



## User Needs for Haptic Communication of VR Fashion Product Shopping

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**Abstract:** Non-contact judgment and evaluation for products are increasingly needed along with a rapid environmental change in fashion that sows urgency in the need to implement services that allows users to judge and experience a tactile sense in a fashion product without actual contact. Technological development is required to provide users with syn-aesthetic experiences that integrate the visual, tactile and the auditory. There is also a need to conduct research to increase immersion that provides users with ICT-related experiences communicated through fashion images. The study analyzed demands for haptic communication technology by Korean users in immersive VR fashion product shopping. Accordingly, it defined haptic communication through literature research, investigated immersion in the VR environment and conducted in-depth interviews for haptic communication applicable to VR shopping. Findings show that hedonic reactions by fantasy, emotion and fun function are an important motive in selecting VR shopping. VR fashion product shopping steps were divided into 4: move to store, search in store, search of product and purchase based on offline store shopping experience. It defined the haptic communication by steps and analyzed the types of the haptic feedback to be implemented. The study results provide basic data for developing haptic communication technology that can enhance a sense of the presence and immersion experiences that can help lay a groundwork for pilot studies on the convergence of the virtual and the real.

**Key words:** haptic communication, haptic feedback, VR shopping, fashion product

### 1. Introduction

In order to ensure the competitive edge through convergence of Information & Communication Technology(ICT) in the age of the fourth Industrial Revolution, attempts applying a variety of technologies are being made by the fashion industry including customer service expansion using Artificial Intelligence(AI), consumer needs analysis or trend analysis on design and color using big data, marketing using a live streaming and brand experiencing by Virtual Reality (VR) technology. In particular, the noteworthy is to apply moving images VR technology to fashion images, leading changes of a fashion retail store and providing consumers who enjoy experiential shopping with special brand experience. It may be utilized as one of omni-channel strategies not only increasing consumer brand loyalty and enhancing relations between consumer and brand. In the future when physical and digital worlds have much closer relations with each other and things are perfectly connected through internet networking, priority should be given to the development of differentiated service based on sensibility and sense as well as on

intelligence and cognitive competency.

Looxid Labs, winner of the CES 2018 Best Innovation Award in virtual reality, and Thirteenth Floor, a cinematic virtual reality creative group which produces sophisticated 360 cinematic and interactive content are Korean start-up companies which have gained great attention by Manchester Metropolitan(“VR Conference”, 2018). Also Vancouver growing reputation as a hub for VR and augmented reality(AR) technology development signed a joint agreement with Korean companies to partners in co-developing VR/AR platforms(Chiang, 2018). As such, Korea’s VR technology has recently received worldwide attention and attempts have been made to build Korea’s VR shopping mall based on this technological potential.

As for online shopping, in a situation where consumers cannot try it on or touch real items, material difference and uncertainty between virtual and real products consumers perceive function as an important factor impeding purchase(Choi & Kim, 2002; Lee et al., 2001; Safari et al., 2013) and at the existing fitting simulation providing only visual experience of a product has a limitation to provision of vivid and realistic experience. As such, non-contact judgment and evaluation on product are being increasingly needed along with a rapid environmental change of fashion and it is urgent to implement service which allows users to judge and experience the tactile sense of a fashion product without actual contact. Therefore, technological development is needed to provide users with syn-aesthetic experience integrating the visual, tactile and the

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auditory. And it is required to conduct research to increase immersion to provide users with ICT-related experience, who communicate by fashion images including a virtual fitting room, virtual shopping, live fashion show, fashion films and the core of technology provided for fashion service lies in provision of immersive contents, 'more realistic than the real'.

In the precedent study on the tactile sense in fashion, DeLong et al.(2012) identified the effect of the tactile characteristics of the fabric on the user's satisfaction and mentioned that most-frequently listed properties were soft, smooth, and warm touch. As for 3D virtual wearing, studies are mainly on software development for implementing virtual fashion product image similar to the real and on improvement of visual elaboration considering physical properties of material(Kim & Choi, 2011; Lage & Ancutiene, 2017; Lee & Kim, 2011; Oh & Ryu, 2015; Vitali & Rizzi, 2018; Yang & Kim, 2014). As for VR shopping, studies are generally about implementation and application cases of a virtual shopping mall under certain controlled conditions(Choi, 2004; Han et al., 2017; Lee & Kang, 2007; Park et al., 2015; Sung, 2016). Hence, there are few studies on haptic technology development as a solution to overcome a limit to realistic experience based on VR technology.

