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The Furniture of Science Fiction: Studying Audience Cognitive Mechanisms to Understand How Designed Objects Convey Social Ideas through the Semantic Differential Method

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People obtain information from the physical world and continuously organize this stream of stimuli data via a complex process known as cognition formation. Due to its the complexity of this process, it is difficult to accurately express and assess people's cognition of objects. However, for designers, understanding the logic and principle behind an audience's cognitive process is essential for their design activities. This study focuses on the cognitive mechanisms of audiences obtaining social-information generated from designed objects. The study seeks to establish an updated cognitive model, building on the hypothesis that audiences form cognition about the social environments of objects through the perception of physical features of and emotional responses to objects. To test this hypothesis, an integrated design research methodology was designed based on the Semantic Differential Method (SDM). An object from a science fiction (Sci-Fi) film was selected as an example to research how designed objects convey social information. The results largely validate the hypothesis by revealing that audience cognition exists at different interconnected levels. The findings of this study can help designers better understand audience cognitive mechanisms, and the methodology described can be a useful tool for designers to obtain and analyse audience cognition of objects through the design process.

Keywords: Design Research; Cognitive Mechanisms; Semantic Differential; Science Fiction

1 Introduction

The purpose of this research is to study audience cognitive mechanisms to understand how designed objects convey social ideas. In this study, the *audience* refers to the group of people who encounter a work of design. Encountering an object includes perceiving the object through the senses, such as vision and hearing as well as interacting with the object, such as usage behaviours. The *cognitive mechanism* is defined as the principle and logic behind people's mental actions or processes of acquiring information, which mainly focuses on the processes and outcomes of cognitive behaviours. *Designed objects* refer to any physical objects that have been designed by people to distinguish from natural objects that

have not been processed by people. *Social ideas* refer to the social information carried by objects, through their production and use in human social environments. Specifically, this includes social conditions of politics, culture, economy, technology, and resources available from the natural environment.

1.1 Science Fiction Films

It has been more than a hundred years since the production of *A Trip to the Moon* (1902), generally considered the first science fiction (Sci-Fi) film. Even though Sci-Fi films are born of the popular culture industry, there are many masterpieces with deep thinking on the human condition in this genre. In a certain sense, Sci-Fi films are thought experiments about the possible future of human social development; therefore, they often express powerful social ideas. They usually construct a singular landscape that is outside reality to contemplate the absurd consequences of human development and explore the ethical dilemmas of human society under particular circumstances. Sci-fi films reflect on the history, the present, and the future of human society—often with profound implications or critique.

Because Sci-Fi films are to some degree social experiments, their creators often adopt vanguard or extreme means of expression. As a result, the visual style of Sci-Fi films is often intense and distinct. In the context of the Sci-Fi film genre, imagination and social thinking are expressed through specific design elements. In other words, the visual elements are the manifestation of the film creators' deep thinking about human society and the thinking are the logical supports behind the visual and set design.

Sci-Fi films are highly dependent on environmental settings, with visual elements playing an important role. Successful Sci-Fi films require consistency in the logic of the narrative, which means film objects, such as props or scene settings, need to fit into the portrayed social environment. Therefore, compared to other genres of films, the designed objects in Sci-Fi films have a greater sense of existence and often carry metaphors about the social environment being explored.

1.2 Audience Cognitive Mechanisms

The study of the information conveyed by the product belongs to the category of product semantics. Krippendorff and Butter (1984) first proposed this term in the Industrial Designers Society of America (IDSA)'s journal Innovation. They defined "product semantics" as both an inquiry into the symbolic qualities of things and as a design tool to improve these cultural qualities (Krippendorff & Butter, 1984). According to Demirbilek and Sener (2003), product semantics study how to identify appropriate visual, tactile and auditory information and incorporate it into product design. The study of product semantics includes the whole process of incorporating and interpreting the meaning of products. The study of audience cognitive mechanisms focuses on mental actions or processes on interpreting the meaning of objects.

Any object that exists in the physical world contains and provides information, and human mental actions or processes for acquiring this information is the cognition of things ("Cognition," 2016). This information is usually about the object itself and its environment. As intelligent beings, humans can directly perceive individual and specific entities as well as understand the surface connections and relationships of objects. They use existing knowledge and previous experience to mentally establish connections, to form concepts of things, to rationalize and judge confrontations with new things, and to solve problems or reconcile inconsistencies.

