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Design for Future User Experience

TJ Kim
Purdue University
Kim1886@purude.edu

Abstract

The world is changing dramatically and rapidly, the introduction of innovative technologies has brought about new user interactions, changed behaviors, and induced new social activities. People now have a stronger desire for authentic and innovative user experiences.

In this paper, I will discuss four distinct types of possible future user experiences that have been discovered from research into user behaviors. Furthermore, I will discuss how designers can deliver these new user experiences for the future, through a strategic design process. 1. Physi-tal experience is using the human body as an input system to control computerized system or objects in digital world as an output. 2. Digi-log experience is combining of digital and analog technologies to deliver more familial interactions and experiences to the end users. 3. Info-matic experience is centered on data collection, composition, and communication from daily activities and applications in our environments and everyday lifestyle. 4. Hyper-reality experience is how we can enhance our real world experience with combing of virtual and augmented reality technologies.

Studies of these newly defined user experience types and behavior patterns will help us to understand better about human desires and our motivation, and assist us in making plans for evolution, revolution, and innovation. They also assist in finding paths in design approaches and in delivering future experiences.

Keywords-User Experience; Service Design; Diamond process

1. Expectations in tomorrow's world

The world is changing dramatically and rapidly, the introduction of innovative technologies has brought about new user interactions, changed behaviors, and induced new social activities. People now have a stronger desire for authentic and innovative user experiences.

In this paper, I will discuss four distinct types of possible future user experiences that have been discovered from research into user behaviors. Furthermore, I will discuss how designers can deliver these new user experiences for the future, through a strategic design process. 1. *Physi-tal* experience is using the human body as an input system to control computerized system or objects in digital world as an output. 2. *Digi-log* experience is combining of digital and analog technologies to deliver more familial interactions and experiences to the end users. 3. *Info-matic* experience is centered on data collection, composition, and communication from daily activities and applications in our environments and everyday lifestyle. 4. *Hyper-reality* experience is how we can enhance our real world experience with combing of virtual and augmented reality technologies.

Studies of these newly defined user experience types and behavior patterns will help us to understand better about human desires and our motivation, and assist us in making plans for evolution, revolution, and innovation. They also assist in finding paths in design approaches and in delivering future experiences.

2. Strategic Design Process

Today, design paradigms have begun to change with more people understanding its value. Design is not only about technical skill sets to improve visual aesthetics; it is also a way to figure out how things work, a process of delivering innovative solutions, and a way to think differently. Additionally, design practice takes many different shapes. Many designers practice the role of design as a consultant, working for design firms. Others have found new ways to practice their design, creating new products for startup

businesses, and building design-focused business models. Also, in many businesses in industry, design is considered an integral part of their business strategy, helping them build sort-term, mid-term, and long-term plans to differentiate their products in the market.
The introduction and practice of strategic design processes and design thinking methods have helped many non-designers, engineers, and marketers in business decisions. This has led to a better understanding of design and its value to their businesses and communities. So, what are these strategic design processes, how are they being used, and what are the impacts on industry? The *Double Diamond* process and the *Big Diamond* process will be described below.

2.1 Double Diamond Process

The *Double Diamond* process model is one of the most commonly used diagrams that explain a new design thinking process and methods. It is also a framework to explain a human-centered design approach, studying human behaviors and motivations to find unmet needs, and delivering innovations to the world by solving common problems in everyday life.

Double Diamond Process Model

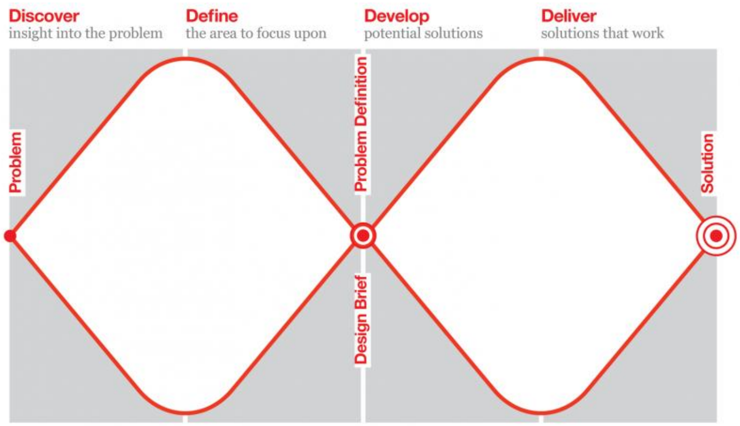


Fig. 1. The Double Diamond Model, by the UK's Design Council, 2005

The double diamond process model was developed by in-house research team at the design council in 2005, to explain and describe the complexity of design process and methods in a simple framework.
Discover is a divergent stage to gather data from multi-dimensional views, information on market trends, social trends, people's behaviors, and their needs. It is about understanding big problems from a macro point of view, finding the issues in our community and business system.
Define is a convergent stage to narrow project focus, finding opportunity areas, insights, and a target demographic segment. It is an important stage to decide on the design directions and goals that aligns with the organization's project objectives.
Develop is another divergent stage to find many potential solutions in different problem areas, brainstorming solutions using many different types of design methods. But most importantly evaluating the concepts though user testing and survey, making iterations of the concepts based on the feedbacks.
Lastly, *Deliver* is another convergent stage to help narrow the focus again, finalizing the solution considering manufacturability and marketability, to deliver final solution to the market and end users. It is a final stage before launching a product, service, or business model.
This is the strategic design process that is commonly understood by many organizations in today's industry, explaining the design thinking process and methods in timely manner and how it can be applied to their product development process. It has helped many people understand the complexity and the objectives of the design process by relating to business simple linear steps of the process.

2.2 Big Diamond Design Process

However, just understanding the steps of the double diamond design process does not make everyone a good designer. To be a good designer we need to train our mind with more tactical thinking and practice the skills that helps us to visualize and communicate our ideas to others, making the ideas into tangible solutions using these skills.

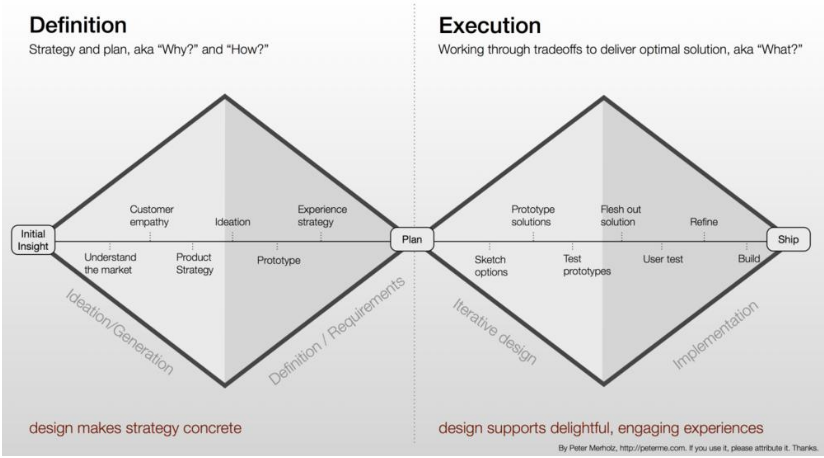
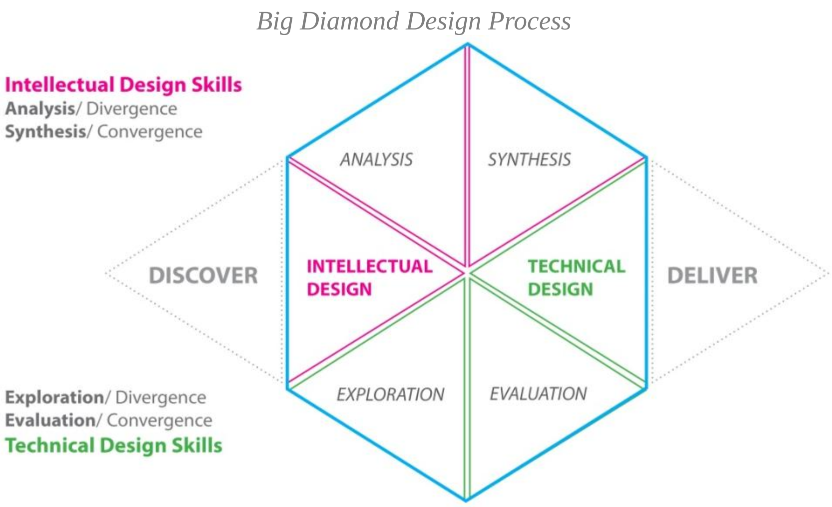


Fig. 2. The Double Diamond Model adapted by Peter Merholz, 2013

Many experienced designers have two main unique skills sets; **intellectual design skill set**, research, analysis, and synthesis, and **technical design skill set,** concepts generation, exploration and evaluation. *Big diamond* is a process map emphasizing these skills and further explaining the complexity of a multi-dimensional design process and dynamic design approaches in the design process.

Analysis is a divergence stage, grouping by similarities in research data, visual and physical evidence, voice of users, and insights, and sorting them in categories by differences. *Synthesis* is a convergent stage of narrowing and deciding the design directions and approaches, setting goals, and plans for the next stage. Large quantities of information are communicated through visual guidelines, charts, diagrams, frameworks, and informatics. *Exploration* is a divergent stage of brainstorming many aspects of solutions and finding applications through visual prototyping, sketching, physical prototyping and mockups. *Evaluation* is a convergent stage of weighing the value of concepts to narrow the project focus even more based on the project goal, feasibility, capability, and viability.



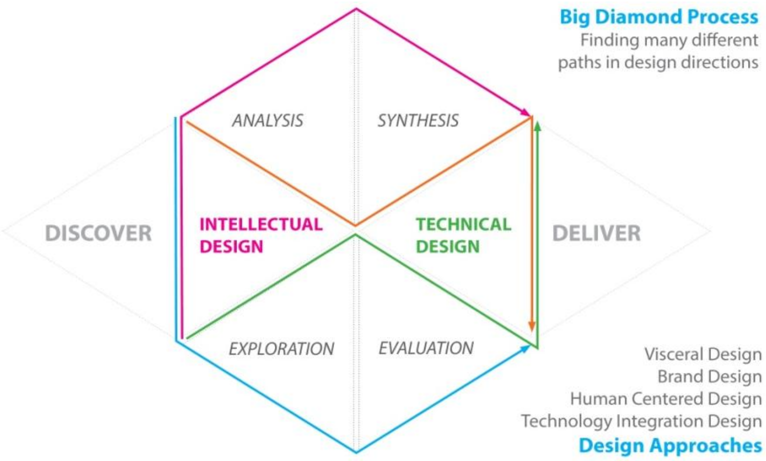


Fig. 3. The Double Diamond Model iterated by Tong Jin Kim, 2013 / Big Diamond Process

Design is a multi-faceted stage with a variety of design approaches. For example, *Visceral design* refers primarily to that initial impact, to its appearance, focusing on developing iconic shapes and visual language. *Branding* is about creating a strong business identity and implicated meanings of their value proposition, through brand expression in their product portfolio. *Human centered design* is about problem solving, discovering user behaviors through observation and interviews, finding unmet needs and opportunity areas to improve everyone's life. *Technology integration* is one of the most recently discovered and practiced design approaches, and the focus of this paper. Technology integration can help in developing new user experiences by understanding current technology, finding better applications, making the technology more acceptable, adaptable, and approachable. In order to understand this approach, we need to study another important design model called *Technology Adoption Lifecycle Model*, created by Everett Roger in 1962.

3. Technology Adoption Lifecycle relating to human behaviors and design approaches

The Technology adoption lifecycle is a sociological model that describes the adoption or acceptance of a new product or innovation, according to the demographic and psychological characteristics of defined adopter groups. In his theory, Innovators are more educated, prosperous and risk-oriented user group, early adopters are younger, also more educated, tended to be community leaders, but less prosperous.
Early majority are more conservative but open to new ideas, active in community and influence to neighbors. Late majority are older, less educated, fairly conservative and less socially active, and laggards are very conservative, oldest and least educated user group.

Technology Adoption Lifecycle Model

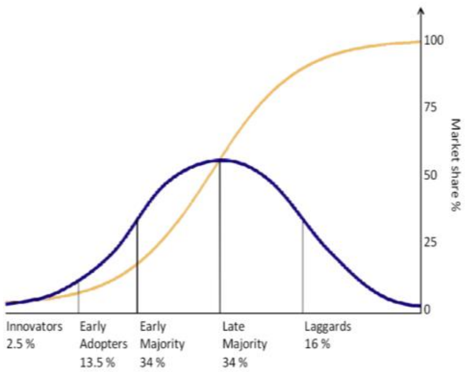


Fig. 4. Technology adoption lifecycle model by Everett Roger, 1962

Strategic Design Approach Model

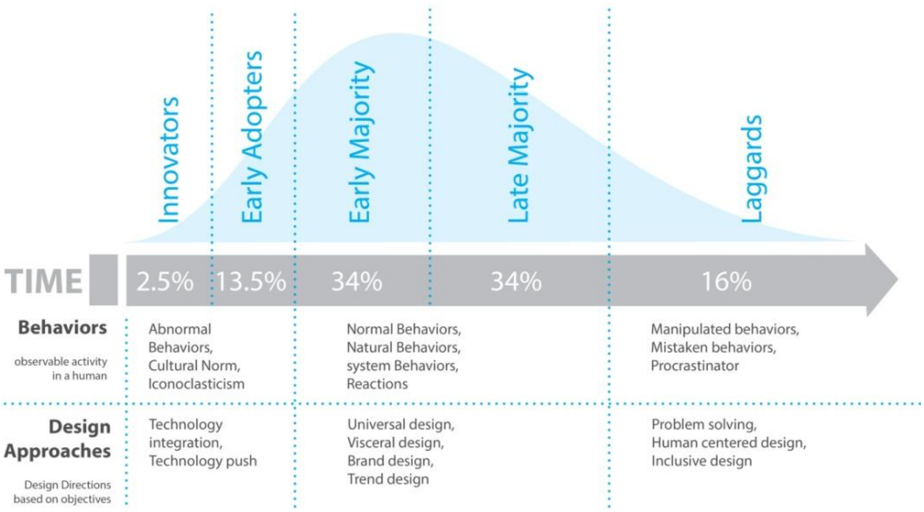


Figure 5. Technology adoption Lifecycle model iterated by Tong Jin Kim, 2013 / Strategic Design Approaches model

When we combine the idea of the *Technology adoption lifecycle model* to the *Big diamond process model*, we can understand better about what types of demographic segments that we need to target, what kind of behaviors that we need to research, to find more suitable design approaches for the project. This combined model provides us more detailed hints for how we can design better for different project objectives and business goals.

3.1 Innovation Gap by technology delay

However, there is still one big concern in the Strategic Design Approach model. In the past, we have seen many innovation gaps caused by technology delays. Our technology was not fast enough to catch up with our imagination and desires. Many visions have been shown thought movies, dramas, and books, how our world would be more advanced and convenient in the future with the help of technology. However, technology was not good enough to meet our expectations, there was a big delay in our technology improvements.

Example of Innovation Gap

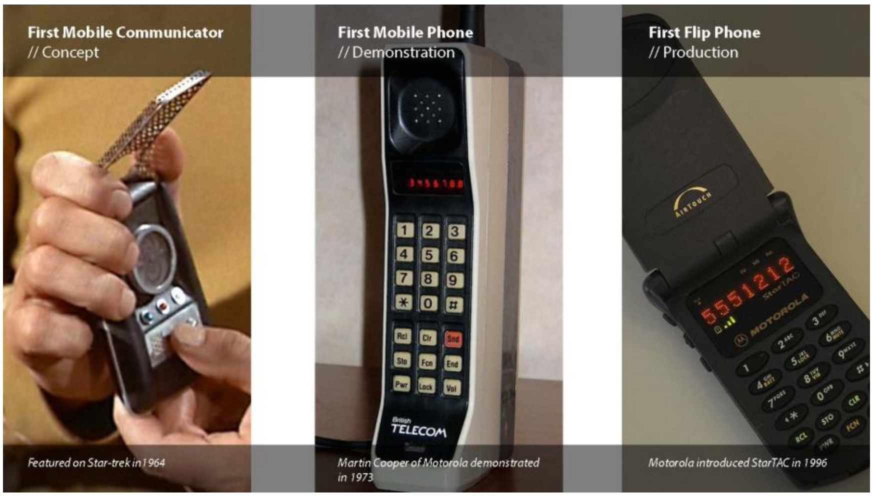


Fig. 6. Motorola mobile phone technology developed by Martin Cooper in 1973 /images compiled by Tong Jin Kim, 2013

For example, a concept of mobile phone was introduced in a TV drama series called "Star trek" for the first time in 1964 and the device was called as a "Communicator". In the movie the device had a cover that flips and open to communicate with others and the user will close the cover to end the conversation. Martin Cooper, an engineer at Motorola, show the device on TV and it inspired him to develop a such a device like this for the real life use. He was able to demonstrate a similar device in 1973. It took him about 10 years to develop a first working prototype of the concept. However, the first device that looks and works exactly like the "Communicator" came out in 1996, that's almost 30 years after the concept was featured in the TV drama.
But today the speed of technology improvement has changed so dramatically, with help of computer system and many newly discovered technologies, we have accelerated the development process and shortened the time for a introducing new technologies. In fact, industry may not be fast enough to catch up with speed of improvements, not able to utilize full potential of these newly discovered technologies, especially finding acceptable applications of them.

