

Design Requirements of Mediating Interface Device for Total Physical Response

focused on protocol analysis of children's behavior patterns

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Abstract: TPR (Total Physical Response) is a new representative learning method for children's education. Today's approach to TPR is that signals from a user becomes input data in a human-computer interaction, but the accuracy of sensing body signals (e.g. motion and voice) isn't so perfect that it seems difficult to apply on an education system. To overcome these limits, we suggest a mediating interface device which can detect the user's motion as correct numerical values like acceleration and angular speed. In this study we suggest new requirements for the design of mediating device which focus on children's behavior as human factors by ethnography research and protocol analysis. We found that; children are unskilled in physical control when they use objects and tend to lean on an object unconsciously with touch. Also, when they use objects, their behaviors are restricted. Therefore a mediating device should satisfy the following design requirements: make up for unskilled handling, support familiar and natural physical activity.

Key words: *Total Physical Response, Protocol analysis, Mediating interface, Design requirements*

1. Introduction

Children, especially preschool children, progress both emotionally and cognitively. Therefore people are interested in learning methods that can raise the quality of this growth. With an increasing supply of computers and the expanding applicable field of IT technology, TPR is introduced for preschool children as a new learning method which can be sufficient for these demands. There are many products related to TPR education or games. Most of the products include a contents based device like Realplay by In2Games or Guitar Hero by Activision or a user's motion tracker like Eyetoy. But motion tracking and voice sensing are still inaccurate in the actual user environment. Because of this technological limitation, manufacturers tend to offer the mediation to make the user interact with TPR contents rather than apply just bodily sensations. In addition, children have a low ability to self-control physically and emotionally, a lack of understanding some sentences and inaccurate pronunciation. So human factors (physical, emotional and cognitive) also must be considered. The purpose of this study is to derive requirements generated by children's characteristics in designing mediating interface device and its TPR and eventually contribute to the generalization of TPR.

2. Background

2.1 What is Mediating Interface?

With development of technology for several decades, image and voice sensing in laboratory and demonstration place show high sensing accuracy. But there are still many problems to develop TPR service or contents by some obstacles like shadow, light and noises both indoor and outdoor which are hard to predict in advance. To solve effectively these technological limitations, the concept of mediating interface appeared.

Mediating interface is one of the interface technologies to overcome limitation of providing TPR service in real environment by problems of image/voice sensing and especially motion. It supports reinforcement of human-machine interaction capability through fusing multi-sensor on mobile/wearable type of device. In direct interaction with user's motion between user and computer (machine), machine can't accurately recognize user's motion. But user's motion can be analyzed as numerical values like 3-axis-acceleration, angular speed, vitality, etc. So if user moves with mediating device, it sends correct data about user's motion to main machine, core of TPR contents. Then TPR contents can accept more accurate input values and can give right feedback to user.

2.2 TPR and Mediating Interface

TPR is a method to aid learning second language. With this method, students must respond 'physically' to the words of the teacher. Focused on physical responses, these days the word TPR is used broadly in a learning method with bodily sensation whether it is for learning second language or else.

There are three reasons why using mediating device is suitable to TPR; sensing capability, reality and compatible to various uses. In case of sensing capability, when a user makes any motion with mediating device, which movement represents his/her gesture directly and can send more accurate motion to virtual reality. So it is suitable to TPR which should sense user's correct reaction. From a viewpoint of the sense of the real, user can have the sense of the realism and immersed in virtual reality by high degree of sensing accuracy. Finally various contents for children's growth should be offered. And because the permissible range of sensing is wider than existing products, mediating device can be applied to various contents.

2.3 Structure of Mediating Interface Device

As considering 3 components of mediating interface - machine, mediating device and user, we can show on the interaction between human and machine as followed [Figure 1] to understand the roles of mediating interface.

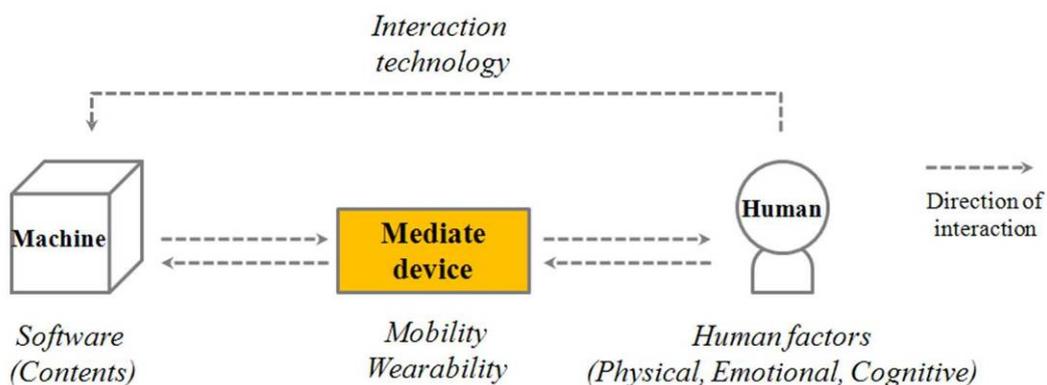


Figure 1. the role of mediating interface device on human-machine interaction

According to this figure, we can define the four considerable factors in embodying mediating interface, which are concept of contents, form design of mediating device (mobility, wearability, etc), human factor for user(physical, psychological), and technology adapted in mediating device and machine. Among these factors, we started with searching human factors and finding the patterns and requirements by ethnography research and protocol analysis in this study.

