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A Theoretical Model of Similarity Judgment based on Ideas of Form and Spirit

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Abstract: Similarity is demonstrably important across many areas of cognition. At present, the main idea is that the similarity of a pair of objects increase with its commonalities and decrease with its difference. However, it's difficult to reasonably explain some counterintuitive situations that often occur. For example, people might find that someone looks similar with a dog, even though most shared features are dissimilar. Inspired by the ideas of form and spirit, we speculate that some key features of objects may have a greater impact on similarity judgment than the others. Therefore, this paper proposed a theoretical model of similarity judgment to illustrate the counterintuitive situation, indicating hierarchical or primary-secondary relationship among shared features between objects, expanding the scope of existing similarity theories. This model has potential applications in many aspects such as the development and protection of intellectual property, product design, game and film industries and so on.

Keywords: the ideas of form and spirit; similarity measurement; similarity judgment models

1. Introduction

Similarity is a basic and important concept in cognitive psychology. Assessment of similarity has great impact on human cognitive behaviours ranging from problem solving to memory retrieval to problem solving (Goldstone et al., 1997). The research of similarity comparison process can help us gain insight into other cognitive processes that involve similarity. The Feature-based model (Tversky, 1977), which is considered as one of the most representative models, assumed that people can recognize and list the features of the objects to be compared and comparing the list for overlap. After comparison, the matching features of two objects are called commonalities, while the mismatching features are called differences. The similarity of two objects increases with its commonalities and decrease with its difference, and the positive contribution of commonalities is greater than the negative contribution of



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difference. The maximum similarity between objects is reached when they are identical, no matter how much commonality they share (Lin, 1998).

Generally speaking, the more similar the matching features of objects, the more likely people are to judge that they are similar. But similarity is based not only on external properties of the stimulus, but also on one's internal representation (Roads & Mozer, 2017). In daily life, we often encounter some situation that against intuitions. For example, animals like cats or dogs have less commonalities with humans obviously, but we can often see comparison pictures of human and animals that are extremely similar on the internet. The other opposite example is that although some fake products can be very similar to the genuine products in shapes, they still can't replace the genuine products in people's mind.

Inspired by the ideas of forms and spirit, this study refers to this phenomenon as "similar in spirit" and "similar in form". The ideas of form and spirit is a philosophical debate that has lasted for thousands of years since ancient China. It can be traced back to the discussion of Taoism in early Pre-Qin Period, which advocates "form" as the external shape of things, and "Spirit" as the spiritual connotation of things. The concept of Zhuang Zi on form and Spirit extends it to the field of art and literature with human mind as the focus, and is widely used in the fields of painting, music, poetry and so on. However, due to the shifts on language connotation and epistemology, the ideas of form and spirit is worthy of in-depth discussion from a contemporary perspective. Gu Kaizhi, a famous painter in the Eastern Jin Dynasty, put forward the idea of "express spirit by depicting form", and believed that the spirit of characters should be reproduced in paintings by depicting the forms. However, Sikong Tu, a poet of Tang Dynasty, put forward the concept of "a sense of similarity regardless of its form", emphasizing the independence of "spirit" from "form". Though it is not completely separated "spirit" from "form", but advocating not being bound by "form", breaking the fetter of "form". The concept of "a sense of similarity regardless of its form" divides "form" and "spirit" into two dimensions, and there is a process of similarity comparison between things. "Similar in form" is the similarity of external shape of things, "similar in spirit" is the similarity of spiritual connotation of things. Intersecting these two dimensions, we can get a matrix containing four kinds of relations between "form" and "spirit": "Similar both in form and in spirit", "Similar neither in form nor in spirit", "Similar in form but not in spirit" and "Similar in spirit but not in form".