4. Design for Future User Experience

So, in order to accelerate the process, catching up with speed of technology, we need to understand our target demographics. We need to research, their behaviors, motivations, and desires? But most importantly their expectation of the future and desired experience. If we can define this, we can narrow the focus of our research areas and reduce our development time to deliver acceptable new user experiences.

Design for Future User Experience

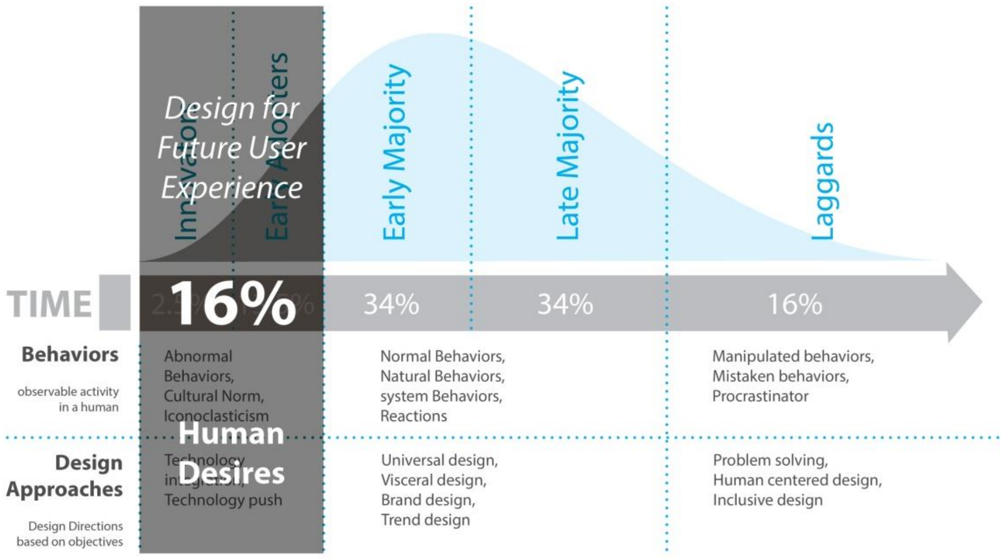


Fig. 7. The Double Diamond Model iterated by Tong Jin Kim, 2013 / Strategic Design Approaches model

In order to design for the future, we have to understand the behaviors of *frontiers*, the first 16% of a products lifecycle, which includes innovators and early adopters, who are educated, risk oriented, and tend to be community leaders. These are the target demographics that who have a strong desire to see something new, make adoption to changes, and innovate the world. They are the groups of people who thinks different from others, push the boundary of imaginations, and forecast the trend in the near future.
We have to study their unique behaviors, cultural norm, and most importantly their undiscovered desires. A design approach and process that focus on delivering future user experience, involves researching in abnormal human behaviors driven from the human desires, the desires that have existed for many centuries but could not been delivered at the time period. *Design for future user experience* is about delivering the new experience today by connecting and integrating new technologies. We can find many hints of these behaviors and desires from movies, dramas, and books that describes the future. We can find suitable technologies to deliver these experiences though technology scouting, pushing to find new applications of the technologies, accelerating the development process of delivering these future experiences.

With the combined process described above, I have found 4 unique types of user experiences, which can lead us to make a plan for more innovative design approaches for designing future user experience.

4.1 Physi-tal User Experience

Phy-sital Experience focuses on using the human body and gestures as an input system in computerized device. We can find evidence of these experience types from the devices in gaming industry. Nintendo Wii was first introduced to the market in 2006, suggested how people can use their bodies to play a game. The Wii system detects the movement of the controller in user's hand, in 3 dimensions and controls digital content in the game. Followed by Microsoft Xbox camera, and Sony PlayStation camera, which use a camera to capture a human body movements and gestures, articulating the user's movement to controlling the characters in the games. This concept of using the body to control computerized system has changed people's mindset about the future user experiences.

Physital Experience= Physical activities + Digital contents

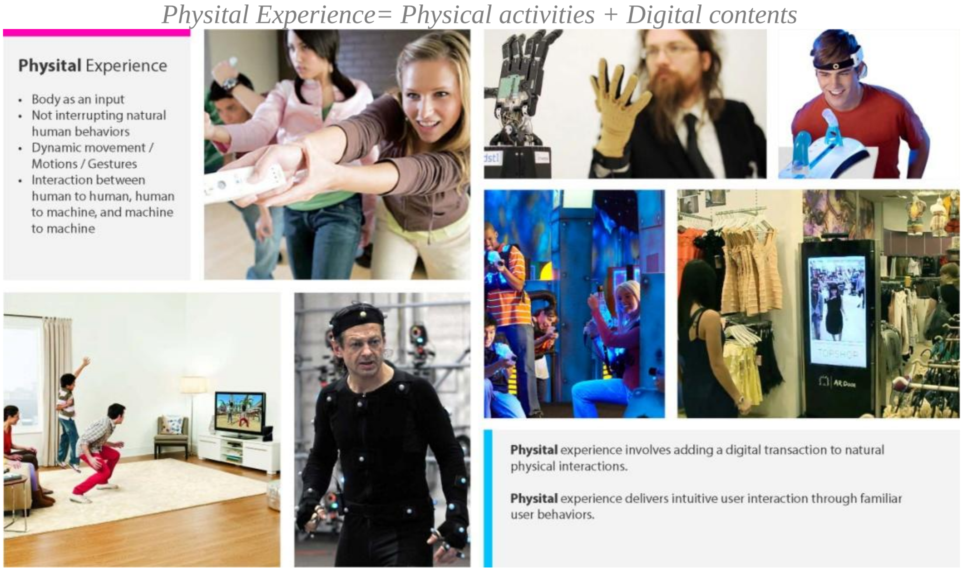


Fig. 8 Example of Physital Experience Behaviors/ images compiled by Tong Jin Kim, 2013

When personal computers were initially developed we had to use a keyboard to input the data and use a monitoring to view the contents as an outcome. Later we learned to connect a mouse as an additional input device and connected a printer as another output system, and more devices were created as input and output systems. Initially users had to learn many computer languages and execution commands to operate the system. There was a very difficult learn curve and it was a specialized skill that only experts would know how to operate the system.
Today we can directly interact with the computerized system, using smart devices, input and output system combined into one, interacting with the objects on the screen by touching, using gestures to manipulate the objects, speak to the device to operate the system, and computerized devices can react to any of your motions through sensors. In the near future, we are expecting to see a human being operating a machines without giving any commands. Many machines could be wearable, integrated into our body to enhance our human capabilities, or even expanding and adding new capabilities. Only our natural behaviors and mind would be input system to operate the computerized devices and our body would be the combined input/output system.

4.2 Digi-log User Experience

As mentioned previously, today's technologies are improving quickly and changing dramatically, we are not only seeing the innovation gap by the technology delay rather by human adaptabilities delay, many individuals are not capable of catching up with the speed of the technology improvements. Technologies are changing even faster than individuals to learn and master the new system.

Nest, digital thermostat, is a perfect example of a *Digi-log Experience* based product. The *Nest* thermostat is a smart-house temperature controlling system that focuses on efficiency of the energy use. There are many other similar products in the market and most of them are offer the same features and benefits as *Nest*. They are connected to a smart phone, wirelessly controlling the unit and monitoring the system. But what makes the Nest unique from the others is the physical interaction. The other devices offer a touch screen controlling system, which is the most popular today as an input and output combined system. However, *Nest* added a traditional analog like interaction, turning a dial to change the temperatures, with a simple digital display showing a big number, showing the temperature. People instantly knows how to operate the system, with a traditional form factor, there is not much of a learning curve to use the device.

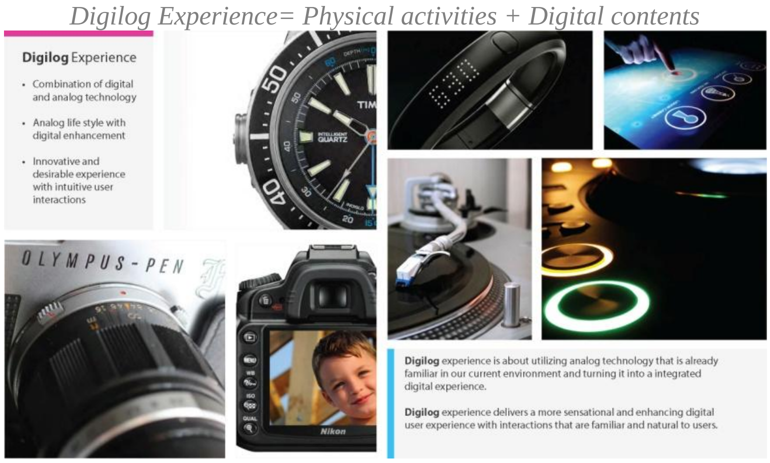


Fig. 9 Example of Physital Experience Behaviors/ images compiled by Tong Jin Kim, 2013

Fig. 10 Nest, Thermostat

There are many new advanced technologies being introduced today that are useful. But it takes time for people to accept, adapt, apply those new technologies, it is hard to change our old habits and perceptions. Digi-log experiences can help in a transition stage from old to a new era.

4.3. Infor-matics User Experience

Today, we are surrounded in data, data is everywhere. Smart devices around us are constantly adding to the data. This collected data can provide designers with hints to help them find pattern of behaviors, narrow the focus of the business. So, there are now many businesses forming around data collection, composition, and communication, trying to find ways to utilize the information, finding applications, and automate service for their potential customers. Some people argue that it's an act of invading individual's privacy but also many argue that it is making our life easier and smarter with the data being used wisely.
Google is a good example of this *infor-matics Experience* design focused business model. The company initially started as an online search engine to help individuals to look for detailed information. Later they have added more searching feature, such as find images and finding direction using their map. They have also created an email system that allows individuals to communicate easier and collaborate with others.

Infor-matics Experience= Data collection + Composition + Communication = Applications

Fig. 11. DIG 8 program participants at Nettle Horst elementary school/ images compiled by Tong Jin Kim, 2013

Now the system can recognize detailed information in my email system, understand the meeting or travel plans and indicating calendar, making suggestions on travel plans based on the traffic conditions, showing weather of the destination. The system is making suggestions based on the user’s current and past behavior pattern, user’s interest, and favorites.

Many people are expecting to see even more smarter experiences in the future, understanding our personalities and knowledge, help making individual’s future plans, making more informed decisions, and delivering more authentic user experiences to assist us in everyday life.

4.4 Hyper-reality User Experience

Hyper-reality Experience is about enhancing the real world experience by combining of technology, making it more dynamic, extreme, and providing more information about the object and scene through wearable displays. Currently we have two different types of wearable display technology in the market, virtual reality, 3 dimensional computer generated worlds that are interactive with some computerized devices. And, an augmented reality, overlaid data on the real-world, integration of digital information with live video or the user's environment in real time.

Hyper-reality Experience= Virtual Technology + Real-world Experience

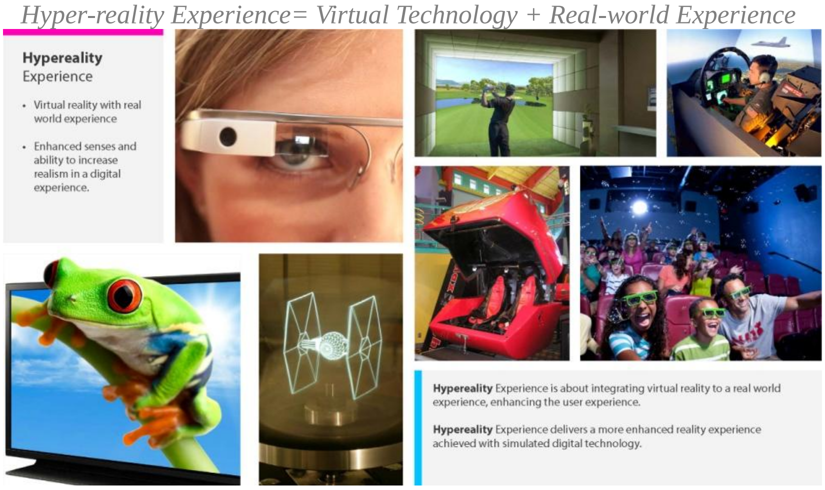


Fig. 12. DIG 8 program participants at Nettle Horst elementary school/ images compiled by Tong Jin Kim, 2013

We find the evidence and desires of the *Hyper-reality Experience* through product like, Facebook Oculus, Google glass, and Microsoft halo lens, that are utilizing the virtual and augmented reality technologies, to play games and watch movies. We also find digital content being enhanced by 3D film combined with physical effects, simulating rain, wind, strobe lights, and vibration, in 4D movie theaters and amusement parks.

But some of these experiences still feel somewhat artificial, unreal, requires the user to wear extra devices that they don't typically use in the real life. However, in the near future, we are expecting to see these display technologies to be more integrated into our environments, such as a house window with built-in with digital display technology, seeing animals playing outside, snow in the summer, and streets in Paris throughout the window. Also, by applying the same technology to the cars, we can increase the peripheral vision, eliminating the blind spot by seeing panoramic view of outside, integrated night vision technology to increase the safety driving a car at night. We are expecting to see more enhanced real world experience with more technology being integrated into our real world environments.

5. Conclusion

The areas of studying design are expanding by more people understanding the value of design, applying design process and methodologies in non-traditional design fields. Specifically, technology integration is one of the fast growing design approaches in design industry that combine the design skills with technology awareness. Designers now have new roles and responsibility to industry and community. We are the creative thinkers and visionary planners to see the new future and innovate the world. We have the responsibilities bring the future that people have been dreamed about for long time.

The future is near us, closer than what we think, we can bring the future even more closer to us if we understand better about human nature, learning from their behaviors and emotional desires. Designers have special abilities, an ability to see the future and an ability to show the future to the others. But most importantly we have the ability to bring the future today by connecting and combining technologies to make dreams into realities.

Delusion vs. Desire vs. Design

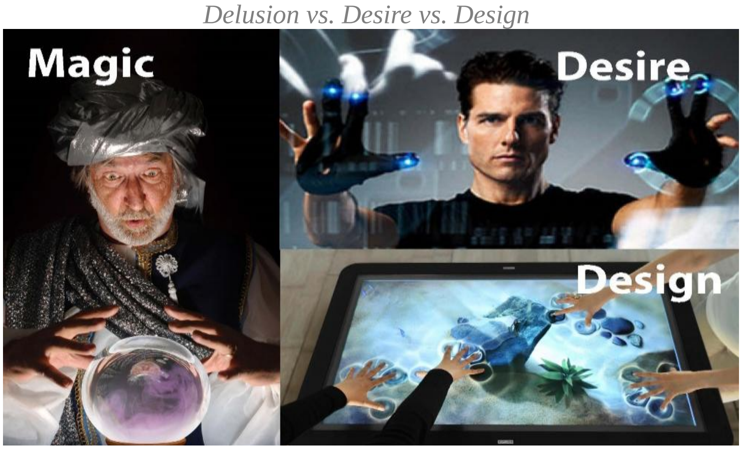


Fig. 13. Comparison of delusion, desire, and design by Tong Jin Kim/ images compiled by Tong Jin Kim, 2013

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Comparative analysis on differences in personification of representative animated characters in China and in the United States

Qing Ma, Chul Young Choi

Department of Visual Contents, Division of Digital Contents
Graduate School of Dongseo University, Dongseo University
Busan, South Korea
maxiaojing19931012@gmail.com, freechoi@dongseo.ac.kr

Abstract

There have been characters for many stories through ancient tales and fairy tales in China. Although animal character such as Sun Wukong is representing China as personified animal character, it is extremely rare to find successful animal characters in China compared with the United States. Therefore, I would like to analyze the background and cause of the commercial success of animal characters by comparing representative personified animal characters in China and America through the form, status, and activity background.

Keywords-animated characters; differences; China; United States; anthropomorphic

1. Introduction

1.1. Research background

Winsor Zenis McCay's <The Story of a Mosquito> in 1912 was known as the first animated work to set a non-human character as the main character. Since then, over the past 100 years, many animal characters have come to the screen by the development of video technology and animation technology and been loved. For example, Mickey Mouse, Donald Duck, Garfield, and characters familiar to people such as <Pleasant goat and Big Big Wolf> aired successfully in recent years in China, not only received the love of the children but also gathered interests by many adults continuously.

"Personification" is widely used as a method of expression as a creation of art forms such as literature and drama. This method is to metaphorically express phenomena and problems existing in human beings by mainly expressing the emotions of people by other things. The application of “personification” to accentuate the animal characters through the animation work should be applied in consideration of the materials and cultural contents of the animation work itself. These combined characters induce the audience to fall into the stories as a character in a harmonious setting, not an awkward existence between objects, animals, and people.