Therefore, the study analysed demands for haptic communication technology by Korean users to experience an immersive VR shopping for communicating realistically and effectively. Accordingly, the study defined haptic communication through literature research, investigated the immersion at VR environment and conducted in-depth interview for the haptic communication applicable to VR fashion product shopping. It is expected to be used as basic data for developing the haptic communication technology to enhance a sense of the presence and immersion and give an important suggestion for implementing haptic technology and system. In addition, it is also expected to lay groundwork for pilot studies on convergence of the virtual and the real, information and sense.

## 2. Literature review

Recently in a digital environment, communication through images prevails over experience through substantial fashion product. Defining the haptic communication as a means of realizing sense of immersion at the VR environment is essential.

### 2.1. Fashion product image and haptic communication

Methodological changes are emerging in searching and sharing new knowledge or information. Compared with the search of contents by texts and still images, increasingly contents are searched and shared by voice and video. Hence, text-centered blogging was changed into image-centered blogging, with a coined word of

vlogging which is compound of video and blogging. A periodic change from contents read and written to contents told, heard and viewed may be said as the transitional(Kim, 2016). In such a change, the noteworthy thing is 'moving image' and 'experience', and it has significance in that fashion performance is delivered by sensory elements. Uhlirva(2013) asserted that 'clothing of moving image' should be added to 'clothing of real', 'clothing of character' and 'clothing of image' classified by Barthes(Roland Gérard Barthes, 1915-1980, structuralism philosopher). It means that in the contemporary era fashion is not consumed as an entirely material object but is represented and consumed through moving fashion images. In the past images played a role of a supplement for fashion object, however, today their boundary has become blurred by interaction between image and objet, materiality and non-materiality, so fashion products come to be experienced by their images. But in case a product has various material attributes like texture, softness, weight, temperature, when evaluating a product, consumers have great motivation for touching(Lederman & Klatzky, 1990; Lund, 2015; Peck & Childers, 2004) and especially for fashion products where clue of the tactile sense has a core effect on product evaluation (Holbrook, 1983), it was found out that consumers touch fashion products longer than those of other categories such as books and records before purchase(Peck & Childers, 2004). It is regarded that the tactile sense is also able to play an important role when one experiences a fashion product by an image so the study pays attention to the haptic communication. Particularly, at a VR shopping environment where non-material attributes are intensified so experiential utilization of the visual and haptic information provided by an image is critical.

The tactile refers to as feeling of pressure, vibration, temperature and pain when a stimulus is given to skin, and the tactile sense means softness, tenderness, hardness, volume, stiffness, elasticity and a sense of temperature. In other words, the tactile means the primary sensation of an object surface felt on one's skin and the tactile sense means the comprehensive sensitivity made of material attribute and prior experience. Such tactile experience which is tactile sense is not done only by an action where one's skin touches the surface of an object, but also by an action pressing, grabbing, rubbing and twisting with one's fingers(Lee & Kim, 2016), and haptic means a wide range of the tactile which acquires information by joint and muscle movements like those of a hand or a finger with pure tactile information by touch. Haptic means touchable and refers to as a form of sense accepting interface or feedback related to the tactile in a VR environment. It may include a wide range of sensations like a 'sense of presence' or 'stereoscopic perception'.

Feedback means every kind of reaction user feels when he or she communicates with media, that is, a concept which is used for

stimulus and reaction received by a user after certain performance. If proper feedback is given through interface connecting human and computer, an action using a computer and user cognition are connected so comprehensive communication is done, which provides user with additional information and even stimulates his or her sensitivity more(Kim & Lim, 2004; Lee, 2007). In such a communicative process, feedback communicated by various tactile stimuli is said as ‘haptic feedback’. The tactile stimuli may be divided into tactile sense and force sense and haptic feedback into tactile feedback and force feedback(Han, 2011). The tactile feedback is a sense which acts on one’s skin. It relates to senses of pressure, temperature and pain perceived by proprioception in the internal body and it may be said as feedback loyal to pressure. To users, it delivers information like temperature, intensity, and surface roughness which allows users to differentiate texture or surface features. Force feedback allows users to feel an actual weight or resistance force and its implementation needs a device which gives force corresponding to that of an actual object to a user. It is a stimulus to motions communicated by distal organs which are distributed on muscles, tendons and joints and means flexibility or weight when holding an object. Hence, it helps users to feel weight and resistance force caused by an actual moving object in VR(Kim & Lim, 2004; Lee, 2007; Wu & Smith, 2015).

