Design Strategies for Long-Term Persuasion of Individuals Using a Virtual Agent

仮想エージェントを利用した長期にわたる説得のためのデザイン方針

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Waseda University
Graduate School of Fundamental Science and Engineering
Department of Computer Science and Engineering,
Research on Distributed Systems

Akihito YOSHII
吉井 章人

Abstract

Computers can provide users with advices, and motivations less limited by locations or times. Besides, users are able to exploit unreal experience generated by computer applications. For example, people perceive a personality from a computer like social presence. An agent is one of virtual presentations of social actors. Agents can emit nonverbal signals such as facial expressions or gestures. However, agents can make users be annoyed and cease using them. Some of reasons are, for example, mismatch between expectation by users and actual abilities, or nonverbal characteristics such as aesthetics. In our research, we divide chronological order during application use into three parts. Then, we propose three elements for designing virtual agent applications for long-term persuasion along with technical methods. Three elements are 1) Intention Adjustment, 2) Adaptive Persuasion and 3) Preference-Based Internalization, which can be applied to a part of each chronological part. Case studies will be mentioned in each element for an explanation.

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Designers of the 3D models. We have used existing 3D model data distributed via websites for the agents: http://{bowlroll.net/up/dl5271, bowlroll.net/up/dl6283, bowlroll.net/up/dl9988, bowlroll.net/file/3708, www1.axfc.net/uploader/so/2364870&key=3939, gangaze25783506.web.fc2.com/index.html}, "Mei" which was designed by the MMDAgent project team at Nagoya Institute of Technology (http://www.mmdagent.jp), and Dana bundled in the Zigfu package (http://zigfu.com).

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Chapter 1

Introduction

We often obtain supports from computers such as smartphones and wearable devices.

While computers around us conduct people to behaviors and this conduct is sometimes based on specific intentions by other individuals or organizations, we also intentionally take advantages of a computer technology to improve our life. For example, a sensor device detects transportation modes and then present graphical representation to motivate a user [24]. Computers can generate more varied multi modal messages than human beings [21]; thus, computer systems can effectively encourage people to change behaviors.

In addition, people can obtain experiences which cannot be generated only by the real world. For example, augmented reality overlays computer graphics on real-world objects as a marker; web services can also incorporate with real worlds such as Ingress [1].

Not limited to entertainments, users can often be encouraged to change their daily behavior supported by computers. People have been attempting to change behaviors and attitudes from the past. For example, ancient Greek philosophers have tried to persuade audiences (rhetoric [3]) [21]. Even in daily life, we often confront many situations that others encourage us to do something. Although persuasion as a term has multiple definitions, we will adopt the definition by Fogg: persuasion is an attempt to change peoples' behaviors or attitudes, or both [21].

Because of the advance in computers and the emergence of the Internet, persuasion becomes more complicated than before. Computers have become persuaders. Fogg named the realm related to designing, understanding and analyzing persuasive computers as "Computers as Persuasive Technologies (Captology)" [21]. Captology organizes related realms such as persuasion methods and roles of a computer as a persuader enabling us to design persuasive computer systems.

However, a room for discussions still exists as for continued persuasion for specific behavior lasting for a certain long period. We still need enough willpower to achieve our goals. For example, if an individual has decided to brush his/her teeth two times per a day, s/he can stop brushing because of the troublesomeness. Gouveia et al. refer to existing behavior stage model named transtheoretical model (TTM) proposed by Prochaska et al. [53]; and then they evaluated their persuasive application suggesting the importance of

[1] https://www.ingress.com

considering those who do not intend to change their behaviors (at the precontemplation stage) or those who continue the behavior changes more than six months (at the maintenance stage) [27]. Nakajima et al. developed and evaluated the persuasive application called Virtual aquarium for daily teeth brushing. They reported that most of the participants obtained improved teeth brushing time compared to times before the application use even after the removal of the persuasive support although the brushing time were shorter than persuasion period with the application [46]. The result projects the possibility of a behavior change after the intervention by a persuasive application; however the discussion regarding longer period is needed because the period for evaluation of Virtual aquarium was 8-12 days.