An audience's cognition of objects is often considered subjective and difficult to accurately express and assess. The cognitive model, previous experience, context and an audience's immediate emotional state, all affect cognition of a specific object at a particular moment. Therefore, cognition of any given object could vary widely between different independent audiences. Moreover, the dominant cognitive outcomes can be formulated in many different forms, such as emotions, feelings, thoughts, ideas, and so on. Therefore, it is extraordinarily complex and challenging to get accurate information about an audience's cognition of an object.

However, for design activities, it is essential to obtain a determined audience's cognition of objects. Norman (1988) pointed out that design is an act of communication. A designed object is a medium that connects its creators and audiences across time and space. Beside the physical properties, functions, and interaction modes of an object, the information contained by the object also includes the aesthetic perspective, attitude, and social contexts (or assumptions) of its creators. As the object interacts with audiences in increasing degrees of intimacy, it inevitably carries more information about time and space: history and environment. Giving information to objects and extracting information from objects are two relatively independent processes. From the moment the object is fully realized through production, interpretation of the object is out of the creator's control. Any audience has the opportunity to interpret that object without considering the designer's intentions. However, cognitive responses of an audience can provide important feedback for designers to evaluate and reflect on their design activities. Therefore, designers, as creators of objects, can benefit from effective tools and methods to better understand audience cognition of objects.

While our cognitive process is complex, cognitive behaviours follow general rules. Through reasonably designed methods, cognition can be evaluated and understood—at least to some extent. Cognitive psychologist Broadbent (1958) studied the cognitive model of humans in his book "Perception and Communication" and proposed the "filter model of attention." His study showed some common mechanisms for people's cognition. According to anthropologist Brown (1991), there are universals common to all human societies. Cognitive science shows that human beings have formed commonalities in underlying psychological mechanisms during the long evolutionary process. For example, Gestalt psychology revealed the general cognitive law of the relationship between parts and the whole (Koffka, 1935). A recent psychological study shows that even for a novel object, people still have at least some shared impressions (Kurosu & Todorov, 2017).

1.3 Hypothesis of the Study

Norman (2004) created a model which indicates that human reaction to design exists at three levels: visceral (appearance of the objects), behavioural (how the objects perform), and reflective (users' personal feelings and opinions about the objects). Based on Norman's theory, an updated cognitive model was proposed as a hypothesis to explain audiences' cognitive mechanisms on acquiring social environment information from objects (Figure 1). Cognition of objects can be divided into three levels. The first is the Sensory Level (Level 1). An audience cognition at this level is based on sensory information directly conveyed through physical features of the object (e.g., material, shape, and colour). Cognition at this level forms instantly without much reflection. Based on cognition acquired at the Sensory Level, after some mental processing, more abstract impressions and responses are formed at the Concept Level (Level 2). Finally, the audience forms cognition indirectly through

association, imagination, and reflection based on abstract information, such as metaphor or symbolic of the object, at the Reflective Level (Level 3). In this study, cognition at the Reflective Level is particularly related to information on the social environmental (social ideas), as conveyed through the objects. Although these three levels are independent, there are relationships between them. The concrete physical features are the basis of cognition at all three levels, and cognition formed at the second and third levels are based on interpretation of the cognition at the first level. The Concept Level is the bridge that connects the Sensory Level and Reflective Level. Cognitions at the second level and third level are abstract and are the results of the combination of concrete information and existing cognition.

