A Study on Creativity in Comparison with Linguistic Interpretation Process

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Abstract

We investigated the process of design creativity by examining the characteristics of thinking during design activity involving concept synthesis. In our experiments, subjects were asked to perform two tasks - to interpret novel noun-noun combinations and to create a design based on novel noun-noun combinations. We analyzed and compared the thinking used in each task using a method reported in cognitive linguistics literature, which assigns the interpretation of novel noun-noun combinations to one of three types: concept abstraction, blending, and thematic relation. We classified the design processes used by our subjects to create design concepts according to these three types and evaluated the creativity of the designs along two dimensions, practicality and originality. Our results showed a significant difference in the amount of blending involved in interpretation and design creation. The proportion of blending during the design task was higher than that during interpretation, and the creativity of design results produced using blending was higher than that based on other types. Since concept blending is an effective way of creating a new idea, we suggest that blending is an important characteristic of the process of creativity.

Keywords: Concept combination; design creation; creative thinking.

Introduction

Many studies have been conducted to analyze the characteristics of the design thought process from the viewpoint of creativity. As a result, it has been found that concept-synthesizing processes, such as analogical reasoning or the blending or integration of two different concepts, are keys to creative thinking. Analogical reasoning and concept abstraction are known to play very important roles in creative design (Gero & Maher, 1991; Goldschmidt, 2001). For example, the "swan chair" is a famous example of a design imaged by using concept abstraction. Its form resembles a swan, and users understand its message of "this chair is soft and elegant, like a swan".

From the viewpoint of mental cognition in the domain of cognitive science, Finke, Ward, and Smith (1992) described conceptual synthesis as an efficient means of developing creative insights into new inventions, and they carried out experiments on creation as mental products generated by imagery synthesis. On the other hand, in studies of cognitive linguistics, Fauconnier (1994) focused on the process of construction of meaning in ordinary discourse. He analyzed how conceptual integration creates mental products and how to deploy systems of mapping and blending between mental spaces. From the viewpoint of mental space theory, he showed that conceptual integration operates on two input mental spaces to yield a third space, which is called the "blend". This blended space inherits partial structures from each input space and has emergent structures of its own. Both mental products-imagery and discourse-show emergent features and have stimulated creativity. Fauconnier and Turner (2002) suggested that a watch is designed by conceptual blending.

Contrary to the above studies, which indicate the importance of creativity in design, other research has pointed out that creative interpretation occurs in the context of the everyday understanding of language, implying that it is a ubiquitous feature in human cognition (Wisniewski, 1996; Costello & Keane, 2000). Given these studies, the following questions arise: Does design have features distinct from those of ordinal human cognition? If so, what is the nature of design creativity? In this paper, we try to address these questions.

We investigated these topics by comparing two different thinking patterns: those used to interpret novel noun-noun combinations and those used to create a design from such noun combinations. People use and interpret combination terms (a type of noun phrase) in daily conversation without requiring special knowledge or professional education. For example, we can easily interpret the meaning of terms such as road sign, dog sled, and wheel chair. The way in which people interpret novel noun-noun combinations has been investigated in the field of cognitive linguistics. Wisniewski (1996) showed that people combine concepts by using three basic strategies. We can also create a new concept by taking a cue from a combination term. For example, a new type of chair shaped like a swan could be designed by taking a cue from the words "swan chair". In this design process, two concepts are synthesized to generate a new concept. We have built on these studies through experimental research focused on the design creation process to determine both the types of concepts that are related to higher creativity and the characteristics of the process of concept synthesis. These studies showed that: (1) higher creativity is more likely when two concepts are highly dissimilar than when they are relatively similar (Taura, Nagai, & Tanaka, 2005); (2) creativity and the extension of the designer's idea space are strongly correlated (Harakawa, Nagai, & Taura, 2005); (3) the presence of a thematic relationship between two concepts during the design process leads to greater creativity (Harakawa et al., 2005); and (4) compounding of the synthesis of two concepts

that individually have many associated concepts leads to a creative design concept whose imagined actions and scenes are related to the originality of the design concept (Nagai & Taura, 2006).

Thus, combination terms are used in the creation of design concepts as well as in interpretive behavior. Consistently with reports from linguistic research, we show that there are three kinds of design thinking patterns in concept synthesis. We first describe the correspondence between different types of linguistic interpretation process and different types of creative design process through concept synthesis. We then look at differences in the proportionate use of various thinking patterns to interpret noun phrases and create designs on the basis of noun phrases, and we analyze which patterns of thinking lead to the highest levels of creativity.