1.1 Definition of problems

We explain problems around persuasive applications in this chapter. We model problems classifying into two major parts and we call them the "modeled problems". An identifier is allocated each modeled problem in major and minor classifications for references in the latter part.

1.1.1 P1: Short-term use of an application

Even if a user begins to use a persuasive application, s/he can lose interest in or have a negative impression of it. When a persuasive application incorporates an agent, the agent can convey nonverbal messages easily. Thus, an agent can be an annoying obstacle if it provide users with negative impressions.

P1-1: Boredom

Boredom in a persuasive application can cause problems. For example, users can act by their curiosity regardless of their actual behavior state.

We have developed a persuasive application, named iDetective, incorporating a conversational agent [72]. We referred to transtheoretical model [53] to model user behaviors and estimate their current behavior stage by a set of questions proposed by Prochaska et al. [74].

This application presents text-based utterances from an agent to users and collects replies from them using multiple-choice questions. However, when user is bored in patters of conversations, they can press buttons just by their curiosity instead of their real opinions [72].

To examine methods for preventing users from or delaying boredom, we have extracted a conversation feature as a web-based prototype and then modified utterances by an agent [74]. An agent can disclose one user's reply to others. We have examined with the prototype asking participants to use the system and then fill a questionnaire.

P1-2: Mismatch between expected and actual behaviors

When a virtual agent is embodied, its appearance and behavior can provide a user with a specific impression or expectation. A user can be annoyed if mismatch exists between expectation held by him/her and actual agent behaviors [61].

If a user is annoyed, the user can cease using persuasive application as a result. For example, Clippy was implemented in Microsoft Office; and supposed to assist a user's task. It seemed to know better about a request from users because they had eyes and can show messages in natural language; however, despite the basis a lot of research, they were so presumptuous and interruptive that they cause users to feel annoyance during tasks (e.g. [61]).

Moreover, relationship is discussed between an agent's appearance or perceived usefulness and use intentions for the application which hosts the agent. Henriette et al. describe the relationship between use intentions by a user and properties of an agent: "engagement process" and "interaction process" [67]. The engagement process includes emotion and attraction aspects. This process affects involvement and distance towards a character [67]. The interaction process is related to affordance and technology acceptance (e.g. [18], [68]).

Based on examples above, controlling and balancing expectations by a user for a virtual agent is needed for continued use of an application incorporates the agent.

1.1.2 P2: Resistance to persuasion

Even if once a user has decided to begin to use an application, the user can be resistant to persuasion itself. We focus on persuasion from the aspect of an application (P2-1) and attitudes to the persuasion as a user (P2-1) in this section.

P2-1: Obtrusive persuasion

Some people, such as those who are on the precontemplation stage [53], can be resistant to behavior changes. This resistance can lead to ceasing application use.

P2-2: Disregardful attitudes

People can be reluctant to be encouraged persuasive messages because of various reasons. Petty et al. proposed Elaboration Likelihood Model (ELM) stating that people have two different ways to hold a reasonable attitude: the central route and the peripheral route [50]. When a persuasive message is perceived with consideration such as personal relevance or responsibility, "central attitude change" can occur. Conversely, "peripheral attitude change" is led by, for example, attractiveness or expertise of the information source [50]. The peripheral attitude changes are temporary, susceptible, and not predictive [50].

If persuasion by virtual agents is perceived and processed by the peripheral route, a user can discount the persuasive message. We discuss adjustment of reality of problems linked with a goal to encourage users to engage persuasive messages.

1.2 Main contribution

We propose Tailorable Persuasive Agent framework to specify functions needed for long-term persuasion by an agent. Particularly, we are focusing on different periods of application use and suitable elements for each period.

This framework is intended to persuade broader range of users. For example, some users do not aware of their lack of exercise and they can be resistant to the persuasion (precontemplation stage [53]). Another user has already started to exercise on a daily basis while s/he still needs a support (action or maintenance stages [53]).

For designers of a persuasive application, they will be able to decide what strategies must be emphasized considering individual. Each strategy is related to framework and modeled problems. They are not always independent; therefore, they can be combined with a part of other strategies. For users of a persuasive application, they will start to obtain a support from a persuasive application reducing obtrusive interventions from an application. A proposed strategies can be weaved into another type of application such as games. In addition, an application can let users participate adaptation of the application to them. This includes the customization aspect of a persuasive application.