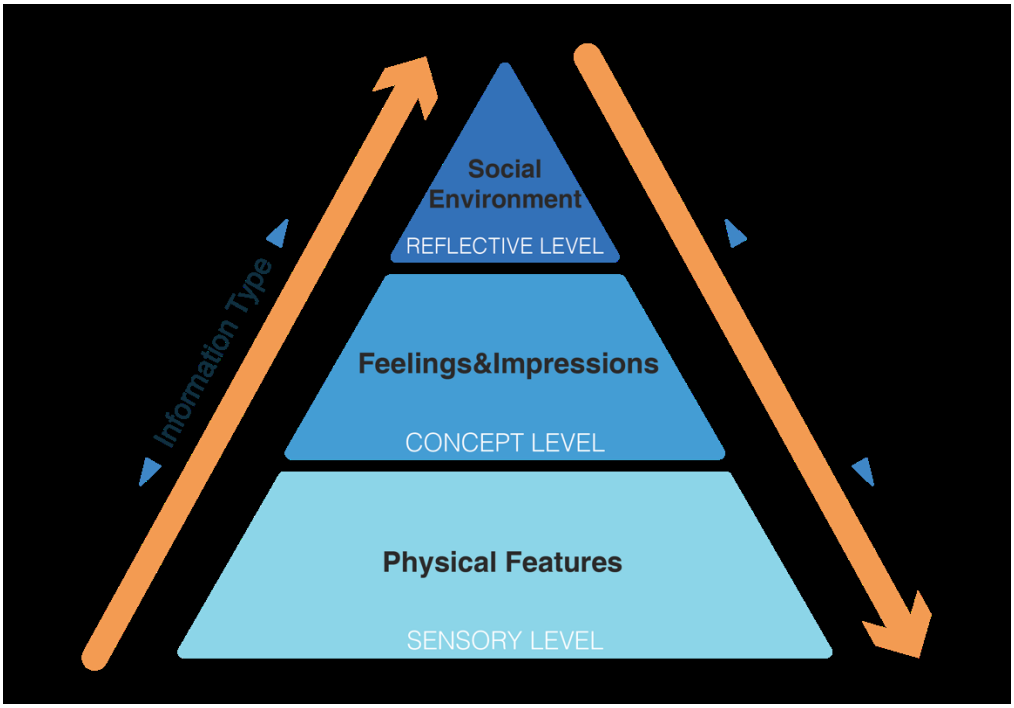

Figure 1 Cognitive Model Proposed in this Study

2 Methods

2.1 Research Method

Based on the proposed cognitive model (Figure 1), this study attempted to reveal patterns of audience cognitive mechanisms by studying how objects in Sci-Fi films convey social-environment information. Researcher designed an integrated research method utilizing the Semantic Differential Method (SDM) and Structured Interview. SDM is a type of a rating scale designed to measure the connotative meaning of objects, events, and concepts (Osgood et al., 1957). It consists of testing and analysis, in which users assess an object according to a list of semantic attributes (Demirbilek & Sener, 2003). These attributes are defined by pairs of antonymous adjectives (bipolar adjectives), which lie at either end of a qualitative scale. For example, “Cold” and “Warm”, “Good” and “Evil”, or “Happy” and “Depressed.” Most frequently, research participants are asked to score their attitudes to an object on a set of scales (Kumar, 2013).

The integrated method was applied to a singular object, the Djinn Chair (Figure 2) from the famous epic Sci-Fi film *2001: A Space Odyssey* (1968), to obtain and analyse the cognition

of audiences. Djinn chair is representative of the futuristic design style of the 1960s, created by French industrial designer Olivier Mourgue in 1965 (Fiell & Fiell, 1997).

Figure 2 Djinn Chair

Researcher extracted attributes of the chair according to the three levels of the hypothetical model. A seven-point semantic differential scales were used to measure participants' cognition of each attribute. At the Sensory Level, attributes were primarily concerned with physical features of the object, such as shape, colour, material, and texture. At the Concept Level, attributes included impressions, feelings, and opinions, such as "Luxurious" or "Plain." At the Reflective Level, seven attributes were used to measure the anticipated conditions of the social environment in which the chair might exist: social order, social structure, cultural tolerance, economic development, technology development speed, natural resources, and natural environment. Researcher selected bipolar adjectives deemed to best describe the attributes. This research did not try to study whether audiences' cognition is consistent with the film content, rather the study focused on relationships between cognition of the social environment as they derived from the sensory and conceptual impressions.

After the attributes and bipolar adjectives were determined, the questionnaire was created. The questionnaire was comprised of seven sections, including both quantitative and qualitative questions. In part 1, participants were asked to write down first impressions of the objects and aimed to obtain cognition formed first by participants. In parts 2, 3, and 5, semantic differential scales were used to obtain participants' cognition at three different cognitive levels. In part 4 and part 6, researcher interviewed participants to obtain more information about the cognition formation process. In part 7, participants were asked to answer several questions related to the research topic to understand participants' personal characteristics, including their perceptions of Sci-Fi generally. Parts 2 (Level 1, Sensory Level), 3 (Level 2, Concept Level), and 5 (Level 3, Reflective Level) are the main parts of the questionnaire, examples of which are given in Figure 3.