The haptic feedback user feels can be broken down into 8 kinds of effects as follows. Firstly, the periodic effect may be used for modelling of vibration of an electric shaver, motion of a seismometer or eruption of a volcano, expressing periodic vibrations through waveform or giving an effect of gradual weakening or strengthening of a periodic vibration. The texture effect is used for expressing texture of a washboard or racquet strings, giving an effect of protrusion. As for the enclosure effect, one comes to feel crashed into a wall in a closed square space and the similar ellipse effect may be used to express a phenomenon to be dragged into a round or oval area and it expresses a form identical to enclosure except a round area. The spring effect may be used to represent a phenomenon to pull or be pressured and it is possible to implement a

simulation feeling the elasticity of a spring when a ball touches a line while falling down. The effect of constant force may be used to generate force in a single direction constantly and the effect of ramp may be used to increase or decrease force in a single direction during certain period. It can display effects of a heavy object pushed on a ramp or a thing rolling the way down. The effect of damper expresses resistance to certain motion and it is similar to movements of an object in the water(Hwang et al., 2003). Table 1 shows a brief summary of descriptions above. The haptic communication may be defined as communication between user and product through delivery of information and emotional stimuli formed when haptic feedback is given, and this study paid attention to the haptic communication mediated by images at a VR environment rather than a real product itself.

2.2. VR environment and immersion

A French dramatist and director, Antonin Artaud used words virtual reality to describe the fantastic nature and objects in a theater and mentioned that it refers to as interface between human and computer, constructing certain situation by computer and making user feel interacting with an actual circumstance or environment (Cha, 2017). Burdea and Coiffet(1994) referred to VR as 3Is, Immersion, Interaction, and Imagination. In particular, immersion means a state where users feel as if they existed at a VR space despite technological limits. There are definitions on immersion, including those by Ghani et al.(1991) who explained characteristics of immersion as complete focus on an acti

on and the resulting pleasure and by Trevino and Webster(1992) who described immersion as self-motivating where one experiences pleasure like playing games and the action in an immersion state is interesting and funny itself so it comes to be rewarded even without external reward. Hoffman and Novak(2009) also defined the immersion as a subjective experience occurred when a degree of one’s challenge to task or activity given corresponds to a level of one’s skills, mentioning that those who experienced such immersion feel the overall satisfaction more than fun. As such, it may be said

Table 1. Types of haptic feedback

Types of feedback	Receptor	Info & property delivered	Haptic feedback effect
Tactile feedback	Skin sense of internal receptor	Geometric shape Wrinkle Temperature Slippery degree	Periodic effect Texture effect
Force feedback	Muscular sensation of muscle, tendon, joint	Force applied to body surface Flexibility when holding an object Weight	Enclosure effect Ellipse effect Spring effect Constant force effect Ramp effect Damper effect

that a sense of presence and immersion in a VR environment lead to pleasure and fun and eventually to increased interaction with an object in which one is immersed.

According to an environment where system is implemented, virtual reality is divided into immersive VR, tele-robotics VR, desktop VR, third person VR. Immersive VR makes humans feel sensory effects as if they were watching and touching actually through special equipment like head mounted display(HMD), data gloves and clothes and lets them be immersed in a vivid environment. Now it is being used very actively in various fields as an efficient tool where input/output devices stimulating five senses can enhance user's immersion in a VR environment. The optimal stimulation to five senses of a human body including the visual, tactile, olfactory, gustatory and the auditory has to be done for the maximum immersion in VR. As humans tend to acquire information mostly by the visual, the most important thing of five senses, immersion can be derived mostly through visual principles. But the auditory and the tactile are needed for tangible experience to maximize the sense of presence of the virtual world.

### 3. Method

VR markets in Korea are at the beginning stage and in particular there are few empirical studies on the haptic communication for

VR shopping so the research should have derived findings of research topics from opinions of Korean fashion professionals who experienced VR. To understand user needs for the haptic technology available to VR fashion product shopping, in-depth interviews were conducted for fashion majored researchers of at least graduate school in their 20-30s who experienced VR in Korea. Having great understanding of fashion products and shopping environments, they were semi-professionals with higher involvement in VR and fashion, who had conducted research especially on VR fashion and shopping before. Beginning with stories of their career at VR, for in-depth interview, objectives of the research were presented and assumptions were derived about present situation of VR fashion product shopping. With the application of the immersive VR system using HMD and input/output devices stimulating five senses, a process of VR fashion product shopping was hypothesized step by step and information was collected on kinds of the haptic technologies and tactile information available by step. They were made to imagine a thing beyond the present technology and asked about what haptic information is needed by shopping step, how appropriately and how far provision of information by the haptic should be done when purchasing a fashion product at a VR shopping environment. Interviews were conducted with 20 persons on one-for-one basis average for about 1 hour from 28th Sep. to 12th Oct., 2018 at school interviewing room. Table 2 shows general information

