouns* as dependent variables since the mediator was operationalized by averages across sentences. The result showed that the positive relationship between information structure and *average creativity* was mediated by cognitive flexibility, *Indirect Effect* = 0.27, *Boot SE* = 0.08, 95% *CI* [0.12, 0.42]. Furthermore, the positive relationship between information structure and *average creative use of the provided nouns* was also mediated by cognitive flexibility, *Indirect Effect* = 0.27, *Boot SE* = 0.08, 95% *CI* [0.12, 0.43]. Therefore, Hypotheses 2 was supported.

3.3. Additional analyses

As in Study 1, we analyzed the influence of information structure on fluency. Participants generated 13.37 sentences on average (SD = 8.64). Unlike in Study 1, participants in the hierarchical information structure condition (M = 16.41, SD = 9.56) generated more sentences than those in the flat information structure condition (M = 10.37, SD = 6.42), $F(1,115) = 16.16$, $p < 0.01$, $\eta^2 = 0.12$. The relationships between fluency and the four types of creativity were inconsistent (see, Table 2). Fluency was negatively correlated with average creativity ($r = -0.18$, $p = 0.048$) and average creative use of the provided nouns ($r = -0.28$, $p = 0.002$); it was not correlated with best creativity ($r = 0.13$, $p = 0.159$) and best creative use of the provided nouns ($r = 0.02$, $p = 0.86$). These findings again point to the possibility that fluency is a distinct construct from creativity, at least not in terms of originality, which is the main focus of our creativity measure (e.g., Förster, Friedman, & Liberman, 2004; Gocłowska, Baas, Crisp, & De Dreu, 2014; Mehta & Zhu, 2015).

Table 2
Means, standard deviations, and correlations in Study 2.

Variables	Mean	SD	1	2	3	4	5	6	7
1. Information structure (0 = hierarchical; 1 = flat)	0.50	0.50							
2. Persistence	85.58	44.28	0.19*						
3. Cognitive flexibility	2.21	0.84	0.31**	0.49**					
4. Average creativity	2.43	0.69	0.40**	0.54**	0.69**				
5. Average creative use of the provided nouns	2.11	0.69	0.44**	0.45**	0.71**	0.89**			
6. Best creativity	3.72	1.00	0.31**	0.29**	0.59**	0.80**	0.72**		
7. Best creative use of the provided nouns	3.26	0.95	0.39**	0.25**	0.57**	0.71**	0.82**	0.81**	
8. Fluency	13.37	8.64	−0.35**	−0.37**	−0.18	−0.18*	−0.28**	0.13	0.02

Note. Effective sample size = 117. All tests 2-tailed.
* $p < 0.05$.
** $p < 0.01$.

Since we conducted Study 2 on computer we were able to record the time participants took to complete the sentence construction task, which might be a proxy for cognitive persistence. The dual pathway model defines cognitive persistence as extent to which individuals can maintain their focus on a given task (Nijstad et al., 2010). It suggests that persistence facilitates deep processing of a given cognitive category, which may lead individuals to initially generate trite ideas, but later on increase the chance of discovering unexplored ideas. Thus, we used average time per sentence as a proxy for cognitive persistence and explored its role in the relationship between information structure and creativity. We calculated *average time per sentence* by dividing the total time each participant spent on the ideation task by the total number of sentences generated.

A one-way ANOVA with information structure as the independent variable showed that the participants in the flat information structure condition were more persistent (spent longer time on each sentence) than their counterparts in the hierarchical information structure condition (M_{Flat} = 93.89, SD_{Flat} = 48.41; $M_{Hierarchical}$ = 77.14, $SD_{Hierarchical}$ = 38.23, $F(1,115) = 4.30$, $p = 0.04$, $\eta^2 = 0.04$). The mediation results indicated that the positive relationship between information structure and *average creativity* was mediated by persistence, *Indirect Effect* = 0.13, *Boot SE* = 0.07, 95% *CI* [0.01, 0.28]. Also, the positive relationship between information structure and *average creative use of the provided nouns* was mediated by persistence, *Indirect Effect* = 0.10, *Boot SE* = 0.05, 95% *CI* [0.01, 0.22]. More importantly, when both cognitive flexibility and persistence were simultaneously entered into the mediation model, both variables mediated the relationship. The result showed that the positive relationship between information structure and *average creativity* was mediated by both cognitive flexibility, *Indirect Effect* = 0.22, *Boot SE* = 0.06, 95% *CI* [0.10, 0.35], and persistence, *Indirect Effect* = 0.07, *Boot SE* = 0.05, 95% *CI* [0.01, 0.19]. Furthermore, the positive relationship between information structure and *average creative use of the provided nouns* was also mediated by cognitive flexibility, *Indirect Effect* = 0.24, *Boot SE* = 0.08, 95% *CI* [0.11, 0.41] and persistence, *Indirect Effect* = 0.03, *Boot SE* = 0.03, 95% *CI* [0.00, 0.12]. This suggests that cognitive flexibility might not be the only mechanism through which information structure influences creativity.