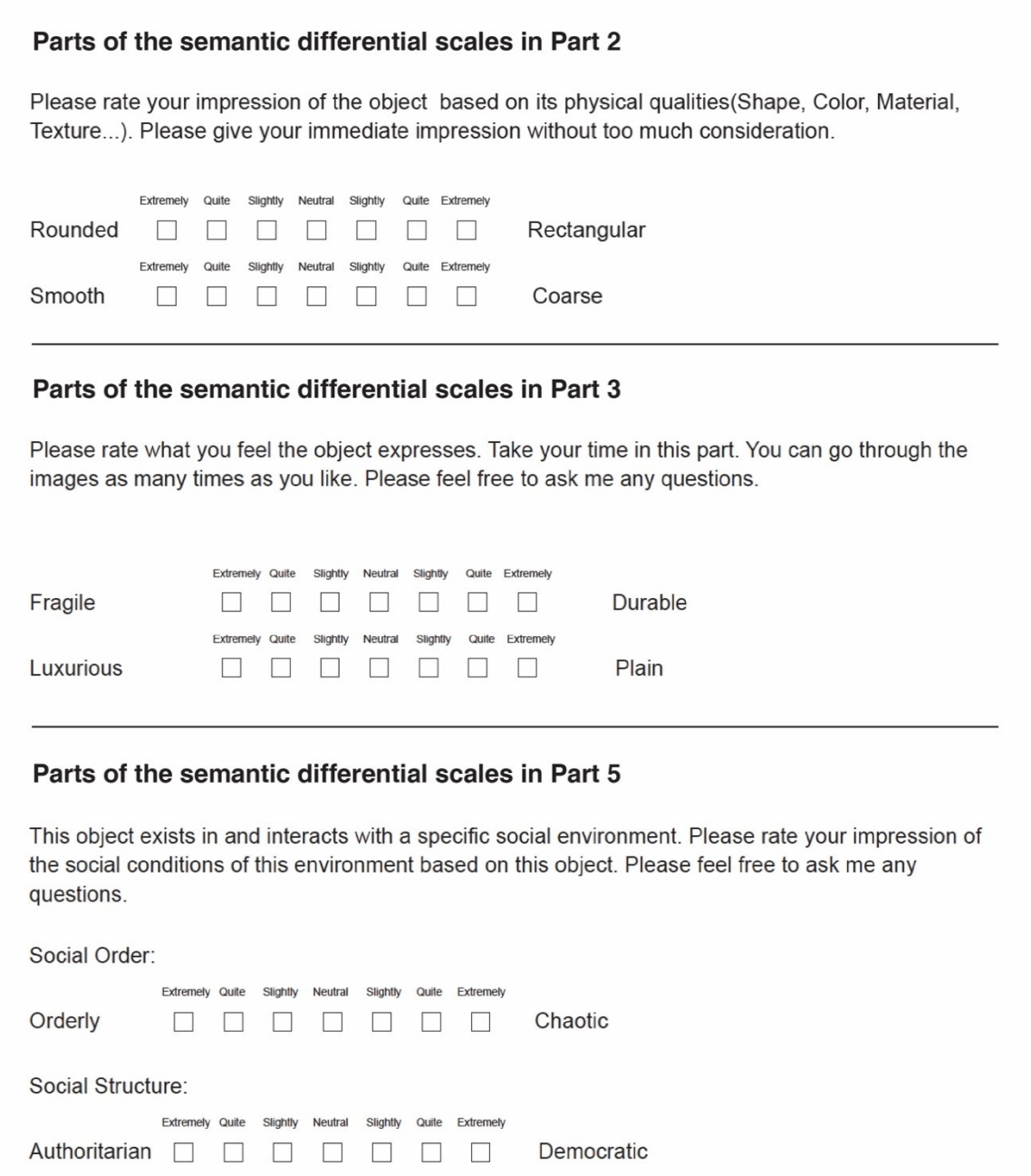

Figure 3 Representative Parts of the Questionnaire

In each individual survey, the object image (Figure 2) was shown to the participant. Participants were then asked to complete the questionnaire based on the image. The instructions given to participants during the survey followed a prepared research protocol and were adjusted only slightly based on different responses of each participant. All the research sessions were recorded with prior consent of the participants.

Twenty-two subjects participated in the research (15 females and 7 males). All were 20-40 years old students in the Master of Design Program (MDes) at University of Cincinnati. Nine of the participants had previously watched the film *2001: A Space Odyssey* (1968), but none of the participants recognized the object as being from that film.