Aims

We conducted an experiment aimed at revealing the nature of creativity in the process of design creation and the differences in the thinking patterns of design creation compared to those of ordinal language interpretation. Our experimental method followed that used in studies in the field of cognitive linguistics, in which novel noun-noun combinations (e.g., clock chair, stone skunk) are used. In our experiment, each subject performed two tasks. In the first task, they were required to interpret combinations, and in the second, they were required to create a design concept from a combination. In addition, we clarified the relationships between the characteristic patterns of thinking during design and creativity processes by evaluating the creativity of the design results along two dimensions, practicality and originality (Finke et al., 1992).

Types of Linguistic Interpretation

Wisniewski (1996) conducted experiments in which participants interpreted a novel noun-noun phrase. Interpretations obtained from the experiments were categorized into three types:

Property mapping An interpretation was classified as property mapping if one or more properties of a constituent were asserted for the referent of the combination, as in "grey clay" for elephant clay, "thin broom" for pencil broom, and "pony with stripes" for tiger pony.

Hybrid An interpretation was classified as a hybrid if it involved combinations of the two objects or of entities involving both of the objects, as in "a very large heavy creature sharing properties of both an elephant and a moose" for moose elephant, or "a combination ladder/broom" for ladder broom.

Relation linking An interpretation was classified as relation linking if it involved a relation between two objects, as in "box that holds ladders" for ladder box, "squirrel that chases cars" for car squirrel, and "robin that eats snakes" for snake robin.

An interpretation was classified as "other" if it did not fit into one of the three categories. For these interpretations, subjects typically gave vague meanings (e.g., "a type of plastic" for fish plastic, "a kind of snake" for clock snake), or used an alternative adjective or the verb form of a constituent (e.g., "a glass used as a pan" for pan glass; "a small paperback book" for pony book).

Wisniewski's Classification Results The interpretations obtained from Wisniewski's experiment were classified as follows: 53% were relation linking, 41% were property mapping, and 1% was hybrid. That is, most of the participants in Wisniewski's experiment used relation linking or property mapping to interpret noun phrases; only a few interpretations were classified as hybrid.

Types of Design Creation

We have studied the processes through which a new concept is created by synthesizing two concepts, and found that three types of synthesizing processes are used in design (Nagai & Taura, 2006).

Concept abstraction This process is based on commonalities of two concepts. For example, "white tomato" for snow tomato, a substance that is a snow-like tomato. This process is a method of concept creation based on transferring the characteristics of an existing concept to a new concept.

Concept blending Concept blending is process that blends two basic concepts at the abstract level and produces a new concept that inherits the abstract features of the two base concepts, but the concrete features of neither; for example, "powder ketchup" for snow tomato, a substance that could be used to add a tomato flavor to food, like powder snow.

Concept integration (Thematic Relation) Concept integration is process that combines two basic concepts from the viewpoint of a thematic scene and generates a new concept. For example, "non-drying refrigerator" for snow tomato, a new concept formed from a scene "a tomato is stored in snow."

It is commonly acknowledged that the process of concept abstraction plays an important role in creative design. In fact, it is frequently used in real-world design processes. However, designs produced by concept abstraction are limited in terms of the originality of ideas because concept abstraction cannot extend beyond the domain of a given concept. In contrast, the process of concept blending can create a truly new concept because the concepts produced by this process do not belong in the domain of the given concepts. Therefore, concept blending seems more suited to creative design thinking than concept abstraction.

Correspondence between Types of Linguistic Interpretation and Design Creation Using Concept Synthesis

The patterns of linguistic interpretation and those of design creation involved in concept synthesis correspond to each other. Transfer is involved in both property mapping and con-

cept abstraction. Hybrid and concept blending involve the same process that creates a new concept by blending the features of two concepts. Relation linking and concept integration share the process that links the two concepts from the viewpoint of a thematic relation.

Methods

The experiment required subjects to perform two tasks: to interpret the meaning of novel noun-noun phrases and to design a new concept with reference to those phrases. The types of thinking used for each task were analyzed and the results compared. The creativity of the design results was also evaluated.

Tasks

The tasks were presented in a booklet containing question and answer forms. A book was given to each subject.

Interpretation Task The interpretation task required each subject to interpret 15 phrases. The subjects wrote down a description of the most natural meaning for each novel phrase on the answer form. The answer form for this task had one line for each noun phrase.

Design Task In the design task, the subjects designed a new concept from each of three noun phrases and described the concept on the answer form. The answer form for this task had five lines with a free drawing space for each noun phrase.

Task Booklets

The task booklets were prepared with reference to Wisniewski's research using the following procedure.