3. Empirical Study

3.1 Test Structuring

In this experiment, we visited kindergarten and conducted an experiment for 20 preschool children (age5 ~7) to search requirements to mediating device design focused on human factors.

We divided the experiment into two parts and conducted during 2 days. First experiment is ethnography research to watch children's daily behaviors and way to handle the objects. In second experiment, we observed the characteristics of children's behaviors when they use a device as similar to mediating interface. To do that, we gave Wii remote controller to children and made them try to play Wii contents. During the experiments, one observer recorded video and took pictures and other two observers watch children and simultaneously record the features of their behaviors on the notes for ethnographical protocol analysis.



Figure 2. Experiment situation

3.2 Coding Scheme Structuring

After ethnography research, we additionally wrote children's behavior watching recorded movies and pictures. The additional data are added on existing data recorded during experiments, then used as main protocol data in the analysis phase. And recorded movie, picture and voice data are used as sub-material. The frame of early analysis is bottom up method. We collected behaviors among observed data having similar characteristics, made some groups and named each groups. Repeating this step, the coding scheme about test1(children's daily behavior) is developed as 3 levels, in condition of (A) conscious behavior/ unconscious behavior, (B) with small object/ with big object/without object and (C) physical/ emotional/ cognitive cause.

In case of test 2 related to children's behaviors with mediating device- Wii remote controller, coding scheme is developed 2 levels based on given tasks, (D) tasks for adapting to TPR and Wii controller/ tasks for playing tennis and (E) 1 person/ 2person/ people nearby.

Table 1. Coding scheme of preschool children's daily behavior

Category level	Subclass	description
A	1. Conscious behavior	Conscious or intended action
	2. Unconscious behavior	Unconscious or unintended action
B	With object <ul style="list-style-type: none"> 1. Small object 2. Big object 	Action with small object
		Action with big object
	3. Without object	Action without object
C	1. Physical	Physical attributes of action
	2. Emotional	Emotional attributes of action
	3. Cognitive	Cognitive attributes of action

Code number	A	B	C	Image cut	Description	Additional comments	
3211d_		2	1	1		두손으로 들거나 끌 수만 있으면 무거워도 머리나 몸을 이용해서 이동시킬 수 있다.	
3211b_		2	1	1		손에 쥐고 있는 연필을 글을 읽을 때 줄을 헛갈리지 않기 위한 포인팅 용도로 사용한다.	미세 조정에 대한 감각을 기르기 위해 처음 사용시 포인팅 훈련이 필요하다
3111c_		1	1	1		서서 균형을 잡으며 신발을 잘 신기 못하므로 앉아서 신발을 신는다. (신발 끈을 매거나 찍찍이 매는 것도 서서 잘 못하므로)	

Figure 3. Example of data array and analysis using Microsoft office Excel program

After completing final coding scheme, we encoded each characteristics of children's behavior according to code levels. And to ensure trust of the encoding, we gave same data to 3 researchers, made them encode it and finally decided each behavior's code through a discussion.

4. Results of Experiment

4.1 Patterns of Preschool children's daily behavior

To find characteristics of behavioral pattern in each level of coding scheme, we compounded two by two, like A-B, A-C, and B-C. In result, preschool children's behavioral patterns as follows. [Appendix 1]

(1) Children try to lean unconsciously on the object whether its size is small or big.

- (A2, C2) Children hug or touch a doll. And sometimes they finger their foot or scratch the floor without object.
- (A2, B1) They keep grasping a pencil and eraser even though they don't need to use it.
- (B3, C2) They tend to be in the small and recessed place or stand in a corner
- (B2, C2) They would lean on the table when they just talk each other.

(2) *When they have some object, they are unconsciously subordinated to it and also their behaviors are restrictive and unnatural.*

- (A2, B1) Although it is uncomfortable and hard to turn a page, they keep holding something in their hand. It seems that they can't perceive that it will be more comfortable if they put it down.

(3) *Without object, an action radius is big and they don't show restrictive behavior.*

- (A2, B3) When they are in motion, they run rather than walk.
- (B3, C2) They feel comfortable in sitting on the floor rather than on the chair.

(4) *They are not well to handle the object. So they use other part of the body.*

- (A1, B2) Children hold big object like chair with their leg or body.
- (A1, B1) They move and hold an object between legs or in the mouth to do something, when they already grasp it in their hands.

