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A Research on the Paradigm of Interaction Based on Attributes

Shan Shu Ya[1], Pan Young Hwan[2*]
[1]Lecture, Division of Visual Communication Design, Zhongyuan University of Technology
[2]Professor, Division of Smart Experience Design, Kookmin University

인터렉션 속성에 기초한 인터렉션 범식화 연구

샨슈야[1], 반영환[2*]
[1]중원공학대학교 시각전달학과 강사, [2]국민대학교 경험디자인학과 교수

Abstract The aim of this study is to demonstrate interaction as a describable field and tries to understand interaction from the perspective of attributes, thus building a theoretical to help interactive designer understand this field by common rule, rather than waste huge time and labor cost on iteration. Since the concept of interaction language has been brought out in 2000, there are varies of related academical studies, but all with defect such as proposed theoretical models are built on a non-uniform scale, or the analyzing perspective are mainly based on researcher's personal experience and being too unobjective. The value of this study is the clustered resource of research which mainly based on academical review. It collected 21 papers researched on interaction paradigm or interaction attributes published since 2000, extracting 19 interaction attribute models which contains 174 interaction attributes. Furthermore, these 174 attributes were re-clustered based on a more unified standard scale, and the two theoretical models summarized from it are respectively focuses on interaction control and interaction experience, both of which covered 6 independent attributes. The propose of this theoretical models and the analyzation of the cluster static will contribute on further revealing of the importance of interaction attribute, or the attention interaction attribute has been paid on. Also, in this regard, the interactive designer could reasonably allocate their energy during design process, and the future potential on various direction of interaction design could be discussed.

Key Words : Interaction Attribute, Interaction Paradigm, Interaction Dimension, Design. Gestalt

요 약 본 연구의 목표는 인터렉션이 하나의 영역으로서 묘사 가능성을 증명하는 것이다. 또한 패러다임화된 시각으로 인터렉션을 이해하려고 시도하는 것이다. 일반적으로 통용되는 규칙에 기초하여 이론모델을 구축하고, 디자이너들에게 인터렉션의 본질을 효과적으로 이해하도록 돕고, 현재 인터렉션 설계가 주로 기초적인 수단으로 의존하게 됨으로써 파생되는 인력과 시간비용의 낭비를 방지하는 것이다. 2000년도에 처음으로 인터렉션 패러다임화의 개념을 제시한 이래 지금까지 관련된 연구에는 일부 결함이 존재한다. 예를들어 제시된 이론 모델들이 서로 다른 척도에서 만들어졌거나, 혹은 접근하는 시각에 객관성이 결여된 것, 그리고 주로 연구자의 개인적 경험 등에서 오는것 등이다. 본 연구의 가치와 뛰어난 성과는 그 전체적 기초가 파일검색이라는 토대위에 구축되었다. 최근 2000년 이래 현재까지의 인터렉션 패러다임화에 관한 연구 총 21편의 수집을 통하여 인터렉션 속성 모델 19개,인터렉션 속성 포함 총 174개를 추출하였다. 또한 이 174개 속성에 대하여 보다 통일된 표준 척도에 근거를 두고 집합류의 연구수단을 이용하여 재분류 귀납함으로써 두 개의 이론 모델을 한 조로 만들었다. 이 두 모형은 각각 인터렉션 운용과 인터렉션 체험의 시각으로 접근하며, 그중 각 모델은 각각 6개의 독립된 속성을 포함한다. 이 인터렉션 모델의 제시 및 집합류 데이터의 분석은 각 인터렉션 속성이 인터렉션 설계에서 얼마만큼의 주목을 받고 중요한지 밝히는데 도움이 될것이다. 이런 데이터는 디자이너가 디자인 과정에서 힘 분배를 합리적으로 할 수 있게 도와주며, 또한 미래에 인터렉션 설계에 관해 발전공간을 설계하기 위한 이론적 근거를 제공한다.