As the birthplace of animation and the largest manufacturer of character works, the United States shows the representative "personified" animal characters with a clear style both in material selections and aesthetic features. In fact, Chinese "personified" animal characters have also been born for a long time ago. Sun Wukong in the famous animation work <Havoc in Heaven (a.k.a. Uproar in Heaven), 1964> is the very most representative personified animal character. Monkey's wisdom and agile features are equivalent to the rebellious and un-bending spirit of mankind. The reason I chose animal characters of China and the United States as research contents is because the Eastern and the Western cultural system are different and characters in each countries' works present precise distinction. By using this difference to summarize the causes, it is possible to analyze the regularity of "personification" that is utilized for animal characters from the surface to the deep inside.

Animation is a comprehensive expression of screen and sound. As a new medium that just appeared in the world, animation works have been constantly appearing with animal characters as main characters in nearly 100 years. And those animal characters are known and loved by people have already become a symbol of culture. For example, Disney's "Mickey Mouse" has become a character that symbolizes America since it's born.

Currently, there are many problems in Chinese animation industry. For example, the aesthetic personality of the design is not clear, there is a misalignment of targeting the public, blind imitation of the Japanese and the American animation concepts, and so on. This has a very disadvantageous effect on the development of the Chinese animation industry and the succession of its ethnic culture. Most of all, the lack of distinguished animation characters seems to be the most problematic factor among them. In Chinese animation work <Havoc in Heaven>, the representative "personified" animal character Sun Wukong has received love of viewers all over the world with its vivid ethnic characteristics and cultural attributes. However, currently there are few such wonderful animal characters. In 2006, SARFT (China's State Administration of Radio, Film and Television) announced a new regulation saying, "All channels of each class of broadcasting stations across the country broadcast or introduce overseas animation programs between 17 c'clock and 20 o'clock every day and display overseas animation programs will be prohibited."[1]

The new regulations provided a platform for a very wide range of exits in domestic animations, so that made significant progress in terms of production volume. However, looking closely at these works, the problems are constantly appearing due to the inexperienced production and monotonous storytelling which lead low level of quality of work. "Animation characters created by some animation companies are oversimplified, conceptualized and formalized, and their characters are not funny and do not have lively feelings and emotions, so they do not leave strong impression on viewers."[2] All these are regarded as urgent problems to be solved in the development of the current Chinese animation industry.

1.2. Research method and scope of research

In order to analyze the data of China and USA of the personification of animated animal characters, the analysis will be carried out in following three aspects. First, I would like to compare and analyze the personification of characters in the representative works of animation companies in China and the United States in order to study the ethnic characteristics of Chinese and American animation in terms of concept design of animated characters. Second, I would like to do comparative analysis in terms of characters, occupations and activity backgrounds in the scenario of animations. Third, based on the comparative analysis study of the first and the second, I would like to analyze the personification of the character attributes according to the creative intentions under the historical backgrounds.

2. Subject

The United States is the country where production studios representing modern animations and movies are located, and the world's largest animal characters are appearing in animations. Chinese animation works reached very high level in terms of artistic knowledge from the 1950's to the 1980's. China has established the world famous "school of China," has made remarkable results in the history of animation in the world, and has created "personified" animal characters that are clearly different from animation in the same period in the United States.

Personified animal characters of China and the United States showed very distinguishable features among animation works. In order to explore the regularity among them, I conducted some research in the following aspects.

2.1. Difference in "personification" of representative animal characters in China and the United States

The level of "personification" in the shape of an animal character is relative concept. There are no character shapes that do not have minor modification, nor do they transform to 100% absolute realistic figure. The shape of the most realistic "human" in animation works is the result designed and selected by the animator according to the prototype of animals. There is only different degrees of high and low levels of "personification." For the subject, I will analyze the difference in the expressions of "personification" on representative animated characters of China and the United States based on the shapes, status and its activity background.

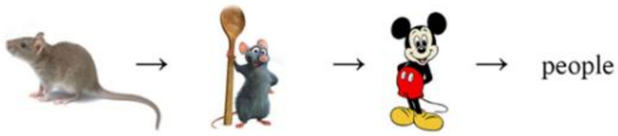


Fig.1 The degree of "anthropomorphic" animal cartoon image

"Personified" animal characters such as Mickey Mouse, Donald Duck, Garfield, Tom and Jerry are the major characters in the United States. "Americans prefer animal roles are reflected from the side they like animals, happy to close the animals Character, the feelings of the characters in the animal's body."[8] The choice of the basic form of animals can be diverse from animals as small as ants and rats to larger animals like elephants and hippos, lions and zebra running around on the ground, sharks and sea turtles swimming in the water, smilodon (commonly known as saber-toothed cat) in the glacial era, the mammoths to dinosaurs in the Jurassic Period as shown in Table 1. However, Chinese animation shows much narrow selection. It is common to choose domestic animals such as a cat, a dog, a rabbit, or typical animals from folk tales like a "cunning" fox or a "gluttonous" pig.

Table 1. Chinese and American Animated Animal Character Comparison Chart

Category Country	Title	Main Character
The United States	The Ice Age	Mammoth, Saber-toothed cat, Sloth, Squirrel, Opossum
	The Lion King	Lion, Hyena, Wild boar, Mongoose, Baboon
	Finding Nemo	Clown fish, Blue tang, White shark, Pelican, Blue, Green sea turtle, Angel fish
	The Penguins of Madagascar	Penguin, Lemur, Otter, Orangutan, Squirrel, Elephant, Kangaroo, Crocodile, Dolphin, Sea Sparrow, Bear, Cow, Chameleon, Deer, Pigeon, Wasp
China	The Wolf's Banquet	Wolf, Chicken, Bear, Fox
	Black Cat Detective	Cat, Pigeon, Mouse, Mantis
	The Blue Mouse and the Big Faced Cat	Mouse, Cat, Bee
	Little Cat goes Fishing	Cats, Fish, Butterfly, Dragonfly

2.1.1. Difference in Shape

Maintaining the prototype of the animal is one of the basic features in animations of the United States. For example, the most common "personification" method applied to bird is making wings function like human "hands"; Regarding the animals moving on limbs, the animated movie <Ice Age, 2002> series maintained the state of movement of limbs, which is the basic form of animals such as mammoths, saber-toothed cats. Depending on the development of the story, the animal character may stand upright on two feet, but walk on four limbs in general. Regarding the postures and shapes of the animals, we can hardly see traces of human beings like clothes and movement of human body.

Garfield and Snoopy are very good examples. Simba at <The Lion King> walks on the grass with four legs and Marlin at the <The Octonauts> sends fresh water to the eggs with gills and caudal fin like wild fish.

In <Garfield>, the distinctive feature of Garfield, the owner John's pet is laziness. He oversleeps because he simply doesn't want to get up and hates John's another pet dog, Dio. It is the characteristics of a extremely lazy and selfish animal character that is not even trying to fix its "laziness".

However, Garfield with such characteristics of human in this manner, does not add many human behavior. Sometimes he complains about tasteless canned food to John, runs away after hitting it as revenge for Dio like human, but Garfield usually acts just like a real cat, sleeping at home and basking in the sun, secretly tasting the flowers John planted or communicating with the neighbor cat. It is necessary to set these "habits of cat" to make viewers feel that the lazy protagonist in the animation is not a person but a very lazy "cat," so that negative impression about laziness of human beings can be avoided.

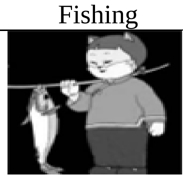
Table 2. Features in Animal Characters of American Animations

Title	Ice Age	The Lion King	Finding Nemo	Garfield
Character				
Features	1, Maintaining the basic characteristics of animals, not wearing clothes 2, Walking on four legs, only in some cases, walking on two legs 3, Exaggerated and rich facial expression			

"Personified" animal character in China is confined to appearance designs and has human traits more than characters of the United States as shown in Table 3. Walking on two legs, wearing clothes, and using utensils and tableware all quote the custom of human behavior as it is.

<Black Cat Detective (a.k.a. Marshall the Black Cat)> is an animation that deals with a moral subject of human which is promotion of virtue and reproval of vice using animal characters. The mouse "One Ear" in the animation is tracked by black cat detective and white cat detective for theft and wicked deed. All "personified" animal characters of "Black Cat Detective" are in typical storyline of "cat and mouse" and all of them including black cat detective, "One Ear", white cat detective, pigeon detective, and warts couple chase and walk on two legs. Their foreleg plays the role of human arms and hands, and even the cats' feet even function like human hands with five fingers as they are. Black cat detective is wearing a police uniform and a helmet, holding a cell-phone in one hand and holding a gun in the other hand shooting at "one ear". Also, the setting such as going to the crime scene riding an electric flying boat completely features the characteristics of human behavior only with the animal figure of cat's whiskers, ears, and a tail. The setting of the roles of both the police officer and the criminal at <Black Cat Detective> reflects the fixed idea of people having about relations between cats and mice. The image of the "thief" of the mouse and the natural attribute of the cat catching the mouse engaged and expressed the theme of "didacticism" through "confrontation" between the cat and the mouse. There are various kinds of animal characters in the film such as warts, birds, playing the role of "residents of the village". They also wear clothes and walk around the village with two legs. Furthermore, it avoids natural attributes that birds eating insects so that they cannot coexist.

Table 3. Features in Animal Characters of Chinese Animations

Title	The Wolf's Banquet	Black Cat Detective	The Blue Mouse and the Big Faced Cat	Little Cat goes Fishing
Character				
Features	1, Always wearing human clothes 2, Walking upright on two legs 3, Subtle and small changes of facial expressions			

2.1.2. Difference in facial expressions and attitudes

American animation work is well known for exaggerated facial expressions and attitudes of all the characters that express the value and idea of animation. For the examples of characters with rich and exaggerated facial expressions are early animal characters "Mickey Mouse" and "Donald Duck" with their eyes and mouth occupying most of their faces. The design concept of the animal character in the animation of the United States has not changed significantly until now. It is no overstatement to say that the exaggerated and transformed facial features and the dramatic facial expressions have already become one of the most representative methods for the character design of animations in the United States.

Fig. 2. <Tom and Jerry, 1940> <Finding Nemo, 2003>

Unlike the exaggerated facial expressions of the American animation character, "personified" animal characters in China show mild changes. They have similar features of relatively plane facial shapes of Asian people, and they don't do exaggerated facial expression such as "raising eyebrows", "showing teeth", and "glaring fiercely" frequently seen in American animation characters. In the face, the range of eyes and nose is either very small, or be omitted from the beginning. For example, "eyebrows" of characters were completely omitted in the animation <McDull> and <Shuke and Beita>. The eyes were designed as "dots" for the face of characters in <McDull>, so it is impossible to express emotions through eyes and eyebrows unlike animal characters with big eyes in the animation of the United States. The characters have to give variety to their facial expressions only by positioning of their eyes and mouth as there is not enough change in eye area.

Fig. 3. <McDull> <Shuke and Beita>

2.2. Differences in social status, occupation and activity background

The setting of the background plays a very important role in the process of "personification" to an animal character. This not only determines the identity and status of the character itself but also influences the materials and contents of the animation work. Animal characters in Chinese animation and those in American animation clearly have different settings of social status. In particular: Chinese "personified" animal characters are mostly put in the social environment of human, and they do their job as people do according to their status and occupation. On the other hand, this kind of setting doesn't apply to American animation. For example, the identity of Garfield is a pet, and Simba is a lion living on the wide plains. They are not affiliated with "personified" status as they live according to their natural attributes.

The expression of the identity change of the animal character in Chinese animation was clearly implemented to character "Sun Wukong". In the film <Havoc in Heaven, 1964> both of the attributes of "person" and "monkey" of Sun Wukong were clearly represented by expressing smart and agile features of a "monkey" and the spirit of rebellion and unyielding of a "person". "Mountain Huaguo (Flower and Fruit Mountain)" is Sun Wukong‘s "house" in the animation and the real environment which naturally matches with the attributes of "Sun Wukong" as a "monkey." The mountain is distinguished from fictitious background like "Heaven" or "Cigarra-peach garden(蟬桃園)" appearing later. The material of <Monkey King Conquers the Demon (a.k.a. The Monkey King and the Skeleton Ghost)> was taken in the original "The Monkey King Thrice Defeats the Skeleton Demon". Although Sun Wukong protects his master with his best throughout the animation, he is a character who is misunderstood as a wicked person. The "human" characteristics are emphasized, but the nature of a "monkey" is disregarded. <Princess Iron Fan, 1941> is one of the series about the four monks borrowing a Basho fan from the princess iron in order to cross the flaming mountain to get the Buddhist Scripture from the original <Journey to the West>. Here, Sun Wukong was portrayed as the image of a great leader who unites the masses to conquer villains. The character has different social status and personalities by episodes in this way, which this is mainly due to the different settings for each activity background in the episodes of the animation.

Compared to a relatively large number of animal characters with human characteristics in Chinese animation, it is rarely seen "personified" animal characters with social status and environment of "human" in American animation. Although there is a lot of social relationships among animation characters in the United States, it is far less than that of animal characters in China. Most of the animal characters in the United States usually have the natural attributes living as a wild animal in nature like Simba or living as a pet in the human society like Garfield. The natural appearance of an animal that's similar to its original figure and application of unique animal attributes indicate expansion of the materials in American animation. As we can see, natural environment is one of the very elements that stimulate viewers to be interested in the work. The material of <The Lion King> comes from the masterpiece of Shakespeare <Hamlet> and "Revenge" is the subject of the whole work. Considering the age and understanding level of children viewers, most of the dark side were deleted. The director of <The Lion King> did not add any "human" characteristics other than the action to compete for "the throne." In addition, setting the "personification" of the animal characters of the whole work is even more convincing because male lions actually fight for "the throne" in real nature. There are glaciers in <Ice Age>, a sea in <The Octonauts>, wide plains in <The Lion King>, and an ants' nest in <A Bug's Life>. Wild nature is a distinctive feature of American animation works.

The identity and activity backgrounds of "personified" animal characters are the main influential factors of animation work material, story conflict, and language settings, and they are an important element to make difference among animal characters as well. A comparison of this point makes it easy to see the distinct differences between the two countries. Table 4 and Table 5.

Table 4. Identity and activity background of Chinese classic “Anthropomorphic" animation Characters

Title	Image	Main Character	Status	Main Activity Back-ground
Princess Iron Fan 1941		Sun Wukong, Pigsy, Princess Iron	Monk, Monster	Human village, Place where Taoist hermit lives
Havoc in Heaven 1961		Sun Wukong	Monkey King	Mountain Huaguo, Heaven
Thank you Small Cat 1950		Cat, Hen	Villager(s)	Animal Society set by Human
Black Cat Detective 1984		Cat, Mouse	Detective Thief	Animal Society set by Human
The Adventures of Sloppy King 1987		Mouse	Every status of human society	Animal Society set by Human
Shuke and Beita 1989		Mouse	Pilot, Tank driver	Animal Society set by Human

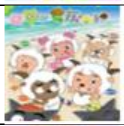
3000 Whys of Blue Cat 1999		Cat, Mouse	Coptic Evangelist	Various kinds of Time and Space
Pleasant Goat and Big Big Wol 2005		Goat, Wolf	Village chief, Villager(s)	Lamb Village, Forest
The adventure of Little Carp 1958		Carp	Children, Parent(s)	Pond, Reservoir
Why is the Crow Black-Coated 1956		Magpie,Woodpecker,Crow	Children, Parent(s)	Animal society set by human

Table 5. Identity and activity background of American classic “Anthropomorphic" animation Characters

Title	Image	Main Character	Status	Main Activity Background
Tom and Jerry 1940		Cat, Mouse	Pet	Human family
Snorks 1984		Snorks	All levels of society	Seabed
The Lion King 1994		Lion, Aardwolf	King, Follower(s)	Savannah
Toy Story 1995		Toy(s)	Toy(s)	Human family
Finding Nemo 2003		Clownfish, Shark	Marine Life	Ocean
Chicken Run2000		Chicken	Poultry	Farm
Shrek 2001		Monster,Cat	Adventurer	Castle, Forest
A Bug's Life1998		Ant, Grasshopper	Insect(s)	Grassplot, Underground cave
Penguins of Madagascar 2014		Lion, Penguin	Zoo animals	Zoo, Uninhabited island

Ice Age2002		Squirrel,Saber-toothed Cat	Wild Animal(s)	Glacier

As can be seen from the analysis above, both China and the United States showed significant differences in all shapes, status and activity backgrounds of "personified" animal characters. Obviously, there is a reason hidden behind such huge difference. I will try to analyze the cause of such differences from three aspects in the main subject. First of all, I will study the idea and intention of the early creators from the background of the developmental stage in the animation history of these two countries. Next, I will look for the fundamental grounds that differences arise through various storytelling materials and requirements and restrictions of the production process. Finally, from the macroscopic side, I will try to analyze the essential distinction that arises from the initial creation of the character caused by the differences in traditional culture between the two countries.

2.3. Comparison of personification according to the historical background

There was a famous cartoon character Felix, who walks upright before Mickey Mouse was born. Felix was born in the period when the US Silent Film prospered and it was around the time that films of Charlie Chaplin the comic genius of the 20th century were gaining popularity. <Felix the cat, 1923> obviously followed the track of Charlie Chaplin in terms of style and narrative material as shown in Fig. 4.

