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Toward Deeper Understandings of the Cognitive Role of Visual Metaphors in Emerging Media Art Practices

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Abstract: In this paper, we explored the role and impact of a visual metaphor and the metaphoric-thinking process in emerging media art practices. We also examined how designers can leverage the metaphoric-thinking process to empirically create a visual metaphor. Our primary focus was to explore what kinds of design considerations are involved and what types of cognitive operations are performed to support designers as they create visual metaphors. By employing a critical analysis method, we probe how participants used metaphors to leverage their prior knowledge, expertise and experience when creating visual metaphors from an information-processing perspective using a cognitive task analysis method.

Keywords: visual metaphor; design process; emerging media art; critical task analysis

1. Introduction

Throughout history metaphors have made significant contributions to expanding our range of thinking. Using the associations between the source and target domains, metaphors enable rich expressions of arts and culture, from literature, painting, and music to user interface design. Indeed, metaphors enable us to integrate disparate entities and bring new perspectives into existence by way of "understanding and experiencing one kind of thing in terms of another."

In the field of visual arts, from traditional painting to the emerging media arts, visual metaphors have been widely used as a means of allegorical, iconic, symbolic, or sign expression. Visual metaphors are also considered as a framework to identify and analyze the underlying structures and intentions of the artwork. Creating visual metaphors is about mapping abstract concepts to visual, experiential elements with their own cognitive percepts; as new insights emerge, deeper levels of meaning are tapped as shown in Figure 1.

Leveraging such unique characteristics, artists and designers have used visual metaphors to produce creative and aesthetic solutions to design problems. According to Casakin (2011),

designers use visual metaphors in the design process for various reasons: 1) to identify, frame, and solve design problems, 2) to justify design decisions, 3) to develop products that resonate with users, and 4) to render the values and meanings they wish to assign to the design outcome.

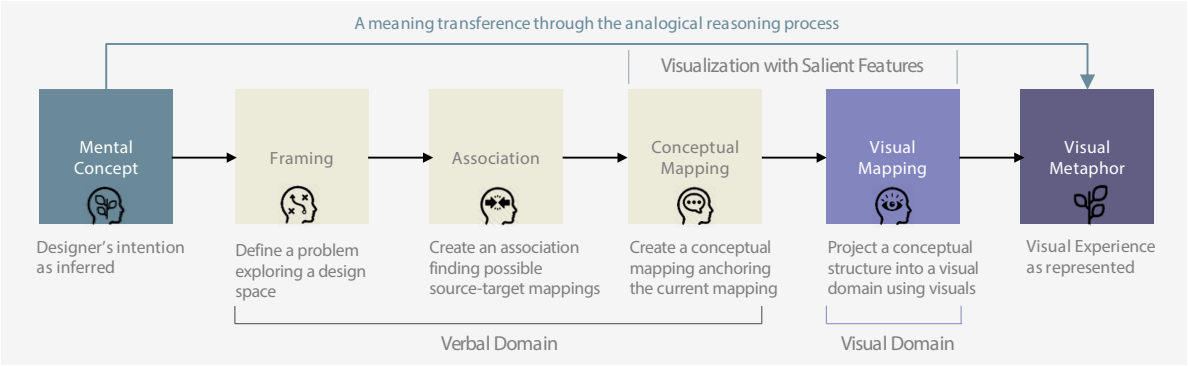

Figure 1 A meaning transference through the metaphorical reasoning process

Recent studies in related disciplines have created new methods for studying and exploring the potential of visual metaphors. Researchers have investigated the roles and impacts of visual metaphors in relation to visual art (Aldrich, 1968; Feinstein, 1985; Kennedy, 2008), architecture (Casakin, 2011), gestures (Cienki & Müller, 2008), cartoons (Forceville, 2005), cinema (Carroll, 1996), advertisements (Forceville, 2002; Phillips & McQuarrie, 2004), interface and software design (Blackwell, 2006; Fishkin, 2004; Hurtienne & Blessing, 2008), information visualization (Ziemkiewicz & Kosara, 2008), and visualization as art (Cox, 2006).

Nevertheless, the focal point of previous studies was geared toward metaphoric expressions and the differences in graphical elements at the presentation level rather than understanding the roles and influences of visual metaphors in the design process. Also, previous investigations did not provide sufficient explanations regarding what design considerations were involved and what types of cognitive operations were performed to support the visual metaphor creation process. Investigating visual metaphors in the field of design is a challenging problem because metaphors are mainly discussed in the context of language.

Thus far, only a few researchers have proposed structured means to incorporate metaphor in design research (Cupchik, 2003; Forceville, Hekkert, & Tan, 2006; Hey et al., 2008; Krippendorff & Butter, 2008; Van Rompay, 2008). However, none of these studies provided a thorough analysis including the visual metaphor's characteristics and the particular type of thought process that generates with a focal point of visual design to see whether the metaphor and metaphoric thinking will play a pivotal role in the creation of emerging media arts.

With these motivations in mind, our goal was to understand the roles and impacts of visual metaphors in the design process. To the best of our knowledge, previous studies did not examine what kind of design considerations were involved when participants created visual metaphors, nor did they examine how participants with different backgrounds can seek

different benefits and values through metaphor.

In this study, we will examine how our participants used metaphors to leverage prior knowledge, expertise and experience while creating a visual metaphor adopting an information processing perspective. A cognitive task analysis (CTA) method was applied with a retrospective verbalization method to analyze the participants' tacit knowledge and cognitive operations involved in the process.