1.3 Structure of this dissertation

First of all, we mentioned the purposes and motivations of our research and defined problems as "modeled problems" in the Chapter 1. And then, we describe background topics needed for explanation of our proposed framework in the Chapter 2. This chapter includes definitions of "agents" in this dissertation and introduction of related research fields. In the 3, we describe an overview of Tailorable Persuasive Agent framework and each element. The framework is shown from two different aspects: a diagram and a chronological model. Moreover, a scenario as an image of the proposed framework applied to the real world problems. Then, details of each element will be described in the Chapter 4, the Chapter 5 and the Chapter 6. These chapters include case studies related to one or more modeled problem(s). In the Chapter 7, based on the case studies, we propose strategies as design implications for applying the TPA framework to more general applications than case studies. Moreover, the solutions for each modeled problem referring to research questions of case studies. Lastly, we conclude this dissertation mentioning and describe future directions in the Chapter 8.

Chapter 2

Persuasive technologies for personalized services

Although we take it for granted that computers are not living things, we sometimes interact with computers as if it is another person. In this chapter, we describe relationship between people and computers and roles of virtual agents as a persuader.

2.1 Nonliving things as social entities

Roles which a computer can play as a persuader can be varied because of its versatility. Fogg described functional triad of persuasive technology: tools, media and social actors [21]. Computers can play a role as a social actor as if it is a living entity. For example, people sometimes name their computer and speak to it whereas it will not reply by its mind. Media equation suggest that people treat a computer as if it is a living thing [56].

Especially, Nass and Moon separate this kind of phenomenon from an aspect of mindlessness. People do not think that computers should be treated as a living things; however, they apply and expect rules in society of human beings to computers. Nass and Moon call this mindless reaction as "ethopoeia" [47]. In contrast, anthropomorphism assumes that people can find traits of human beings from objects [47].

Anthropomorphism can also be exploited to integrate fictions with the real world entities. Although a reason why people anthropomorphize nonhuman animals and nonliving objects is discussed by multiple aspects (for instance, they are mentioned in [20]), DiSalvo et al. suggest that anthropomorphism can explain unknown things and reflect attributes of something [20].

Based on these examples, computers and daily objects have a potential of effective persuader referring to people behaviors.

2.2 Virtual agents

In this section, we explain meanings of "agents" referring to related realms. A research field named Human-Agent Interaction (HAI) has emerged and target interactions with an "agent" as an artificial entity. We also describe relationship among other related research fields: Multi-Agent Systems (MAS), Human-Robot Interaction (HRI), and Human-Computer Interaction (HCI).

MAS is one of research fields which have the word "agent" as a part of its name. According to Yamada, basically agents are assumed to be homogeneous in MAS [71]. HRI is a research field whose main topics are related to an interaction with robots and HCI mainly targets an interaction with computers [71].

As a new field, HAI includes the existence of humans as heterogeneous entities into a system. Thus, an "agent" in the HAI field includes a computer, a robot, an artificial object, and even a living being [71]. This trend is suitable for current and future computing that a user is surrounded by a smart daily object and carries portable devices.

As described above, agents are not always an embodied entity, we mainly focus on an agent which is embodied on a computer or a physical object. In this dissertation, we use a word "virtual agent" as an entity which has an embodied form. Virtual agents are sometimes called by other names such as an avatar or a virtual character (e.g. [33]).

Agents can incorporate nonverbal properties like a virtual character (an avatar). For example, an agent can convey a message using facial expressions and gestures inherently.

Being accompanied by nonverbal communications, an agent is applied for user assistance (e.g. Shabette-Concier [1]), medical activities (e.g. [9]), and many other applications. That is, an agent can deliver nonverbal information such as facial expressions and emotions if the agent is expressed as an embodied virtual character which has a specific appearance or personality.

Existing researches have been discussing constructing relationship between a conversational agent and a user. For instance, Zanbaka et al. have compared persuasiveness of three types of agents changing their reality and resemblance to human beings [76].