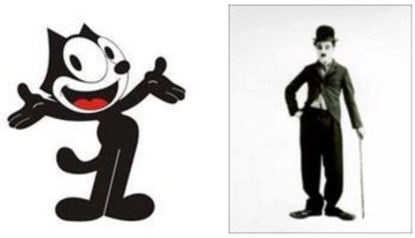


Fig.4 <Felix the Cat, 1923> and Charlie Chaplin

The US economy was in a very severe recession when Felix and Chaplin were running. The movie theater was a sanctuary for the depressed people who lost their jobs. They had to relieve the stress of unemployment with mental relaxation. This was the time when the animation of the United States greatly flourished. Disney developed a character called Mickey Mouse after Oswald, which has ears, a nose, and a tail emphasis on the original shape of the mouse. Mickey emerged as an optimistic, adventurous, brave and clever animal character in numerous animated films. People fell in love with the animations for its fun and enjoyable stories of realistic daily life of the personified animal characters and began to actively purchase goods derived from them. Even though amid the US economy was in a downturn, Disney's operating income reached $ 6 million and advertising revenue of $ 3 million was also in it.[9] As we can see here, the appearance of "personified" animal characters in the United States played a role as a "comforter" in so many parts. Before animation broadcasting is not universalized, the components of characters in animation films with exaggerated animal shapes and appearances, human-like lifestyles, and interesting and funny stories pleased many viewers.

Unlike the dark atmosphere of the US economic downturn, the national emotions of China escalated under the influence of Japan's invasion that was repressed by the puppet government. Consequentially animation became one way to express national sentiment of Chinese people. The synopsis corresponding to characters such as Sun Wukong in the episode <Princess Iron Fan, 1941> implied the result that Japan would fail in the end and aroused the voice of the heart of Chinese people. It was a crucial cause of the time that this work succeeded under such historical circumstances. Since the development of Chinese animation history passed through a difficult period such as "Great Leap Forward" and "Cultural Revolution" (both well-known political activities of China), animation works of the time were powerful means of political propaganda that influenced design elements such as character shapes and status in animation works. A large number of characters created to praise the "Great Leap Forward" appeared in Chinese animation around 1950‘s to 1960's. Among them, animal characters take up a very large part of the characters. <The Adventures of Little Carp> released at this time with the story of the carp decided to settle at the Dragon

Gate in final chapter, which implies success of the "Great Leap Forward."

China's animal characters with high quality "personification" poured out from the middle of the 1950's to the beginning of chinese economic reform. This is because the animation character at this time was always made for the two purposes, "political propaganda" and "child education". Animation <我知道 (I know), 1956>, <拔萝卜 (I will pull the raddish), 1957>, there was a plot that "I accomplished what I could not do by myself through collaboration", and expressed a theme of "we become stronger when work together". In animation film <Little Swallow, 1960>, China was delivering a severe reality of lack of food in 1960‘s through enlighten education from old swallow to little swallows that there is no easy way to obtain food.

Fig.5 <Adventures of Little Carp, 1958>, <Little swallow, 1960>

2.3.1. Comparison according to the creative intention

Unlike in China, the United States responded sensitively to market trends and survived through fierce competition is now known as a representative country of animation production. This has been a clear distinction from highly non-commercial Chinese animations by the long-term direct and indirect intervention of the government. "Hayes code" (MPAA) [10] appeared in the movie industry of the United States in the 1930's. This is an evaluation system that categorizes movies according to contents and materials and stipulates films according to age groups. Depending on the evaluation rule, animation films are mostly rated G which means the film is suitable for viewers of all ages. In order to get rated "G", the harmful expression to children is excluded, which is more pronounced in the expressions of "personified" animal characters.

All negative elements of animal prototypes had were excluded. A mouse in reality that is dirty and steals food from everywhere, appears positive and enthusiastic as a smart and funny human friend in the film <Stuart Little>. A wild predator lion in nature is smart and courageous in the movie <The Lion King> and demonstrates a heroic figure that ultimately wins his throne back. In this way, all "personified" animal characters are carefully considered with factors such as "prettiness" "cuteness" or "friendliness" in design which is preferred by viewers more than realistic depiction of animals. Even though the subject of storytelling in <The Lion King> is centered on "revenge", the main character Simba appears as a figure of a cute and active baby lion in the animation. These animal characters show a remarkable difference from those playing a role of "an educator" in Chinese animation. They do not directly teach a lesson from the perspective of the experienced but have the audience understand a message for themselves in the development of the story. Every viewer understands the animation and the animal characters on their own. This method gives a great help to young viewers to build the ability of thinking independently. In terms of delivering a message, American animations make viewers think about it for themselves, and that is significantly different from the stereotyped education of Chinese animation.

Since the beginning of the 20th century, education has been a major subject for creating Chinese films. It is an interesting and refreshing experience for children to watch the animal characters playing the role of the "educator" in animations. New China's animation business began to greatly evolve from the 1950's, a large number of animation works released and became familiar to public such as <Adventures of Little Carp> <Little cat goes fishing> <Why is the Crow Black-Coated> and etc. It draws the attention that there is always an animal character as an "educator" specifically "sister" in <Little cat goes fishing> or "grandmother" in <Adventures of Little Carp>. These animal characters educate other animals with their conflict and mistakes in a serious manner as "adults". Animals in reality cannot act like a human "educator". The "personification" level of the animal characters has been increased for the purpose of creating "animal educators".

2.3.2 The influence of ethnic culture

China's traditional Confucian ideas have already permeated into our life, study, and work. The Confucian ideas also played an important role in the contents of artistic creation and subject matter. "If it is materialized to a work it will be "Chinesization". Absorb an essence of traditional culture, enrich creation of animation by referring to elements in Chinese drama, music, several shaping arts.; Implement the aesthetic of the Chinese, talking about the Chinese, express the character, thought, emotion, lifestyle, etc of this nation. "[11] The Chinese philosophy of animation became known to people, animal characters such as Pigsy in <Pig eat watermelon>, Sun Wukong in <Havoc in Heaven> made their appearances with unique and elegant class of Chinese nationality.

"The second spring" of Chinese animation came after 1979. In the following 10 years " 'Nationalization' is basically established by relying on "traditional culture". During this period, animations which were adapted from a large number of Chinese private legends, historical stories, four-character idioms, and fables appeared on the screen. [12] <Battle of crane and shellfish> is telling a fable that teaches people a lesson through a message saying "battle of crane and shellfish is only good for fishermen".; <Where is Mamma? (a.k.a. Little Tadpole Looks for Mamma)> has implicated the depth of traditional Chinese culture with ink painting techniques with just a few brush strokes. Human ethics and morality from Chinese traditional culture were entirely expressed through those works.

Images of exaggerated characters often seen in American animation, the outgoing personality of the character and the active and enterprising theme all reflect the huge influence of the spirit of freedom.

"Equality" and "Freedom" is spoken very clearly by "personified" animal characters in American animation. Obviously it is very important in the design of the character to deepen the interest toward animation, expand the material for the animation films and extend viewers' thoughts by using the character shapes of the animal prototype and the real life habit of animals. Animated movie <A Bug's Life, 1998> depicted a story of "Ants gathering their power together and fighting against grasshoppers." The background of this story was set by the attribute of the insect "ants" digging up holes and living in a highly complex colony. Meanwhile, ants as a small creature represent the weak in human society and convey "the dream of being a hero" in ordinary people. In <A Bug's Life, 1998>, setting an element in the story with free will to the main character is crucial because the setting gives an influence directly to the ending of main character Flik a worker ant defeating a group of savage grasshoppers, becoming a hero and falling in love with the ant princess. Thus, the will of freedom and equality can be a driving force for continuous development of society.

3. Conclusion

The difference between Chinese and American creative ideas and cultures could be seen on striking differences in "personified" animal characters of both countries as well. Both countries have commonalities in creating and delivering "personified" animal characters to create hopes and dreams in difficult and challenging times. There are still many characters that have been loved for many years in the United States. On the other hand, there are not many characters maintain their popularity in China. It is true that the early "personified" animal characters of the United States were loved and given dreams and hopes to people in the difficult and arduous times of the Great Depression. From another point of view, however, it should not be forgotten that manufacturers have made great efforts to develop their own characters, protect their copyrights, and maintain their box office to survive on their own.

Disney did not acquire Oswald's copyright in the early days, and developed a new character called Mickey Mouse. It created a sustainable cause of animation and character creation through commercialization and theme park Disneyland using character goods of animations. Another reason is that they have a structure of storytelling that does not force them to solve their own problems. This has become a factor that American animation is to be natural for children around the world. On the other hand, China has produced a lot of animations during difficult times, and many productions were carried out in order to educate them to enlighten and overcome reality with government support. The positive side is that the production is activated, and the negative side is that there are not many factors that could be commercially successful in character concept or storyline in a not competitive situation. Stories about the role of the educator to teach also have been produced around the world during the war, and even Disney has produced war-promoting works using Donald Duck. These works, made in America, Japan, and China, were buried in history.

Animation has an art form that is essentially fictional. By giving human consciousness and actions to animals and objects, and let audience indirectly have dreams and hopes through animations. In order for Chinese "personified" animation characters to be loved by people around the world, it is necessary to strive to narrow the gap between creative ideas and cultural differences from the global market.

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Educational Contents using Interactive VR Technology for Experiential Science Education - Focusing on VR Content Production for Earth Science Education -

*Minha Park, **Hyeyoung Ko

*Dept. of Contents Design, Seoul Woman's university
**Dept. of Digital Media Design&Application, Seoul Woman's university
621, Hwarang-ro, Nowon-Gu
Seoul, Republic of Korea
*minha1993@naver.com, **kohy@swu.ac.kr

Abstract

Technological advancement achieved by the 4th Industrial Revolution has brought many changes in education. The use of VR technology, which has been attracting attention recently, is effective in increasing the concentration of learning contents and enhancing memory because the experience of virtual space such as real space is expanded. On the other hand, although the importance of science education continues to grow, Korean students have lower interest and confidence in science learning than the international level. Therefore, Measures are needed for this. In this study, VR technology was used to plan and implement VR contents for earth science education for middle school students with low interest in science. Based on the regular curriculum, VR contents design was designed to improve the efficiency of the design and to improve the communication. Then, based on this, we implemented the final VR contents. Earth science education, which requires concepts and understanding of principles and which is difficult for students to directly experiment or observe, will create synergies with the characteristics of VR and provide an opportunity to increase students' interest in science.

Keywords-Virtual Reality; VR; Earth Science Education; Experience Education Contents

1. Introduction

These instructions Recently, environment and technology are rapidly changing, and it is important to cultivate talented people with creative fusion ability all over the world. In Korea, the STEAM education model has been introduced in 2011 and continues to be established in school education. The STEAM education model is "Education to enhance students' interest and understanding of science and technology and to develop STEAM Literacy based on science and technology and real life problem solving skills". It is a model for fostering creative fusion talent based on Korean science by adding art to STEM education of USA which is abbreviation of science, technology, engineering, and mathematics education [1].

As such, the importance and necessity of science is increasing worldwide, but the interest and confidence of Korean students in science subjects are very low compared to the international level [2]. While advancing from elementary school to middle school and high school, the level of interest and enjoyment of science is continuously decreasing. As a major problem of this phenomenon, Experience-oriented learning is strongly required because science must go through learning and application of technology based on understanding phenomena and principles. In fact, experience is recognized as an important means and method because it increases realism and increases engagement and interest. Also, according to Edgar Dale's Cone of Learning Theory, people generally are able to remember 90% of what they have learned when they actually experience, even after two weeks, and they are proving to be highly efficient [3]. However, most of the middle and high school science classes in Korea are still not able to escape the textbook-oriented infusion education. In order to enhance students' interest and confidence in the underlying science learning, it is urgently necessary to improve existing education methods. Especially, it is necessary to provide realistic education to enhance experience in existing science education.

Recently AR, VR (Virtual Reality) and MR technology have been attracting attention in contents field due to the development of technology due to the 4th industrial revolution. This makes it possible to experience a sense of realism compared to the existing contents transmission method. Among them, VR has been used in various fields, but it has been tried many times in the field of education. This is because it can strengthen the experience, it is effective to give a sense of immersion into learning, and it can enhance the learning effect through interaction in a virtual space. In this paper, we apply VR to science education to create educational VR contents that can enhance the interest of students with low interest in science through realism and experience. We will design educational contents to apply virtual reality technology effectively, focusing on the learning field of solid earth area among the earth science which is difficult for the learner to experience in the field directly, and to design the planning method for VR implementation. Finally, we propose an effective method and possibility to utilize VR technology in science education through the implementation result.

2. Research for Base

2.1. Status of Simulation Contents using VR Technology

Recently, VR technology has begun to be widely used in space that is difficult to experience such as the universe, undersea, and inside human body, and contents that can experience the past era like dinosaur era. In addition, VR simulations are actively used in areas where there is a great need for training to reduce risk factors, such as medical and firefighting education.

(1) Medical education content "Osso VR - Virtual Surgery” [4]

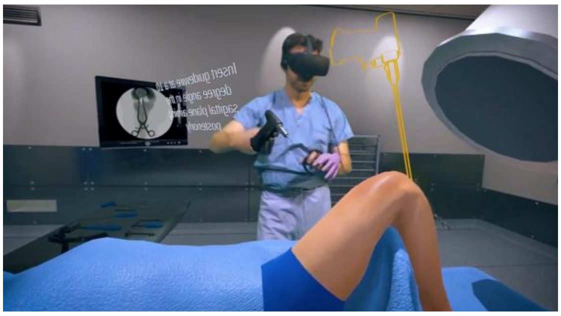

Fig. 1. Osso VR - Virtual Surgery

<Osso VR> is a surgical training platform. As shown in Figure 1, the user hands the virtual surgical equipment by hand and provides a virtual image of the actual surgical procedure. It is difficult to practice trial and error in a live operating room that deals with life, but Ossor VR has the advantage of being able to experience and train a surgical procedure virtually. Currently, surgical training for orthopedic spine treatment is possible and has been expanded and utilized in various medical fields.

(2) Firefighting education content "Firefighter VR" [5]

Fig. 2. Firefighter VR

<Firefighter VR> is a virtual experience content for firefighting training developed by MWN Tech, and can be played using OculusRift and its own proprietary hose controller. It consists of seven fire suppression scenarios, two fire evacuation scenarios, fire extinguisher usage, and a rigger usage. It is characterized by systematically designed contextual contents to enable fire drill experience by experiencing virtual fire situation. This can be used as a useful fire training simulation to prepare for various fire situations.

2.2. Education Status using VR, AR, MR Technology

The HIT Lab in New Zealand and the HIT Lab in Washington, USA, have developed an AR tool kit that recognizes a specially designed rectangular marker that receives a real image and expresses the virtual content related to the marker. And they developed 'Augmented Reality Story Book', which is used to observe experiences and analyze the improvement of reading comprehension ability [6]. The 'World of Comenius' project is a virtual reality content utilizing Oculus Rift and Rift-mounted Leap Motion Controller, it is pursuing a change in the way education and communication are conducted. Also, Korea is making efforts in response to these changes [7]. MSIT (the Ministry of Science, ICT and Future Planning) and KOFAC(the Korea Foundation for the Advancement of Science & Creativity) have created 'Science Level Up' and 'Next Up! Virtual reality'. The contents were provided with 360degree VR images to enable students to observe ecosystem and to increase students' interest in science education [8]. In order to enhance the educational effect based on experience in the field of education, VR, AR and MR technologies are being actively introduced. However, in order for many students to benefit from experience-based education using these technologies, a close connection with the curriculum is needed.

In fact, in January 2017, the Korean Ministry of Education announced plans to develop realistic digital textbooks that introduced VR and AR in the science curriculum for third-fourth grade students in elementary school and first grade students in middle school from 2018[9]. Korea is also interested in applying VR, AR, and MR to the education field. However, it still does not fully utilize the latest technologies, and there are a lot of deficiencies, so continuous efforts and effective production methods are needed.

2.3. Earth Science Education Contents "The Lab-Solar System" Using VR Technology [10]

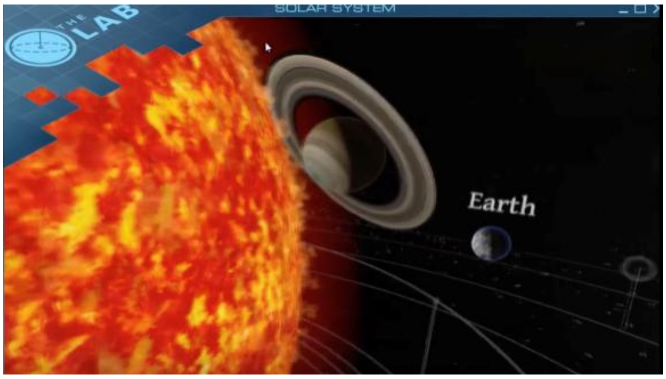

Fig. 3 The Lab - Solar System

<The Lab - Solar System> is a virtual reality video game developed by Valve and plays with HTC Vibe device. It can be used to search and manipulate planets circling around the sun with solar-themed content, and to observe the gigantic sun nearby. It has the advantage of displaying the universe as real. However, when selecting various planets, information or explanation other than the name of the planet is not provided, so there is a limit to learning earth science in depth. In addition, there is no interaction other than capturing a planet, which limits the ongoing interest. When VR content is developed for education, gorgeous graphics will be important. But most of all, it will be necessary to have a variety of interactions related to education that can effectively convey the important information in the regular curriculum while maintaining the interest of the learners.