3.4. Discussion

Study 2 supported the two Hypotheses. Participants in the flat information structure condition generated more creative sentences than those in the hierarchical information structure condition using different measures of creativity. In addition, the effects of information structure on creativity were mediated via cognitive flexibility such that those in the former condition used nouns from more categories than those in the latter condition. Study 3 aimed to replicate results from Study 1 and 2 using a different task to make sure that our results are not limited to the sentence construction task. Further, we replicate it in Study 3 that information structure influences creativity also through persistence, measured by average time spent per sentence.

4. Study 3: LEGO task

In Study 1 and 2, we used English nouns to represent units of information. The results supported our predictions that a flat information structure led to more creative sentences. In Study 3 we attempt to show that our predictions are not limited to abstract constructs but any units that can be combined to create new objects. We used LEGO bricks. LEGO bricks are analogous to units of information in many ways. First, the adaptive character of thought theory defines declarative information as any object that has unique, distinguishable attributes. In this sense, task materials such as LEGO bricks are declarative information (Wan & Chiu, 2002). Second, similar to information, there are almost an infinite number of alternative uses for LEGO bricks (Wan & Chiu, 2002). A LEGO brick may be a part of a circle, quadrangle, triangle, or line. Just like new information can be created by combining existing information, LEGO bricks can be combined to make complex shapes and structures (e.g., houses, robots, and creatures). Lastly, similar to other declarative information, LEGO bricks can be categorized by higher-order categories such as color and shape. Thus, we used LEGO bricks in Study 3 to see whether our findings can be generalized to a task that does not involve sentence constructions. Another advantage of using the LEGO task is that it is similar to Herbert Simon's watchmaking example and parallels many organizational production activities.

4.1. Method

4.1.1. Participants

One hundred eighty-six undergraduate students voluntarily participated in this experiment in exchange for one course credit or $10 (64 males, 122 females). We excluded four participants in the main analyses because they did not allow us to use their data in the reconsent form. Thus, the final dataset consisted of 182 participants (61 males, 121 females). The average age of the participants was 20.90. The majority of the participants' ethnicity was East Asian (N = 116, 63.7%) followed by South Asian (N = 23, 12.6%), Caucasian (N = 16, 8.8%), Hispanic (N = 2, 1.1%), and others (N = 24, 13.2%).

4.1.2. Procedure

We used the Alien task developed by Ward (1994). Originally, this task asks participants to *draw* an alien by imagining that they are visiting a planet in another galaxy and encounter an alien living on that planet. Instead of drawing an alien, in this study experimenters asked participants to make an alien out of the LEGO bricks. Upon arrival, participants were randomly assigned to either the hierarchical or flat information structure condition. In the hierarchical information structure condition, a total of 442 LEGO bricks, which consisted of 9 colors and 11 quadrangular shapes (99 possible categories), were categorized into two large boxes. Each box (33 cm × 22 cm × 7.5 cm) had 24 cells (4 rows, 6 columns) partitioned by plastic walls. The bricks were categorized by a total of 48 cells. Each cell (5.4 cm × 5.4 cm × 7.5 cm) contained on average 9.21 bricks of the same color and shape. In the flat information structure condition, the same LEGO bricks were contained in two large boxes of identical size to those in the hierarchical information structure condition. However, in the flat information structure condition there was no partition, so all the 442 bricks were mixed and divided into the two large boxes (see, Appendix D). In both conditions, participants were asked to make an alien by assembling LEGO bricks. In addition, participants were instructed that they were not allowed to pour the bricks onto the table and could only take pieces directly from the boxes when they needed them. They were also told that they could take as much time as they need within the constraint of the session duration (60 min). The experimenter recorded the time participants took to complete the LEGO task using a stopwatch in the control room. All participants were able to complete the task within 60 min.