2. Background Related Work

In this section, we will review various research perspectives in metaphoric-thinking process that are heavily influenced the theory of conceptual metaphors and the recent advancements in visual metaphor research to build a theoretical foundation for our user studies. We will address how and why there has been significant gap between conceptual metaphor theory research and its application to the visual domain. Also, we will also discuss the working definition of a visual metaphor and its characteristics.

2.1 Interdisciplinary Approach on Metaphor Research

As Gibbs Jr (2008) pointed out, metaphor research becomes multidisciplinary and interdisciplinary as any topic being studied based on the conceptual metaphor theory. Researchers in the various fields of study investigate the functions and meanings of metaphor. In this section, we will discuss a multifaceted metaphor research that is related to our research context. For example,

Metaphors in Information Processing

Gentner (1983) claims that metaphors enable the reflection and communication of complex topics and the anticipation of new situations, but also affect further perception, interpretation of experiences. Therefore we consider that metaphors an important matter for information process not only for its instrumental value for self-reflection and communication but also an important function as mind settings, which influence our cognition of the self and the world as Ottati et al. (1999) suggested.

Metaphors as Reliable and Accessible Measurement to Tacit Knowledge

Sternberg (1999) reported that on tacit knowledge and tacit expertise, not only the representation but also the accessibility of tacit knowledge is an important issue. As metaphors are a linguistic manifestation of tacit knowledge, which is easily accessible because metaphorical expressions cannot be avoided in everyday or professional language, it can be used as reliability measurement to psychological studies.

Metaphors as Holistic Representations of Knowledge

Metaphors can be a representation of complex knowledge and analogical problem-solving. Compared to propositional representations, mental models and metaphors can be a more holistic representation of understanding and knowledge as Schnotz (1988) noted. By

investigating on one's metaphoric expressions, we can understand how one understands his or her present situation, but also indicates a more general understanding of his/her situation to know about which problem-solving skill is preferred more than others.

Combining Quantitative and Qualitative Approaches to Metaphor Research

While the quantitative analysis of metaphors reveals general tendencies in metaphor use, the full potential of metaphor analysis can only be reached when combining it with a qualitative approach according to Moser (1999). He suggested that the qualitative approach enables the analysis of metaphor use in context and understanding the function of metaphorical expressions. The combination of qualitative metaphor analysis with content analysis and narrative text analysis proved to be especially productive for the understanding of situational, biographical and social functions of metaphor use.

2.2 Visual Metaphor Research

For this study, we consider a visual metaphor is a visual representation of a metaphor that reflects an artist or a designer's mental image as our working-definition. In more detail, a visual metaphor is non-verbal, a visual manifestation of metaphorical thought, where one or both domains of the metaphor are rendered with various visual elements. With this difference, especially in the related field of visualization, researchers or practitioners have faced significant challenges in developing appropriate and comprehensible modes of abstracting and representing complex information in order to have deepened our understanding of how metaphors shape information and how different visual elements can influence our comprehension in the field of information visualization.

Carroll et al. (1988), who pioneered the field of user-interface design, proposed a systemic, five-stage methodology for developing user-interface metaphors. Before proposing this five-stage framework, the authors identified three distinct cognitive stages of metaphorical reasoning: instantiation, elaboration, and consolidation. The authors were concerned with the tension between metaphorical representation based on the real world and computer functionality as well as the mental model gap between the users and designers.

Cox (2006), who coined the term, "visaphor," explored the possibility of using a visual metaphor to visualize complex, high-dimensional data with an artistic eye. The author claimed that there is a direct relationship between data visualization and the cognitive, creative-mapping process but emphasized that the relationship cannot be formulated in a one-to-one or arbitrary manner. The author also used the term "concept network," which includes various sociocultural values, such as beliefs, concepts, symbols, cultural biases, assumptions, and personal impressions.

Casakin (2006) also considered metaphors to be powerful problem-solving tools for dealing with design tasks in terms of architectural design. Because metaphors enable structural alignments between the design problem and other domains that eventually serve as an inspiration to designers, the author suggested that the use of metaphors in problem-

solving can be characterized by the following: (1) the retrieval and interpretation of a concept, (2) the mapping and transference of a new relationships, and (3) the application of new relationships to generate and develop a design solution. The idea of reorganizing the framework from a design-thinking perspective was heavily inspired by this approach. Ziemkiewicz and Kosara (2010) considered metaphors as "a set of structural properties that provide a framework for meaning." Based on this, they developed various design strategies to use such structural properties to aid the user's understanding of visualized information. The results of their empirical study suggest that the nature of information visualization can rely on the visual metaphors it uses to structure information.

3. User Studies

In this section, we explore the cognitive processes of artists and designers while they create visual metaphors, through a cognitive task analysis method. From a conceptual, intermediate, and surface level, we identified what kind of design considerations were involved while our participants were materializing the significance of metaphoric expressions to achieve their design goals. We also address how participants' backgrounds could lead them to seek different benefits and values during the creation of metaphor.

3.1 Methods

In this study, we examined how our participants used metaphors to leverage prior knowledge, expertise and experience while creating a visual metaphor adopting an information-processing perspective. A cognitive task analysis (CTA) method was applied with a retrospective verbalization method to analyze the participants' tacit knowledge and cognitive operations involved in the process.

With this in mind, all interview sessions were analyzed and verbal protocols transcribed and segmented for coding according to our coding schemes using the principles of protocol analysis suggested by Suwa and Tversky (1997) and Gero and Mc Neill (1998). In every interview session, we assumed that practitioners had more stories and design rationale than they have could represent in their works. It means that we were not just focused on the knowledge exhibited in a piece of artwork explicitly, as the final outcome, but also the tacit knowledge used in its creation.