[1] http://www.nttdocomo.co.jp/english/service/customize/index.html#p01

Chapter 3

Tailorable Persuasive Agent (TPA) Framework

We propose a conceptual framework for development of a persuasive computer application which incorporates a virtual agent which persuades people for a long period (more than six months). This framework is named Tailorable Persuasive Agent (TPA) framework. TPA consists of three elements: Adaptive Persuasion (AP), Intention Adjustment (IA), Preference-Based Internalization (PBI). TPA is intended to be utilized across stages from the beginning of application use to being accepted and continued use. Figure 3.1 shows an overview of the TPA framework.

Among the elements, PBI has the possibility of a link existing media and pop cultures with a persuasive application based on preferences of a user. Therefore, an embodied virtual agent can be utilized effective using its expressiveness and contexts; and PBI element is one of the ways to combine real-world experiences with fictions.

3.1 Three elements

In this section, each element in the TPA framework is explained.

3.1.1 Adaptive Persuasion (AP)

This element includes adaptive persuasion based on providing users with different persuasion strategies using estimated behavior status. We can use existing theories for modeling of individual current behaviors.

Transtheoretical model was proposed by Prochaska et al. [53] as a staged behavior change process.

According to Prochaska, the basic question in the transtheoretical model is whether or not there are common principles that can reveal the structure of changes occurring with and without psychotherapy [53]. The transtheoretical model has been applied for many kinds of behaviors. For example, this model has been applied for evaluating the readiness to use a food thermometer in order to prevent consumers from foodborne illness [66].

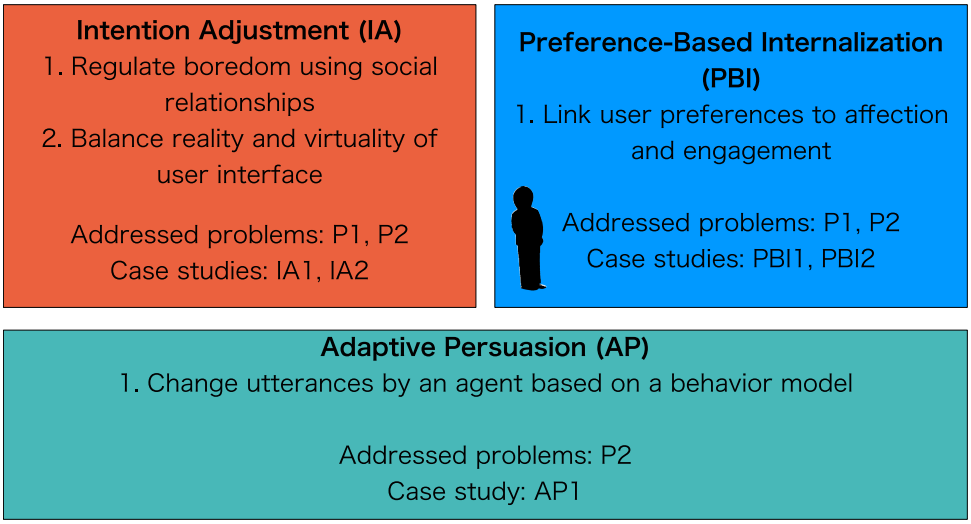


Figure 3.1: TPA framework Overview

Table 3.1: Stages of the transtheoretical model [53] (A number is added for later explanations)

No.	Stages	Descriptions
1	Precontemplation	There is no intention to change behavior in the foreseeable future
2	Contemplation	Seriously considering changing behavior in the next six months
3	Preparation	Intending to take action in the next month
4	Action	Having successfully altered the behavior for a period from one day to six months
5	Maintenance	Remaining free of the behavior for more than six months

In the transtheoretical model, five stages have been identified along the way of modifying one's behavior (Table 3.1). Most of individuals change their behavior with relapsing among the stages and go spiral-like patterns instead of going from *precontemplation* to *maintenance* linearly [53].

In addition, preferable combinations of particular processes of changes and points between stages have been specified [53]. A processes of a change is "covert and overt activities and experiences that individuals engage in when they attempt to modify problematic behaviors" [53] and the several processes are listed in (Table 3.2). Therefore, proper combinations have to be used in order to augment an effect of persuasion.