**Table 2.** General information of interviewees

Number	Sex	Age	Major	VR-related career
1	M	29	Fashion technology	VR R & D
2	F	26	Fashion marketing	VR research participation & game
3	F	27	Fashion marketing	VR research participation
4	M	34	Fashion retailing	VR research participation
5	F	36	Fashion marketing	VR research participation
6	F	33	Fashion marketing	VR R & D
7	F	28	Fashion technology	VR research participation & game
8	F	28	Fashion marketing	VR research participation & game
9	F	35	Fashion marketing	VR research participation
10	F	26	Fashion retailing	VR research participation
11	F	27	Clothing ergonomics	VR game & store
12	M	37	Fashion technology	VR R & D
13	F	36	Fashion retailing	VR research participation
14	F	34	Fashion marketing	VR R & D
15	M	34	Fashion technology	VR research participation
16	M	35	Fashion marketing	VR research participation
17	F	29	Clothing ergonomics	VR game & store
18	F	28	Fashion design	VR game & store
19	F	33	Fashion design	VR game & store
20	F	38	Fashion design	VR game & store

of interviewees.

It was reviewed by authorized institutional review board (IRB No. 1810/001-006) and acquired its approval for ethical/scientific validity of the research plan and privacy protection for research participants. Also they were given a written instruction and an agreement with explanations of research objectives and processes before starting an interview. Research data were analyzed using the constant comparative analysis, a qualitative method for analyzing research data. Open coding is to give a code to a thing repetitive or important and categorize data, and concepts were derived by analysis on interview data by line or word, comparing conceptual similarities and differences through repetitive review (Strauss & Corbin, 1998/2001). The generated categories with similar contents (subcategories) were grouped together as higher order categories (generic categories), and those categories were grouped again into even higher order categories (main categories) (Kim et al., 2014). And the results were reviewed by 3 researchers for their validation.

## 4. Results & discussion

Findings from in-depth interviews reveal that users emphasized the need for the haptic experience at a VR shopping environment and they mentioned that various haptic information should be applied by shopping step to increase the immersion. Detailed analytic findings are as follows.

### 4.1. The need for haptic experience at VR shopping environment

Research participants said experiential/hedonic values should be pursued through the haptic experience. Participants stated VR is primarily related to game and fun of entertainment so experiential shopping is important. VR system is adequate for delivering experiential and hedonic characteristics of a fashion product since syn-aesthetic multisensory information is provided. Furthermore, apart from emphasis on experiential elements, they mentioned a role of delivering actual tactile information and the need for the haptic technology which allows VR shopping to function as an independent shopping channel. As shown from Chung (2018)'s research on factors influencing the immersion in experiencing VR contents, immersion is effective when emphasis is put on tactile elements synchronized with visual changes along with three-dimensionality of graphic on a screen, and in such a context, the importance of the haptic could be understood.

"These days, you know, there are many people who are window shopping at store and buying it at an internet shopping mall. They value experience, I think. I can search info soon with my cell phone but *very real feeling is limited on internet. Still VR is fun or game*

*to me so I think it's better if I can experience and get info by the haptic.*" (Participant 1)

"People say they go shopping because they can't touch at online shopping mall but it is booming now. There are many consumers saying they believe and purchase if images give info helpful for shopping decision. Online malls are booming and *I think by introducing experiencing and then the haptic skills, purchase should be constructed from offline to online and VR store.*" (Participant 6)

In particular, in terms of efficiency of shopping including convenience or rapidity when comparing VR shopping with online shopping, users tend to prefer online purchase so they mentioned the haptic experience at VR shopping should pursue experiential and hedonic values, emphasizing entertainment aspects of shopping like pleasure, excitement and fantastic experience.

"If my main purpose is rapid shopping, maybe I'll not use VR, *something fun and joyful is needed...* What about purchasing on internet, should I use VR and wear something like headset, maybe click on internet is more effective... *if I can experience a brand image.*" (Participant 4)

"*Now, maybe it is more useful to create a VR shopping mall for those who cannot access easily to an offline store....* For the haptic, you know tactile sense, and I think it'll be more effective to make it for those who cannot access to it actually." (Participant 4)

"Now VR is a lot uncomfortable, *it's a new technology.* There are many people having no experience. *I think in such a situation of an early step, giving fun is an answer.* For example, they seem to prefer going and coming here and there, people can feel more fun if experiencing is included. And the haptic is even more comfortable than by visual so it's better." (Participant 15)

As shown from Jang and Kim (2018)'s research, the development of VR-related technologies like the haptic allows users to have deep sensitive experience by delivering vivid real sense of contents. Therefore, they can experience full immersion through VR experience enough for them to mistake it for the real world.