3. Contents of Research

This project aims to plan and produce science education contents using interactive VR technology for easy understanding and effective education of the contents of earth science to middle school students.

3.1. Target Analysis

Adolescents aged 13-15 years are middle school students in the Korean education system. Since this period corresponds to the adolescent period in which the concentration is lacking, the learning method using the virtual reality technology can increase the learning efficiency by giving the immersion feeling. In addition, it is an important time to be free from entrance examination burden relative to high school students and to be an opportunity to increase interest and curiosity in science. In this study, it is aimed to produce contents with middle school student as main target considering the effect of scientific education and appropriate timing.

3.2. Analysis of Existing Earth Science Education Curriculum

Elementary, middle, and high school science education is included in the science educational curriculum (National Curriculum) of the Ministry of Education, Science and Technology. Among them, the ‘Solid Earth’ section is divided as below [TABLE I]. It is common that they are learning the content of the 'Solid Earth' in the curriculum of elementary, middle, and high school science, by difficulty level. And it shows the importance of the contents can be known.

Table 1. The Solid Earth part in Earth science for elementary, middle, high school [11-17]

Category		**Key Concept**	**Learning Content**
Elementary school		volcano and earthquake	Understanding that volcanic activity and earthquakes have a large impact on people, such as harming people and property
		The shape of the earth	Understanding the features of the earth we live in and the characteristics of the earth, sea, and air
Middle School		Changes in geosphere	Understanding the nature of the material that makes up the Earth's internal structure and indicators.
High School	**General Science**	System of the earth	Integrated Understanding on the features of the earth in a systematic way as an optimal environment for living creatures
	Earth Science I	Fluctuation of the geosphere	Understanding the surface of the earth is constantly changing.
		History of the earth	Understanding the earth's environment and creatures have constantly changed over the geological period
	Earth Science II	Formation of the earth and field of force	Understanding the formation and evolution process of the solar system, identify the internal structure revealed through seismic waves, and understand the characteristics and changes of gravity and magnetic fields.

3.3. Earth Science Education Contents Design

Table 2. Contents of Education

Category	**Key Concept**	**The Element of Contents**	**Interactive Learning**
The Solid Earth	History of the Earth	Learning the Birth Process of the Earth	
	Formation of the	Earth's layered structure (crust, mantle, outer core	Earth's layered

	earth and field of force	and inner core in the earth) and learning of Magnetic field concept	structure
			Magnetic field
	Plate tectonics	Learning of the Earth's surface consists of several plates and the concept that earthquakes and volcanoes occur at plate boundaries	Earthquake
			Volcano

(1) History of the Earth

The Intro shows a short 3d animation of the earth's birth process that takes place over a long period of time. The earth created by meteorite collapses gradually and shows the image of today's earth. By watching and seeing the birth process of the earth with a vivid 3d animation in virtual reality, we will have interest and curiosity about earth history.

(2) Earth's layered structure

The Earth is composed of crust, mantle, outer core and inner core inside. The contents are configured to show the three-dimensional earth and inner figure in virtual reality. The learner can move his hands directly to cut out the earth and take out the earth crust, mantle, outer core, inner core in the earth, and provide each location and feature to learn. It is possible to easily understand and memorize the contents that I only studied with textbooks in the actual structural form. In addition, interest and educational effects can be enhanced in the sense that learning proceeds according to the speed of the user's operation.

(3) Magnetic field

Solar wind refers to various particles coming from the sun. The earth's magnetic field serves as a shield, as the earth blocks the solar wind. When an electron, one of the solar winds, enters the magnetic field, the direction of movement is deflected by the force of Lorentz. The electrons that are in linear motion are subjected to a curved or rotational motion. At this time, the electrons (-) and the positons (+) are bent in opposite directions. Earth's magnetic field is active and dynamic because it is affected by the sun's changes. While there are many blasts of solar wind, powerful magnetic storms can create auras, cause radio and television disturbances, and cause problems with navigation of ships and airplanes with compass and power outages. The learner will be able to understand the principle and concept of force by allowing the solar wind to move directly to check the change of the magnetic field.

(4) Earthquakes

An epicenter is the first occurrence of an earthquake inside the earth. When an earthquake occurs, a body wave that passes through the object and a surface wave that moves from the object surface are created. Among the seismic waves moving from within the earth, the actual waves are divided into longitudinal waves and transverse waves, which are called P waves and S waves. The P wave is the earliest recorded wave in the earthquake of the body wave that passes through the earth. The second wave after the P wave is called the S wave of the secondary wave. The learner can choose the origin and can easily understand the P wave and S wave according to the earthquake process and the origin.

(5) Volcano

Inside the earth there is a magma formed by the melting of rocks. The magma is called a volcano when it penetrates through the weak cracks of the crust and emits it out of the surface at a time for a short time. When a volcano erupts, various substances come out, which are called volcanic eruptions. the learners can easily understand the principles of volcanoes by learning the process of volcanic eruption by raising the magma in the magma.

3.4. Interaction and Screen Planning

(1) Flow Chart

As shown in Figure 4, when a user selects a topic, the corresponding DB is matched to start the content. User can experience various graphics, motion, audio, text, narration in contents and various interactions are possible.

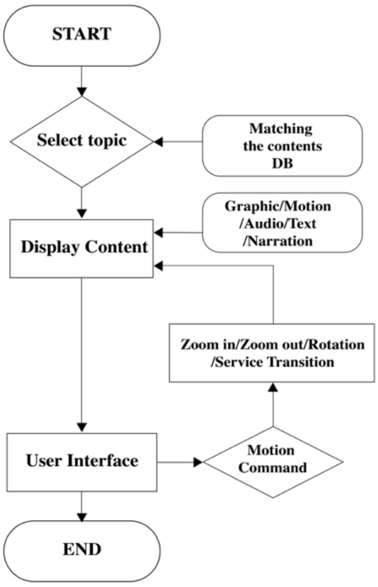

Fig. 4 Flow Chart

(2) Interface Design

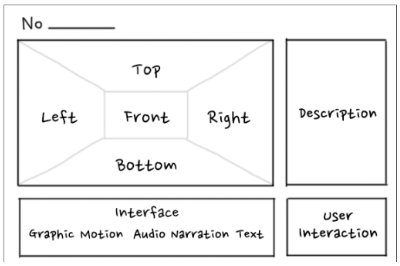

Fig. 5 Sketch of Interface Design

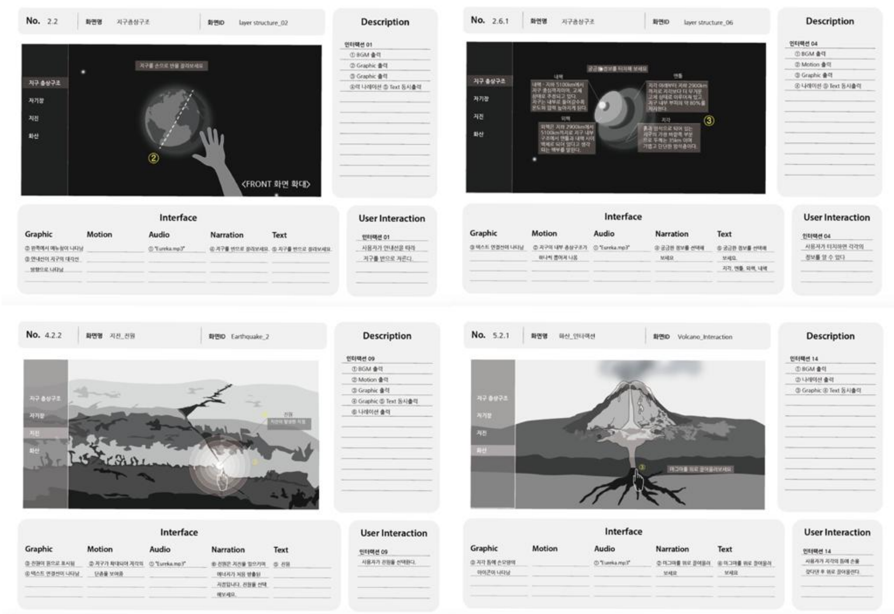

Fig. 6 Interface Design

In this project, we felt the necessity of a design document suitable for VR content implementation like the design guide for web design that was established previously. In consideration of VR's technical environment and characteristics of contents, we made a basic design that can be shared by planning, design, and developers in common.
Based on the visual field viewed through the HMD, the learner constructs the front, top, bottom, right, and left screens to be included in the design. In addition, the screen-specific information is classified into Graphic, Motion, Audio, Narration, and Text, and the description is numbered according to the appearance order so that no crosstalk occurs in the actual development process collaboration. User Interaction includes a description of the interaction learning that the learner can move by hand.

3.5. Implementation technology

The production technology of this content is as follows. First, 3D graphics images can be realistically implemented using Unity, a game engine. Second, HMD equipment uses Oculus lift and provides a first-person immersive virtual reality environment. Third, the learning effect is enhanced by allowing the learner to interact with the learning contents using the lip motion, which is a motion recognition device

3.6. Final Implementation Results

Fig. 7 History of the Earth Animation

Fig. 8 Interaction of Earth's layered structure

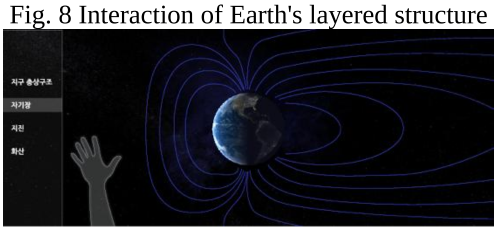

Fig. 9 Interaction of Magnetic field

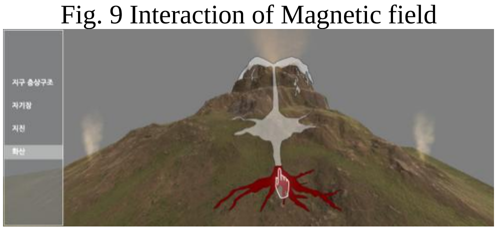

Fig. 10 Interaction of Volcano

In this project, learning contents are divided into Earth's layered structure, magnetic field, earthquake, and volcano. In the intro, the video of Earth's history begins with the universe of meteorites falling. After one of the meteorites has left its course and collides with the user, the initial earth is created, and the early earth gradually appears today. ①the earth stratified structure is guided by the guideline of the part to be cut, and it is implemented so that the structure inside the earth can be observed by selecting the cutting surface again after the motion to cut. ②the magnetic field is implemented so that the length of the solar wind can be adjusted assuming that there is sun at the position of the user's hand. ③the earthquake is implemented so that the user can select the origin and observe the effect of the wave on the epicenter.

④the volcano is implemented so that when a user clicks on the black part of the 2D magma and pulls it up, the volcanic eruption can be observed.

4. Conclusion

In this study, the importance of science is increasing day by day, but we have focused on middle school students who are not interested in learning process. Recently, new VR technology has been effective in enhancing experience and interest, and educational contents using it have emerged. However, in the curriculum, most of the infusion education centered on textbooks is occupied. In other words, the need for change in science education is recognized by many people, but now it is considered necessary to develop efficient educational contents in the process of change. The researchers created the VR contents as follows to find out the possibility of creating the VR contents effectively while holding the necessary contents in the science curriculum.

For the middle school students, we designed the contents of education about the solid district among the earth science education contents and made the basic VR design through the systematic constitution of the implementation elements so that joint development can be made in the production of VR. Based on this, we designed and implemented educational contents that combine live 3D stereoscopic image and interaction. The advantage of this content is that the learner interacts in the direction of the force acting directly, so he can understand the principle of force while seeing visual and physical changes. In addition, the speed of learning can be adjusted according to the level of understanding of the learners, which leads to the advantage of being able to learn and experiencing in real life. It will be interesting to concentrate on learning, and it will be educational contents that can increase interest in earth science learning which is impossible to experience in actual environment and improve learning effect effectively, and can be extended to other scientific fields.

Acknowledgment

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A Study on Guidance System of Public Parking Lots ——Focus on Busan Gimhae International Airport Parking Lot

Zhang Feng, Lee Sung Pil

Graduate School of Design, Dongseo University
47 Jurye-ro,Sasang-gu,
Busan 47011,South Korea
Sungplee@gdsu.dongseo.ac.kr

Abstract

As the important component factor of the parking lot, the guiding system becomes the key to improve the parking service. With the increase in urban car ownership, the surge in demand for urban public parking lots has evolved into a global problem. With the maturing of the 21st century's information communications technology and materials technology, the guidance system of public parking lot needs to be reformed in order to better meet the parking demand of users. This study focuses on the public parking lot of the Busan Gimhae International Airport, and investigates the pain points in the guidance system of the administrators and drivers of the parking lot when they use the airport parking lot. In order to gain insight into user needs and service contact points, ethnographic and interview survey methods are used in the research process, and the service blueprint and customer groceries map are drawn. The results show that in the guide system of the parking lot of Busan Gimhae International Airport, the pain points such as vague guiding signs, unclear guidance information, lack of guidance details, the difficulty in user's feedback and the lack of the guidance inductors are key to solve the problem. By proposing the design strategy of optimizing the guiding system of the airport parking lot to provide humanized guiding service, so that the service quality of the public parking lot's guidance system is improved.

Keywords-public parking lot; guidance system; service design; pain point;

1. Introduction

With the recovery of the global economy, the South Korean economy began to improve and show steady growth. Among them, South Korea's automobile industry growth trend is obvious. According to statistics, as of August 2017, South Korea's domestic car sales increased by 11.7% compared with the same period in 2016. As the second largest city in South Korea, Busan has a personal vehicle registration of nearly 100,000 vehicles. With the increase of personal car ownership in Busan, Busan parking lots will be faced with many parking problems. Public parking lot, as a city planning and construction and public building supporting facility and a business parking lot for the parking of social vehicles, will provide the public with a large number of parking spaces, which also led to that the public parking lots are important public spaces to solve the problem of urban parking. It is essential to improve the efficiency and use experience of public parking lots by optimizing the guiding facilities, guiding signs, guiding planning and guiding processes of public parking lots. In the thesis, it uses service design method to make systematic analysis and arrangement on the parking lots service with basic theory of service design; it find out the individualized requirements of users who visit parking lots. It is the key point of the paper about how to systematically improve the parking lot service. Compared to product design, solutions with much emphasis on design services are more effective to meet people's needs. Service design should be used as a strategy in production and consumption systems, which can provide an opportunity for sustainable development of the environment and society [1].

As an important transportation hub in South Korea and East Asia, the annual throughput of Busan Gimhae International Airport maintains at around 15 million people. As shown in table 1, the total number of passenger and flights has increased linearly since 2012 at Busan Gimhae International Airport.

Faced with such a huge flow of people, as an important airport transportation hub, the Busan Gimhae International Airport parking lot is required to provide quality public parking lot services for the public and passengers, especially to set up excellent parking lot guidance services to effectively prevent problems such as difficult in parking and slow in parking, so as to speed up the use efficiency of the airport parking lot. At present, Busan Gimhae International Airport has three public parking lots, totaling more than 4,000 parking spaces.

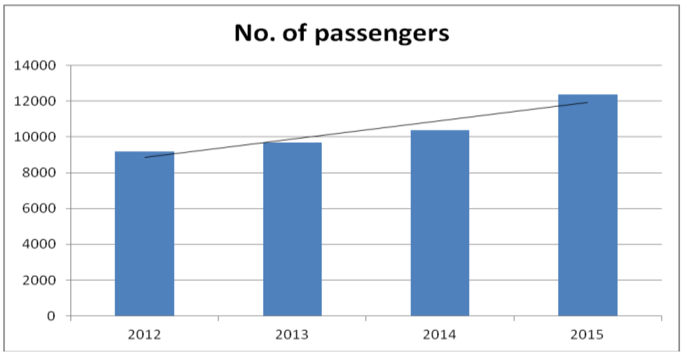


Fig. 1. Total No.of passengers of Busan Gimhae International Airport
Busan Official Information Center

2. Research Objective and Research Method

In this paper, the service design method is used to analyze and study systematically the guiding system of the parks of Busan Gimhae International Airport, aiming to excavate the key problems of the parking guidance system of Busan Gimhae International Airport, and put forward corresponding countermeasures. Through field observation and face-to-face interviews, the paper aims to find out the key pain points of the park Guide System of Busan Gimhae International Airport; To find out the key needs to improve the parking lot guidance system of Busan Gimhae International Airport by drawing service blueprint and the customer journey map, to provide design guidance to improve and optimize the parking lot guide system of Busan Gimhae International Airport.