주제어 : 인터랙션 속성, 인터랙션 언어, 인터랙션 치수, 디자인, 게슈탈트

*Corresponding Author : Pan Young Hwan(peterpan@kookmin.ac.kr)
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1. Introduction

As things stand, human exploration about interaction of science and technology has never halted, from the initial instruction interface command user interface (CUI) [1] to the graphical user interface GUI, and then to subsequent gestures TUI, body feeling even immersion operation embodied interaction. Interactive surfaces are no longer merely panel-like collections of controls to access function. [2] Every new interaction method can be a revolution in the field of interaction caused by the emergence of a new technology platform, in a no small measure. At present, the mainstream understanding of interaction language and interaction logic among practitioners in this field, both user experience researchers and interaction interface designers, derives from devices and technologies. And they argue that new devices and technologies will subvert the original way of interaction, and the change of operating instructions between users and devices will create new interaction patterns and interaction languages. In recognition of the fact that the technology has made fast progress, the interaction practitioners' understanding of interaction and theoretical framework are also constantly updated, so iterative design has evolved as the mainstream of the design trend. Whenever a new device and technology platform appears, people's original understanding of interaction can't continue to be used. Thanks to the iterative design, interactive practitioners can, under the condition of little understanding of the new equipment, explore the user's experience preferences and interaction logic, and constantly summarize and improve the new interaction theory system and practical application experience based on the design attempts in several directions for small projects and the feedback of user data after they are put into the market.

However, iterative design is not a perfect way for interaction improvement, which involves a lot of investment of man power, capital and time cost. Against the backdrop that there is no law to follow, the design samples released in the early stage can only be based on blind prediction, and the final elimination of most experimental samples also means a large amount of cost waste. The shortcomings of the iterative design approach do not stem from the iteration itself, but from the rapid development of technology and the way in which interactions and devices are understood.

2. Theoretical Background

As Stolterman's theory stated, Media, tools, and methods for expression have traditionally been essential for design. [3] Not all researchers and designers in the field of man-machine interaction are committed to the analysis and construction of basic theoretical models. At present, the mainstream understanding and theoretical model of man-machine interaction are derived from users and devices. Stuart K. Card, Allen Newell and Thomas P. Moran initially proposed the concept of man-machine interaction, [4] and defined it as a research area focused on user-based device use and design. With respect to the discipline division, it not only includes computer science and media studies at the level of devices, but also behavioral science, cognitive science and psychology at the level of users. Put together, the current definition of human-computer interaction can be expressed concisely in the following model as showing in Fig. 1. Based on the in-depth study of user experience and device technology, researchers simulate and estimate the interaction relationship and interaction behavior based on people and devices. In the label on the classification of academic contributions published at the famous interactive academic conference CHI, experts

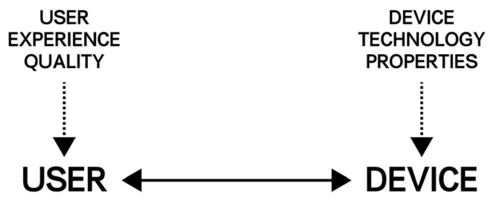

Fig. 1. Model of traditional human-computer interaction

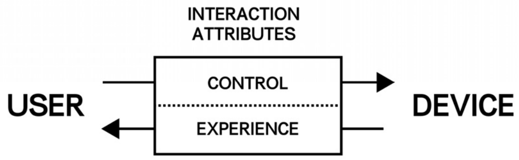

Fig. 2. Model of human-computer interaction based on attributes

and scholars also split the field of interactive experimental contributions into the field of systematic academic contributions in the experimental field and the field of user academic contributions in the experimental field. [5] This split is sufficient to demonstrate the researchers' understanding of the infrastructure of interaction.

However, a paradigmatic perspective should be created between the device and the user to facilitate interaction understanding. Hallnäs and Redström pointed out the importance of presenting such an interaction perspective in their earlier study[6]. This study also proposed a perspective on understanding “interaction representation” by expressing interaction design based on basic attributes, which coincidentally agrees the notion of this study. Similarly, the importance of this paradigmatic perspective on interaction is also supported by Svanaes in his study [7]. Visual depictions of design attributes are commonplace in mature design fields such as product design, visual design, interior design and architectural design. For example, in visual design, a paradigmatic perspective requires designers to understand and manipulate core design attributes such as shape, color, font, and spacing to complete a visual design work more effectively and precisely. Similarly, in product design, it has become an integral part of the product design theory system to enhance products’ aesthetics and functionality by rationally allocating and utilizing various materials with different attributes [8]. However, due to the invisible interaction attributes, a similar paradigmatic perspective is still under exploration [9].