Following the LEGO task, they completed a questionnaire containing demographic questions and three manipulation check items (e.g., "the LEGO bricks in the box were disorganized"; $\alpha = 0.89$) as in Study 1 and 2. At the end of sessions, participants reconsented to the uses of their data, and were debriefed and compensated.

4.1.3. Evaluating alien creativity

Three independent raters, who were blind to conditions and hypotheses, were recruited to evaluate the creativity of LEGO aliens. Following coding methods developed by Ward (1994) and Maddux and Galinsky (2009), the three evaluators rated overall creativity ("how creative is this LEGO product?") ranging from 1 (*not creative at all*) to 7 (*extremely creative*) and similarity to earth creatures with three items (e.g., "how similar is this LEGO alien to Earth creatures?") ranging from 1 (*not at all*) to 7 (*very much*). We created two dependent variables by collapsing ratings across the three evaluators on the basis of acceptable inter-rater reliabilities: overall creativity, ICC = 0.46; similarity to earth creatures, ICC = 0.47. In addition to the two dependent variables, we measured *elaboration* by counting the total number of bricks each participant used for the LEGO creature because elaboration has been considered as one of the creativity dimensions (Guilford, 1967; Nijstad et al., 2010). Elaboration is conceptually similar to fluency in Study 1 and 2 since they both look at the quantity aspect of the product.

4.1.4. Cognitive flexibility

To measure cognitive flexibility, two research assistants counted the total number of categories, classified by colors and shapes of LEGO bricks, participants used during the experiment. The counting was done immediately after the session and before the next session started. We expect that higher level of cognitively flexibility should manifest in wider range of LEGO bricks participants used to build the alien. Participants on average used LEGO bricks from 16.07 out of 48 categories.

4.2. Results

4.2.1. Manipulation check

We submitted the three-item manipulation check measure to a one-way ANOVA with structure as an independent variable. The result revealed that participants indeed perceived the LEGO boxes to be more disorganized in the flat information structure condition ($M = 4.75$, $SD = 1.50$) than the hierarchical information structure condition ($M = 2.16$, $SD = 1.49$), $F(1,180) = 137.74$, $p < 0.01$, $\eta^2 = 0.43$.

4.2.2. Overall creativity

We conducted a one-way ANOVA with overall creativity as the dependent variable, and structure as the independent variable. There was the predicted main effect of structure on overall creativity, $F(1,180) = 23.93$, $p < 0.01$, $\eta^2 = 0.12$, such that the flat information structure condition ($M = 4.41$, $SD = 1.18$) had a higher level of overall creativity than the hierarchical information structure condition ($M = 3.53$, $SD = 1.26$).

4.2.3. Similarity to earth creatures

We next submitted similarity to Earth creatures ratings to a one-way ANOVA with structure as the independent variable. As predicted, the main effect was significant, $F(1,180) = 15.16$, $p < 0.01$, $\eta^2 = 0.08$, and the hierarchical information structure condition ($M = 4.22$, $SD = 1.32$) had a higher level of similarity to Earth creatures (lower creativity) than the flat information structure condition ($M = 3.52$, $SD = 1.08$).

4.2.4. Mediation analyses

We submitted the mediator, cognitive flexibility, to a one-way ANOVA with information structure as an independent variable. The results showed that participants in the flat information structure condition ($M = 19.26$, $SD = 9.36$) were more flexible than those in the hierarchical information structure condition ($M = 13.00$, $SD = 6.60$), $F(1,173) = 26.43$, $p < 0.01$, $\eta^2 = 0.13$. The hypothesized indirect effect of information structure on creativity via cognitive flexibility was analyzed using the SPSS PROCESS macro with bootstrapped standard errors (N = 10,000). We found that the relationship between information structure (0 = the hierarchical information structure condition, 1 = the flat information structure condition) and overall creativity was significantly mediated by cognitive flexibility, *Indirect Effect* = 0.35, *Boot SE* = 0.09, 95% CI [0.19, 0.55]. The effect of structure on similarity to Earth creatures, however, was not mediated by cognitive flexibility, *Indirect Effect* = −0.07, *Boot SE* = 0.07, 95% CI [−0.22, 0.06].