For an observation approach, usually a talk-aloud/think-aloud method is used, meaning individuals are asked to say out loud what they are thinking, as Ericsson (2006) noted. Similar approaches have been applied to examine designers' activities and intents, demonstrating their suitability for this study's purpose (Casakin (2011, 2006); Kavakli and Gero (2002); Lu and Liu (2011)).

3.2 Participants and Procedure

For this study, we recruited six experts highly respected in the field of emerging media (two females and four males). They had a mean of 9.17 years (range was 5-18 years) of

professional experience in their fields. Four of the participants had a Ph.D. in a field related to emerging media arts, such as a doctorate of design, media arts and technology, and one of the four had a Ph.D. in mechanical and aerospace engineering. The sixth had an MFA in interaction design as shown in Table 1. Please note that we removed their names, gender and current positions, as some of our participants wanted to remain anonymous.

Table 1 Brief participants' profiles.

	Research Interests	**Background**	**Experiences in the related field**
P1	New Media Design	Interaction Design	5 years with a Ph.D. in Media Arts and Technology
P2	Information visualization	Interaction Design	5 years with a Ph.D. in Computer Science
P3	Interaction Design	Visual Arts	10 years with a Ph.D. in Media Arts
P4	Interaction Design	Visual Arts	18 years with a M.S. in Media Arts and Sciences
P5	Human-Computer Interaction	Machine Learning	5 years with a M.F.A. in Computational Arts
P6	New Media Design	Interactive Robotics	12 years with a Ph.D. in Mechanical and Aerospace Engineering

Each interview was conducted via Skype, as our participants were scattered all over the world. Five of the interview sessions were conducted in Korean and translated into English, whereas only one interview was conducted in English, which was the participant's mother tongue. The sessions were audio-recorded.

The protocol involved three phases. In the warm-up phase, we explained the procedure of the experiment, and participants were trained in the practice of retrospection; this took 10-15 minutes. After, in the semi-structured interview phase, participants were asked to recall the design process of a specific work of their choosing and answer various questions based on our survey design; this took 60-80 minutes. In the final phase, we conducted follow-up interviews in which we asked about the potential benefits of using a visual metaphor to achieve a design goal, and here we used a five-point Likert scale to record responses.

We also asked participants to describe their typical design process, focusing on its relative length, the order of tasks and the number of attempts to use a metaphor, if any; the final phase took 15-20 minutes. During the early phase of the interview, we did not mention the word that is related to a metaphor or visual metaphor in order to minimize possible interviewer-interventions, as well as to remain as neutral as possible so that they can recall their own design process as natural as it can be. After the interview, we collected the recorded audio and transcribed it to investigate participants' visual-metaphor creation process according to our coding scheme described in Tables 2 and 3.

3.3 Development of Coding Scheme

We have developed three coding schemes that allow us a further analysis organize designers' intentions into certain categories. according to our coding scheme. Our coding scheme comprised three categories: (1) design considerations, (2) cognitive operations in a visual metaphor creation process, and (3) potential benefits of using a visual metaphor. The design-consideration category was developed and refined based on the Carole et al. (2009)'s Kansei Information Processing protocol.

The cognitive operation scheme was based on the work of Finke et al. (1992), as their empirical studies of creative-idea generation demonstrated how conceptual structures that give rise to imaginative thinking are revealed. In more detail, five categories and their definitions were developed based on association Finke et al. (1992): decision-making Lu and Liu (2011), perceptual action Suwa and Tversky (1997), transformation Finke et al. (1992) and questioning Casakin (2006) as described in Table 2.

Table 2 Coding scheme for cognitive operations

Category Label	Description	Examples
Association	Find similarity/difference between domains or explore possible combinations to create a proper conceptual network	**P1***: We treat the distinct visual features of fingerprints as an open musical score whose performance can be executed in diverse ways* **P2**: *What the audience sees is a kind of memory of her through the lights so that was a conceptual inspiration* **P5**: *Your likeness is appeared to be white flakes of snow*
Decision Making	Select or not select one option over another with rationale and evaluate ideas according to the design information, or artistic motif	**P1**: *This tended to create a very limited range of output timbres even though .... In order to broaden the diversity of timbre, we employed FM synthesis* **P2**: *I started trying to apply logic as to what is it that I like about this and try and shape it towards something that I like ...*
Perceptual Action	Create, modify and refine visual elements and information to achieve the visual concept	**P5**: *... starts to become a shape and things like that and that creates something that we haven't really thought of in the first place ...*
Transformation	Transform abstract ideas into visual elements with or without a functionality for the work to be more interesting, engaging and useful such as new value and analogy	**P1**: *Finding their own sound identities through the fingerprints gives a unique experience to the audience.* **P4**: *it's kind of a digital body and thinking about how what it means to have a body in the digital space and how it can be copied and pasted just like regular digital data*

Questioning (Reflection)	Inquiry about the concept and methods that are related with dealing with emerging issues	**P3**: *I pondered hard on what should be the most natural material to use at that time ... What makes our work more unique?*

Remaining responses, such as short pauses or vocal expressions that did not agree with any of the main categories, were recorded in a miscellaneous category. This category was small relative to the others. Please note that we are aware these operations can happen in a non-linear fashion, and a strict line between categories was not always possible because some operations happened concurrently. We attempted to build a coding scheme that helped us better understand how different cognitive processes and considerations happened in the different phases in our participants' design process.