In our research, we believed that such an invisible quality is concretely describable, similar to the way of describing physical materials. As such, we propose a generic attribute-based perspective as showing in Fig. 2, which fundamentally changes the way to understand interaction, frees interaction from being tied to users and devices, and recognizes its independent existence. And the understanding way also provides a theoretical basis for the grouping of specific interaction attributes and the proposal of the model.

Among HCI-related papers, interaction attributes were first proposed in the early 21st century [10,11]. Many scholars have explored this area further and have proposed some theoretical models [12-15]. However, since these models are based on different scales and emphasize different priorities, some emphasize the manipulation of interaction [15], some emphasize the presentation of interaction [13], and some emphasize the experience of interaction [12]. Most of the theoretical models were proposed based on scholars’own prior experiences rather than previous studies. Therefore, even though this concept has been explored and confirmed since 2000, few studies have deepened or integrated it, while most of the existing models available are independent models that cannot be mutually verified, which leads to an unsatisfactory accumulation of theories. In order to prevent this study from falling into another result of many independent models, it would be a fairer and more valuable start to review and compare the previous studies. Without such a review, publishing a new view might require us to bear the same paradoxes as our predecessors. More seriously, it would be impossible to guarantee whether it isa new perspective and never overlaps with previous findings. Based on this, the author decided to start this study by reviewing the relevant academic papers.

3. Literature Review

When reviewing the literature, “interaction paradigm”, “interaction attributes,” and “interaction dimension” were set as key words in this study for literature retrieval using Google Scholar. The field was limited to design and art, and similar studies in unrelated fields (e.g., sociology or economics) were filtered out. The papers were selected from internationally recognized and influential academic conferences and journals, such as CHI or Personal and Ubiquitous Computing to guarantee the reliability of the research results. According to the time when interaction attributes were initially proposed, the author obtained 21 papers on interaction language and the describable nature of interaction from 2000 to the recent past. Except for two articles that simply defined the concept of interaction attributes, the remaining 19 articles proposed theoretical