2.2 Data Processing

After the questionnaire was completed, the responses for the semantic differential scales were converted into quantitative data by assigning values to different points in the scale (Figure 4). All data collected from participants were analysed to study the relationship between the three cognitive levels—especially, the relationship between the Reflective Level and the other two levels. The statistical software, SPSS Statistics, was used to conduct the correlation analysis. Further analysis, such as regression analysis, was conducted based on the results of the correlation analysis. The analysis of qualitative data obtained from interviews primarily aimed to obtain the cognitive logic of participants to support the analysis of the quantitative data.

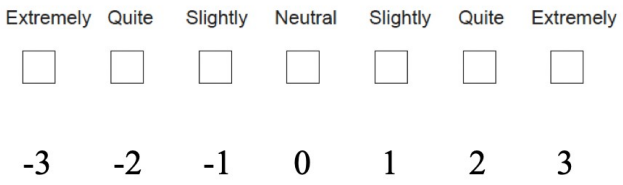

Figure 4 Value Assigned to Different Points in the Scale

3 Results

3.1 Correlations between Cognition at Different Levels

The rating results for each attribute—responses from 22 participants—comprised one data set. Each data set was treated as one continuous variable. All 31 variables (31 semantic differential scales in total) were divided into three different groups according to their relevant cognitive levels. There were eight variables in group 1 (Level 1), 16 variables in group 2 (Level 2), and seven variables in group 3 (Level 3). The correlation analysis was used to establish possible connections between two variables in two different groups.

This study used the Pearson Correlation Coefficient (PCC) to measure the statistical relationship or association between two continuous variables. It was developed by Karl Pearson (1895) and is regarded as one of the best methods of measuring the association between variables of interest.

Based on the analysis, all attributes with correlations are shown in Table 1. Whether the correlation is positive or negative is related to the sequence of the two adjectives in a pair of bipolar adjectives. To ascertain the neutrality of the question in the research, the sequence of adjectives was randomly set. In Table 1, all correlation relationships have been converted into positive correlations by converting the sequence of two adjectives in one pair of bipolar adjectives.

Table 1 Attributes with Correlation

Bipolar adjectives of Attribute A	Bipolar adjectives of Attribute B	Coefficient of Determination
Depressing-Happy	Cold-Warm	44.50%
Understandable-Incomprehensible	Whole-Combined	30.70%
Harmonious-Discordant	Whole-Combined	30.50%
Understandable-Incomprehensible	Warm-Cold	29.60%
Masculine-Feminine	Heavy-Light	26.10%
Practice-Decorative	Hard-Soft	23.90%
Masculine-Feminine	Cold-Warm	23.60%
Practice-Decorative	Heavy-Light	22.70%
High-tech-Low-tech	Hard-Soft	22.30%
Creative-Unoriginal	Clean-Dirty	20.80%
Classy-Vulgar	Coarse-Smooth	19.60%
Social order: Orderly-Chaotic	Clean-Dirty	21%
Social order: Orderly-Chaotic	Heavy-Light	18.60%
Social order: Orderly-Chaotic	Understandable-Incomprehensible	44.50%
Natural Resources: Scarce-Abundant	Particular-Common	27.00%
Social Structure: Authoritarian-Democratic	Luxurious-Plain	24.40%
Social order: Orderly-Chaotic	Practice-Decorative	22.20%
Culture Tolerance: High-Low	Classy-Vulgar	20.20%
Natural Environment: Thriving-Ruined	Obedient-Rebellious	18%
Note		
	Correlations Between Sensory Level and Concept Level (1-2)	
	Correlations Between Sensory Level and Reflective Level (1-3)	
	Correlations Between Concept Level and Reflective Level (2-3)	

The results show there are correlations between different attributes and these correlations occur between any two cognitive levels of the three. Specific to the two correlated attributes, this correlation is further reflected in the relationship between two specific characteristics of the attributes. For example, the attribute assignment “Happy-Depressing” is correlated with attribute assignment “Warm-Cold”, corresponding to specific assignments within these two attributes: “Depressing” is related to “Cold” and “Happy” is related to "Warm.” Since the correlation has been converted to positive correlation, while not very accurate, this can be interpreted that if the participant perceives the object as “Warm” rather than “Cold,” he/she has a greater chance of feeling that the object is “Happy” instead of “Depressing,” and vice versa.