Preparing the Noun-Noun Phrases Three categories of nouns were used to construct combinations: substance terms, artifact-count terms, and animal-count terms. Pairing these categories yields nine combination types. Eight of these types were used in the study; substance-substance types were excluded. To construct examples of the eight combination types, we arbitrarily selected 5 substance terms, 10 artifact-count terms, and 10 animal-count terms.

We constructed 160 noun-noun combinations consisting of 20 examples of each of the eight types. They were derived in the following manner. Substance-artifact pairs were constructed by randomly pairing each of the five substance terms with four artifacts, so that each of the 10 artifacts appeared twice in the head noun position. Substance-animal terms were constructed in a similar manner. The animal-substance and artifact-substance terms were made by reversing these combinations. The artifact-artifact pairs were constructed by randomly dividing the artifacts into two lists of five artifacts and pairing each noun from the first list with two from the second list, such that each artifact in the second list appeared twice as a head noun. These combinations were then reversed, so that each artifact in the first list then appeared twice as a head noun. Animal-animal terms were constructed in a similar manner. Artifact-animal terms were constructed by randomly pairing each artifact with two animals, such that each of the 10 animal terms appeared twice as a head noun. The animal-artifact terms were formed by reversing these combinations.

Table 1: Lists of combinations.

List 1		
artifact-animal	animal-artifact	substance-artifact
car skunk	snake broom	stone pencil
pan elephant	frog box	glass pencil
chair deer	sparrow vase	clay chair
vase frog	fish clock	glass clock
box deer	deer box	stone vase
List 2		
substance-animal	animal-animal	artifact-artifact
glass skunk	skunk frog	chair box
clay elephant	deer elephant	pan ladder
stone squirrel	sparrow squirrel	car broom
chocolate fish	fish elephant	book vase
chocolate squirrel	fish frog	ladder pan
List 3		
artifact-substance	animal-substance	substance-animal
box plastic	skunk chocolate	plastic sparrow
book glass	snake plastic	stone pony
car chocolate	snake clay	stone deer
broom clay	pony stone	plastic pony
clock chocolate	squirrel chocolate	glass elephant

Making the Booklets We reduced the number of combinations to 45 because the number of subjects was less than the number Wisniewski used in his experiment. The combinations were divided into three lists. Table 1 shows details of the lists of combinations. Each booklet consisted of 12 pages: six pages for the interpretation task, four pages for the design task (a cover sheet described each task), and two blank pages between the interpretation and design tasks. The noun phrases for the interpretation task consisted of a set of phrases from one of the three lists. Those for the design task were randomly picked from the list used for the interpretation task in an effort to avoid any overlap in the type of combination; thus, if the interpretation task was composed using a set of phrases from list 1, the phrases for the design task consisted of three phrases from list 1.

To control for order effects in carrying out the tasks, we divided the subjects into two groups, A and B. Subjects in group A performed the interpretation task then the design task in that order, while subjects in group B performed them in the reverse order. To divide the subjects into two groups, we labeled each booklet with A-1 to 3 or B-1 to 3 according to the task order with the number in each label corresponding to the number of the list used to make the booklet.

Explanatory Text on the Cover The explanatory text typed on the cover sheet for both tasks is as follows.

- Interpretation task
  Below, you will read some noun phrases. Noun phrases that you have probably heard before include "road sign", "car window", and "mouse pad". Many of the phrases you will see in this booklet are probably novel to you - you may never have heard them before. Examples of possible novel noun phrases are "factory fish", "bottle frog", "earthquake school", and so on.
  Your task is to write down a description of the most likely meaning of each novel phrase. Pretend that you have just heard the phrase during a conversation. What meaning of the phrase would seem most natural to you?
  The cover sheet for the interpretation task asked subjects to "Write down a description of the most natural meaning of each novel combination", to encourage the subjects to approximate their usual cognitive behavior.

- Design task
  Below, you will read some noun phrases. Many of the phrases are probably novel to you - you may never have heard them before. Examples of possible novel noun phrases are "factory fish", "bottle frog", "earthquake school", and so on. Your task is to design a new concept with reference to each novel phrase. For instance, you might design a new vehicle, furniture, or stationery concept.
  The answer form is divided into two parts. You can use the upper part to draw figures or sketches, and the lower part to write an explanation of the design concept. For example, what is your design, what function does it have, when is it used, and why is it used?
  The design idea will be evaluated from the viewpoint of creativity (practicality and originality). Please make an effort to think as creatively as possible. The design idea will not be evaluated only from the sketch. Please write an explanation of the design concept.

Subjects

The subjects were 37 undergraduate students with no formal experience in design. There were 18 subjects in group A and 19 in group B.