Our coding schemes have been developed over time as shown in the Appendix. With the guidance from Saldaña (2015), we started to explain the reality of our data, the interview scripts, and aim to progress toward a more thematic, conceptual, and theoretical direction, from the top to the bottom in the diagram.

In the first iteration, we focused on building some vocabularies and categories that allow us to describe various design activities. To develop an initial coding scheme, we adopted three themes that are considered as core principles underpin visual design any designer create such as Visual grammar, Visual syntax, and Sensation. The category of visual grammar and visual syntax has adopted the concept of Dondis (1974)'s work that provides the basic building blocks that are essentially required and used for visual communication.

In addition to the first two categories, we added the sensation category, which is closely associated with the image schema or a primary metaphor, because we, as designers, empirically understand that using imagined physical sensations can help us to make the visualization vivid and realistic. We also expected that our participants would use lots of vocabularies related to this category as the conceptual theory emphasizes the importance of embodiment as well as an experiential basis in a metaphor. However, as the interview process went further, we realized that the three categories in the first iteration were not appropriate to capture various aspects in the design process. It means that each category and element was precise enough to describe a certain behavior.

In the second iteration, we went in the direction of building more generalized categories, as we were inspired by other approaches such as that of Grady (2005) and Ortiz (2011), who mostly focused on primary metaphor and the multimodal quality of a metaphor. We expected that we could better capture the participants' design considerations from a macroscopic perspective than the previous iteration.

For example, we identified concrete dimensions such as form, color, texture, and patterns, and procedures, as these elements can be explicitly presented. We also decided to create a function category since we expect it would help us describe some aspects of interactivity. For the abstract dimension, we added various categories that can be presented implicitly

such as values, semantic descriptions, emotions, and considerations for users/audience and their contexts. We applied the categories derived from the second iteration to the interview scripts as explained in Table 3.

Table 3 Coding scheme for design considerations

Category Label	Description	Examples
Conceptual Level		
Analogy	Words that are closely related to a metaphorical process including inspirations, conceptual references	Like a funhouse mirror; as if we were in the ocean;
Semantic Descriptors	Words that are related to color, form, or texture of an object, but also can represent a personal impression or attitude	cheerful, welcoming, talkative, soft
Style	Words that represents specific characteristics of an object or mood	classic, futuristic, fluid, cool
Values	Words that represent behavioral values or socio-cultural values	freedom, defamiliarization, fulfilling, rewarding, strange
Intermediate Level		
Context	Some circumstances that form the setting for an event such as time, place, environment of the product use	morning, at night, at the gallery, in the dark
Function	Technical solutions or properties that operate as intended	computer vision, recognition, frequency analysis
Structure	Words that describe how all visual elements can and should go together for the best results	harmony, emphasis, hierarchy, balance, gestalt
Surface Level		
Color	Basic element of light that help convey emotions in and add variety and value	green, red, golden, shiny, matte
Form	Words that describe visible contour or some quality that encloses a volume or three dimensional area	rounded, open, symmetrical
Texture	Words that describe patterns, material and touch of a surface	bright, rough, smooth, woody

4. Results

Based on the coding schemes, we identified what kind of design considerations were involved in our participants' creation of a visual metaphor. The results are reported using three levels of design-information analysis: a conceptual, an intermediate and a surface level. The first level presents the basic design tasks and considerations that participants reported in their process. The second level is a type of common component analysis that shows what

types of cognitive operations were performed to support design activities; in this case, the cognitive operation was association.

4.1 Design Considerations Involved in Visual Metaphor Creation

Figure 2 shows the distribution of keywords related to design considerations. The analysis suggested that conceptual keywords were used most frequently (45.4%), while intermediate level and surface level keywords were observed 37.3% and 17.3% of the time, respectively. Therefore, the conceptual level activities, such as values, analogy, semantic descriptions and style, were the most dominant during the design process.

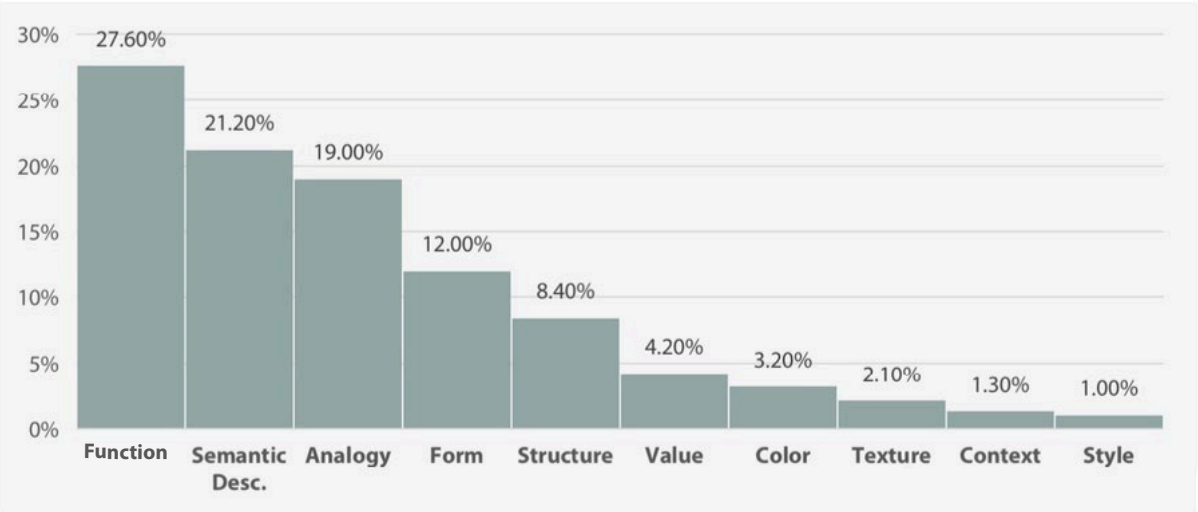

Figure 2 Distribution of words observed within the categories of design considerations

From a microscopic perspective, activities related to function (27.6%) were used the most to describe technical solutions or properties that helped participants shape their work as intended. For example, the following technical terms representing a specific functionality were observed: “computer vision,” “recognition” or “frequency analysis.”