The existence of correlations partially illustrated the rationality of the cognitive model proposed in this study. Particularly, the relationships between attributes at the Reflective Level (social environment) and attributes at the other two cognitive levels (Sensory Level and Concept Level) can exemplify the hypothesis of this study: audience cognition exists at different interconnected levels.

The regression analysis was then performed on each pair of correlated variables to measure the degree of the correlations. The results revealed that the degree of correlation for different pairs of related attributes is different, which means some correlations are stronger than others. The difference in the degree of correlation is illustrated by the coefficient of determination. The different degrees of correlations can be interpreted as: A pair of attributes with a larger coefficient of determination has a stronger correlation in participants’ attribute assignments. Take the example of participant’s cognition on the social order of the environment. As shown in Table 1, there are four attributes correlated with participants’ opinions of social order. Based on the coefficient of determination, it is reasonable to draw the conclusion that, compared to the assignment of “Heavy”, “Understandable” is more related with the assignment of “Orderly” in the cognitive interpretation of participants.

3.2 Hierarchy of the Cognitive Model

The analysis of the coefficient of determination further validates the hierarchy of the cognitive model proposed in this study. By calculating the average of all coefficients of determination between two cognitive levels, the “average coefficient of determination” can be determined. This can be used to measure the degree of correlation between two cognitive levels. Shown in Table 2, the average coefficient of determination between two adjacent levels (1-2, 2-3) are close and greater than the average coefficient of determination between nonadjacent levels (1-3). In other words, the correlation between adjacent levels is stronger than nonadjacent levels, which matches the hierarchy of the cognitive model.

Table 2 Average Coefficient of Determination between Two Cognitive Levels

Correlation between Levels	Average Coefficient of Determination
1-2	26.75%
2-3	26.05%
1-3	19.80%

The analysis of qualitative data indicates that there is a sequence to the formation of different levels of cognition. In part 1 of the questionnaire, researcher collected the words participants used to describe their first impressions of the object. There are 95 words in total, sorted according to the cognitive levels to which they belong. Forty-five of the words belong to the Sensory Level, forty-six of them belong to the Concept Level, and only four words belong to the Reflective Level. Figure 5 shows the distribution. With almost 95% of all words belonging to the Sensory and Concept Level, it is reasonable to assume that the formation of cognition at the Sensory Level and Concept Level happens prior to the Reflective Level.

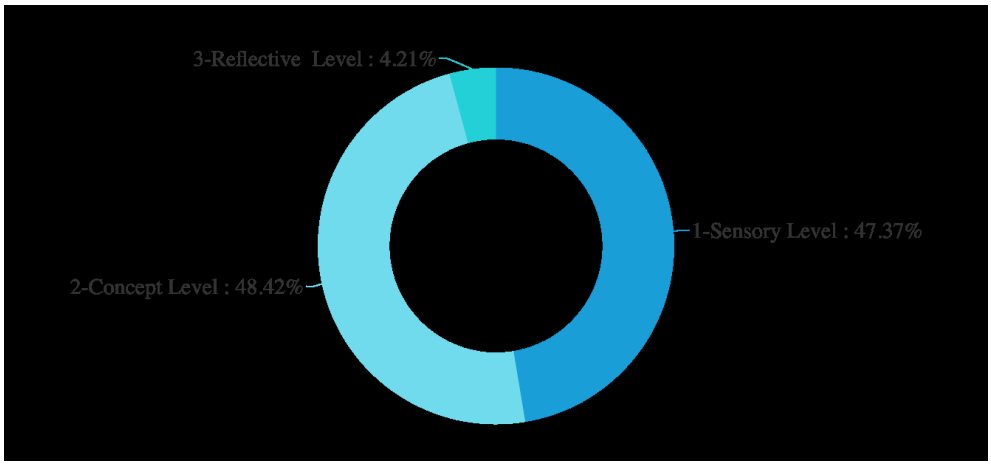

Figure 5 Distribution of First Impression of Participants

Further analysis of the interview data indicates the formation of cognition at the Sensory Level occurs prior to the formation of cognition at the Concept Level. According to the interview data, cognition at the Sensory Level is the basis for cognition at the Concept Level. For example, the two most frequent words at the Concept Level are “Comfortable” and “Feminine.” According to most participants, the perception of “Comfortable” was based on the perception of “Soft”, and the perception of “Feminine” is based on the “Pink” colour and “Round” shape. “Soft”, “Round”, and “Pink” all belong to the Sensory Level. Even when participants used words belonging to the Concept Level to express their first impressions,