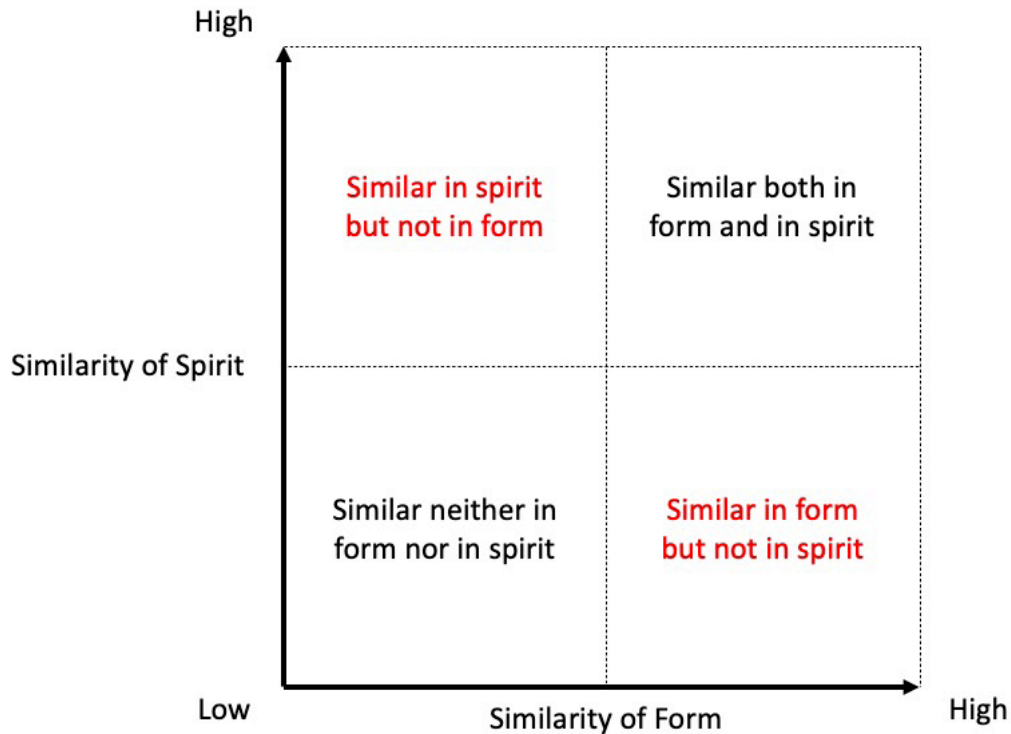


Figure 1 Four kinds of relation between “form” and “spirit”.

At present, there are many researches on similarity judgment. By comparing the physical values of the external attributes of objects or similarity measurement functions, it may be possible to judge whether the objects are similar in shapes or not, but the phenomena of “similar in form but not in spirit” and “similar in spirit but not in form” has not been reasonably explained.

If these two phenomena can be explained rationally and scientifically, we may master the method to create them, which is of great value to the development and protection of intellectual property. With the continuous development of the new generation of digital technology, the creative industry is facing problems such as insufficient intellectual property development and transformation, and weak intellectual property protection, which also directly or indirectly leads to constant intellectual property disputes and disputes (S. Sun et al., 2019). In 2011, Apple and Samsung’s intellectual property dispute case officially started. After an eight-year lawsuit, Samsung was judged to pay Apple 538.6 million dollars in infringement costs, of which only 5.3 million dollars were due to infringement of two Apple Utility patents, and the remaining 533.3 million dollars was due to infringement of three Apple design patents (Horwitz, 2018). Because utility model patents can determine the number of infringements through the split of technology, the design patent part cannot be split and quantitatively evaluated for similarity, so it can only be compensated as an entirety. Looking at the patent laws of various countries in the world, there are three main procedures as follows, which are Patent Application Examination, Invalidation Application and Patent Infringement Determination, need to judge the similarity of patents.

Table 1 Comparison of design patent similarity judgment in different countries or region.

Country	Subject of judgment	Judgment premise	Judgment method	Judgment steps
China	Average consumer	The patent involved in the case is the same or similar categories to the infringed patent or product	Overall observation and comprehensive judgment	
Japan	General demander		“Corrected the ambiguity”	1. Determine the scope of protection for design patent rights; 2. Compare the patent involved with the patent infringed.
USA	Ordinary observer	Comparative patents are not restricted to the same or similar categories	“The two-step test”	
EU	Knowledgeable people		Judging by the overall impression	

At present, the intellectual property rights of different countries have different judgment methods in judicial practice. Although there are restrictions on the subject of judgment to reduce the subjective factors of similarity judgment, it is still not a complete objective assessment. If the cognitive processes of “similar in form” and “similar in spirit” can be describes, it is possible to develop methods to quantify the similarity of things, thereby improving the objectivity of similarity judgment and providing more effective protection for intellectual property rights. In addition, “similar in spirit but not in form” designs can be created, providing ideas for the development of intellectual property. All possible applications are based on the cognitive processes of similarity and judgment mechanisms, especially the similarity of spirit.