This article adheres to the human-centered design idea, takes the guiding system of the parking lot of Busan Gimhae International Airport as the research object, analyzes the user pain points of the airport parking lot with managers and users of the parking lot as the research subjects, and puts forward the key directions to improve the guiding system, thus to meet the parking guidance demand of Busan Gimhae International Airport, and achieve the goal of improving the service of the airport parking lot.

3. Case Study

3.1. Ethnographic & Interview

During the initial stages of Ethnographic and Interview, on the one hand, it is necessary to conduct on-spot observation of the guidance system of Busan Gimhae International Airport parking lot to grasp the actual situation of the guidance system of the parking lot, including the type, quality, distribution and size of the guiding signs. On the other hand, it is necessary to formulate corresponding interview questions, processes and ways according to the interviewees. Finally, according to stakeholder relations, we divided the interviewees into parking lot administrators and drivers. In the second figure we sorted out the graphs on the stakeholders of parking lot, from the figure we can clearly see the relationship between the parking lot and related organizations. “Stakeholders are all individuals and groups that can affect the realization of an organization's goals, or to be affected by the impact of an organization in its goal realization process [2].” This stakeholder analysis is good for us to comb design ideas, it is also the key to find out the core problems to lay the foundation for drawing service blueprints and customer journey diagrams.

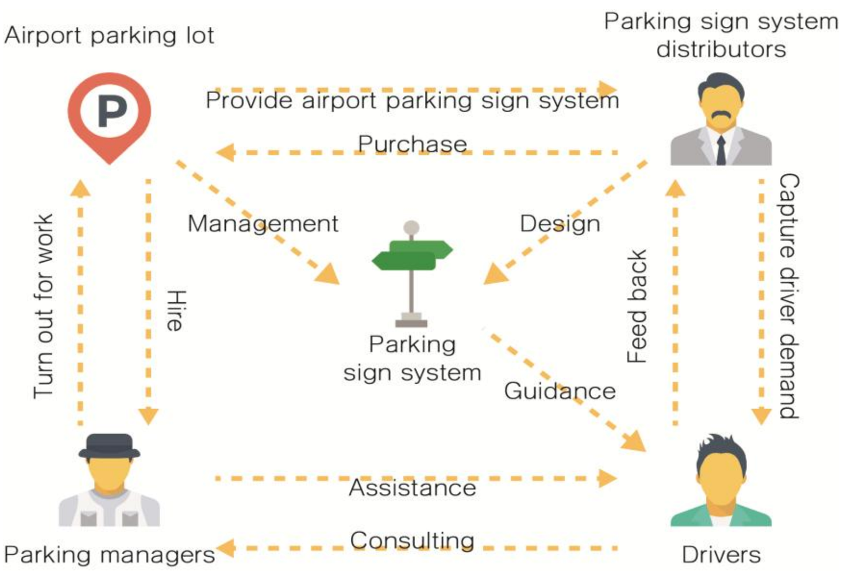


Fig. 2. The relationship of stakeholders

The Ethnographic and Interview this time were conducted in a face-to-face interview way. According to interview questions formulated in advance, we interviewed three administrators and four drivers. During the interview, we also used photos and recordings to collect information. In the paper, the interview results of one administrator and one driver are listed respectively as examples.

Table 1. Interview and Problem

Character	Manager
Photo	
Age	56
Problem	1. The driver did not look at the sign but always asked. 2. All the letters on the floor are erased and cannot be seen. 3. From 6:00 am to 9:00 pm and 6:00 pm to 9:00 pm, there will be long line during the two periods.
Character	Driver
Photo	

Age	32
Driving experience	8 years
Problem	1. Cannot understand the sign. 2. It is neither visible nor understood, nor does it obscure. 3. The marking of the inlet and outlet shall be improved.

3.2. Service Blueprint

The service blueprint is the method proposed by Lynn Shostack in 1984. The content of the method is to construct the service flow of an enterprise or an organization from customer's point of view. It draws service order and steps in a blueprint. The drawing process consists of four main steps: (1) Identify the necessary processes (2) Segment fail points (3) Create a time axis for services (4) Analyze its cost and profitability [3].

Service blueprints differ from quality standards (Example: ISO 9001: 2008 Quality Management System) or something like Business Process Modeling Notation (BPMN). The service blueprint is intuitive, which can be executed directly. It doesn't take special skill or a lot of time to draw [4]. The service blueprint of this paper carefully records all necessary service links in the parking lot and the key factors that underpin these services, depicting the service process that the driver has completed in the process of entering and leaving the parking lot and time taken.

Fig. 3. The service blueprint

3.3. Customer journey map

In service design, customer journey graph is an effective research method. In addition to interpersonal interaction, service contacts also include customers and other tangible and intangible factors, such as interaction between service facilities, environment, service atmosphere, etc. From these interactions we can find changes in the user's experience, which is the direct performance about whether the service design is excellent.

The process for the production of the Customer Mapping map relates to the related content of the Personas design. Personas design refers to the representative of specific individual by establishing one or several virtual or typical user models. They are not real people but created based on those observed real people’s behavior patterns and motives [6].

By deducing the various service operations by virtual characters in the parking lot according to the set script, we are able to draw informative and detailed Customer journey map. The Customer journey map of the parking lot in this section records user's emotional experience as well as elaborate in detail the cause of the emotion, which are the core basis of the later service optimization scheme.

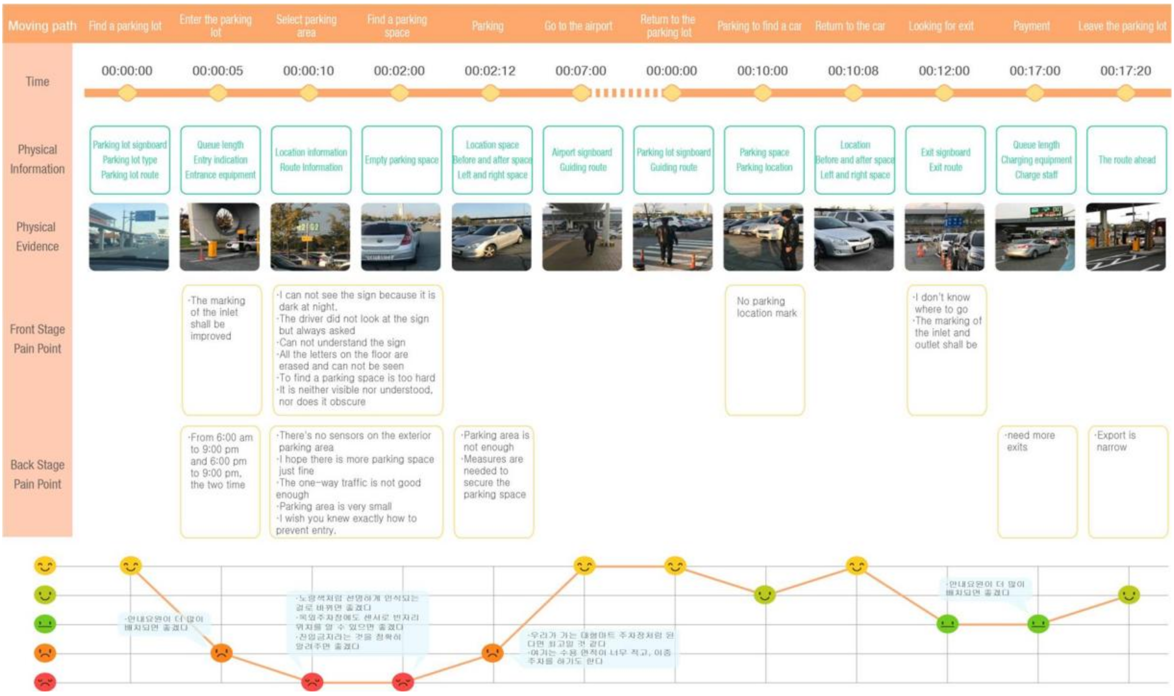


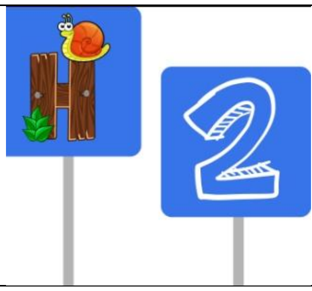
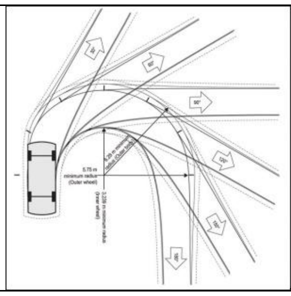
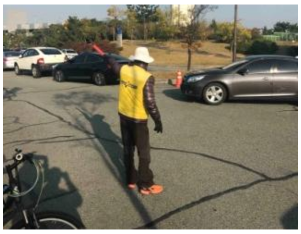
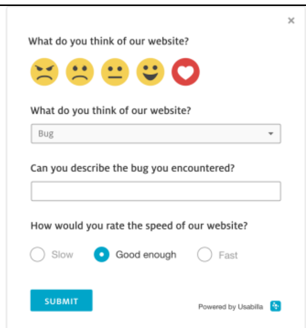
Fig. 4. The customer journey map

3.4. Pain Points and Service Improvement Schemes

In this chapter, through sorting and summing up the problems of the 7 interviewees, and drawing them on the service blueprint and customer journey map, we found five groups of pain points, they are: A. vague guiding signs; B. unclear guidance information; C. lack of guidance details; D. the difficulty in user's feedback; E. lack of guidance inductors. With regard to the five groups of pain points, we refined the design keywords for optimizing guidance system of Busan Gimhae International Airport parking lot, respectively, Readability; Meaning; Detail; Feedback; Inductors. Through the detailed description of the five keywords, the paper has designed the corresponding optimization schemes.

Table 2. Pain points and service improvement schemes

Pain points A	Improvement schemes
	
Guidance identification is fuzzy	

	Readability 1. Stereoscopic sign; 2. Big size sign; 3. Intuitive sign; 4. Easy to understand for drivers;
Pain points B	Improvement schemes
	
Guidance information is vague	Meaning 1. Figurative symbols; 2. Expressive symbols; 3. Interesting symbols; 4. Symbols that conform to user conceptual models;
Pain points C	Improvement schemes
	
Guidance details are missing	Detail 1. Detailed guidance information; 2. The guidance information is combined as a guide sign for people to observe. 3. Simple and unambiguous language + useful information
Pain points D	Improvement schemes
	
Users' feedback is difficult	

	Feedback 1. Feedback information table; 2. Record of problem and opinions;
Pain points E	Improvement schemes
	
Lack of guidance inductors	Inductors 1. Outdoor inductors with simple structure; 2. Can be quickly installed and removed; 3. Record and identify the number of available parking spaces in the parking lot and the total number of cars

4. Conclusion

Through service design method, such as interview and making of service blueprint and customer journey map, the paper have deeply excavated the use pain points of the airport parking lot administrators and drivers in airport parking guidance system. The service blueprint describes in detail the relationship between each service link and the pain point when the users use the parking lot guidance system. Customer journey map describes the users' pain points at the aspect of emotional change. Five groups of pain points are sorted out and summarized, and 5 corresponding design key words are put forward to guide the design scheme to improve the guidance system. With regard to the pain point A, we designed a stereoscopic large size signs for enhancing the readability of the guidance system. With regard to pain point B, we select more specific and expressive guidance symbols to enhance the meaning of the guidance system. With regard to the pain point C, we combine the detailed guidance information into a guidance sign to compensate for the detail of the guidance system. With regard to the pain point D, we designed a feedback information table which can be used for communication to improve the feedback communication. With regard to the pain point E, we conceived a simple outdoor inductor to help the parking management system detect whether there is vacant parking space.

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Interaction between processing of motion parallax and expansion of retinal image in depth perception

Hisaki Nate* and Satoru Kawamura
Tokyo Polytechnic University
2-9-5 Hontyo
Nakanoku, Tokyo 156-0055, JAPAN
nate@img.t-kougei.ac.jp

Abstract

This study examined how motion parallax and expansion of retinal image affect each other, when both these cues are available for depth perception. We measured subjective depth for stimuli in which the relative intensity of these cues was manipulated systematically. It was found that there were two forms of interaction between the cues: either each cue interfered with the processing of the other cue or only one cue interfered with the processing of the other. This finding indicates that the relative intensity of the cues determines which is the case.

Keywords-component; formatting; style; styling; insert (key words)

1. Introduction

In everyday life, we function by obtaining, without difficulty, information of three dimensional formation, i. e., the depth and shape objects. It is, however, difficult to explain precisely how our perceptual system obtains this information. An observer perceives the depth of an object on the basis of a retinal image consisting of light reflected from the object. The confusion stems from the fact that, mathematically, the calculation of the depth of the object from a 2-D retinal image does not always have only one solution. Namely, depth cannot be perceived correctly from a mere static image on the retina whose surface is 2-D [1]. Therefore, it is expected that cues such as binocular disparity, convergence, and texture gradient, as well as a static retinal image, are used to perceive depth. However, not all of these cues are always available. And the use of one cue alone might lead to an incorrect judgment. To perceive depth correctly and stably, various cues must be integrated including the perceiver's own motion as well as the retinal image.

Some of the cues for depth perception are related to the motion of the perceiver or of the perceived objects. Motion parallax and expansion of retinal image accompanying movement of objects in depth are representative of these cues.

Depth perception is possible even when only motion parallax is available as a cue [2]. Motion parallax is the spatio-temporal pattern of relative motion in the optic array (or in the image formed on a projection surface such as the retina) created by the 3-D structure of an object when there is a relative movement between the perceiver and the object [1]. The vectors of the pattern are in proportion to the relative depth of the object and to the velocity of the observer, and are in inverse proportion to the square of the absolute distance of the object from the perceiver [3], [4]. If motion parallax, the distance of the object from the observer, the relative depth between the objects and the distance moved by the observer are represented by δ, D, d and i, respectively, the relationship among these four elements is expressed by

$$\delta = di / D^2. \quad (1)$$

In addition to the four elements, a fixation point is needed when discussing motion parallax because the depth of an object is easily reversed [3], [5]. Furthermore, it has to be considered that there are three cases of relative movement between observer and object; the case where only the observer moves, the case where only the object moves or the case where both move. Although depth can be perceived by using motion parallax in all three cases, it has been found that this was more difficult when motion parallax did not contain movement of the observer than when it did [5].

Another cue for depth perception related to the movement of an object is expansion of the retinal image induced by the approach of the object. If instantaneous velocity, the ratio of expansion and instantaneous position vector are represented by v, k and x, respectively, the relationship among them is expressed by the following equation [6].

$$v = kx. \qquad (2)$$

An example of a situation where expansion of the retinal image is used for depth perception would be a baseball game where a player watches a ball flying toward them. The image of the ball on the player's retina expands as the ball approaches. At the time, the player does not perceive the size of the ball itself to be increasing but rather, the ball to be approaching. This illustrates that expansion of retinal image can be a cue for depth perception. According to the previous research, subjects, having adapted to the change in square size, did show a decrease in sensitivity to the change in size [7]. Moreover, subjects perceived the motion-in-depth after-effect, having adapted to the square whose four sides reduces [8]. From these results, a man can extract depth by size change.

As described above, both expansion of retinal image and motion parallax operate as cues for perceiving depth. Then, how do these two cues differ? In motion parallax, objects at the same depth move at the same velocity and in the same direction. Meanwhile, the retinal image of an object expands in a radial pattern and, therefore, the position of the object in depth can not correspond to the velocity of expansion. Consequently, the velocity and the direction of expansion of image are not used in depth perception or distance perception. The cue for perceiving relative depth of objects is estimated to be the rate of expansion [9].

In normal situations, for example, in the case where the observer is running toward an approaching object, there is more often both expansion of retinal image and motion parallax. Previous studies, however, have not investigated the relationship between motion parallax and expansion. Both are cues for the perception of depth based on the flow of retinal image induced from the movement of observer and/or object. Therefore, clarifying the relationship between these two components will provide a useful information on the cues for depth perception in terms of motion factors. Accordingly, there is significance in examining the relationship between the processings of these two cues.

2. Experiment 1

In Experiment 1, to examine whether expansion of retinal image interferes with perception of depth by motion parallax, a simulation was prepared where the subjects could use both motion parallax and expansion of retinal image as cues for depth perception and one where they could use only motion parallax. The subjective depths in these two situations were compared. If expansion of retinal image interferes with depth perception by motion parallax, the subjective depths will differ. If, inversely, motion parallax does not interfere with depth perception by expansion of retinal image, the subjective depths will be identical.

2.1. Methods

Subjects: Four undergraduate students (three females and one male) ranging in age from 20 to 22 participated in the experiment.

Apparatus: Stimuli were controlled by an IBM compatible personal computer (GATEWAY-2000 G6-200) and displayed on a 17 inch CRT monitor (GATEWAY-2000 VIVITRON700 vertical frequency 60Hz). The stimulus was presented in a 19.2cm × 14.4cm rectangular window in the center of the screen. The area surrounding it was covered with black paper to conceal the frame of the screen and any superfluous images on the screen. The subject observed the stimulus monocularly in a dark chamber. Their eyes were fixed 100 cm from the monitor with a chin rest.