4.3. Additional analysis

4.3.1. Elaboration

A one-way ANOVA revealed that structure significantly influenced participants' elaboration in the LEGO task, $F(1,173) = 7.17$, $p < 0.01$, $\eta^2 = 0.04$. Participants in the flat information structure condition ($M = 59.90$, $SD = 54.51$) used more bricks than those in than the hierarchical information structure condition ($M = 41.97$, $SD = 31.35$). In addition, elaboration was positively correlated with creativity ($r = 0.36$, $p < 0.05$), but not with similarity ($r = -0.10$, $p = 0.20$, see Table 3). Combined with results from Study 1 and 2, this suggests that information structure can also impact the quantity of the output, although the specific relationship between quantity and creativity remains open to question.

4.3.2. Persistence

As in Study 2, we also tested whether persistence, operationalized by time spent on the task (minutes), mediates the relationship between information structure and creativity. A one-way ANOVA result showed that participants in the flat information structure condition ($M = 16.83$, $SD = 11.90$) were more persistent than those in the hierarchical information structure condition ($M = 11.53$, $SD = 8.94$), $F(1,180) = 11.56$, $p < 0.01$, $\eta^2 = 0.06$. Persistence mediated the influences of information structure on overall creativity, *Indirect Effect* = 0.21, *Boot SE* = 0.07, 95% CI [0.10, 0.38] and similarity to Earth creatures, *Indirect Effect* = −0.09, *Boot SE* = 0.05, 95% CI [−0.21, −0.02]. Again, we tested whether both cognitive flexibility and persistence simultaneously mediated the influences of information structure on creativity. We found that the relationship between information structure and overall creativity was signifi-

Table 3
Means, standard deviations, and correlations in Study 3.

Variables	Mean	SD	1	2	3	4	5
1. Information structure (0 = hierarchical; 1 = flat)	0.49	0.5					
2. Persistence	14.16	10.9	0.23**				
3. Cognitive flexibility	16.07	8.63	0.36**	0.56**			
4. Creativity	3.95	1.31	0.36**	0.42**	0.45**		
5. Similarity	3.86	1.24	−0.29**	−0.23**	−0.17*	−0.75**	
6. Elaboration	50.78	45.05	0.20**	0.64**	0.85**	0.36**	−0.10

Note. Effective sample size = 182. All tests 2-tailed.
* $p < 0.05$.
** $p < 0.01$.

cantly mediated by both cognitive flexibility, *Indirect Effect* = 0.22, *Boot SE* = 0.10, 95% CI [0.06, 0.43], and cognitive persistence, *Indirect Effect* = 0.14, *Boot SE* = 0.07, 95% CI [0.04, 0.31]. The effect of information structure on similarity to Earth creatures was mediated by cognitive persistence, *Indirect Effect* = −0.10, *Boot SE* = 0.06, 95% CI [−0.25, −0.02], but *not* by cognitive flexibility, *Indirect Effect* = 0.02, *Boot SE* = 0.09, 95% CI [−0.15, 0.20].

4.4. Discussion

In Study 3, we tested our hypotheses using LEGO bricks. We found that participants in the flat information structure condition made more creative alien figures than those in the hierarchical information structure condition. Further, the effects of structure on creativity were mediated by both cognitive flexibility and persistence. Thus, our hypotheses were largely supported.

5. General discussion

In three studies, the current research showed that individuals presented with a flat information structure were more creative compared to those presented with a hierarchical information structure. We define a flat information structure as a set of information that is presented without higher-order categories, and a hierarchical information structure as a set of information organized by higher-order categories. We found that the increased creativity in a flat information structure condition is due to an elevated level of cognitive flexibility. Additionally, exploratory analyses showed that participants in the flat information structure condition spent longer time on their tasks than those in the hierarchical information structure condition. Given that time spent could be a proxy for how cognitively persistent participants were on the task, this suggests that the absence of structure might also increase creativity through cognitive persistence.

5.1. Theoretical and practical implications

Organizational studies have had a long history advocating for hierarchical structures that increase efficiency of work. Since the processing of large amount of information is limited by human capacity, structures emerge to reduce complexity and enhance efficiency (March & Simon, 1958; Simon, 1962). For this reason, many organizational activities are built around hierarchical structures. The principle of division of labor, for example, organizes labor forces by worker specializations, creating a hierarchical information structure where information clusters around job roles and skills. Such structures are important or even necessary for efficiency (March & Simon, 1958). When it comes to creativity, however, rigid walls between categories in hierarchical information structures may be harmful because creative ideas often rise from combinations of distal information (Mednick, 1962, 1968; Nijstad et al., 2010). The current research aims to explore the negative effects information structure has on creativity. We showed not only that presenting information with a hierarchical information structure organized by higher-order categories reduced creativity, but also that this effect was mediated by cognitive flexibility, or the degree to which individuals can simultaneously explore and process information from distal categories. A hierarchical information structure seems to prime the ideation process within salient cognitive categories (Anderson, 1996), whereas a flat information structure frees up flexible exploration over distal cognitive categories in ideation.