4.2 Patterns of Preschool children's behavior with Mediating device

In Test2, using Wii as an example of mediating device for TPR, children's behaviors are encoded in 2 levels. One is about type of tasks and other one is about participants. In the result, the patterns of children's behavior with mediating device as follow. [Appendix 2]

(1) *Their behaviors are unnatural because of difficulty of controlling mediating device.*

- (D1, E1) Minute control is hard to children, so they tried to hold a device in both hands and their moving range is getting smaller.
- (D1, E1) When they concentrate on their right hand (which hold a device), their left hand is also strained.

(2) *The degree of understanding linkage between reality and virtual contents is low.*

- (D2, E1) When the character in screen moves without children's gesture, children think it strange.
- (D2, E1) Children concentrate just movement, not correct motion like forehand stroke and backhand stroke. So they move at random irrespective of direction.
- (D2, E2) In 2-person game, they can't recognize who is who in the divided screen.

(3) *They are affected by surrounding people during playing TPR. But when they deeply immersed in the contents, communicating is hard to achieve.*

- (D2, E2) There is a danger that 2 children bump against each other when they play together.
- (D2, E3) Although children nearby player talk to player, player can't hear it because of absorption in the contents.

5. Conclusion

We focus this study on the importance of human factors and how we can apply them to developing mediating devices that are based on technological solutions for TPR. We considered preschool children's behavioral patterns as human factors which have the closest relation to TPR. We were able to approach user research differently through protocol analysis by applying an ethnography method. We also recorded children's thought processes as well as their behaviors. It is useful to find the reason why they do a particular action. In this study, the remarkable behavioral characteristic is that children used dependent behavior on each object even though they were active and had a wide range of action. The patterns of preschool children's behavior in perspective of human factors offer the fundamental requirements for designing a mediating device.

First, a familiar type of device or contents for adapting to the device is needed. Children do not have perfect physical growth and are not well matched in the real world with virtual reality. As a result, we should make them familiar with TPR by providing an accustomed shape device.

Second, it should be easy to interact with nearby or surrounding users. When using a mediating device, they concentrate on virtual reality too much and run into one another or pose incorrectly. Therefore we should make them recognize their surroundings and nearby users, which promotes sociality with interaction, even though they are focusing on the contents.

Third, a child should be able to wear and use the mediating device by oneself. There is a significant possibility of dropping the device because children are active in general, so it should be worn on part of the body. We also need to consider the wearable type for children which they can have by themselves. This can be solved by applying familiar shapes of daily objects as the first requirement.

Finally, the aim of this study is primary research of analyzing the human factor for TPR. We want to regard it as indicating one example about what human factors and how those are considered for designing a mediating device as well as analyzing preschool children's behavioral patterns. Through further research, we'll try to draw design requirements based on the three factors which compose the mediating interface-human, machine, and mediating device. To do this, we will apply studies about the type of TPR contents, and its characteristics and usability/mobility/wear-ability of the mediating device to the results of this study. We expect that a more creative and comparable device design can be offered when we consider these three components of mediating interface.

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Appendix

Appendix 1. Patterns of preschool children's daily behavior

		A		B			C		
		1	2	1	2	3	1	2	3
A	1			Low physical development	Using other part of the body		Low physical development	Hasty judgment and action	Desire to possess
	2			Leaning on object Chained to object		High degree of freedom of action	High degree of freedom of action	Chained to object and surroundings	Leaning on object The crowd mind
B	1						Low physical development	Unnatural action by chained to object Absorbed in object or situation	Leaning on object
	2						High degree of freedom of action		
	3								
C	1								
	2								
	3								

Appendix 2. Characteristics of preschool children's behavior with mediating device

		E (Participants)		
		1 person	2 persons	People nearby
D (task type)	Adapting to contents (Making character, Registering name)	<ul style="list-style-type: none"> • It is hard to input the words, because they are not well on delicate controlling of controller. • They can't wear a strap by themselves. • Concentrating on handling the controller with right hand, left hand is also strained and unnatural. (The motion of both hands is restricted.) • They pay careful attention to make character. • Their pose is changed to incorrect little by little. 		
	Playing Sports content	<ul style="list-style-type: none"> • The sphere of action is gradually bigger, because children who repeat same task are familiar to that. • Although that task is performed with just gesture, they push the button. • They move extremely and stagger out of balance. • They drop the controller because it is big and hard to hold tightly. • The player don't listen well the other people's comments, because he concentrates on the screen. • They think that it is strange, when they don't move and their character moves. 	<ul style="list-style-type: none"> • There is in danger of bumping against each other and being injured. • They have no idea of distinguishing front person and person behind in the contents. So they confuse that who is them. 	<ul style="list-style-type: none"> • They want to participate on the game. So they comment to the actual player or move as if they are players.