Semantic description (21.2%) followed in frequency. This category is related to the color, form or texture of an object, as well the participant’s personal impression of the object. For example, “blueish,” “darky,” “hairline” or adjectives that described forming and shaping were often observed.

The third category examined analogy (19.0%). This category is related to a metaphorical process that included inspirations and conceptual references. One of the participants described a possible “audio- and visual-like composition” as a “fingerprint.” Another used a metaphoric expression to describe the impression of visual elements, saying they appeared as “white flakes of snow.”

The fourth and fifth most-observed categories were form (12.0%) and structure (8.4%), and they were ranked as surface level. The remaining categories were mentioned relatively less frequently: value (4.2%), color (3.2%), texture (2.1%), context (1.3%) and style (1%).

4.2 Cognitive Operations Performed in Visual Metaphor Creation

Figure 3 shows the distribution of different cognitive operations performed in the design process. On average, associations accounted for 44.9% of all cognitive operations observed; decision-making accounted for 18.0%; perceptual action, transformation and questioning accounted for 12.9%, 12.1% and 9.7% respectively. As an association is a cognitive operation performed to find similarities or differences between domains or explore possible combinations to create a proper conceptual network, it is reasonable that we observed association-related operations the most. For example, one participant said her work offers her audience a memory of her revealed by partial lighting, while another described a visual structure as a likeness created by tiny flakes of what appear to be snow.

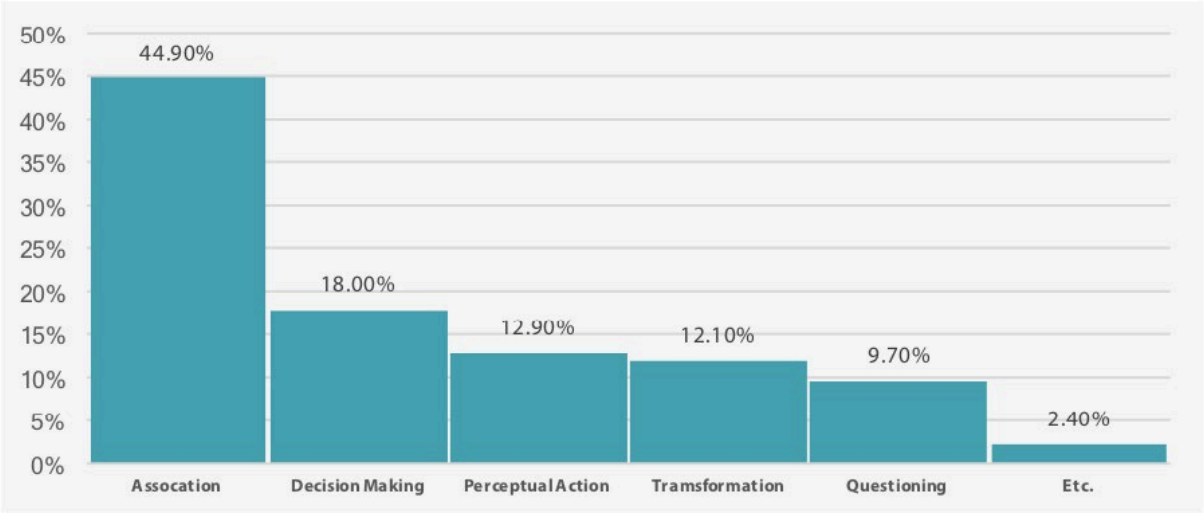

Figure 3 Distribution of words observed in the categories of cognitive operations

Since operations related to making an association should come before a design task is begun, decision-making was observed as the second most frequent cognitive operation. Perceptual actions and transformation were less frequently observed, as participants were more focused on operations to create and refine visual elements.

It is also considered a reasonable consequence because the focal point of our semi-structured interview was to search for any cognitive operations performed in support of visual-metaphor creation, rather than the creation of other forms of design, such as graphic design, interface design or generative design. In addition, it is possible that interviewees answered with metaphorical expressions, as our questions were open-ended and required they retrieve and recall all related tasks and rationales after the activity was complete.

Since we observed that association was frequently used to describe elements of the process belonging to another category, a more detailed analysis was conducted within the category of association, as shown in Figure 4. Similar to the results of the design consideration category, 35% of responses within the association category were related to describing a function that represented the intent of the visual metaphor; 19.82 % responses were

related to the structure that represented how the visual elements were organized; 16.26 % accounted for the form category that represented visible qualities, such as rounded, open or symmetrical. Color (12.03 %) and texture (12.03 %) were considered another category used frequently to make associations. Only 8.02% of the words were related to the style category. This may be because words describing or explaining styles can be quite literal and self-explanatory in this study.