He et al. suggested different persuasion strategies as a motivational framework according to each transtheoretical model stage [30]. They focused on energy use behavior and construct their framework using motivational goal(s), recommendation and rationale [30]. A recommendation represents how can a goal be achieved using technologies and a

Table 3.2: Processes in the transtheoretical model and preferable points for which the process is applied (the contents was extracted from [53] and edited partially, and a stage number is based on Table 3.1)

Processes	Definitions	Preferable points
Consciousness-raising	Increasing information about self and problem	$1 \rightarrow 2$
Self-reevaluation	Assessing how one feels and thinks about oneself with respect to a problem	$2 \rightarrow 3$
Self-liberation	Choosing and commitment to act or belief in ability to change	$3 \rightarrow 4$
Counter-conditioning	Substituting alternatives for problem behaviors	$4 \rightarrow 5$
Stimulus control	Avoiding or countering stimuli that elicit problem behaviors	$4 \rightarrow 5$
Reinforcement management	Rewarding one's self or being rewarded by others for making changes	$4 \rightarrow 5$
Helping relationships	Being open and trusting about problems with someone who cares	$4 \rightarrow 5$
Dramatic relief	Experiencing and expressing feelings about one's problems and solutions	$1 \rightarrow 2$
Environmental reevaluation	Assessing how one's problem affects physical environment	$1 \rightarrow 2$
Social liberation	Increasing alternatives for nonproblem behaviors available in society	$1 \rightarrow 2$

rationale explains the goal and the recommendation [30].

3.1.2 Intention Adjustment (IA)

An application can adjust expectations by users to actual abilities of an agent and encourage users to continue to use the application. This element is described in two aspects.

Augmenting use intentions

For example, an application can let a user stop interaction with an agent preventing annoyance [61]. As Henriette et al. examined [67], visual appearances can be chosen to reduce disappointment by users.

Encouraging interest in persuasion

Agent properties can be arranged to encourage a user to take persuasion seriously. For example, Zanbaka et al. compared different characters in different gender, species, and

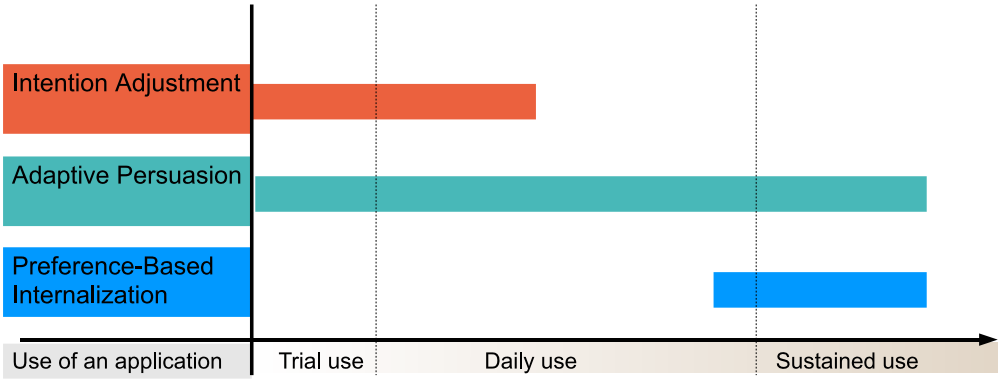


Figure 3.2: Chronological model

reality [76]. According to their experiment, people tend to be persuaded by a person in different genders (male / female). In addition, nonhuman characters were seen more bold than real human ones [76].

Voice also has an effect on the impression held by users. Mullennix et al. showed that human voice is more liked than synthesized one [45].

3.1.3 Preference-Based Internalization (PBI)

This element contains virtual experiences provided by customizable features from an application. Thus, the application attempts to prevent users from ceasing behavior change if they are bored in the needed task.

Drawing virtual representation, an application can link its functions with different media such as games and anime. User preferences has a possibility to trigger intrinsic motivation. Intrinsic motivation is caused by enjoyment and challenge while extrinsic motivation is outcome-oriented and provided by external pressures and rewards [58].