Broadly speaking, our findings shed new light on the information transfer literature, which tends to focus on information availability as the most important predictors of creativity (Boh & Wong, 2015; Huang, Hsieh, & He, 2014; e.g., Nonaka, 1994). Researchers suggested that employees learn information from diverse sources (e.g., job manuals, text books, coworkers) and combine them to generate creative ideas (Gong, Kim, Lee, & Zhu, 2013; Shalley et al., 2004). Having a large amount of diverse information likely increases creativity because the larger the pool of available information, the higher probability of generating new combinations (Simonton, 1999a, 2002, 2003). However, empirical evidence on the relationship between information transfer and creativity is inconclusive. While some studies showed a positive relationship (e.g., Gong, Huang, & Farh, 2009), others showed a non-significant relationship (e.g., Huang et al., 2014). The current research suggests that in addition to making information available, how information is stored and presented may be a critical factor that affects creativity. Thus, a promising venue for the future research would be to investigate the link between information transfer with either a flat or hierarchical information structure and creativity in real organizations.

In the additional analyses, we also found that cognitive persistence may be another mechanism through which information structure affects creativity. It is possible that a hierarchical information structure reduces cognitive persistence because contextual-priming from a hierarchical information structure leads individuals to quickly and effortlessly categorize information into the most salient and accessible category (Anderson, 1996). For instance, Schooler and his colleague (Schooler, 1993; Schooler & Anderson, 1997) showed that individuals working with a set of conceptually related information spent less time understanding the set, relative to those working with a loosely connected information set. Unlike a hierarchical information structure, a flat information structure does not make any specific category salient, thereby discouraging automatic categorization. However, we should be cautious when interpreting the findings regarding the cognitive persistence pathway. This is because our measure of persistence (i.e., average time spent on each sentence) is simply a proxy of cognitive persistence, not a direct measure of cognitive persistence. It could tap into deep information processing (i.e., cognitive persistence), but it could also capture task motivation. Thus, we are not certain whether structure indeed affects creativity through cognitive persistence. Future studies should examine this possibility by using a more accurate measure, such as the "within-category fluency" (i.e., the average number of generated ideas per a category) suggested by Nijstad et al. (2010).

Although the main focus of the current research is on the cognitive mechanism (i.e., cognitive flexibility) underlying the relationship between structure and creativity, this does not mean that motivational mechanisms play no role. Many social psychological studies have shown that in addition to cognitive capability, motivation matters for task accomplishment (Mitchell & Daniels, 2003) and creativity (Amabile, 1985). As aforementioned, our post hoc analyses found that the relationship between information structure and creativity is also mediated by task time, which could tap into both cognitive and motivational forces. It is possible that when presented with a flat information structure, individuals might perceive the task to be more challenging and thus work harder to produce novel and creative outcomes. Although our analyses showed that both cognitive flexibility and task time mediated the relationship, pointing to the possibility that motivational forces and cognitive mechanisms work orthogonally, we believe that future studies should present a more complete picture of the cognitive and motivational underpinnings of the relationship between information structure and creativity.

It is worth noting that our studies relate to previous studies that have looked at environmental messiness and creativity. Vohs and colleagues have shown that working in a visually messy environment (e.g., a working desk with piles of books and scattered files) facilitates creativity by increasing the willingness to violate estab-

lished norms and order (Vohs, Redden, & Rahinel, 2014). However, Vohs and colleagues' research focuses on the priming effects of environmental disorganization, whereas the current research focuses directly on the information structure itself. Clearly, a flat information structure does not equal messiness. All of our studies were conducted in controlled, tidy experimental rooms with no clutter or messiness. Further, the presentation of information in the flat condition in Study 1 and 2 was not visually messy (Appendices B and C); likewise, the LEGO bricks in the flat information structure condition were contained in boxes, not in a visually messy array (Appendix D). Thus, environmental messiness cannot explain our findings. More importantly, our studies have clearly shown that the effect of information structure is mediated through cognitive flexibility – a key pathway that is related to how information is shared and presented. That said, the interactional effects of information structure and environmental messiness on creativity might be an interesting and unexplored area for future research.