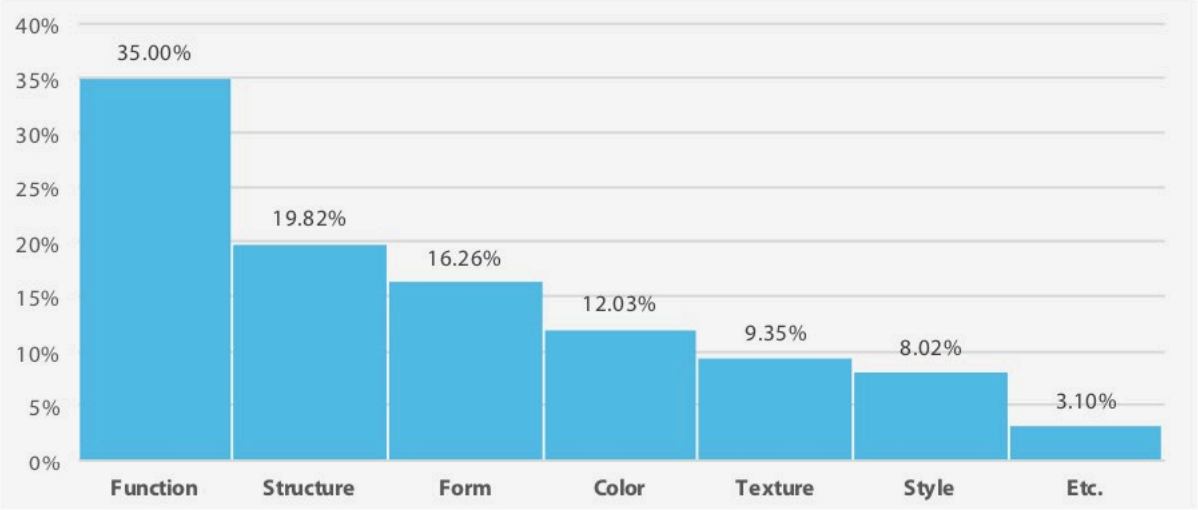

Figure 4 Distribution of words observed within the categories of association

5. Discussion

As the conceptual-metaphor theory suggests, metaphoric thinking is a fundamental cognitive mechanism in the human brain. From this point of view, we understand that a design researcher or practitioner, whether consciously or subconsciously, draws from previous experience or knowledge to solve problems, and they use implicit, tacit and experiential knowledge to accomplish this, as argued by Bang (2009), Lawson (1979), Stolterman (2008). Findings from the CTA and coding-scheme analysis extend our understanding of the role and impact of a visual metaphor and metaphoric thinking in one's design process; they also explain how one can leverage metaphoric thinking in empirically solving a design problem especially in the field of emerging media arts.

One of our study's most important findings is the systematic analysis of a visual-metaphor creation process based on empirical evidence. This analysis deepens our general understanding of what kinds of design considerations and activities are involved when artists create visual metaphors. As previous research results, both in theoretical works and empirical works, suggests, the entire visual-metaphor creation process can be considered as a design process that involves various design considerations and activities in order to build a logical map leading from a verbal domain (more abstract) to a visual domain (more concrete). During this process, one can leverage a metaphorical thinking process, association in this case, or information that is acquired in the early stage of his or her design process to

reduce abstraction and clarify constraints, as noted by Bonnardel and Marmèche (2005).

As Figure 2 suggests, our participants extracted various conceptual properties from a metaphor, such as semantic description, analogy and value. They used such information to develop their concept. The surface-level properties, such as form or color, were more frequently used to transform their abstract concept into a visual element, whereas function was the only property that was observed frequently at the intermediate level. This suggests that a visual metaphor and the thinking that created it can be seen as a source of inspiration and knowledge influencing one's design process from the conceptual level to the surface.

In addition, two distinctive operations were observed in cognitive operations that supported visual-metaphor design activities: association accounted for 44.9%, whereas decision-making accounted for 18.0%. Association is a cognitive operation needed to find similarities and differences between domains or to explore possible combinations to create a proper conceptual network. It predicts the presence of association-related operations more than any other; the results proved that an artist relies considerably on association throughout the design process.

Furthermore, association plays an important role in supporting other design considerations and activities, either indirectly or metaphorically. To acquire an in-depth understanding of which categories are supported by association, we conducted further analysis within the categories of association, as Figure 2 demonstrates. The results show that properties such as function and structure were most used in the intermediate level.

Form and color on the surface level were also supported by association. The results suggest that participants drew inspiration from a visual metaphor as it allowed them to describe a specific function or structure intuitively. However, we did not find any evidence that one can consider an order between two properties such as function-structure or structure-form.

6. Conclusion

We explored the role and impact of a visual metaphor and the metaphoric-thinking process in design. We also examined how designers can leverage the metaphoric-thinking process to empirically create a visual metaphor. Our primary focus was to explore what kinds of design considerations are involved and what types of cognitive operations are performed to support designers as they create visual metaphors. By employing a CTA and qualitative research approach, we explored how participants used metaphors to leverage their prior knowledge, expertise and experience when creating visual metaphors from an information-processing perspective.

We successfully explored the visual metaphor creation process by analyzing different participants' design processes through the retrospective verbalization method. For this purpose, we created coding schemes to identify what kinds of design considerations were needed and what cognitive operations were relevant. Our empirical studies clearly demonstrated the kinds of design considerations and activities involved when artists create

visual metaphors; their design processes were significantly influenced by metaphorical thinking. For example, our participants extracted the various conceptual properties of a metaphor from a conceptual, intermediate and surface level.