Stimuli: As shown in Fig. 1 (A) and 1(B), three squares, inside each of which 250 black random dots were arranged, were arranged lengthwise (upper, middle and lower) on a black screen. The diameter of the dots was 0.05 cm when the squares was measured 3.0 cm × 3.0 cm. Previous research suggested that it was unnatural to let dot size constant [10]. Therefore, in this research, the size of a dot expanded with the square size. The middle square was defined as the standard stimulus and the lower square as the comparison stimulus. Simulation where they could only use motion parallax as cues for depth perception (the M condition) and where the subjects could use both motion parallax and expansion of retinal image (the ME condition) were prepared. Initially, in the M condition, the centers of the upper, middle and lower squares were 2.4 cm, 6.3 cm, and 10.2 cm, respectively, under the upper edge, and 1.5 cm to the left of the left edge of the window. Since, in this position, the three squares were outside of the window, they could not be seen. The three squares did not expand. All started to move horizontally to the right. The upper and middle squares moved 6.0 cm and 9.0 cm, respectively, at a constant velocity. The distance moved by the lower square was varied across trials with a range of 7.2 cm to 18.0 cm in steps of 1.2 cm. One after another the squares came into view. In the ME condition, the three squares were arranged as in the M condition. The upper and lower squares did not expand but the middle, standard stimulus, expanded 1.5 cm in length at a constant rate. As in the M condition, the upper and middle squares moved 6.0 cm and 9.0cm, respectively, horizontally to the right. The lower square also moved horizontally to the right, a distance of 7.2 to 18.0 cm in steps of 1.2 cm. In the M condition, the length of all the squares was 3.0 cm initially. In the ME condition, the initial length of the upper and lower square was 3.0 cm, and that of the middle square was 1.5 cm. Since there were two conditions and ten distances for each condition, 20 types of stimuli were applied in total.

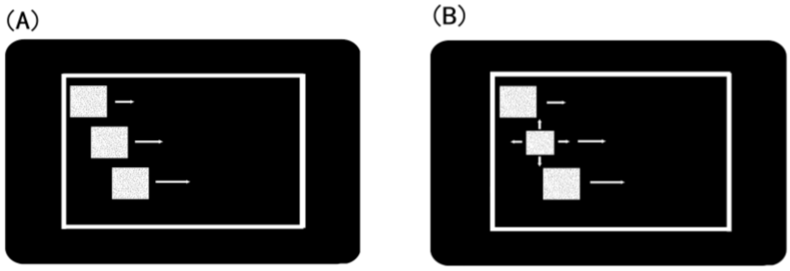

Fig. 1(A)(B). An example stimulus in the M and ME condition ((A)=the M condition, (B)=the ME condition). The area outside of the white frame was concealed and only the inner area was visible.

Procedure: In each trial, one second after the subjects clicked a button on the display, one of the stimuli was presented for five seconds. After the presentation, a black screen was presented for one second. The subjects were required to compare the standard stimulus (middle square) with the comparison stimulus (lower square) just before the end of presentation of the stimulus and to judge which square was closer to them. They then chose one of three responses ('the standard is closer', 'the comparison is closer', or 'the same') displayed on the screen by clicking a mouse. The experiment was divided into 10 blocks and in each block, 20 different stimuli were presented in random order. As a result, each subject responded to 200 trials. The subjects were permitted to rest at any time. Further, they were required to pursue the upper square with their eye so as to stabilize the use of motion parallax.

2.2. Results and Discussion

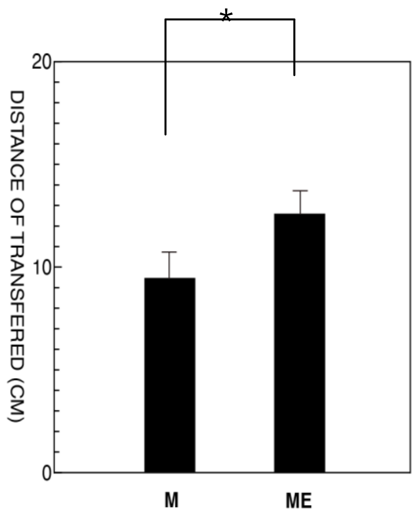

Fig. 2. Mean PSE's in the M and ME condition. Error bars indicated the standard errors. “*” means p<.05.

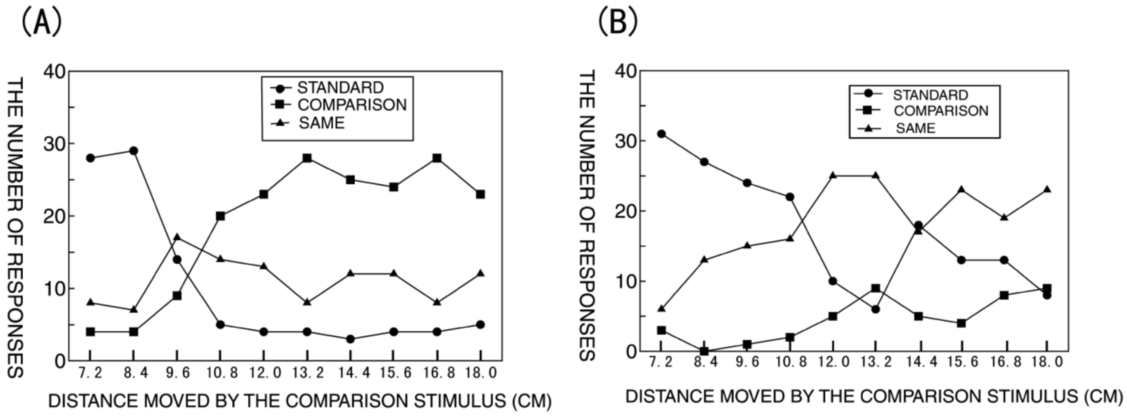

Fig. 3(A)(B). The number of each type of response (‘ the standard is closer ‘(filled circle), ‘ the comparison is close ’(filled rectangle), or ‘ the same ‘ (filled triangle)) as a function of the distance moved by the comparison stimulus in the M and ME conditions ((A)=the M condition, (B)=the ME condition).

For each subject, the point of subjective equality (PSE) was calculated by the constant method. PSE refers to the distance moved by the comparison stimulus at the point where the standard and comparison stimulus are perceived to be at the same depth. As shown in Fig. 2, the mean PSEs in the M and the ME condition were 9.4 cm and 12.7 cm, respectively. A within-subjects design of ANOVA for the PSEs showed a significant difference between the two conditions [$F(1,6) = 11.87$, $p < .05$] . This result means that the standard stimulus in the M condition was perceived to be closer than the standard stimulus in the ME condition. That is, the expansion of retinal image interfered with the processing of motion parallax.

An χ^2 test showed a significant difference among the number of the three types of responses; 'the standard is closer', 'the comparison is closer', and 'the same' in the ME condition [$\chi^2 = 95.53$, $p < .01$] (Fig. 3(A)). Further, a multiple comparison test showed a significant difference in number between 'the comparison is closer' and both 'the same' and 'the standard is closer', but not between 'the standard is closer' and 'the same'. The difference in the PSE between the conditions indicates that expansion of retinal image varied the amount of depth perceived by motion parallax and that motion parallax interfered with the processing of depth by expansion of retinal image. Such an interpretation is valid because if only expansion was used as a cue for depth perception, the response 'the same' would have been obtained the most since the standard stimulus and the comparison stimulus were equal in length at the end of the presentation. These results indicate that they did not judge depth by the use of expansion of retinal image or motion parallax alone.

A theoretical equation on motion parallax, equation (1), forecasts that, in the M condition, the depths of the standard stimulus and of the comparison stimulus will be perceived to be equal when the velocity of these two stimuli are equal. Consequently, it is expected that the depths of the comparison and standard stimulus will be perceived to be equal when the distance moved by the comparison stimulus is 9.0 cm. However, the actual PSE was 9.4 cm. Why then the difference from the expected value in the M condition? There are several possible explanations for this. In the experiments conducted by previous research, the stimulus used was a rectangle which covered consistently the horizontal width of the display from the left to the right edge [3], [5]. Then, such rectangles were arranged in several lines and subjective depth as judged using motion parallax was measured. The present study used squares which moved from left to right on the display. The objects were further apart in the stimulus used in the present study than in that used in the experiments conducted by Hayashibe’s researches [3], [5]. It is possible that the greater distance between the objects made more difficult the judgment of depth in the present study. Alternatively, the difference in PSE may be because the subjects observed the stimulus standing still in the present study. In the experiments conducted by the Hayashibe’s research [3], the condition where the subjects observed objects moving on the display standing still and the condition where they observed objects moving while they moved their head were compared. It was found that the sensitivity to motion parallax was greater when the subjects observed the objects while moving their head. Given this result, the difference was likely due to the fact that the subjects observed the stimulus standing still.

While the PSE differed from the theoretically expected value in the present study, this in itself does not mean that the subjects observing the experimental stimulus did not use motion parallax as a cue. As illustrated in Fig. 3(B), the shape of the graph is similar to that for the number of responses which ought to be obtained if the subjects judge depth by using only motion parallax. In addition, also in the Hayashibe's research [3], the subjects could perceive depth when they stood still although the sensitivity for motion parallax was reduced. From these analyses, it is clear that, in the present experiment, the subjects used motion parallax as a cue for depth perception although the sensitivity to motion parallax was reduced.

3. Experiment 2

Experiment 2 was designed to examine whether motion parallax interferes with the processing of expansion of retinal image by presenting a simulation where the subjects could use both motion parallax and expansion of retinal image and one where they could use only expansion of retinal image. As in Experiment 1, subjective depths in the two conditions were compared. If motion parallax interferes with the perception of depth using expansion of retinal image, the subjective depths in the two conditions will differ. If not, they will be equal.

3.1 Method

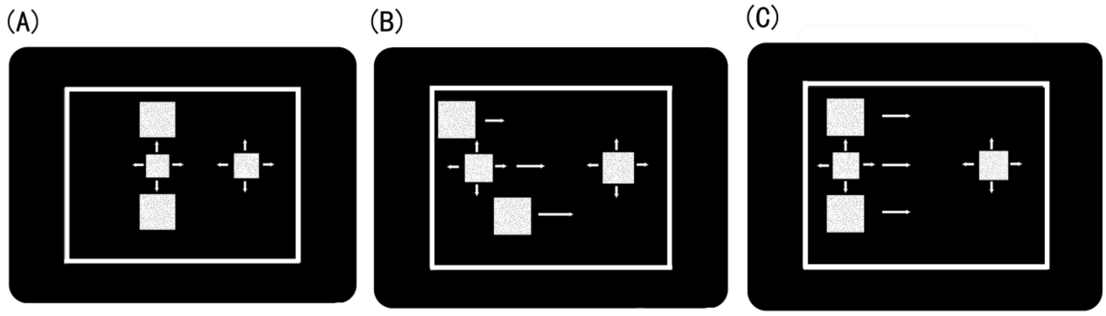

Fig. 4(A)(B)(C). An example stimulus in the E, ME and T condition ((A)=the E condition,(B)=the ME condition, (C)=the T condition). The area outside of the white frame was concealed and only the inner area was visible.

Subjects: Five graduate and under graduate students (3 females and 2 males) ranging in age from 20 to 27 participated in the experiment.

Apparatus: The apparatus used was identical to that used in Experiment 1.

Stimuli: As in Experiment 1, squares comprising 250 black random dots were used as stimuli. However, a fourth square was added to the three arranged lengthwise in Experiment 1. This square was positioned to the right of the other three, as shown in Fig. 4(A), (B) and (C).

There were two experimental conditions; that where the subjects could use only expansion of retinal image as a cue for depth perception (the E condition), and that where they could use both motion parallax and expansion of retinal image (the ME condition). In addition, a transfer condition (the T condition) was prepared as a control. In the E condition, the centers of the upper, middle and lower squares were 2.4 cm, 6.3 cm and 10.2 cm, respectively, under the upper edge of the window, and 7.5 cm from the left edge. The upper and lower squares did not expand but the middle square (standard stimulus) expanded 1.5 cm on all four sides. These three squares did not move horizontally. In the ME condition, the centers of the upper, and middle and lower squares were 2.4 cm, 6.3 cm and 10.2 cm, respectively, under the upper edge and 1.5 cm to the left of the left edge of the window. As in Experiment 1, since the upper, middle and lower squares were positioned outside the window initially, only the right square was visible at the beginning of the presentation. As in the E condition, the upper and the lower squares did not expand but the middle square expanded 1.5 cm. Further, the upper, middle and lower squares moved 6.0 cm, 9.0 cm and 13.8 cm, respectively, horizontally to the right. In the T condition, the upper, middle and lower squares were positioned as in the ME condition. The middle square expanded 1.5 cm and the upper, middle and lower squares moved 9.0 cm horizontally to the right. In all the three conditions, the center of the right square (comparison stimulus) was 6.3 cm under the upper edge and 15.0 cm from the left edge of the window. This comparison stimulus did not move and the amount of expansion was varied in the range 0.6 cm to 2.4 cm in steps of 0.3 cm. Initially, the upper and lower squares were 3.0 cm, the middle square 1.5 cm and the right square 1.5 cm long. Since there were seven degrees of expansion for each of the three conditions, 21 types of stimulus were prepared in total.

Procedure. In each trial, one second after the subjects clicked a button on the display, a stimulus was presented for five seconds. After that, a black screen was presented for one second. The subjects were required to compare the standard stimulus (middle square) with the comparison stimulus (right square) just before the end of the presentation of the stimulus and to judge which square was closer choosing the response 'the standard is closer', 'the comparison is closer', or 'the same' displayed on the screen by clicking a mouse. The experiment was divided into 10 blocks and in each block 21 different stimuli were presented in random order. As a result, each subject responded to 210 trials. The subjects were permitted to rest at any time. Further, they were required to pursue the upper square with their eye to stabilize the use of motion parallax.

3.2 Results and Discussion

As in Experiment 1, the amount of expansion of the comparison stimulus at the point where the depths of the standard and the comparison stimuli were perceived to be equal was calculated by the constant method, and was named the PSE of the amount of expansion. The mean PSEs in the E, ME and T conditions were 1.5 cm, 1.6 cm and 1.5 cm, respectively, as shown in Fig. 5. A within-subjects design of ANOVA for the PSEs in the three conditions did not show a significant difference among them［$F(2, 12) = 0.55$, $p > .05$］. This result indicates that the standard stimuli in the three conditions were perceived to be equal in depth. Namely, the subjects perceived depth by using expansion of retinal image in all three conditions. Further, this result indicates that motion parallax did not interfere with depth perception by expansion of retinal image.

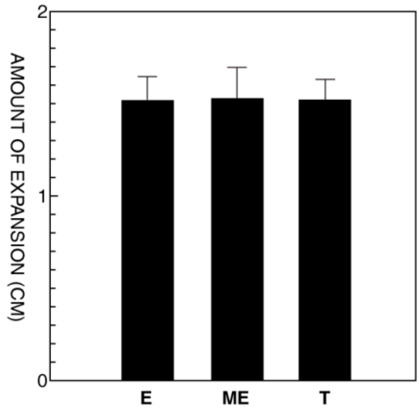

Fig. 5. Mean PSE's in the E, ME and T condition. Error bars indicated the standard errors.

This conclusion can be verified by examining the graphs of Fig. 6(A), 6(B), 6(C) illustrating the number of each type of response; 'the standard is closer', 'the comparison is closer' and 'the same'. In all the three conditions, 'the standard is closer' response was greatest when the degree of expansion was relatively small but decreased in number as the extent of expansion decreased. Meanwhile, 'the comparison is closer' came to be the greatest response as the extent of expansion increased. The relationship between the number of 'the standard is closer' and 'the comparison is closer' responses at the point where the expansion was 1.2 cm was reversed at the point where it was 1.8 cm. Note that the value of 1.5 cm at which the extent of expansion of the standard and comparison stimulus became equal, falls between 1.2 cm and 1.8 cm. Moreover, 'the same' became the greatest response when the square expanded 1.5 cm. That is, the subjects responded 'the same' when the expansion amounted to 1.5 cm, i. e., when the standard and the comparison expanded equally, and in the other cases, they judged the square that had expanded more to be closer. This finding also indicates that judgment of depth depended not on motion parallax but on expansion of retinal mage.

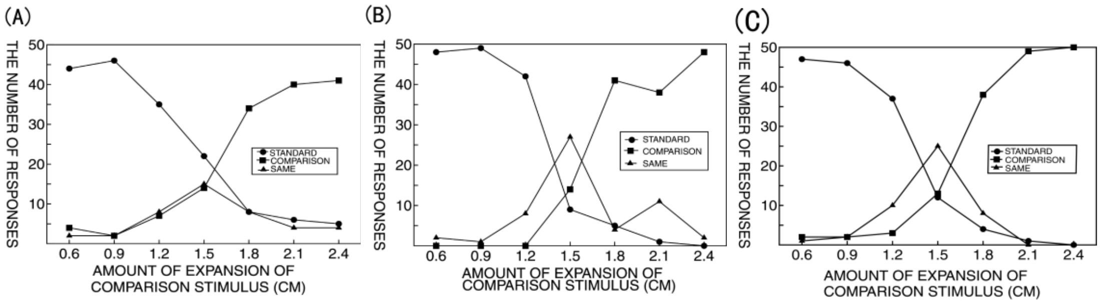

Fig. 6(A)(B)(C). The number of each type of response (‘ the standard is closer ‘ (filled circle), ‘ the comparison is close ’ (filled rectangle), or ‘ the same ‘ (filled triangle)) as a function of the amount of expansion of the comparison stimulus in the E, ME and T conditions ((A)=the E condition,(B)=the ME condition, (C)=the T condition).