Table 1. Literature Review of Interaction Attributes

AUTHOR / TITLE	INTERACTION ATTRIBUTES
Hummels, C., Ross, P., & Overbeeke, K. C. J. (2003). In search of resonant human computer interaction: Building and testing aesthetic installations.	control
Djajadiningrat, T., Wensveen, S., Frens, J., & Overbeeke, K. (2004). Tangible products: redressing the balance between appearance and action.	freedom of interaction, rich interaction, unity of action and reaction
Hunicke, R., LeBlanc, M., & Zubeck, R. (2004). MDA: A formal approach to game design and game research.	expression, fantasy, sensation, challenge, discovery, submission, narrative, fellowship
Löwgren, J., & Stolterman, E. (2004). Thoughtful interaction design. A design perspective on information technology.	ambiguity, surprise, immersion, fluency, pliability, control/autonomy, anticipation, seductivity, playability, usefulness, relevance, social action space, identity, personal connectedness, elegance, transparency, efficiency
Miroslaw Rogala.(2005).Towards a theory of interactive art experience	common ground, interface, boundaries, space, time, scale, improvisation/spontaneous/freedom, scripting/artist control, learning curve, repetition, rhythm, flow, behavior, gesture, proximity, vividness, randomness, dynamic mapping
Reeves, S., Benford, S., O' Malley, C., & Fraser, M. (2005). Designing the spectator experience.	magical, expressive, suspenseful, secretive
Lim, Y., Stolterman, E., Jung, H., & Donaldson, J. (2007). Interaction gestalt and the design of aesthetic interactions.	movement, continuity, pace, speed, state, time-depth, directness, connectivity, resolution, proximity, orderliness
De Jong Hepworth, S. (2007). Magical experiences in interaction design.	unnatural, exciting, unordinary, surprise
Dalsgaard, P. (2008). Designing for inquisitive use.	challenge, risk, resolution
Landin, H. (2009). Anxiety and trust: And other expressions of interaction.	anxiety, imagination, alienation, dependence, thrill, suspiciousness, confusion, trust, magical, indistinct, illusionary, fragile, changeable
Lim, Y., Lee, S.-S., & Lee, K. (2009). Interactivity attributes: a new way of thinking and describing interactivity.	expectedness, continuity, movement speed, concurrency, movement range, response range, proximity
Löwgren, J. (2009). Towards an articulation of interaction aesthetics.	fluency, pliability, dramaturgical structure, rhythm
Lundgren, S., & Hultberg, T. (2009). Time, temporality, and interaction.	live time, real time, unbroken time, sequential time, fragmented time, juxtaposed time
Saffer, D. (2009). Designing gestural interfaces.	duration, sequence, motion, orientation, size, presence, position, combination/number of touch points, number of participants, including objects, discoverable, pleasurable, appropriate, trustworthy, good, meaningful, playful, responsive, clever, smart
Ross, P. R., & Wensveen, S. A. G. (2010). Designing aesthetics of behavior in interaction: Using aesthetic experience as a mechanism for design.	dynamic development, body attitude, shape qualities, kinespheric reach, initiative, interaction effort, external connections, body parts involved
Hallnäs, L. (2011). On the foundations of interaction design aesthetics: Revisiting the notions of form and expression.	timing, spacing
Lundgren, S. (2011). Interaction-related properties of interactive artifacts.	difficulty, predictability, openness, company, privacy, locality, movement, evolution, temporal aspects, interaction flow, directness, response time, adaptability, robustness, dependency, feedback, precision, clarity, information order, presentation, freedom of interaction, input modalities, tasking, output modalities, versatility
Diefenbach, S., Lenz, E., Hassenzahl, M. (2013). An interaction vocabulary. Describing the how of interaction.	slow-fast, stepwise-fluent, instant-delayed, uniform-diverging, constant-inconstant, mediated-direct, spatial separation-spatial proximity, approximate-precise, gentle-powerful, incidental-targeted, apparent-covered
Graham D. Bodie, James M. Honeycutt, & Andrea J Vickery. (2013). An analysis of the correspondence between imagined interaction attributes and functions.	frequency, negative valence, discrepancy, self-dominance, variety, proactivity, retroactivity, specificity

models and covered a total of 174 interaction attributes as showing in table 1 Except for some attributes from a specific field (such as product design or game design), most of these attributes fall within the scope of interaction theory. The openness of the domain is also more in line with the general principle of paradigmatic expression desired in this paper.

In this study, the preliminary results of the literature search were reviewed and analyzed thoroughly. 174 interaction attributes were obtained from a total of 19 theoretical models on interaction paradigm. Among these 19 models, the number of attributes in each model ranged from 1 to 25, but most of the models aggregated 10 to 12 interaction attributes. Therefore, we use this quantitative category as a base reference to cluster the 174 attributes and try to construct a theoretical model of interaction attributes based on previous studies, with a more fair, convincing and universally constrained scale.

Before clustering, the 174attributes were analyzed for their descriptions and were found to be concentrated on two main domains. The first domain is the practice of interaction control. The scaling basis of the attributes in this domain is derived from the disaggregation of specific interaction control, with an attempt to construct and explain interaction control utilizing the physical world's underlying units. In the theoretical models proposed by Diefenbach.S et al., slow-fast, stepwise-fluent, instant-delayed and constant-inconstant all deconstruct interaction control from a practical point of view[16].In relates, the position proposed by Saffer. D or the movement range proposed by Lim. Y et al. deconstruct interaction control from a spatial point of view[17,18]. The second domain is the describing of user experience during interaction, and the scaling basis of the attributes in this domain is derived from the users' perception and emotion during the interaction. In the model proposed by Landin, H, anxiety, thrill and confusion are descriptive attributes of interaction experience [19]. Such a way of classification coincides with the modeling framework foundation proposed in the preceding section. Therefore, this study will categorize the collected interaction attributes into two parts of interaction control and interaction experience through clustering, and refine both of them into an attribute-based describable theoretical model.