Procedure

The experiment was done in a group setting, and was structured as follows:

1. Booklet distribution (10 minutes)
   The subjects were each given a booklet at random. They were then divided into two groups depending on the label on the booklet they received.

2. Verbal explanation of task to be done in first half of experiment (5 minutes)
   The subjects were told various details about the task but were not told what the actual task was. Each subject performed the task with reference to the explanatory text on the cover sheet for the task.

3. Performance of first task (30 minutes)
   Group A subjects did the interpretation task and group B subjects did the design task.

4. Order to stop working on first task and verbal explanation of second task (5 minutes)
   The subjects were again told details about the task but not what the actual task was. Each subject carried out the task with reference to the explanatory text on the cover sheet for the task.

5. Performance of second-half task (30 minutes)
   Group A subjects did the design task and group B subjects did the interpretation task.

Method of analysis

Classification of thinking pattern

We set the classification standards with reference to Wisniewski's classification. Table 2 shows the classification standards and examples. The thinking used in each task was classified according to the standards and compared.

In this experiment, there were some answers to which we could not directly apply Wisniewski's classification. Such answers were classified by the following standards for exceptions:

- Some design ideas did not directly indicate either of the two concepts presented. For example, one participant suggested "a vacuum cleaner shaped like a snake" for snake broom). It can be considered that these ideas were created by associating a new concept with the ones presented. Such ideas were classified according to the relation between the new concept and the presented concepts (the above example was classified as an "property mapping"). When the features of a new concept associated with the one presented disagreed with the conventional features of that concept, the idea was classified as "blending". For example, "a living vacuum cleaner that acts like a snake" for snake broom. A 'living vacuum cleaner' differs markedly from existing vacuum cleaners. Therefore, it was considered that it was neither a snake nor a vacuum cleaner.

- Some answers were classified with reference to the sketch drawn by the subject. For example, an answer with a sketch of a broom could obviously be considered to include "broom" even if "broom" was not used in the written explanation.

Creativity evaluation

The creativity of the design results was evaluated from the viewpoint of practicality (whether the idea seemed possible to achieve and was feasible) and originality (whether the idea

Table 2: Classification standards and examples.

Classification	Classification standard and example
Property mapping	This category corresponds to "property mapping". Properties of one noun are mapped onto the other noun. One can say that A is like B (absolutely B, and a new kind of B) or B is like A. (Example from an interpretation task: "a squirrel that doesn't move at all" for stone squirrel) (Example from a design task: "A broom with a handle curved like a snake. It is useful for cleaning inner spaces." for snake broom)
Blending	This category corresponds to "hybrid". Something can have the properties of both A and B yet be neither A nor B. One can say it is both A and B. (Example from an interpretation task: "a creature sharing properties of both a deer and an elephant" for deer elephant) (Example from a design task: "It is a computer virus that hardens various applications into stone (that is, it causes various applications to crash). It transmits important information in the computer to the hacker like a squirrel taking an acorn home to its nest" for stone squirrel)
Thematic relation	This category corresponds to "relation linking". The two nouns are combined from the viewpoint of a thematic scene. (Example from an interpretation task: "cage for deer" for deer box) (Example from a design task: "It is a defense system shaped like a skunk to prevent car break-ins. It is set up in an obvious place within the car. It puts a criminal out of action by emitting a gas that irritates the eyes and nose." for skunk car)
Other	Cases that do not fit into any of the other three categories. (Example from an interpretation task: "shooting star" for stone pony) (Example from a design task: "a machine that display a vision of fishes" for fish elephant)

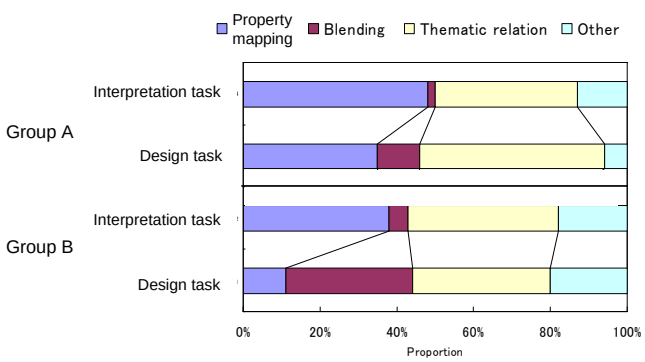

Figure 1: Results of classification.

was innovative and novel) based on Finke et al. (1992)'s creativity evaluation. Twenty raters evaluated the creativity of all ideas (n= 109) on a four-point scale (1: low - 4: high). The rating scores were averaged for each idea. Ideas with lower average scores for practicality than the overall average scores for practicality were excluded from the following analysis. For the remaining ideas, average scores for originality were considered as the measure of creativity.