The purpose of this research is to try to propose a more complete similarity model based on existing similarity studies, to explain the principle of “similar in spirit” which against intuitions, expand the scope of similarity theories, and briefly discuss its potential application directions.

2. Literature Review

In the field of cognitive psychology, similarity seem to be important for a variety of cognitive acts. There are currently four mainstream theoretical models for evaluating similarity (Goldstone & Son, 2012):

- Geometric Model (Shepard, 1962) assumes that mental representation can be seen as a kind of mental space, and concepts can be represented as points in the space. Those concepts represented by neighboring points are more similar psychologically than those with far distance;
- Feature-based Model (Tversky, 1977) pointed out the limitations of Geometric Model, and thought that people represented concepts by describing various feature lists of things. Similarity comparison is to compare these attribute lists for overlap. The matching features of two objects are called commonalities, while the mismatching features are called differences;
- Structural-mapping Model (Gentner & Markman, 1997) pointed out further elaborated that comparing only the lists of matching features is not enough to judge the similarity of things, structural alignment or mapping relations of these features are also necessary to be considered. In addition, those differences that are linked to commonalities (matching features) are called alignable differences, which have great impact on similarity judgment. For example, both Car and motorcycle have wheels, but car have 4 wheels and motorcycle have 2 wheels. In contrast, the difference brought by mismatching features is called nonalignable difference. Another study has also found that the impact of alignable difference on similarity is more pronounced than the impact of nonalignable difference (Markman & Gentner, 1996);
- Transformational Model (Hahn et al., 2003) proposes that the similarity is determined by the transformation distance between entities. The fewer the number of transformations, the more similar the two entities are.

With the rise of cognitive science, similarity has been used to explain the nature of concept development and object categorization in the field of psychology. Rosch (1973) proposed the Prototype Theory of categorization, which holds that there is a typical member in a category, that is, prototype. Categorization is to judge whether a thing belongs to this category by comparing the similarity between the thing and the prototype in the category. Once the similarity reaches a threshold, it can be categorized into this category. Medin & Schaffer (1978) first put forward the Context Theory of categorization, which holds that there are examples in a category, and examples are the real members of the category. In the process of categorization, people compare things with examples in the category to determine whether they belong to this category. Some researchers conclude that both Prototype Theory and Context Theory play a role in categorization. In the initial understanding of a category, people will average the features of things in the category to form a prototype. With the accumulation of experience, they will produce the most representative examples (Keri et al., 2002; Malt, 1989). Some other research results show that Prototype Theory plays a more prominent role in judging large categories and Context Theory plays a more prominent role in judging small categories (Minda & Smith, 2001).

From the literature on the definition of object similarity, we can find that judging similarity by matching and comparing the features is a relatively influential theory, it also explains the

reason why the Prototype Theory and the Context Theory emerge in categorization theory based on similarity. At present, the research of judging similarity based on the features of things mainly focuses on the comparison of commonalities or differences between the matching features of things, and there are also some quantitative studies of corresponding similarity calculations like the Contrast Model (Tversky, 1977). However, the phenomena of “similar in spirit” indicate that the matching features of things may have a hierarchical or primary and secondary relation. Some primary features may have greater impact on similarity judgment than other secondary features, and even if we ignore the similarity of some secondary features, a consistent similarity judgment results can be obtained. But in current research, few mentions about the matching features of things themselves and their effect on similarity. Therefore, the theory of similarity may be further improved. One possible way is to improve the mechanism of similarity judgment to cover the principle of the phenomenon of “similar in spirit”. The other possible way is to judge whether there are unknown factors affecting the judgment of similarity, leading to the occurrence of the phenomenon of “similar in spirit”, or the two ways are parallel.

3. Theoretical Model and Hypothesis

According to the theories of Feature-based and Structural mapping Model, combined with the concepts of “similar in form” and “similar in spirit” proposed in the Ideas of Form and Spirit, this study points out that the theoretical prerequisite that there are some key features in the shared features. When the similarity of these key features is higher than a certain threshold, people will consider these two things similar or categorize them into the same category. In this situation, the similarity of other non-key features has little influence on the judgment of whether objects are similar or not. On the contrary, when the similarity of these key features does not reach a certain threshold, even if the similarity of other non-key features is very high, people may not think that these two things are similar.