After determining the theoretical model's basic framework, the 174 attributes obtained from the previous literature retrieval, together with their annotations, were sent to two raters for clustering and comparing the clustering results. When the clustering results were disputed, the third rater was assigned to make further decisions until the results were agreed upon and the objection was eliminated. The three raters are long-time practitioners aged between 32 and 45 in interaction design and research, with two females and one male. In order to ensure the unified division of clustering dimensions, this study provides a uniform reference for the raters at the initial stage of clustering. In classifying the attributes related to interaction control, we draw on the fundamental dimensions of the physical world that are highly compatible with most of the dimensions of interaction control, such as time, space and force, and combine them with some dimensions specific to interaction control, such as interactive feedback and interactive environment. In classifying the attributes related to the interaction experience, we relied on the previous findings, especially the ten dimensions of human psychological needs proposed by Sheldon et al. in 2001 [20] (Autonomy–Independence, Competence–effectance, Relatedness–belongingness, Influence-popularity, Pleasure-stimulation, Security-control, Physical thriving–bodily, Self-actualizing–meaning, Self-esteem–self-respect, Money–luxury), as well as the seven dimensions derived by Marc Hassenzahl et al. in 2010 after optimizing the attributes proposed by Sheldon et al. in their study in the specific context of the interaction domain [21] (Stimulation, Security, Competence, Autonomy, Relatedness, Meaning, Popularity). This clustering mainly covers two purposes. First, on the basis of previous theoretical models, these attributes are further divided so as to put forward atheoretical model with fairer and more universal dimensions. Second, the attention of the attributes in this model gained in previous studies, the function of these attributes in interaction design and their application potential in the subsequent stages are discussed and a new understanding perspective of interaction is provided.

4. Result

After all the objections were discussed and agreed upon, the clustering results showed that most (152 of 174)of the attributes could correspond to the two categories of interaction controland interaction experience with a few exceptions. Among the 22 uncategorized attributes, 18 attributes classified into neither of the two categories, and the rest 4 attributes express interaction experience but are relatively neutral without any tendentious descriptions. The attributes proposed by Saffer, D inDesigning Gestural Interfaces [17], "good," "clever," and "smart" simply state that it is a positive user experience but do not carry a pronounced tendency to describe how positive it is. Löwgren, J., & Stolterman, E., proposed an attribute "usefulness" in Thoughtful interaction design. A design perspective on information technology[13], which merely indicates that the interaction can trigger the desired function. Attributes of this kind cannot contribute to the dimensional breakdown of the overall theoretical model. Of the remaining 152attributes that could be further clustered, 84 (55%) fell into the category of interaction control while 68(44%) fell into the category of interaction experience. Among the 19 theoretical models clustered in this study, 12 focused on a single category, with 6(32%) models focused on interaction control and 6(32%) models focused on interaction experience. The rest 7(36%) models focused on both but did not clarify the connection between the two. It reconfirms the rationality of describe interaction control and interaction experience by two theoretical models in this study. Simultaneously, it reveals the scope for future research that can further focus on the linkage between the two in search of causal orientation.

4.1 Interaction Control Attributes

43 of the 84 (55%) attributes describing interaction control are derived from 6 theoretical models that describe interaction control exclusively. The focuses of these models overlap considerably, and the dimensions differ slightly in terms of scaling. In the paper In search of resonant human-computer interaction: Building and testing aesthetic installations [22], Hummels.C et al. proposed a theoretical model in witch all interaction controls are summarized as control. In the paper Interaction gestalt and the design of aesthetic interactions [23], Lim.Y et al. split the interaction control from temporal, spatial, interactive feedback, and resolution perspectives. Similarly, Lundgren.S et al. further split the dimension of time into specific attributes such as live time, real time, and unbroken time in Time, temporality, and interaction [24]. These papers further demonstrate the possibility of re-clustering all attributes in this study. In addition, another41 attributes describing interaction control were extracted from 6 models focusing on both interaction experience and interaction control. These models are mostly refined by subdividing interaction control at a specific scale, implying there is a causal relationship between the

interaction control attribute and the interaction experience attribute. Attributes at the fundamental level may trigger attributes at the high level. Such as in the paper Towards an articulation of interaction aesthetics[25], Löwgren. J not only subdivides interaction attributes into fluency and rhythm for the temporal dimension but also implies that changes in these two attributes can lead to changes in the dramaturgical structure of the experience attributes.