The haptic experience at a VR fashion product shopping environment was classified into two directions, offline shopping experience-oriented and hedonic experience-oriented.

#### 4.1.1. Offline shopping experience oriented

Research findings reveal that offline shopping experience-oriented users regard it effective to pursue reality-based offline shopping experience at a VR shopping environment based on the haptic communication. At a VR shopping environment which implemented immersive VR system, even wearing HMD and going around a virtual offline store can replace the pleasure of window shopping. Interviewees emphasized the pleasure of shopping experience without spatial and temporal limits including enjoying alone at

their own store without clerk and experiencing a store such as in New York City even though they do not visit a store in real.

**“Impressive to visit an overseas department store I want to go. If can, going around will be fun ...** If I go to Macy’s, I think the immersion (by the haptic) is important. Feeling vibration and something... And maybe we have fun when we touch it at an offline shopping. Such texture felt when touching it a little... **So I think it will be useful to do something we do when choosing dress at an offline shopping store at VR even without going there physically.”** (Participant 9)

Many studies demonstrated users purchase a fashion product by selecting online or offline channel according to their purpose and situation and interviewees said making users experience what they can experience only at an offline store is a direction for VR shopping to be implemented by the haptic communication since fast and convenient purchase is done at online stores. In particular, they regarded if tactile sense of a fashion product can be delivered by the haptic, it will be offer the sense of reality replacing offline shopping.

“If I feel it too much virtual, maybe I’ll take off HMD after several attempts for fun. **But if it gives me sense of reality by the haptic, I’ll do the VR shopping for sure.”** (Participant 20)

“Certainly online is convenient and I don’t need VR shopping. But maybe VR is good if it can replace an offline store. **I think VR is good for offline stores when I can get help if I go there.”** (Participant 2)

#### 4.1.2. Hedonic experience-oriented

Hedonic experience-oriented interviewees made much of the pursuit of maximized hedonic values, meaning the haptic experience should prioritize fun at a VR shopping environment, and regarded it effective to implement entertainment-typed haptic communication where they can have special VR-optimized experience rather than a concept moving the real into the virtual. Studies on hedonic experience demonstrated hedonic consumption manifests itself from reactions related to multisensory, fantastic and emotional things and generated mainly by products arousing fantasy, pleasure and fun(Holbrook & Hirschman, 1982; Lee & Jung, 2008). It may be experienced from VR shopping and reveals that pursuit of hedonic experience may function as a strong motive for VR shopping.

“VR can be a desirable tool for the vulnerable group in purchase decision process but for those who are not it should be something pursuing entertainment. Vibration or haptic, these can be factors for VR shopping, can’t they? **If it is the same as the real, it’s all right to go (offline stores), no need for VR shopping. I think there should be interesting effects differentiated from offline** like performing it like mission according to instructions on a screen or getting a

unique tactile stimuli.” (Participant 14)

In particular, research participants mentioned it is easy for VR shopping to give a feeling as if being in the other different world unlike real shopping and setting for fantastic experience is important for VR shopping. They regarded it necessary to implement experience spectacle and fantastic just beyond construction of an offline store including space shopping or 4D fashion show.

**“Seems to be good, if selling clothes under the dramatic background, say, war or Greco- Roman period.** If they want experience, let them experience something really fantastic, in case of the haptic for opening a store door, let them open a very and very large door, it’s good if we can have fun as such.” (Participant 4)

“Fantastic if delivering buyers a feeling of a fashion show by the haptic, or a windy feeling at a fashion show, holding a VR fashion show at a 4D theater. **More fantastic if giving a feeling of a fashion show held at the sea.”** (Participant 4)

“You have to wear something so I think you should have a **feeling as if you were at a little different world.”** (Participant 1)

#### 4.2. Haptic information needed by shopping step

Steps of VR fashion product shopping were divided into 4 including move to store, search in store, search of product and purchase based on offline store shopping experience. The research defined shopping experience needing the haptic communication by step and analyzed types of the haptic feedback to be implemented.

##### 4.2.1. Step 1: Move to store

It is a step to visit a store after planning shopping and deciding which store and how to visit. As a result of analysis, the experience was categorized into entrance, moving, using transportation and flow guidance, and it shows that the haptic communication is needed to give a feeling of opening a door or even a feeling of crossing a threshold in case of a store without a door so deliver a realistic illusion that one is moving around the real space.