Our findings have important implications for practitioners. For example, our research might inform leaders how to better manage functionally diverse teams (e.g., cross-functional product development team). Researchers have suggested that functional diversity in teams increases creativity because team members from various functional backgrounds supposedly bring different sets of information in team ideation processes (Williams & O'Reilly, 1998). However, empirical evidence for cross-functional teams have been inconsistent (Shin, Kim, Lee, & Bian, 2012; Williams & O'Reilly, 1998). For instance, some studies have found that functional diversity in cross-functional product development team was unrelated to innovation in new product development (Sethi, Smith, & Park, 2001). This is attributed to team members categorizing themselves in terms of similarity (Byrne, Clore, & Worchel, 1966), escalating team conflicts (Tajfel, Billig, Bundy, & Flament, 1971) and in effect creating a hierarchical information structure where information is organized around job functions. Thus, diversity in information alone might not be a sufficient condition for creativity. Our research suggests that to reap the benefits of cross-functional teams, managers need to create flat information structure where diverse information brought by team members is dispersed flatly across the team rather than cluster around functional categories. This can be achieved by formal procedures such as having team members jot down as many new product ideas as possible and then mix them so as not to make any organizing categories salient before combining them for new product development.

5.2. Limitations and future research

It is important to consider several theoretical and methodological limitations when interpreting our findings. We are not suggesting that the lack of structure (or flat information structure) is always the seed of creativity; in fact, sometimes a flat information structure may discourage individuals from making creative combinations. For instance, the relationship between information structure and creativity may be moderated by individual differences. Kruglanski et al. (2012) suggested that an individual's willingness to initiate a task depends on the trade-off between the amount of cognitive resources he/she can invest in a task (i.e., potential driving force) versus the amount of energy required to complete the task (i.e., restraining force). Only when the individual estimates the potential driving force to be equal to or greater than the restraining force will s/he engage in the task. Thus, cognitive capacity and the availability of cognitive resources may be potential moderators of the structure-creativity relationship. Those low in cognitive capacity may be more easily discouraged by the high cognitive load demanded by a flat information structure and disengage early on, which negates the positive effects of the flat information structure on creativity. Thus, for future research, it would be interesting to investigate individual differences that could moderate the relationship between information structure and creativity.

Furthermore, social and cultural factors could also influence the relationship between information structure and creativity. For example, empirical studies showed that individuals in tight culture, characterized by strong emphasis on conformity to social system and harsh punishment on deviance, were higher in conformity to existing social structure, compared to those in loose culture (Gelfand et al., 2011; Harrington & Gelfand, 2014). Tight culture socializes individuals by offering an implicit theory that social structure exists because it is beneficial for solving social problems (Gelfand et al., 2011). More importantly, Chua, Roth, and Lemoine (2015) showed that such conformity could translate to an adaptor cognitive style that tends to conforms to the structure, norms, and assumptions of the situation where one is embedded. This evidence points to the possibility that people from tight cultures may be more likely to conform to existing information structures. Thus, we believe that the detrimental effects of a hierarchical information structure on creativity may be stronger for those in tight culture than those in loose culture because the former may be more willing to conform to information structure and suppress creative deviations from. It will be worthwhile for future researchers to investigate social, cultural factors explaining the information structure-creativity relationship.

Across the three studies we found inconsistent relationships between quality (creativity) and quantity (fluency or elaboration). In Study 1, while fluency had a non-significant positive relationship with *average creativity*, it had a significant positive relationship with *best creativity*. Contrary to Study 1, Study 2 showed a negative relationship between fluency and *average creativity*, suggesting that participants achieved creativity at the expense of fluency. Further, fluency was unrelated to *best creativity* in Study 2. In Study 3, elaboration (i.e., the quantity of information used by participants to illustrate an alien) was positively related to creativity, but had a non-significant negative relationship with similarity. These results are consistent with the existing creativity literature, which has found conflicting relationships between quality of ideas (i.e., novelty and usefulness) and quantity (the number) of ideas. A positive relationship between quality and quantity may arise if the quantity of ideas represents the process of trial-and-error; however, a negative relationship may manifest when individuals do not put much efforts into developing the quality of each idea but rather focus solely on generating many ideas (Förster et al., 2004; Gocłowska et al., 2014; Mehta & Zhu, 2015; Montag et al., 2012). Future research is needed to resolves this inconsistency in the quality-quantity relationship.