When clustering attributes in this study, the raters finally reached a consensus after several rounds of discussions that except for control as a generic attribute, as showing in Fig. 3, all other attributes describing interaction control were classified into the following six dimensions: time, space, force, context, feedback, and presentation. Moreover, a theoretical model was built.

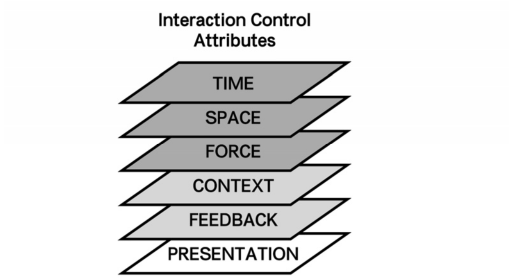

Fig. 3. Model of interaction control attributes

Among them, the dimension with the most attributes after clustering is "time" (26 of 84, 30%) and "space" (18 of 84, 21%). In these two categories, most of the attributes are highly coincident, but they differ slightly in dividing scale or expression. For example, "live time" is a subdivided attribute of "timing", or "movement range" is another expression of "scale". At the same time, some attributes are both of these kinds. "Speed"can be seen as a combination of time and space. Therefore, these two categories can be considered as an inseparable whole. Another similar category that belongs to the same basic dimension of the physical world and can be considered as an indivisible whole is force (2 of 84, 2%), which has the fewest attributes after clustering. In this study, it is important to state here that the number of attributes a category has after clustering is not an intuitive indication of the value of the category's existence. In the current context, force is a category with fewer attributes, probably due to the fact that force is not easily subdivided and therefore lacks highly overlapping attributes like the first two categories. Secondly, because the mainstream interaction devices in the market do not support the force dimension, such as the traditional GUI design or WIMP design, their mainstream carrier is the computer screen, with the interaction media as the mouse and the keyboard. These devices are not equipped with operations involving the force dimension, and in the touch screen of smart phones, only a few devices will involve pressure in a few operations. However, the force dimension has significant design potential in future interaction design. For example, in the interaction design of games that rely on joysticks or somatosensory devices as interaction media, the force dimension can better restore the scene for players to achieve an immersive experience. Meanwhile, in the market environment where wearable devices will become the next mainstream trend in the future, the force dimension deserves to be further developed. The categories with the second most attributes after clustering are "context" (11 of 84, 13%) and "feedback" (17 of 84, 20%). They together can be considered as the precondition and the consequence of interaction control. The "context" dimension of interaction is closely related to the support of the interactive device as a prerequisite, which determines the realizability of the interaction. The "feedback" dimension of interaction, as a consequence of interaction, is bound up with the user experience, and it also presents one of the unique characteristics of interaction, serving as a bridge between the user and the device. The presentation (10 of 84, 14%) is classified as a separate dimension because it is more indirectly related to interaction control compared with the previous dimensions. The presentation of interaction control does not intuitively determine the interaction control itself, but it is an indispensable alternative representation that can synchronize the interactive process. Please see Fig. 4 for interaction attributes percentage details.