A limitation of the current experiment is that five of our interviews were conducted in Korean and translated into English. Therefore, it is possible cultural differences may not have been fully accounted for. Analysis of these variables may prove interesting with a larger pool of designers. The current study does not focus on the differences between experts and novices, unlike other formal experiments that adopted a CTA. These factors and related questions are certainly deserving of further study.

Validation of the roles, impacts and potential benefits of a metaphor, a better understanding of what causes it, and ways to leverage such characteristics in the creation of visual metaphors will help lay the foundation for future visual-metaphor research and artistic practice especially in the field of emerging media arts. Continued exploration of the implications and nuances of this theory will contribute to the understanding of how and why a metaphor works, whether we use it consciously or subconsciously.

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7. References

Bang, A. L. (2009). Facilitated Articulation of Implicit Knowledge in Textile Design. *Methodology*, (June):1–12.

Bonnardel, N. and Marmèche, E. (2005). Towards supporting evocation processes in creative design: A cognitive approach. *International Journal of Human-Computer Studies*, 63(4):422–435. Computer support for creativity.

Blackwell, A. F. (2006). The Reification of Metaphor As a Design Tool. *ACM Trans. Comput.- Hum. Interact.,* 13(4):490–530.

Blackwell, A. F. (2006). The reification of metaphor as a design tool. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *13*(4), 490-530.

Carroll, J. M., Mack, R. L., and Kellogg, W. A. (1988). Interface metaphors and user interface design. In *Handbook of Human-Computer Interaction*, pages 67–85. Elsevier.

Carroll, N. (1994). Visual metaphor. In Aspects of Metaphor, pages 189–218. Springer. Carroll, N. (1996). *Theorizing the Moving Image.* Cambridge University Press

Casakin, H. (2011). Metaphorical Reasoning and Design Expertise: A Perspective for Design Education. *Journal of Learning Design*, 4(2):29–38.

Casakin, H. P. (2006). Assessing the Use of Metaphors in the Design Process. *Environment and Planning B: Planning and Design*, 33(2):253–268.

Casakin, H. P. (2007). Factors of metaphors in design problem-solving: Implications for design creativity. *International journal of design*, 1(2):21–33.

Carole, B., Jieun, K., and Améziane, A. (2009). Kansei information processing in design. *In Proceedings of IASDR Conference*, pages 3327–3337.

Cienki, A. and Müller, C. (2012). Metaphor, gesture, and thought. In *The Cambridge Handbook of Metaphor and Thought*, pages 483–501.

Cox, D. J. (2006). Metaphoric Mappings: The Art of Visualization. In *Aesthetic Computing*, pages 89–114. The MIT Press.

Cox, D. J. (2008). *Astral Projection: Theories of Metaphor, Philosophies of Science, and the Art of Scientific Visualization.* Unpublished doctoral thesis, University of Plymouth, UK.

Dondis, D. A. (1974). *A Primer of Visual Literacy*. Mit Press.

Dorst, K. and Dijkhuis, J. (1995). Comparing paradigms for describing design activity. *Design Studies*, 16(2):261–274.

Finke, R. A., Ward, T. B., and Smith, S. M. (1992). *Creative Cognition: Theory. Research, and Applications*. MIT Press, Cambridge MA.

Forceville, C. (2005). Visual representations of the idealized cognitive model of anger in the Asterix album La Zizanie. *Journal of Pragmatics*, 37(1):69–88.

Forceville, C. J., Tan, E. S. H., & Hekkert, P. (2006). The adaptive value of metaphors. In *Heuristiken der Literaturwissenschaft. Einladung zu disziplinexternen Perspektiven auf Literatur,* Paderborn: Mentis, pp. 85-109.

Gentner, D. (1983). Structure-mapping: A theoretical framework for analogy. *Cognitive science*, 7(2):155–170.

Gero, J. S. and Mc Neill, T. (1998). An approach to the analysis of design protocols. *Design studies*, 19(1):21–61.

Gibbs Jr, R. W. (2008). *The Cambridge Handbook of Metaphor and Thought.* Cambridge University Press.

Hey, J., Linsey, J., Agogino, A. M., & Wood, K. L. (2008). Analogies and metaphors in creative design. *International Journal of Engineering Education*, 24(2), 283.

Hurtienne, J., Weber, K., & Blessing, L. (2008). Prior experience and intuitive use: image schemas in user centred design. In *Designing inclusive futures*, Springer, London, pp. 107-116.

Kavakli, M. and Gero, J. (2002). The structure of concurrent cognitive actions: A case study on novice and expert designers. *Design Studies*, 23(1):25–40. 25.

Kennedy, J. M. (1982). Metaphor in pictures. *Perception*, 11(5):589–605.

Krippendorff, K., & Butter, R. (2008). Semantics: Meanings and contexts of artifacts. In *Product experience* (pp. 353-376). Elsevier.

Lawson, B. R. (1979). Cognitive Strategies in Architectural Design. *Ergonomics*, 22(1):59–68.

Lu, S. C.-Y. and Liu, A. (2011). Subjectivity and objectivity in design decisions. *CIRP Annals*, 60(1):161–164.

Moser, K. S. (1999). Knowledge acquisition through metaphors: Anticipation of self change at transitions from learning to work. *Arbeit und Bildung-das Ende einer Differenz*, pages 141–152.

Ottati, V., Rhoads, S., & Graesser, A. C. (1999). The effect of metaphor on processing style in a persuasion task: A motivational resonance model. *Journal of Personality and Social Psychology*, 77(4), 688.