In this context, how to determine the key features of things is an important premise to judge whether things are similar. The process of Similarity judgment will be influenced by the context and objects of comparison (Goldstone et al., 1997). The context of a comparison may influence the weights assigned to the features, and different compared objects may create or recruit a new context, which in turn influences the salient of the specific features. This suggests that the key features of a thing may be change dynamically with the compared context and objects. Besides, the process of similarity judgment is also affected by the theoretical knowledge related to the objects. In the absence of theoretical knowledge, individuals mainly make appearance-based similarity judgment, while individuals will make knowledge-based similarity judgment after mastering theoretical knowledge (H. Sun & Yin, 2019). The results of a bird naming experiment show that bird experts use more specific names to name bird image, while non experts use more general names (Tanaka & Taylor, 1991). It suggests that knowledge and experience have a significant impact on object categorization, and people with different knowledge and experience may have significant differences in the determination of key features.

According to the prior studies, the processes of comparison can be divided into two situations, one is that two objects of comparison exist at the same time, the other is that only one object appears and compare to the object in people's mind. Based on Selective Attention Theory (Treisman, 1969) and Categorization Theory (Rosch, 1973; Medin & Schaffer, 1978), we can reasonably suggest that when two objects exist at the same time, people are more inclined to judge the similarity by comparing the features of perceptual attention; when only one entity appears, people are more likely to carry out the categorization process of prototype or context based on similarity. The phenomenon of "Similar in spirit" often occurs in different categorization of objects, for example, the similarity between human and animals. Therefore, the objects of comparison can be divided into the same category and the different categories.

According to the theoretical prerequisite and prior studies, this study defines "similar in form" and "similar in spirit" as follows: under the certain knowledge experience and a certain cognitive situation, when two things exist in the shared features that can be recognized, if the similarity of non-key feature is higher than a certain threshold, the two things are considered to be "similar in form" to each other; and if the similarity of key feature is higher than a certain threshold, the two things are considered to be "similar in spirit" to each other.

Based on the above theoretical prerequisite and definitions, a theoretical model can be established to describe the results of the similarity comparison between two things as Figure 2, assuming that the compared things are A and B, the X-axis represents the set of shared features of A and B. In the comparison of A and B, the Y-axis represents the degree of similarity of a shared feature, 0% means that the features are completely different, and 100% means that the features are completely the same. Theoretically speaking, comparing any two things according to the similarity of features will be presented as a curve on the chart.

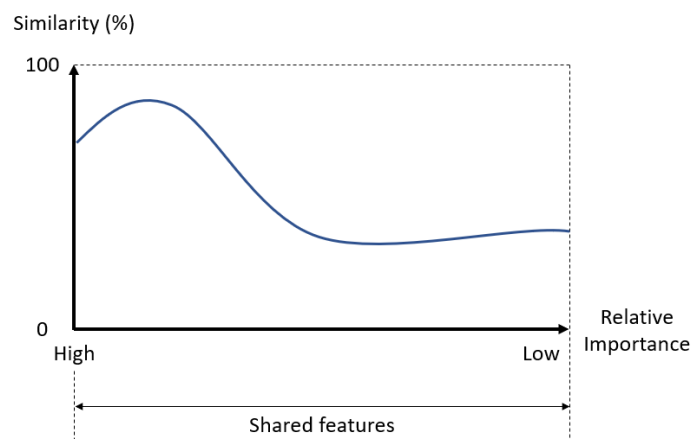


Figure 2 Feature similarity curve in two things comparison.

In Figure 3, the shared features (X-axis) can be ranked in order of relative importance. Those features, which the relative importance is higher than a certain threshold, can be known as “key features”. x_1 represents the number of key features of the shared features between A and B, and features with relative importance less than x_1 are non-key features. Considering the cognitive ability restriction of human being, x_2 represents the number of shared features that humans can recognize under the limitation of physiological conditions. Those features outside the x_0 - x_2 interval mean that they can’t be perceived by humans and are of lowest relative importance. Therefore, x_0 - x_2 interval is the shared features to be compared, where x_0 - x_1 interval is the key features and x_1 - x_2 interval is the non-key features.