Using user's favorite worlds, we are examining behavior change combining user preferences and personification [75]. Personifying objects and services is familiar among people; thus, we are trying to persuade users to feel target problems more friendlily. We will describe this prototype in the later chapter.

3.2 Chronological model

We have divided time flow of the application use as Figure 3.2. The time flow consists of three parts: trial, daily use and sustained use. This stages are similar to "three stages of life assist applications to encourage users" proposed by Kimura: making use, attitude change and continuous change [34]. However, our chronological model focuses on intention of users.

"Trial" represents a stage when a user meets an application for the first time and tries using it. "Daily use" means the user has decided to continue to use the application. Lastly, "sustained use" is maintained state that a user confronting long-term persuasion.

In the Figure 3.2, three elements are placed along the vertical axis showing the relationship between each time frame and element.

3.3 Scenario

Based on the TPA framework, we describe a scenario as an example of an application to which the TPA framework is applied.

> Doe is a 25-years-old office worker. Doe has not been interested in exercising and exercised intensively before. When he went back his home town and seen his family, his family were aware of the change of his shape; he gains weight every time they see him. Doe have not continued exercising although they have recommended exercising to him. Doe's father gave him an activity tracker with abilities to show the total walk distance visually and set goals half year ago. However, Doe had got bored immediately despite the initial use by the curiosity.
>
> One day, one of Doe's friends tells Doe about a new smartphone application. The application seems to be a game that a player explores in the real world using smartphone. Actually, this application was a persuasive application and designed based on TPA framework; however, Doe does not know about the fact, obviously. He is interested in the game and decides to play it.
>
> The application includes a virtual character letting a player choose favorite ones. Doe found and chosen his favorite anime character among them. Main rule of the game is that players aim at the achievement of a given mission. During the play, players can collaborate virtual characters and find clues leading to the achievement. The first mission requires Doe to find and save one of his favorite characters who is in bondage at a location near his house. The location is existing in the walking sphere. Doe must go out and "check in" at the arranged locations using his smartphone. Doe decided to take the mission as other favorite characters asked him to save the pathetic friend.
>
> Characters provide him with useful information and clues during the play. The characters have a specific image and their utterances and manners are adjusted to match the image, enough not to cause unnatural impression by a player. They sometimes start conversations including short questions along with chatting. In response to them, a player can answer to question by choosing one item from the options. Readings from sensors such as a GPS and an accelerometer, and answers to questions uttered by a character are used for estimating current behavior status. The status is processed as a stage of TTM and utterances from the character can change according to the estimated stage. Players are not informed of these implementation details.
>
> Missions are designed to last multiple days; however, time needed to play varies from 10 minutes to about an hour letting a player arrange according to his/her schedules. Doe needs to reach check points on the way to the achievement of the mission. The checkpoints are located at existing spots surrounding

> Doe's house. Doe have to finish some tasks such as taking pictures or answering to the questions at each checkpoints. After three days of play, he successfully save the character at last. Doe has continued to play the game for more than half year because he hardly be bored to the interaction with characters which present variety of utterances. While he interact with the application, he comes to be interested in health and exercising. He go out and exercise without being told by others these days.

This scenario describes an example of ideal implementation of TPA framework including essences of each element. We explain details of the elements from next chapters.

Chapter 4

Case Study 1: Adaptive Persuasion

In this chapter, we describe case studies regarding the Adaptive Persuasion (AP) element. This element contains one case study and the main theme is persuasion considering current behavior status. The implicit persuasion, which is defined in the case study AP1, is intended to extend the target user group consists of those who are on the various behavior stages.

4.1 AP1: iDetective

In TTM, those who is the least encouraged to change a behavior belongs to *precontemplation* stage and such individuals can be resistant to the behavior change [53]. We especially focused on the existence of precontemplation individuals (we call them as "precontemplators") and our main goal in this case study is to elevate such individual's behavior stage to upper stages.

In a case of some problematic behaviors, behavior changes of multiple individuals at the same time in general public rather than that of a single individual result in going toward solving of a larger problem. That is, for example, a public space is used by many individuals and can be a mess unless they have intentions of making it clean.