Phillips, B. J. and McQuarrie, E. F. (2004). Beyond visual metaphor: A new typology of visual rhetoric in advertising. *Marketing theory,* 4(1-2):113–136.

Saldaña, J. (2015). *The Coding Manual for Qualitative Researchers.* Sage.

Schnotz, W. (1988). Instructional implications of text processing research. *European Journal of Psychology of Education*, 3(2):111–121.

Sternberg, R. J. (1999). What do we know about tacit knowledge? Making the tacit become explicit. In Sterngberg, R. J. and Horvath, J. A. (eds.), *Tacit knowledge in professional practice: Researcher and practitioner perspectives*, London: Lawrence Erlbaum, pp. 231–236.

Stolterman, E. (2008). The nature of design practice and implications for interaction design re- search. *International Journal of Design*, 2(1):55–65.

Suwa, M. and Tversky, B. (1997). What do architects and students perceive in their design sketches? A protocol analysis. *Design studies,* 18(4):385–403.

Van Rompay, T. J. (2008). Product expression: Bridging the gap between the symbolic and the concrete. In *Product experience* (pp. 333-351). Elsevier.

Ziemkiewicz, C. and Kosara, R. (2008). The Shaping of Information by Visual Metaphors. *IEEE Transactions on Vizualization & Computer Graphics*, 14(6), 1269-1276. https://doi.org/10.1109/TVCG.2008.171

Ziemkiewicz, C. and Kosara, R. (2010). Beyond Bertin: Seeing the Forest despite the Trees. *IEEE Computer Graphics & Applications*, 30(5), 7–11.

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Appendix: Iterative development process of the coding schemes

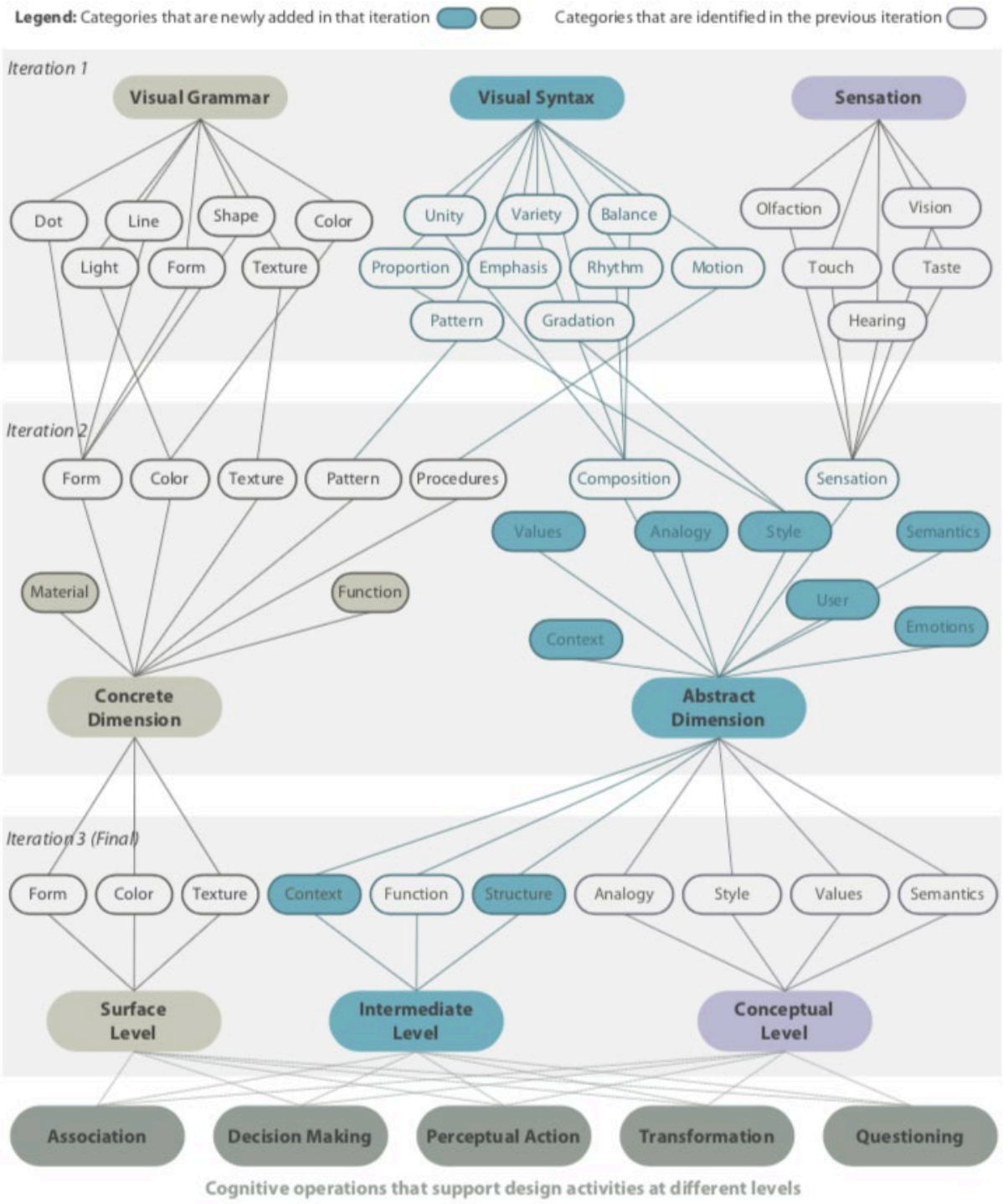

Image showing the iterative development process of the coding schemes over three iterations