More importantly, our additional analyses showed that information structure differentially predicted creativity and fluency. A flat information structure consistently increased creativity in the three studies, but the effects of information structure on fluency varied across studies. This finding implies that fluency might be qualitatively different from other dimensions of creativity and have its own set of predictors (Förster et al., 2004; Gocłowska et al., 2014; Mehta & Zhu, 2015; Mehta, Zhu, & Cheema, 2012). This is consistent with findings from existing creativity research. For instance, Mehta and Zhu (2015) found that resource scarcity increased novelty of ideas without influencing fluency. Gocłowska et al. (2014) showed that social schema violation increased creativity among those low in need for structure, but not fluency. In a similar pattern, Förster et al. (2004) found that abstract thinking did not increase fluency while it did for creativity. Therefore, we call for future research to investigate the differences between fluency and other measures of creativity, such as originality, usefulness, and elaboration.

Lastly, we acknowledge that generalizing our findings warrants caution for several reasons. First of all, the samples across the three studies were undergraduate students at a North American univer-

sity, which may not represent the general population. Second, the information we used in the experiments (i.e., English words and LEGO bricks) were minimal, simplistic information that involved low levels of elaborations. In organizations, employees are likely to use more elaborated, sophisticated, and complex information as a basis for idea generation. Third, the type of creativity that was measured in the laboratory may be different from the type of creativity in organizations (Montag et al., 2012). In particular, the creativity task in Study 3 might capture only the novelty aspect of creativity, as the alien task created by Ward (1994) was developed specifically to measure only novelty. The word construction task, on the other hand, captures both novelty and usefulness as the evaluators considered two factors of usefulness in their evaluations: (1) whether the sentences make sense, and (2) whether the sentences are grammatically correct. Regardless, those tasks differ from the creativity reflected in the workplace. Lastly, we explored the most basic form of hierarchical information structure (vs. flat information structure) by looking at high-order categories that are only one level up. It is uncertain whether our findings can be generalized to more complex hierarchical information structures. Thus, it is important for future research to explore whether the extent to which our findings can be replicated in complex organizational settings.

Author note

We thank the Social Sciences and Humanities Research Council (SSHRC) of Canada for funding this research. We thank Jacob Hirsh for his helpful comments and Sojin Park and Ilhom Abdul Razaq for assistance in data collection. We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study. In determining sample size, we generally followed the rule of thumb of having at least 50 participants per cell. The final numbers may vary slightly due to sign ups and attendances but we never checked results before terminating data collection. Data for studies reported here can be found at osf.io/7nv4b.

Appendix A. A brief review on procedural information and creativity

Scholars have investigated whether possessing procedural information regarding a specific ideation task influences levels of creativity. Rietzschel, Slijkhuis, and Van Yperen (2014), for instance, manipulated procedural information by either showing or not showing the procedures for drawing an object, and found that procedural information alone did not increase creativity in drawing. Instead, it increased creativity only for participants with high need for structure, "a chronic aversion to ill-structured situations to and a longing for certainty and predictability" (Rietzschel, De Dreu, & Nijstad, 2007, p. 856). In addition, Goldenberg and his colleagues developed six *creativity templates* – systematic procedures for creating a new product or advertisement. They found that the *templates* generally increased creativity (Goldenberg, Mazursky, & Solomon, 1999a, 1999b, 1999c). In one study they found that 89% of award-winning advertisements implicitly used one of the six templates (Goldenberg et al., 1999a). Likewise, Sagiv, Arieli, Goldenberg, and Goldschmidt (2010) found inconsistent but generally positive effects of *creativity templates* on creativity. In sum, despite some inconsistencies, existing empirical studies show that individuals who possess procedural information on a particular type of ideation task (e.g., drawing, advertisement development) tend to show higher levels of creativity in the task.