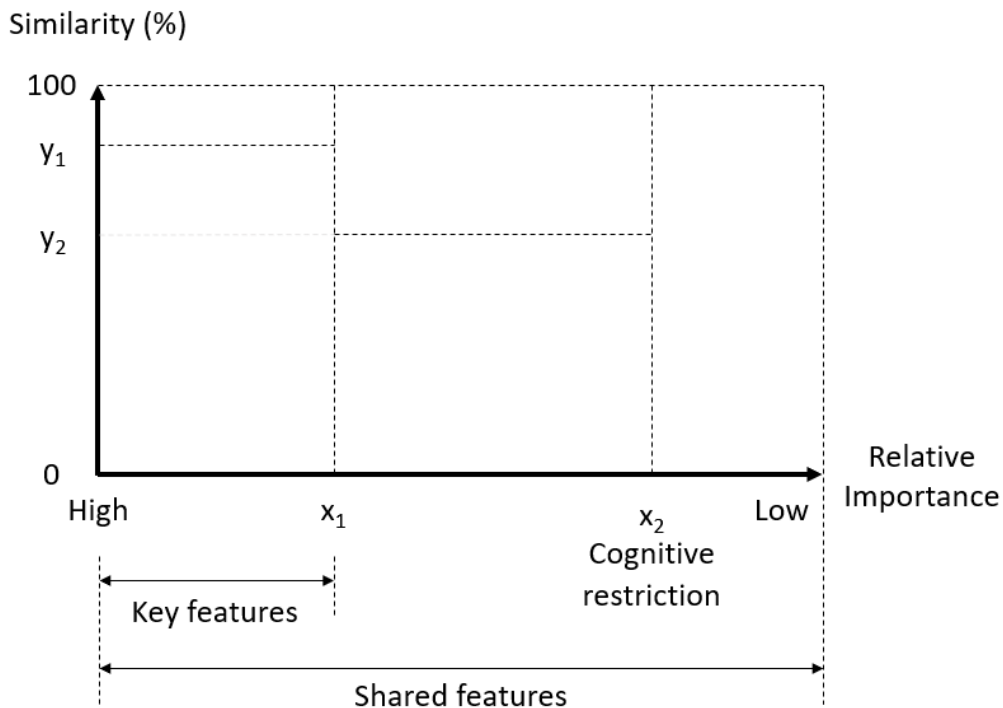


Figure 3 Feature similarity curve in two things comparison.

If individuals want to judge whether two things are similar to each other, the similarity degree of features needs to reach a certain threshold. The threshold required for similarity between key and non-key features is different, y_1 represents the threshold of key features required for similarity judgment, and y_2 represents the threshold of non-key features required for similarity judgment. When the similarity of key features (x_0 - x_1) reaches y_1 , the compared objects are “similar in spirit” to each other, and at this time, it is considered that A and B are similar whether the similarity of non-key features reaches y_2 or not. When the similarity of non-key features (x_1 - x_2) reaches y_2 , the compared objects are “similar in form” to each other, but whether people think that A and B are similar or not may depends on whether the similarity of key features reaches y_1 threshold. The four relations between “form” and “spirit” described in Figure 1 can be further described by the following four curves in Figure 4 by using this chart:

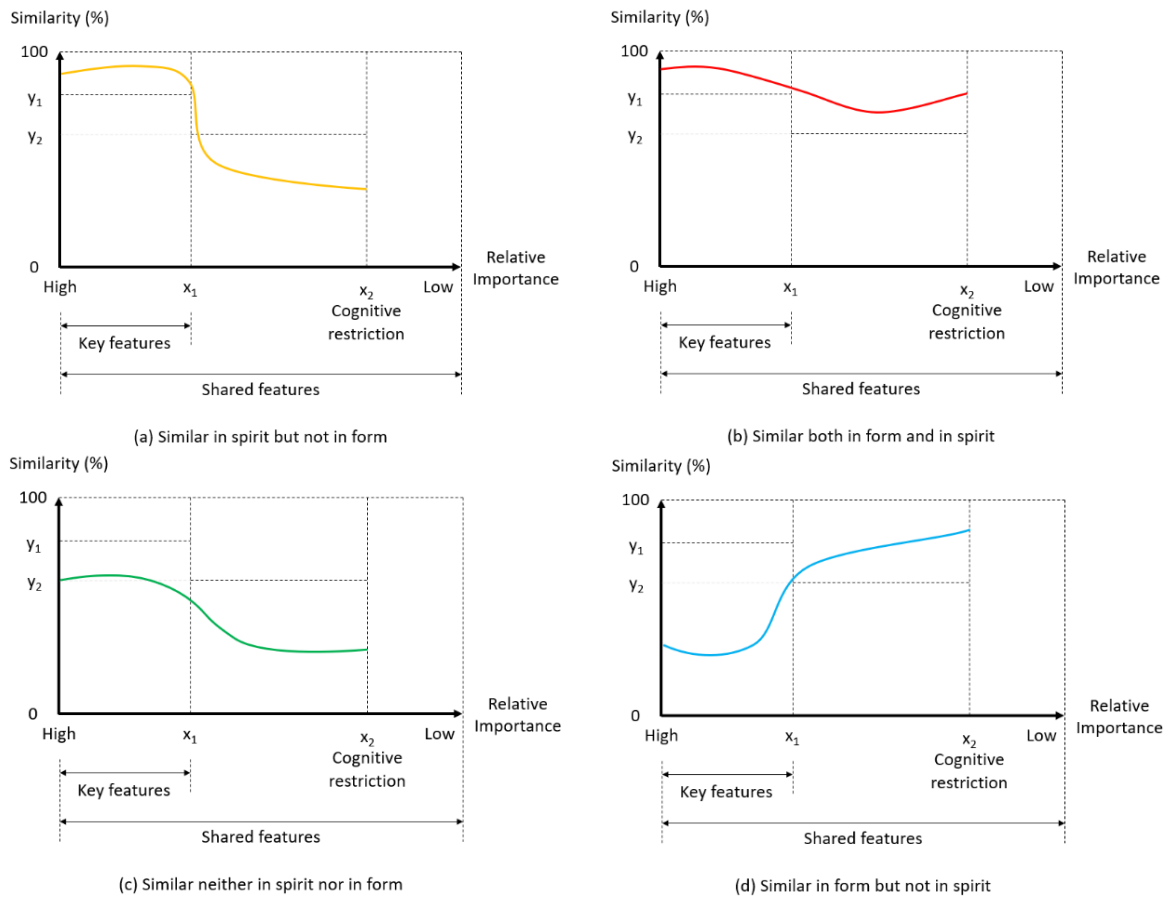


Figure 4 The four relations between “form” and “spirit” described by theoretical model.

The feature similarity of any two things can be roughly divided into the above four situations: (a) when the similarity of each key feature in the shared feature is higher than or equal to y_1 , but the similarity of other features is lower than y_2 , it is considered that the two things are “similar in spirit but not in form”; (b) when the similarity of each key feature in the shared feature is higher than or equal to y_1 , and the similarity of other features is higher than or equal to y_2 , it is considered that the two things are “similar both in form and in spirit”; (c) when the similarity of each key feature in the shared feature is lower than y_1 , and the similarity of other features is lower than y_2 , it is considered that the two things are “similar neither in form nor in spirit”; (d) when the similarity of each key feature in the shared feature is lower than y_1 , but the similarity of other features is higher than or equal to y_2 , it is considered that the two things are “similar in form but not in spirit”.

In the (b) situation of “similar both in form and spirit” or (c) situation of “similar neither in form nor in spirit”, people probably can easily judge whether the two things are similar or not. But whether people will not consider the two things are similar in the (d) situation of “similar in form but not in spirit”, or whether people will consider they are similar in the (a) situation of “similar in spirit but not in form”, needs to be verified by survey and research.

In the previous theoretical prerequisite, judging “similar in spirit” needs to satisfy that the similarity of all key features between two things to be compared has to reach the certain

threshold (y_1). Judging “similar in form” needs to satisfy that the similarity of other features has to reach the certain threshold (y_2). Taking the judgment of “similar in spirit” as an example, when only part of the key features between two things reach the threshold y_1 of similarity, whether people will consider that they are similar at this situation, needs further research.