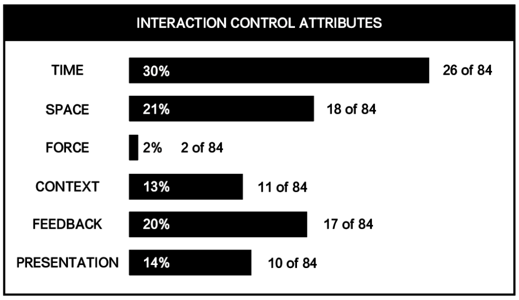

Fig. 4. Percentage of interaction control attributes

4.2 Interaction Experience Attributes

A total of 68(44%) attributes related to interaction experience were included in this literature search, which explained the factors that could induce positive or negative user experience from different perspectives. These attributes are closer to the foundation of user experience, they are the deconstructive components of user experience. After this clustering, as showing in Fig. 5, all the interaction experience attributes can be classified into six dimensions: stimulation, challenge, autonomy, safety, connectivity, and meaning. They are consistent with the most basic psychological needs of human beings in psychology.

From the clustering results, the category with the most attributes was "stimulation" (38 of 68, 55%), which accounted for more than half of the

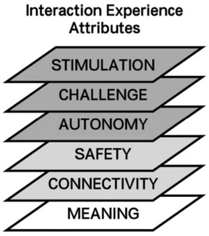

Fig. 5. Model of interaction experience attributes

total interaction experience attributes. A wide range of attributes can trigger stimulation, including

"unordinary" and "surprise" suggesting that interactions that defy conventional user habits can lead to memorable user experiences, and "immersion,"suggesting that new interaction-bearing technologies and devices (such as wearable devices or immersive interaction scenarios) can provide users with positive interaction experiences. Correspondingly, the category of "challenge"(4 of 68, 6%) is also used to form positive interaction experiences by creating unconventional senses. Unlike the former category, this category has a common design domain. According to the literature search, the attributes mentioned in the category of challenge, such as "challenge" and "difficulty", are mostly focused on game design, which enhances the interaction experience by increasing the interaction difficulty and reducing the interaction efficiency. These two categories contradict the traditional metrics of interaction usability proposed by Donald Arthur Norman (e.g., high fault tolerance, conformity to user habits). However, they are in line with the basic needs of human psychology, which should make us wonder whether, rather than design devices that are simple, efficient and easy to use, we should focus more on how to get positive feedback from users by creating surprise, adding mystery and helping users improve their skills. The second category with the number of attributes is "autonomy" (9 of 68, 13%) and "security" (8 of 68, 12%), the attributes of which are closely related to the functions achieved by the interaction, and are important criteria for assessing the quality of the functions completion. They are generally applied in business, finance, and user account management scenarios. The common feature of these two categories, namely "controllability, "coincidentally meets users' core needs in such scenarios. Therefore, these two categories are conditional on providing positive experiences for users. The categories with fewer attributes are "connectivity" (6 of 68, 11%) and "meaning"(3 of 68, 4%), both of which have certain linking feature. For example, "connectivity"can be regarded as the link between individuals, while "meaning" can be regarded as the link between expressions. Since the interaction control is mostly intuitive and directed clearly, it may be challenging to build such a complex link on top of the interaction control. Please see Fig. 6 for interaction attributes percentage details.

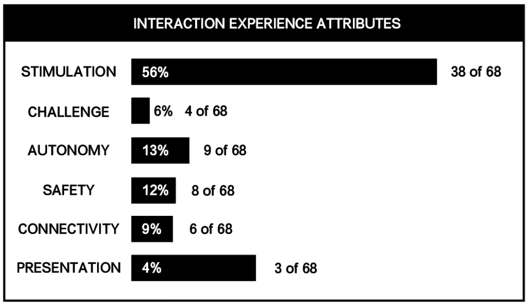

Fig. 6. Percentage of interaction experience attributes

5. Conclusion

This study confirmed that interaction as a design language is describable through literature retrieval and clustering, and further refined interaction as atheoretical model from the perspective of attributes on the basis of previous studies. As showing in Fig. 7, the structure of the theoretical model is divided into two sections, one section describes the interaction control, the other describes the interaction experience, each of which outlines six attributes. Based on this conclusion, we can preliminarily understand the two model sections as a hierarchical relationship. Interaction control attributes are underlying attributes that determine the behavior, while interaction experience attributes are upper-level attributes that determine the goal. This inference was rarely mentioned in the previous papers searched because the current mainstream understanding of interaction is based on the user or the experience respectively. Even the very few documents which mentioning the correlation between the two sections, have not clarified the causal relationship between the two.