“But I’d like to feel I entered a store. It’s needed to feel I entered a store rather than a field. Force felt when I open the door or push it.” (Participant 1)

“In fact, there’s few store with closed doors. I rather see stores around when turning 360 degrees. When entering a store, it’s better to have a feeling of rattling. If visually divided setting is not proper, I rather have a feeling crossing something with clicking (if the haptic is delivered).” (Participant 6)

As for types of the haptic feedbacks applicable effectively, in case of an independent store damper effect is needed to have a feeling as if opening a door through a sense of resistance when visiting a store. In case of an offline department store, it is important to implement division of stores by the haptic for operational

convenience for VR shopping. Here, it seems that texture feedback delivering a protrusion effect is needed for feeling crossing a threshold.

For feeling of move, use of transportation, and flow guidance interviewees wanted to have a feeling as if they were walking around a store and get correct information for moving flow through the haptic communication. In particular, they said haptic feedbacks like stepping on an escalator or walking are important feedbacks for moving to a store.

“For me, when moving, a feeling of an escalator seems to be important. Strange if there is nothing when stepping on an escalator. Strange if I can't have a feeling holding on to handrails. Because I do so always. And a feeling of a down escalator.” (Participant 7)

“In case of a large shopping mall, (when moving), I think it'll be okay if a guide is. And better if I can feel something on my hand, maybe like an alarm or a reminder. And there are footprints. Certainly it'll be better if I get the haptic feedback when I get out of a path.” (Participant 2)

The haptic feedback applicable to such a process may be implemented by giving different constant force effects into specific directions. Besides, to suggest a correct flow, the haptic to bump against an area impossible to move into can be implemented using enclosure or ellipse effect. Particularly, when taking an elevator, one can experience a sense of going up and down by increasing or decreasing force into a single direction if haptic feedback is implemented using the ramp effect.

#### 4.2.2. Step 2: Search in store

The step of search in store includes the moment from entering a store to moving in a store, and it was classified into reception by a clerk, customer attention, increase of needs for purchase, guidance/control of customer position. Clerk's reception or handshake begins as welcome to VR shopping and if it is implemented with the haptic, it may derive users' pleasure and interest. In addition, inconvenience of VR shopping would be removed if style division, zone or product category with detailed information could be provided at a proper moment and place with useful haptic feedback.

“Clerk service varies by store and brand but at a VR store emphasizing friendliness it'll be good for clerk to approach me, shakes hands with me, or places her hands upon my shoulders, you know, it is a humane touch... Usually, at a store I thank her for her reception but think it'll be okay if she stays away from me. In fact at VR they're virtual characters so I cannot be offended by them so much. It's not real contact so may be an amazing and happy experience.” (Participant 5)

Interviewees thought it necessary to give the haptic information helpful for search of a store along with a sense of excitement or

event information for bargains to increase needs for purchase. Besides, they mentioned it is needed to inform them of a location they should go or a place they should watch to identify product information for VR shopping. Also, they needed the haptic feedback to provide customers with guidance to their location and control direction of their eyes to solve problems like VR-sickness since they had to move much to search a guide and information. Due to the VR-sickness some research participants expressed their discomfort over using VR technologies at the step of search in store.

“My heart flutters when entering a store, excited about shopping, heartbeat, faster than heart beat before? Need the haptic for people whose heart beats.” (Participant 1)

“If I get vibration whenever walking down a corridor while looking around, it's so offensive. But if I get guidance for events or bargains, (haptic) is okay.” (Participant 12)

“If there's a product someone has to look at, and if he doesn't, it'll be very helpful to give a haptic feedback or make a product appear on a screen.” (Participant 12)

“As for control of motions by the haptic, people want to move around freely. But when they stay away from (a flow fixed), it'll be okay to say 'a wrong direction'. You'll get a haptic feedback.” (Participant 6)

Here, periodic effect of haptic feedback may be applied and it will be effective to implement repetition of vibration raising a sense of excitement or gradual intensification of feedback inducing move into an adequate position. In particular, it may be possible to control body and eye movements through alarming of wrong attention by intensified feedback effect. It may be a solution for VR-sickness by reducing frequent movement of sight and VR device operations in a process of move and search for VR shopping. VR-sickness is the greatest problem of VR user experience and it functions as an obstacle to use of VR contents. According to reports, cyber sickness related to principles of stereoscopic cognition using HMD, and technical problems including resolution, display reaction rate and viewing angle causes users to have vomiting, dry eye and dizziness (Jang & Kim, 2018). Hence, application of the haptic technology to control users' motions and suggest an eye direction efficiently is able to provide a significant solution for satisfaction of VR shopping users.