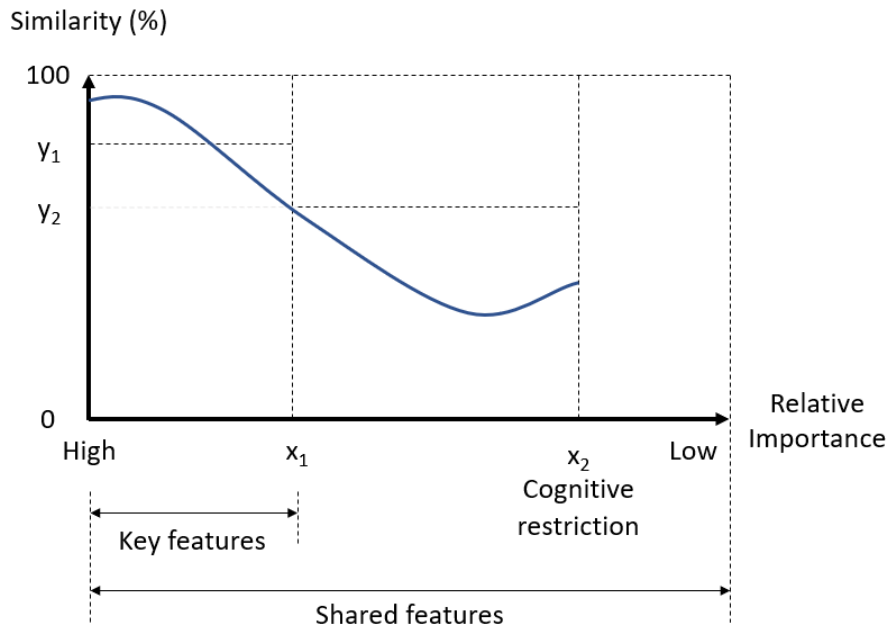


Figure 5 Part of the key features reach the threshold.

In this situation, there are two possible solutions. One shows in Figure 6 is to adjust the threshold of the relative importance of key features, and move those features that can't reach the feature similarity threshold (y_1) into other features to ensure that each remaining key feature meets the similarity threshold (y_1), and then the remaining key features should be investigated again to confirm whether it is enough to judge “similar in spirit”.

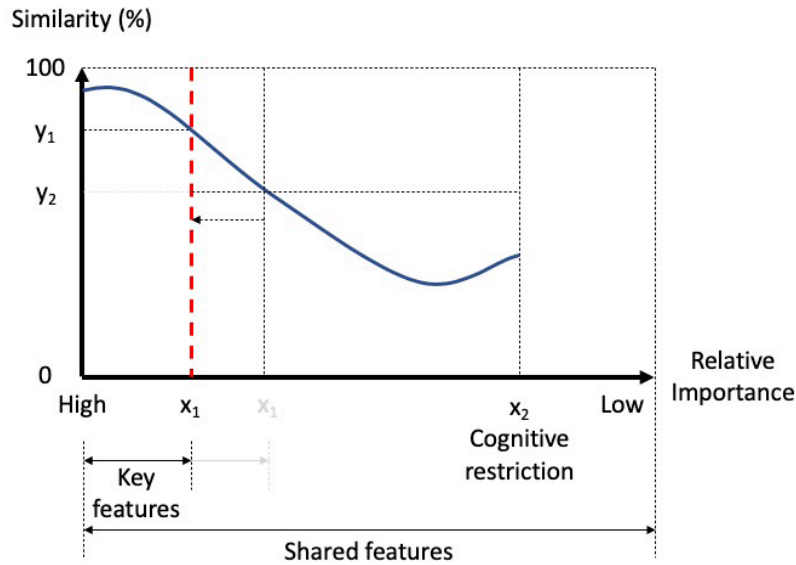


Figure 6 The relative importance threshold adjustment of key features.

The other method shows in Figure 7 is to calculate the area S_1 formed by the curve of the similarity degree of the shared features and the number of key features (x_1), and compare it with the area S formed by the similarity threshold (y_1) of the number of key features (x_1). When $S_1 \geq S$, people may judge the two as “similar in spirit”; when $S_1 < S$, they may not be judged as “similar” to each other.