Results

Comparison of interpretation and design task

Figure 1 shows the proportion of property mapping, blending, thematic relation, and other for each task for group A and group B. In the interpretation task, there was a high proportion of property mapping and thematic relation, and the proportion of blending was low for both groups. This is consistent with the results of Wisniewski's experiments.

In the design task, the proportion of property mapping was lower, and the proportion of blending was higher than for the interpretation task for each group. The proportion of thematic relation was higher than that for the interpretation task for group A, but not for group B. A chi-square test showed that there was a significant difference between the results of the interpretation and design tasks for each group: Group A, $\chi^2(3) = 12.269, p < .01$; Group B, $\chi^2(3) = 35.734, p < .01$. A significant difference was found in blending for group A, and significant differences for property mapping and blending were found for group B using residual analysis (Ryan's method).

These results show that there were differences between the two groups in the proportion of the thinking patterns applied, even though the order effect of each task was controlled.

Result of creativity evaluation

The consistency between raters was calculated using Kendall's coefficient of concordance. For both practicality and originality, significant concordances were obtained: practicality, $W = 0.176, \chi^2(19,108) = 380.889, p < .01$; originality, $W = 0.242, \chi^2(19,108) = 521.556$, and $p < .01$.

Figure 2 shows the average scores for creativity for each thinking pattern. Consistent with our hypothesis, "blending" seemed to produce the highest creativity. To verify this, we conducted an analysis of variance, which showed significant differences between the creativity assessed for each pattern of thinking: $F(3,49) = 3.71, p < .05$. Multiple comparisons (LSD) showed a significant difference between "blending"

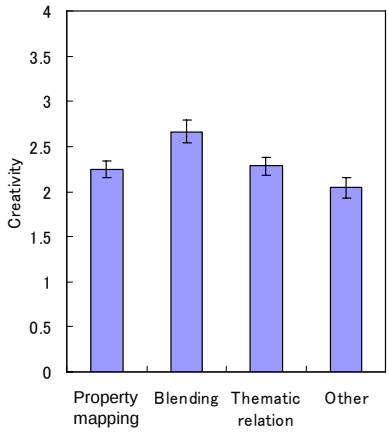

Figure 2: Result of creativity evaluation. The error bar shows the standard error of the mean.

and the other three patterns ("property mapping", "thematic relation", "other"). There were no significant differences between "property mapping", "thematic relation", and "other".

Discussion

Our experiments on the interpretation of combination terms followed those of Wisniewski (1996). Our results from the interpretation task were consistent with his, supporting the belief that ordinary cognitive behaviors (e.g., language interpretation) are based on property mapping or thematic relation. The proportion of blending used in the design task was significantly higher than that in the interpretation task for both groups, suggesting that the characteristics of design behavior are based on blending. This result supports the belief that blending is more pro-design thinking than "property mapping", as mentioned in the ealier section.

When they are in the act of designing something, people have to think about various aspects that are not included in the interpretation of language (e.g., shape and function). In the design task, conceiving a design idea also requires a degree of originality. We believe that the need to consider more creative concepts (that is, newer concepts) results in the application of blending. The differences between groups A and B regarding the proportionate use of each thinking pattern might have been due to the order effect of the tasks, or the purpose of the task might not have been explained to the subjects clearly enough.

While there was some variation, every rater seemed to evaluate the ideas according to a consistent policy; that is, whether or not the design idea was novel compared with an existing concept. For example, there were two ideas for car chocolate: "Chocolate that is eaten in a car to relax and reduce tiredness while driving", and "Chocolate that can erase alcohol eaten in a car to prevent drunken driving". The former idea incorporates the existing features of chocolate, but the latter does not. Therefore, the latter was rated higher (especially on originality) than the former. Blending was a feature of ideas evaluated as being more creative and appears to be a useful thinking pattern in creating a novel idea. For this reason, we consider that blending is a requirement of the creative design process.

Conclusion

To understand the nature of creativity during the process of design, we attempted to clarify the differences between the characteristic thinking used in performing ordinary tasks and that used in design creation. Our aim was to identify the characteristics of design thinking and find key factors that could be used to develop a design-support methodology. The results from our experiments suggest that the characteristic thinking used in ordinary interpretation is based on "property mapping" and "thematic relation", but the characteristic thinking used in the design process is based on "blending". When the creativity of design concepts was evaluated, thinking categorized as "blending" produced the highest ratings for creativity. Concept blending is an effective way of creating a novel idea, and novelty is considered important in creativity. Our results indicate that the nature of creativity in the process of design creation is based on "blending". We believe this work will lead to more specific methods to support the creative design process.

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