they still based this on their cognition of the Sensory Level. In the interviews, participants indicated they did not use words associated with the Sensory Level to express their first impressions as they preferred to express the concepts and opinions they felt they had formulated rather than the “too obvious to say” physical features at the Sensory Level. Therefore, the process of obtaining information and forming cognition is sequential, which is reflected in the reaction time of cognition formation. It is not a strict sequence, but it does illustrate that cognition is generally formed first at the Sensory Level, followed by the Concept Level, and finally at the Reflective Level (social environment).

4 Discussion

4.1 Interpretation Process

The research results illustrated the rationality of the hierarchy of the proposed cognitive model. It is reasonable to infer the progressiveness of the cognitive levels, that is, the formation of higher-level cognition is largely based on lower-level cognition. The process by which audiences form higher-level cognition based on lower-level cognition can be called the "Interpretation Process."

There are large individual differences in this process, which is the direct cause of cognitive differences of audiences. Standard deviation is a measure that is used to quantify the amount of variation or dispersion of a set of data values. The standard deviation of each data set was calculated. When the standard deviation is larger, the participants’ cognition difference on that attribute is greater. By calculating the average of the standard deviation of attributes at the same cognitive level, the “average standard deviation” can be determined. This can be used to measure the degree of difference in the overall cognition of the participants at a certain cognitive level. Table 3 shows the average standard deviation of the three cognitive levels.

Table 3 Average Standard Deviation of Three Cognitive Levels

Cognitive Level	Average Standard Deviation	Approximation
3-Reflective Level	1.506	1.5
2-Concept Level	1.325	1.3
1-Sensory Level	1.347	1.3

The average standard deviation shows the degree of difference of participants’ cognition at the Sensory Level and Concept Level is close, but there are greater differences at the Reflective Level. The greater differences come from the Interpretation Process. Take Participant-1 and Participant-20 as examples. Figure 6 shows their rating responses of the attributes at the Sensory Level (semantic differential scales 1-8). It is obvious that they formed similar cognitive impressions at the Sensory Level. However, according to their interviews, they formed very different cognition interpretations of the social environment (Reflective Level) based on their similar impressions of the physical features (Sensory Level) of the object. Participant-1 thought the society the object would exist in must be a democratic society while participant-20 thought that society must be a totalitarian one. Figure 7 shows their different interpretation processes. They started from similar points but ended with completely different conclusions.

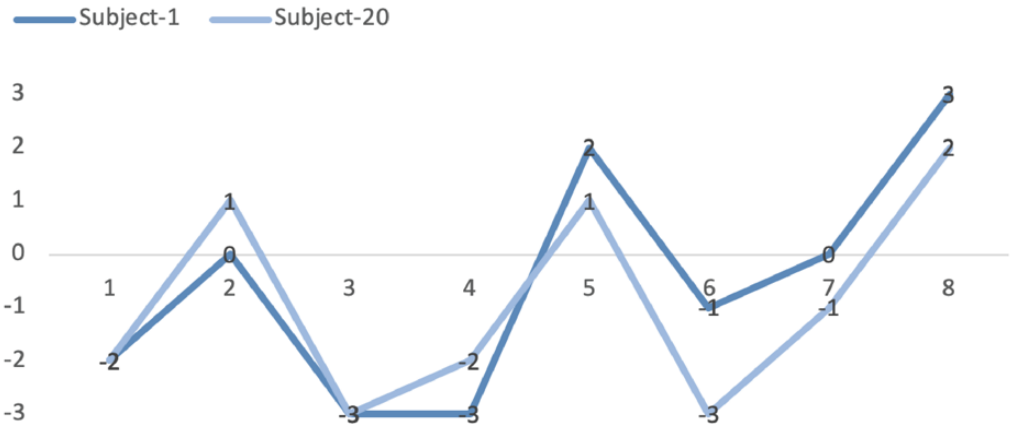

Figure 6 Rating Results of Attributes at the Sensory Level of the Two Participants