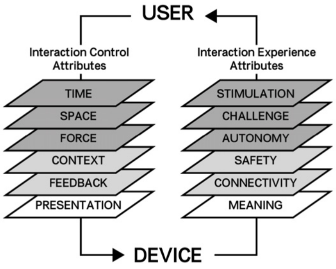

Fig. 7. Model of interaction experience attributes

To sum up, this study is just the tip of the iceberg. Behind it lurk more promising but less explored research directions in the field of interaction, which can be summarized as the following three aspects.

First of all, There is an explore potential on what constitutes a better interaction. As we know, the current mainstream methods for optimizing interactions and interaction evaluation systems are based on iterative design. It is mainly based on independent user data feedback. Although such a system has made significant contributions to interaction research and interaction design in the current situation, it has some inherent drawbacks of the big database, such as huge time-consuming and labor-intensive. Furthermore, the constant upgrading of device has hindered the generalization of foundation principal. Because of that, there are no consensus on what constitutes a better interaction, let alone on the factors for judgment. Even though there are previous studies attempted in making contribution on new interactive evaluation criteria based on demand, their focus is generally limited, primarily on usability and efficiency, or whether the functionality of interaction is achieved. According to the literature review and theoretical model from this study, it can be concluded that satisfying the function is only one of the elements to assess the interaction quality, besides that, interaction also needs to satisfy the specific psychological expectation or emotional experience of the users during the interaction. Ease of use is also contrary to the "playfulness and challenge" that some users might consider as positive, so it should not be the only criterion. This study can be regarded as a first step in this area, not only presenting an objective basis for interaction describeability, but also pointing out the gaps in previous research on the evaluation of interaction.

Second, the attributes in the theoretical model proposed in this study can be used as a valid indicator to explore the current interaction design. The frequency with which the model's attributes are used, explored, and paid attention to allows us to make predictions about which field of interaction contribute more to a qualified interaction. At the same time, some neglected attributes, such as "force", reveal the lack of pressure perception in the current interaction-bearing devices. These dimensions can also become a development potential for future interaction devices. Therefore, we need to conduct a holistic and comprehensive comparative study to summarize the importance of the attributes in creating quality interactions and how the neglected dimensions can be transformed into potential development space for interactions.

Third, the proposed theoretical model provided in this study involves two sections, interaction control and interaction experience, which show a hierarchical relationship in this study. The interaction control attributes are the underlying attributes which represent behaviors, while the interaction experience attributes are the upper-level attributes which represent goals. Therefore, certain attributes in the interaction control model should trigger certain attributes in the interaction experience to some extent. In the follow-up study, we should further explore the relationship between the two, and investigate how each attribute in the two models corresponds to each other, and how designers and practitioners should construct the attributes in the interaction control model to trigger the desired interaction experience.

In conclusion, the research on interaction language and interaction describability is still in its early stage, and scholars have different opinions on creating qualified interactions. As researchers in the interaction domain, we should take it as our duty to stand at the forefront of interaction studies, build the theoretical foundation, and explore more efficient and convenient practical methods. We hope that the theoretical model of interaction attributes built in this study will be another step forward in the theoretical research of interactions.

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샨 슈 야(Shan Shuya) [정회원]

· 2011년 1월 : University of the Arts London Graphic Design(석사)
· 2019년 3월 ~ 현재 : 국민대학교 테크노디자인전문대학원 경험디자인학과 박사과정
· 관심분야 : 인터랙션 디자인, 서비스 디자인
· E-Mail : shuyashan@163.com

반 영 환(Pan Young Hwan) [정회원]

· 1991년 2월 : 한국과학기술원 산업공학과(공학사)
· 1993년 2월 : 한국과학기술원 인간공학(공학석사)
· 1999년 8월 : 한국과학기술원 인간공학(공학박사)
· 2006년 9월 ~ 현재 : 국민대학교 테크노디자인전문대학원 교수
· 관심분야 : 인터랙션 디자인, 사용자 경험(UX)
· E-Mail : peterpan@kookmin.ac.kr