#### 4.2.3. Step 3: Product search

Search of product is a core function of offline shopping and it is a process where users can identify detailed information of a product. Research participants mentioned the step of product search as the situation where haptic communication is most needed for VR shopping and wanted offline shopping's strong points to be implemented by the haptic technology. It may be categorized into specific

item search activity itself and product information, and in case of product information, haptic communication process has been described relating to identify information about inventory and size as well as physical attributes of a product.

Firstly, item search refers to acts to leaf through or take out clothes on a hanger and it is regarded that damper and spring effect are most appropriate haptic feedbacks to be used. It is possible to display a sense of resistance caused when leafing clothes if using damper to express the resistance to certain motion, and a sense of reality felt when taking clothes out with a little elasticity may be expressed by spring effect of haptic feedback.

“I like that kind of thing, you know, leafing clothes through on a hanger and looking at them in between. A feeling like checking one by one? With my hand... And I select clothes, and I hold them in my hand. Really, it’s good if I have such a feeling at a store. Everyone holds something to give a feeling as if they were shopping really.” (Participant 1)

Next, it is a process to check product information, and they wanted to feel a weight of clothes they are holding or sense of grip as if they were gripping and releasing real clothes’ material. In addition, in a fitting process, they said a simple sense of touch when product touches their body would consist of the efficient haptic communication even without wearing clothes. In particular, when providing information on inventories and stocks or products themselves which are likely to be expressed by visual, they thought multisensory suggestion adding the ‘haptic’ of tactile information could enhance convenience of VR shopping.

“I want to feel a sense of weight when holding something. For things like bags, really weight is important so I want that it will be implemented by (haptic).” (Participant 11)

“When selecting a product at a store, I can see its information. And, it’s good if the haptic is applied to it. I come to pay more attention to information with the haptic reaction like alarm. In addition, it is also good if it can deliver acts holding and selecting a thing.” (Participant 8)

“Maybe I’ll not touch things like cotton T-shirt but maybe I’ll touch things with a fringe. I’d like to touch special decorations or details so it’s good to have a feeling to identify them (by the haptic).” (Participant 1)

“I wish there would be my avatar that could implement my body at a VR environment. It’ll be okay to get a haptic feedback effect if my dress is too small or it is tight when I move. I want a kind of vibration to deliver.” (Participant 11)

As for the haptic feedback applicable to cases above, a sense of weight when picking dress up or a sense of grip when holding it in one’s hand can be felt using damper and spring effect including a feeling of resistance by the weight and touch on one’s hand. Besides,

for information of inventories, periodic effect may be applied by an alarm through the vibration. Texture, an effect of protrusion, may be used for displaying product information, and damper, an expression of resistance giving a sense of touch on a body may be applied for a fitting. Also, information on a tight part may be represented by periodic and damper effect. And also information availability could be delivered enclosure effect of haptic communication.

#### 4.2.4. Step 4: Purchase

As a final step of shopping where purchase decision and payment are conducted after the process of product search, the steps could be categorized into shopping cart, payment and purchase confirmation. As for a shopping cart, a feeling of loading items into a cart and a feeling of weight when they are increasing could be implemented by the haptic feedback such as periodic and ramp effect and it is necessary also to apply at the step of payment which allowed them to experience difference between the paying methods, cash or credit card. Depending on the cash and credit card, the direction of moving can be presented as haptic feedback using a constant force effect to generate forces in a single direction. However, a large number of participants mentioned that it would be unnecessary to raise a feeling of reality at the step of purchase. The reason was that getting a realistic feeling about how much they paid would be a factor interrupting an actual purchase, hoping that payment could be simplified or even omitted. However, some stated their immersion could be increased in a manner similar to that of an actual shopping situation by allowing them to perceive greater psychological spending and so it is necessary to be maintained just like offline shopping setting.

“I heard consumer’s psychological spending varies as payment option. They perceive it when paying in cash more than by credit card. If so, I think in a shopping situation feeling of reality may be increased by the haptic of feelings like swiping a card in a card reader or getting the change in bills or coins.” (Participant 3)

As for the confirmation of purchase, they wanted the haptic of alarming for preventing overspending to be implemented in case there is a product in a cart, exceeding their budget or against their preference. It is assumed that such haptic information may be represented by the haptic feedback to give an alarm using periodic effect.