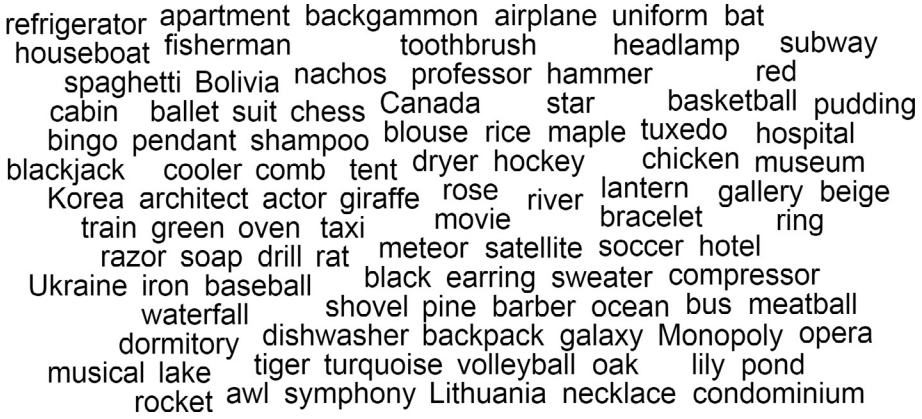
While those studies are inspiring and meaningful, we think that they are less relevant to our research for several reasons. First, our main focus is on structure in declarative information. This is because a flat or hierarchical information structure, that we think an important feature of information structure, can clearly underlie a set of declarative information. Second, it does not seem plausible that procedural information can be organized in terms of multiple higher-order categories to form a flat or hierarchical information structure. It is an essential characteristic in our theory that declarative information can be potentially categorized by many different higher-order categories because with that characteristic, a piece of declarative information can transform its meaning in several different ways. On the other hand, we do not have any theory for defining procedural information by higher-order categories, and even if we have, we do not think that there are many different higher-order categories that can simultaneously subsume the same procedural information. Third, the previous studies illustrated above are mainly about creativity resulting from whether or not individuals had procedural information, rather than structural differences in a set of procedural information.

Appendix B. Information structures in Study 1

Hierarchical information structure

blouse	gallery	Korea	hammer	musical
uniform	museum	Canada	shovel	opera
tuxedo	hotel	Bolivia	drill	ballet
sweater	condominium	Lithuania	compressor	movie
suit	hospital	Ukraine	awl	symphony
red	professor	rat	cooler	maple
beige	actor	tiger	tent	lily
green	barber	giraffe	backpack	oak
turquoise	architect	bat	lantern	pine
black	fisherman	chicken	headlamp	rose
spaghetti	razor	oven	baseball	river
rice	soap	refrigerator	hockey	ocean
meatball	comb	iron	volleyball	waterfall
nachos	toothbrush	dryer	basketball	lake
pudding	shampoo	dishwasher	soccer	pond
subway	condominium	ring	chess	galaxy
bus	houseboat	necklace	Monopoly	star
taxi	cabin	bracelet	bingo	rocket
train	dormitory	pendant	backgammon	meteor
airplane	apartment	earring	blackjack	satellite

Flat information structure

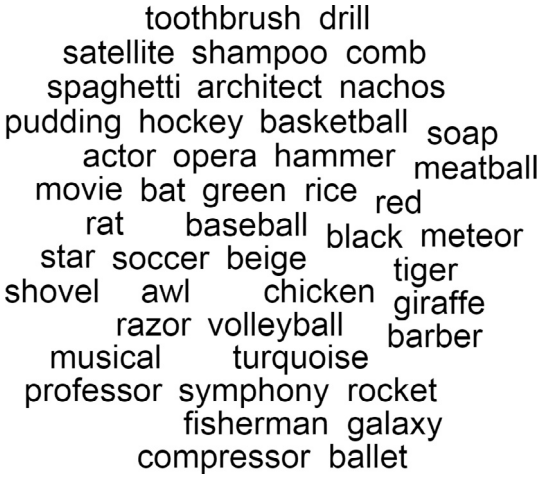


Appendix C. Information structures in Study 2

Hierarchical information structure

professor	rat	hammer
actor	tiger	shovel
barber	giraffe	drill
architect	bat	compressor
fisherman	chicken	awl
razor	red	baseball
soap	beige	hockey
comb	green	volleyball
toothbrush	turquoise	basketball
shampoo	black	soccer
musical	spaghetti	galaxy
opera	rice	star
ballet	meatball	rocket
movie	nachos	meteor
symphony	pudding	satellite

Flat information structure



Appendix D. Information structures in Study 3

Hierarchical information structure

Flat information structure

Appendix E. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.obhdp.2016.10.001.

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