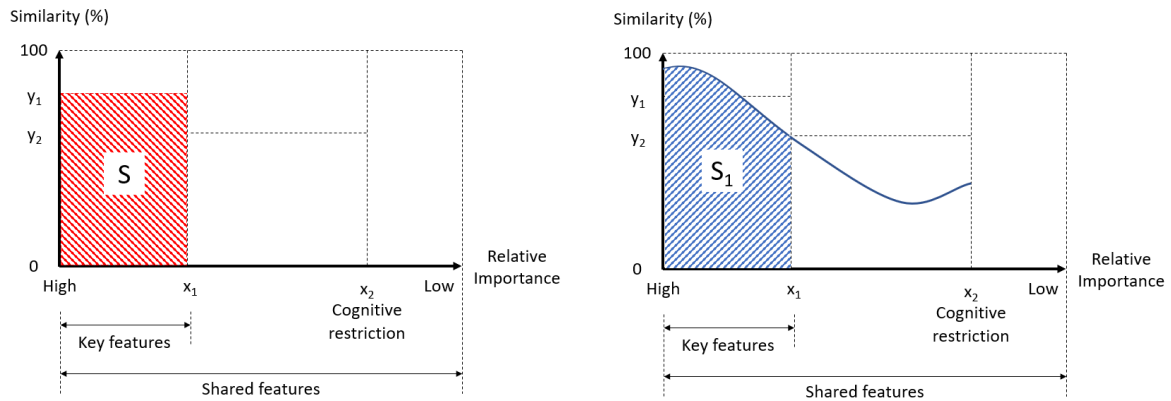


Figure 7 The comparing area S and S_1 .

4. Summary and discussion

4.1 Theoretical inference

Based on the ancient Chinese theory of form and spirit and related theories of cognitive psychology, this research proposes a theoretical prerequisite that the relative importance of features will affect the similarity judgment process based on the comparison of shared

features of objects. There are some key features in the shared features of compared objects. When the similarity of key features reaches a threshold, the influence of the similarity of non-key features on the judgment will be reduced.

To verify this model in Figure 3, there are multiple thresholds that need to be clearly defined.

1. The first is the threshold (x_1) of the number of key features of things. Because the key features of a thing will be influenced by the compared context and objects, so the key features of a thing are changing dynamically. Therefore, when making similarity judgment, the first thing to do is to determine the shared key features of things;
2. The second is the similarity threshold of key features (y_1) and non-key features (y_2). When the similarity of non-key features is higher than the threshold y_2 , people may consider that two objects are “similar in form”. When the similarity of key features is higher than the threshold y_1 , people can judge similarity directly from the key features, even ignoring the similarity of other features;
3. The third is the percentage of features (Y-axis). One physical way is to measure the similarity of features through the ratio of physical properties of the objects, such as length and volume. The other psychological way is to measure the similarity of features through the psychological scale score by doing survey. The attributes of the shared features are the decisive factors in determining which way to use to measure similarity.

4.2 Related Potential Applications

The core of this model is to determine the similarity in a quantitative way, and there are many potential application directions:

1. This model can provide quantitative standard for the protection of intellectual property rights (IPR). Similarity is one of the most important standards for examining IPR, especially the design patents. There are three main procedures, which are Patent Application Examination, Invalidation Application and Patent Infringement Determination, need to judge the similarity of patents. In current judicial practice, it is mainly judged whether IPR have been infringed by subjective and qualitative way, lack of quantitative evaluation.
2. After determining the key features of things, it is assumed that as long as the similarity of key features reaches the threshold (y_1), then the impact of other non-key features is relatively insignificant at this time. In other words, the non-key features can be created freely without worrying about changing the essence. For example, when we try to create a series of products with consistent brand image, we can grasp the “spirit” of brand characteristics to create a novel “forms”, while ensuring the diversity of product shape, but also to maintain a consistent brand image.
3. The model of this may provide ideas for bionic design. The core of bionic design

is to imitate the special ability, shape or structure of biological principles to design products. How to extract the biological “spirit” to design the “form” of products is one of the possible applications that this model can explore.

4. In addition to traditional product design, relate applications may also be obtained in the movie, game and animation industries. For example, in common character modelling and special effects processing, it is necessary to process people’s appearance into different forms to meet the needs of games or movies. If the model of this study is established, we can maintain the character’s “spirit” to create corresponding “forms” that required, or even algorithms can be developed to automatically generate various different effects.

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