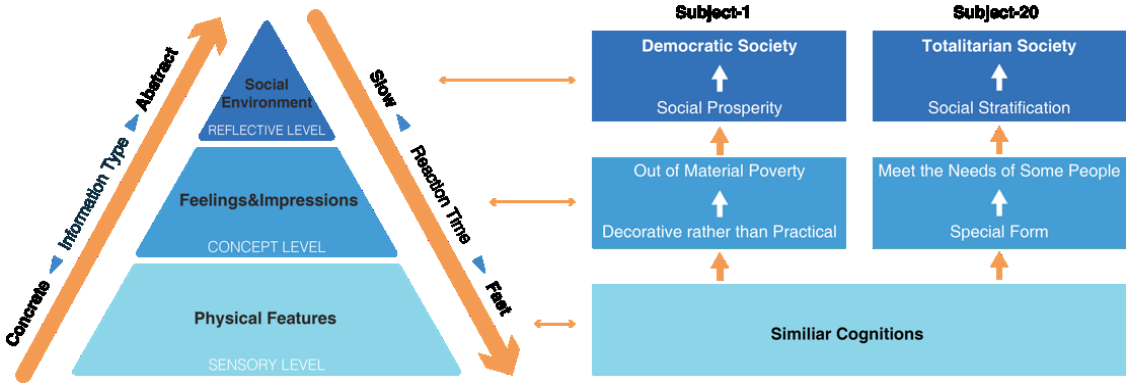

Figure 7 Different Interpretation Processes of Two Participants

The interpretation process is ambiguous and uncertain. When the information obtained by audiences is limited, which is very common in daily life, there will be more uncertainty in the interpretation process. For example, in this study, the chair image (Figure 2) and the sentence “this is a chair that comes from a film” were the only information given to participants. When participants talked about their opinions of the social environment information, the most common sentences were “I am not sure” and “I don’t have enough information to judge.” Under this circumstance, the social ideas they formed are blurred and uncertain. This uncertainty illustrates the complexity of the formation of cognition at the Reflective Level compared to the cognition at the Sensory and Concept Level.

4.2 Practical Application for Designers

Because of the characteristics of the objects in Sci-Fi films discussed above, this study selected one object that came from a Sci-Fi film. However, the research methodology used and results concluded in this study are not limited to furniture or objects in Sci-Fi films. Designed objects in real life also convey rich social information. In fact, the Djinn Chair was designed for commercial production prior to the creation of the film. The chair was later chosen by the director Kubrick to use in the film because of its unique design style. The methodology proposed and tested in this study can be customized and used in design activities to augment the design process, including during early stages of product development.

The applied research methodology combined with the Semantic Difference Method (SDM) and the Structured Interview can be an effective tool to help designers carry out design activities. Whether for commercial or experimental purposes, whether responding to external requirements or self-driven, designers are always translating social ideas into material forms. These ideas may be claims, values, or unquestioned assumptions. Most of them are abstract and operate at the second and third cognition levels (Concept Level and Reflective Level). However, in the process of designing, what designers deal with are not ideas but the concrete features of designed objects such as shape, colour, and materials. These operate at the first cognition level (Sensory Level). It is essential for designers to build a bridge to connect the abstract ideas they aim to express to the concrete features they design. The basis of this bridge is understanding the cognitive mechanisms of their audiences.

The core idea of this methodology is to study the connection between abstract and concrete information in the cognition of audiences, which is valuable to all design activities. Specifically, it can be used across different phases of design activities. In the preliminary research phase, it can be used to conduct research to understand the cognitive characteristics of the target user group. During the ideation phase, this methodology can provide quantitative data to inform design decisions. In the evaluation phase, it can be used to collect feedback on designed objects from specific audiences, augmenting decision-making for finalizing the specifications of an object's design.

4.3 Conclusion

Based on previous research, this study proposed an updated model (Figure 1) to explain audience cognitive mechanisms for interpreting social ideas (social environment information) from designed objects. Using the Semantic Differential Method (SDM) as the central method, an object from a Sci-Fi film was selected as the object to study. The study results validate the rationality of the cognitive model. The results show audience cognition operates at different levels, which include the Sensory Level (Level 1, physical features), the Concept Level (Level 2, feelings and impressions), and the Reflective Level (Level 3, social environment). There are correlations between cognition at different levels, and the degrees of these correlations are different. The abstract cognition at higher-level are based on the concrete cognition at the lower-level. The process of obtaining information and forming cognition at lower-level occurs prior to the high-level process in general, suggesting a sequential nature to the levels' relationships. The cognitive model proposed in this study can help designer better understand the mechanisms of audience cognition.

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