In this experiment, to investigate the possibility that a transfer component of the square affects depth perception, a T condition was added as a control. The result did not show a significant difference in depth perception between the conditions where both the processing of the transfer and expansion component was necessary and the condition where only the processing of the transfer component was necessary. This finding indicates that, in depth perception, the processing of the transfer component did not affect that of the expansion component.

4. Experiment 3

The results of Experiment 1 and 2 indicate that there are two cases of interference between motion parallax and expansion of retinal image when both the cues are available. In one case, each cue interferes with the processing of the other and in the other case, only one of the two cues interferes with the processing of the other cue. From this result, we assumed how these cues interfere with each other depends on their intensities. With this assumption, the relation between motion parallax and expansion of retinal image was classified into the following three cases depending on the relative intensities of the two cues.

Case 1: If the intensity of expansion of retinal image is relatively large, motion parallax interferes not at all or only slightly with the processing of expansion.

Case 2: If the intensity of motion parallax is relatively large, expansion of retinal image interferes not at all or only partially with the processing of motion parallax.

Case 3: If the two cues compete with each other, there is interference.

Case 1 would apply to the stimulus used in Experiment 1, and case 3 to the stimulus in Experiment 2.Although the validity of case 1 and 3 is evident, that of case 2 is not. Experiment 3 was designed to validate case 2 and our hypothesis by manipulating the extent of expansion of retinal image.

4.1 Method

Subjects: Five graduate and undergraduate students ranging in age from 20 to 28 participated in the experiment.

Apparatus: The apparatus used was identical to that used in Experiment 1 and 2.

Stimuli: As in Experiment 1, squares comprised of random dots were used as stimuli. As in Experiment 1, the centers of the squares were 2.4 cm, 6.3 cm and 10.2 cm, respectively, under the upper edge, and 1.5 cm to the left of the left edge of the window. The middle square expanded (standard stimulus) with movement horizontally to the right. The initial size of the middle square was varied from 3.0 cm to 1.5 cm in steps of 0.3 cm. As the length of the sides decreased, the extent of expansion increased from 0 cm to 1.5 cm in steps of 0.3 cm. The sides of the middle square were 3.0 cm just before the end of the presentation of the stimulus in all the simulations. The upper, middle and the lower squares (comparison stimulus) moved 6.0 cm, 9.0cm and 12.0 cm horizontally to the right, respectively. The upper and the lower squares did not expand and the lengths of the sides were consistently 3.0 cm. Consequently, the combination of expansion and distance resulted in 6 types of stimuli.

Procedure: The task required of and instructions given to the subjects in this experiment were identical to those in Experiment 2. The experiment was composed of 10 blocks and in each block, 6 types of stimuli were presented in a random order. Consequently, each subject responded to 60 trials in total.

4.2 Results and Discussion

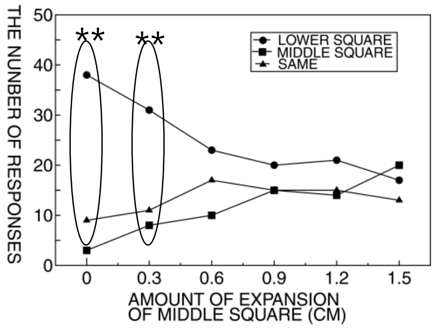

Fig. 7. The number of each type of response (‘ the standard is closer ‘ (filled circle), ‘ the comparison is close ’ (filled rectangle), or ‘ the same ‘ (filled triangle)) as a function of the amount of expansion of the comparison stimulus. “**” means $p<.01$.

As the extent to which the standard stimulus expanded increased, the response 'the comparison stimulus is closer' tended to decreased in number (Fig. 7). This result is consistent with our hypothesis and indicates that as the intensity of expansion of retinal image increased as a cue, the ratio of the subjects' use of motion parallax as a cue decreased. Namely, it indicates that the use of motion parallax varied depending on the relative intensities of the two cues. A within-subjects design of ANOVA for the numbers of responses in the cases where the square expanded 0 cm and 0.3 cm showed a significant difference. A multiple comparison test for this effect showed that the response 'the comparison stimulus is closer' was obtained significantly more often in the cases where the expansion was 0 cm and 0.3 cm ［$F(2, 12) = 8.38$, $p < .01$, $F(2, 12) = 75.07$, $p < .01$］. This result indicates that when the intensity of expansion was sufficiently small, i. e., 0.3 cm, the subjects perceived depth by using only motion parallax despite that they could use expansion.

From these analyses, it is suggested that when both motion parallax and expansion of retinal image can be used simultaneously, the extent to which the cues interfere with each other varies depending on the relative intensity of the two cues. As in Experiment 1, when the intensity of expansion is much larger than that of motion parallax, motion parallax does not interfere with the perception of depth by expansion of retinal image. As shown in the case where the expansion is 0.3 cm, if the intensity of motion parallax is much larger, expansion of retinal image does not interfere with the perception of depth by motion parallax. As in Experiment 2 or in the case where the extent of the expansion is small, when the intensities of the two cues are similar, there is interference.

Contrary to expectation, the number of responses 'the standard stimulus is closer' increased as the extent of expansion increased and the number of responses 'the same' did not increase as the degree of expansion increase. It is possible that the subjects over-estimated the expansion of the standard stimulus by overshooting its final size.

5. General Discussion

In Experiment 1, to test whether expansion of retinal image interferes with the processing of motion parallax, two simulations were used; that in which only motion parallax could be used as a cue for perceiving depth (the M condition) and that in which both motion parallax and expansion of retinal image could be used (the ME condition). The subjective depths under the two conditions defined by the PSEs between the standard and comparison stimulus measured by the constant method were compared. In Experiment 2, to test whether motion parallax interferes with the processing of expansion of retinal image, a simulation in which only expansion of retinal image could be used (the E condition) and another in which both motion parallax and expansion could be used (the ME condition) were prepared. In this experiment, a transfer condition (the T condition) was added as a control. As in Experiment 1, the subjective depths for the three conditions defined by PSEs were compared.

In Experiment 1, the subjective depths in the M and ME conditions were significantly different. This indicates that expansion of retinal image interfered with the processing of motion parallax. Moreover, the response 'the middle was closer' and 'the same' in the ME condition did not differ in number. This indicates that the subjects did not perceive depth by using only expansion of retinal image in the ME condition. Namely, when both motion parallax and expansion of retinal image could be used, the two cues interfered with each other. In Experiment 2, the subjective depths in the E condition and the ME condition were not different. This indicates that the subjects perceived depth by using only expansion of retinal image as a cue in the ME condition.

From the results of Experiment 1 and 2, it was concluded that when both motion parallax and expansion of retinal image could be used as cues for perceiving depth, there were two cases in terms of the manner of interference between the two cues; that in which the two cues interfered with each other and, that in which expansion of retinal image was processed without interference from motion parallax. We assumed that the difference between the two experiments was caused by the relative intensities of motion parallax and expansion of retinal image as cues for depth perception. Experiment 3 was designed to investigate this assumption. In the experiment, it was tested whether motion parallax could be processed without interference from expansion of retinal image even when both the cues existed, by varying the intensity of expansion step by step. The results showed, as expected, that motion parallax was processed without interference from expansion of retinal image if the intensity of the expansion was small, as in the case where the middle square expanded only 0.3 cm. Moreover, the interference from the expansion decreased as the intensity of it decreased.

The results of the present three experiments can be summarized as follows. When motion parallax and expansion of retinal image could be used simultaneously as cues for depth perception, the subjects perceived depth in one of three manners. In Experiment 2, the subjects perceived depth by using only expansion of retinal image almost without interference from motion parallax. In the case where the amount of expansion was 0.3 cm in Experiment 3, the subjects perceived depth by using motion parallax almost without interference from expansion of retinal image. In the case where the amount of expansion was large in Experiment 2 and 3, the two cues interfered with each other. From these results, the interference between motion parallax and expansion of retinal image can be classified into the following three cases in terms of the intensity of cues for depth perception;

Case 1: If the intensity of expansion of retinal image is relatively large as a cue, motion parallax hardly or not at all interferes with the processing of expansion (Experiment 1).

Case 2: If the intensity of motion parallax is relatively large as a cue, expansion of retinal image hardly or not at all interferes with the processing of motion parallax (the case where the amount of expansion was 0.3 cm in Experiment 3).

Case 3: If the two cues compete with each other, these is interference (the case where the expansion was more than 0.3 cm in Experiments 2 and 3).

Regan and Beverley claimed that since our visual system is biased to execute the safest and the most profitable motor response, the movement of retinal image which can be interpreted as both the approach and the expansion of an object brings the impression of motion in depth to the observer [8]. It would not be until the object is relatively close to the observer that a judgement as to how to respond to it would be made. In contrast, when an object is relatively distant, the observer is relatively safe even if they can not use the information. Motion parallax can be used as a cue for perceiving the depth of an object several kilometers away. As an example, we use motion parallax as a cue for depth when we see a landscape through the window of a train. Which case of the three outlined above applies when both motion parallax and expansion of retinal image are available is expected to depend on the distance of the object from the observer. When an object is relatively close, the observer will actively use expansion of retinal image for depth perception because there is a good possibility that this cue is available in such a case. Consequently, the processing of expansion will not be interfered with by motion parallax. As the distance of the object from the observer increases, the processing of expansion of retinal image will begin to be interfered with by motion parallax. At the same time, expansion of retinal image will also interfere with the processing of motion parallax. Further, when the distance of the object from the observer reaches a certain value, the interference from expansion will all but disappear and the observer will come to perceive depth by using only motion parallax. It is, here, necessary to note that motion parallax can be used not only when objects are distant but also when they are close. Namely, when both expansion of retinal image and motion parallax can be used simultaneously for close objects, the processing of motion parallax is interfered with by expansion of retinal image.

In everyday life, it is rare for an object to approach head-on. Mostly, objects approach out of the subject's gaze, and sometimes while rotating on their own axis. When that is the case, as for the flow of the retinal image caused by an object's approach, a transfer and a rotational ingredient are added to an expansion. It has been yet clarified whether transfer and expansion are processed independently. Te Pas, Kappers and Koenderink indicated that the expansion had been independent of its transfer [11], and De Bruyn and Orban showed that the expansion had been independent of rotation [12]. On the contrary, Duffy and Wurtz and Simpson claimed that the expansion has not necessarily been independent of the transfer [13], [14].

In Experiment 1, to examine whether the transfer of a square on a frontal-parallel plane interferes with depth perception by expansion of retinal image, a T condition (transfer condition) was prepared. The results did not reveal a significant difference between the PSEs in the condition where only expansion of retinal image was presented and in the condition where the transfer on the frontal-parallel plane and expansion of retinal image were intermingled. This indicates that when an observer perceives the depth of an object with transfer on the frontal-parallel plane, the transfer does not interfere with the processing of expansion of retinal image but the two cues are processed independently. This is consistent with previous claims by Te Pas, Koenderink and Kappers [11].

6. Conclusion

This study examined how motion parallax and expansion of retinal image affect each other, when both these cues are available for depth perception. Experiments results showed that the interference between motion parallax and expansion of retinal image can be classified into the following three cases in terms of the intensity of cues for depth perception;

Case 1: If the intensity of expansion of retinal image is relatively large as a cue, motion parallax hardly or not at all interferes with the processing of expansion.

Case 2: If the intensity of motion parallax is relatively large as a cue, expansion of retinal image hardly or not at all interferes with the processing of motion parallax.

Case 3: If the two cues compete with each other, these is interference.

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(Use 10 point Times New Roman) The abstract is a brief (50-80 words) synopsis of your paper. Its use is to provide a quick outline of your presentation, giving the reader an overview of the research. This is an important aspect of your paper, as it is this description that may attract the reader to continue and finish your full report. Keywords should be so chosen that they best describe the contents of the paper. In most cases, these words can be found in the title and abstract. Noun forms without articles must be used. The use of hyphens and prepositions should be avoided. Keywords, 5-10 in number, should be typed on the next line after the abstract, starting with the headline Keywords: Each keyword, except proper nouns and acronyms, should be typed in lower-case letters and followed by a comma, except for the last one. (Example keywords: VLSI, CMOS and SOI)

Keywords-component; formatting; style; styling; insert (key words)

1. Introduction

These instructions give you basic guidelines for preparing camera-ready (CR) papers for IJCT. The instructions assume that you have computer desktop publishing equipment with several fonts. Your goal is to simulate, as closely as possible, the usual appearance of published papers in the ACM Journal. These instructions have been prepared in the preferred format.

2. How to Format the Page

2.1. Full-Size Camera-Ready (CR) Copy

Prepare Camera-Ready paper in full size format, on A4 size or 8 1/2” x 11” (215.9 mm x 279.4 mm) paper.

2.2. Heading

The **headings** and **subheadings**, starting with "**1. Introduction**", appear in upper and lower case letters and should be **set in bold and aligned flush left**. All headings from the Introduction

to Acknowledgements are numbered sequentially using 1, 2, 3, etc. Subheadings are numbered 1.1, 1.2, etc. If a subsection must be further divided, the numbers 1.1.1, 1.1.2, etc.
The font size for **heading is 12 points bold face** and **subsections with 11 points bold face.** Do not underline any of the headings, or add dashes, colons, etc.

2.2. Fonts

The best results will be obtained if your computer word-processor has several font sizes. Do not use fonts smaller than the fonts specified in Table 1. As an aid to gauging font size, 1 point is about 0.35 mm. Use a proportional, serif font such as Times or Dutch Roman.

2.3. Formats

In formatting your A4-size paper, set top margin to 30 mm, bottom margin to 25.4 mm (0.98 inches), left margin to 25.4 mm and right margin to 25.4 mm.

You should left- and right-justify your columns. On the last page of your paper, try to adjust the lengths of the two columns so that they are the same. Use automatic hyphenation, if you have it. Don't forget to check the spelling.

3. Illustrations

Position figures and tables at the tops and bottoms of columns, if possible. Large figures and tables may span both columns. Figure captions should be below the figures; table captions should be above the tables. Try to place the figures and tables after their first mention in the text. Use the abbreviation (e.g., “Fig. 1”) even at the beginning of a sentence.

All half-tone illustrations (pictures/photographs) should be clear black and white prints. Do not use photocopies. These illustrations should be furnished within the copy. Make certain to include a caption in the paper for the illustration as well as to label the illustration on the back.

Table 1. Font Sizes for Camera-Ready Papers

Font Size	Bold	Italic	Text
10			Main text, authors’ affiliations
10	Yes		Headings, i.e. **Abstract**
12			Authors’ names
14	Yes		Paper title
11	Yes		Sub-headings, i.e., 1.1
10			References, table, table names, table captions, figure captions
9			Footnotes, sub- and superscripts

Fig. 1 This is a sample figure. Captions exceeding one line are arranged like this.

4. Helpful Hints

4.1. References

List and number all references at the end of the paper. When referring to them in the text, type the corresponding reference number in square brackets as shown at the end of this sentence [1]. Number the citations consecutively. The sentence punctuation follows the brackets. Do not use “Ref. [3]” or “reference [3]” except at the beginning of a sentence.

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it is cited. Do not put footnotes in the reference list.

Give all authors’ names; do not use “et al” unless there are six authors or more. Papers that have not been published, even if they have been submitted for publication, should be cited as “unpublished” [4]. Papers that have been accepted for publication should be cited as “in press” [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

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4.2. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used. Acronyms such as MOSFET, AC and DC do not have to be defined. Redefine acronyms when first used in the text, even if they have been defined in the abstract.

4.3. Equations

Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1). To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Use parentheses to avoid ambiguities in denominators. Punctuate equations with commas or periods when they are part of a sentence, like this,

$$\int_{0}^{r_2} F(r,\phi)\,dr\,d\phi = \left[\sigma r_2 \,/\, (2\mu_0)\right] \cdot \int_{0}^{\infty} \exp(-\lambda |z_j - z_i|)\lambda^{-1} J_1(\lambda r_2) J_0(\lambda r_i)\,d\lambda. \quad (1)$$

Be sure that the symbols in your equation have been defined before the equation appears or immediately following. When you refer to equations in the text, refer to (1). Do not use “Eq. (1)” or “Equation (1)” except at the beginning of a sentence: “Equation (1) is used....”

4.4. Other Recommendations

Use either one or two spaces between sections, and between text and tables or figures, to manipulate the column length. Use two spaces after periods at the end of sentences (full stops).

5. Conclusion

Following these instructions will improve the quality of your paper and the ICCT 2017 Proceedings. If you have questions, please contact the Technical Program Committee chairs.

Acknowledgment

This research was supported by .. (Optional)

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