“If I enter my today’s budget when beginning a shopping, maybe there’s no refund or return if I can be informed of information appeared by the haptic, like an alarm by vibration telling ‘you can’t buy it’ because it exceeds my budget when putting things in a cart. Or after entering things I like or do not, (when putting them in a cart), telling ‘it is not your favorite material, are you okay?’ ” (Participant 11)

**Table 3.** Analysis of haptic information and haptic feedback by shopping step

Haptic information			Types of haptic feedback effect	
Main categories	Generic categories	Subcategories		
Move to store	Entrance	Feeling of opening a door	Damper effect	
		Feeling of crossing a threshold when entering a store without door	Texture effect	
	Moving	Feeling of walking and moving	Constant force effect	
	Using transportation	Using of stairs, escalator, elevator	Ramp effect	
	Flow guidance	Suggestion of correct flow	Enclosure effect Ellipse effect	
Store search	Reception	Clerk receipt, handshake	Spring effect.	
	Attention	Product category	Enclosure effect	
		Style division		
		Zone division		
	Customer attention	Excitement for increasing purchase needs	Periodic effect	
	Customer position	Info	Info for check products	Periodic effect
Position	Control	Attention control	Damper effect	
Product search	Item search	Leafing through clothes on hanger	Damper effect	
		Taking clothes out	Spring effect	
	Product info	Physical attribute	Weight while holding clothes	Constant force effect
			Feeling of grip	Damper effect
		Feeling of touch		
	Inventory	Activation of product available	Periodic effect	
	Size	Comparison of dress size for fitting	Damper effect	
Alarm of tight parts		Product info display	Damper effect Periodic effect	
Purchase	Cart	Loading into cart, increasing weight	Ramp effect	
	Payment	Cash/credit card payment	Constant force effect	
	Confirmation	Alarm of excessive budget	Periodic effect	
		Checking planned consumption		

“I think when putting things into a cart it can lead to purchase if I can show them all at once but in detail for final selection. And also if I can touch or do something (by the haptic).” (Participant 9)

Table 3 shows haptic information and the corresponding haptic feedbacks effectively applicable to increase a sense of immersion and reality at VR fashion product shopping that research participant mentioned.

## 5. Conclusion

The haptic communication of fashion product shopping may be defined as communication of user-environment and user-product by delivered information and tactile stimuli when the haptic feedback is given and the study paid attention to the haptic communication mediated by non-material images in virtual reality. Especially in case of fashion products, since multisensory experience

has a very significant effect on evaluation of goods and selection of shopping channels, it is required to enhance immersion which provides users with a sense of reality. Hence, they need to feel multi-senses in addition to visual reality so at a VR fashion shopping application of the haptic technology delivering experiential/tactile information may be an effective measure to use VR technology.

The study examined user needs for haptic information to implement a VR fashion shopping environment with the immersive VR system and findings show that users experience the immersion when tactile elements synchronized with visual changes is very important. Furthermore, haptic communication for fashion product shopping is to provide experience optimized to a VR shopping environment and increase pleasure and interest. Also it demonstrates that hedonic reactions by fantasy, emotion and fun function as an important motive for selecting VR shopping. Research participants gave a variety of descriptions about haptic information and types of

the corresponding haptic feedbacks to increase a sense of the immersion by shopping steps. The noteworthy is that a lot of participants put stress on provision of various haptic communications including product screening and information about physical attributes, size and location of a product at the step of product search. In particular, tactile information of material including physical attributes like density, thickness, elasticity and flexibility are stressed. However, since haptic information which is not realistic enough could be an obstacle to VR shopping, priority should be given to the haptic communication which increase users' experiential/hedonic satisfaction.

To develop user-centered haptic communication technology, a priority should be given to users' technical review examined in the study so convergent research is to be conducted by professionals together in the fields of fashion, VR and the haptic technology. Even just one haptic feedback development for a shopping step such as textile effect for product search would trigger off a huge research topic in terms of delivery method, type of texture, or device selection. Making VR shopping immersive, it is facing lots of obstacles to be overcome but challengeable. Above all, measuring technology for the immersion of users who experienced a VR fashion shopping environment which grafted the haptic communication implemented by technical review should be developed. In addition, follow-up studies on products suitable for implementing immersive VR fashion shopping environments will be required for industrial applications. In general, immersive VR fashion shopping can be expected to be mainly used for sportswear, where physical activity or experience is important. However, it is necessary to study how to apply it to the shopping of luxury brands or cosmetics beauty products that seek sensory experience or pleasure consumption through more granular consumer research.

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