In such kind of problems, we have to take into consideration not only those who are interested in changing their behavior (we call them "conscious individuals" below) but also individuals who are not aware of their problematic behavior (we call them "not-aware individuals" below). The former type of individuals would be highly motivated to use the application and the latter type individuals' intention to use the persuasive application is questionable. In a more "personal" behavior case, where the behavior involves one individual's behavior, the behavior change without an individual's awareness can provide the individual with more natural interaction.

As stated above, an extra consideration is required for covering not only "conscious individuals" but also "not-aware individuals" of a persuasive application because if the application's persuasive features are appealing too much to such individuals, they may have a feeling of resistance and cease using the application itself.

In this case study, to extend the influence of a persuasive application to "not-aware

individuals", firstly we give explanation of the "implicit persuasion" which changes individuals' behavior without being noticed and specify design strategies in order to make persuasion less outstanding by embedding persuasive features into an application which is seemingly-not persuasive. Then, we introduce a prototype mobile application which we have developed and it has "implicit" persuasive features deployed on a smartphone and discuss the corresponding effects and problems. In addition, we also conducted a user study in order to not only verify and review our design strategies but also specify directions of further improvements and future work.

4.1.1 Definiton of the implicit persuasion

In this dissertation, we define "implicit persuasion" as "the persuasion which does not inform an individual of it on an application which is seemingly-not persuasive". The "implicit persuasion" includes "implicit sensing" and "implicit feedback". These elements give and obtain the users' current state of behavior without any notice. A "consciousness level" represents the level of achievement of the target behavior by users based on the transtheoretical model.

4.1.2 Related work

To target "not-aware individuals" who can be resistant to changing his/her behavior, we have to design feedback which will not be noticed by them. There are few related work on implicit persuasion.

Subliminal priming

Ham et al. have discussed an effect of persuading implicitly with developing an interactive application [29]. This application attempts to encourage its users to choose appliances which consume lower power. It shows for a very short period a face of a virtual character named Robin according to the level of the energy consumption of the chosen appliance. The technique showing information for too short period to be noticed by the user is called subliminal priming and it affects an impression and a decision making of the user.

Unconscious human behaviors in interaction design

Sohn et al. have focused unconscious human behaviors and developed the framework for the interaction design related to it. The interaction design using unconscious human behaviors means that, an individual can change his/her behavior through the interaction without telling them to do so. This framework has included a matrix based on the types of interaction behaviors and unconscious human behaviors [64] and the prototype system to which the framework was applied was evaluated.

4.1.3 Design strategies

To implement a prototype system incorporating implicit persuasion techniques, we have considered the design strategies which meet the following requirements.

Strategy 1: The design not to be recognized as a persuasive application

People use a persuasive application when they want to improve their behavior. If the user is on the *precontemplation* stage (i.e. do not have an interest in target behavior), his/her resistance against changing or recognizing their behavior is stronger than others [53]. Therefore, s/he is not likely to use the persuasive application.

In order to implement the implicit persuasion, the persuasive features can be embedded into the application as the seemingly-not persuasive ones. That is, making implicit persuasion less outstanding is preferable so that users who are not interested in the target behavior would use the persuasive application. However, if the application works in an unusual manner, users can have a sense of distrust.

Strategy 2: Equivalence between using application and performing the target behavior

When low-consciousness-level users use persuasive applications, we cannot persuade them obviously because if they are aware of persuasion, they can be more resistant and not likely to keep using it. Therefore, it is necessary that we prepare another purpose for performing the target behavior. In other words, users perform the target behavior without being aware of doing so using the application. As a result, the users can perform target behavior without explicit persuasion.

Strategy 3: Persuasion change to fit situation

We adopted transtheoretical model in order to evaluate users' current behavior and each user is on a stage where a stage-specific process is introduced to him/her. Therefore, individually-targeted persuasion is needed in order to perform implicit persuasion and estimation of the user's stage.

In order to know the current level of users, designers can give users some questions including the period of behavior changes [54]. However, it is difficult to measure accurate levels without being noticed by users, because measuring stages accurately would require a lot of information about a user's state and querying these information can be too explicit. Therefore, we have considered modifying the transtheoretical model stages in order to make them match the proposed implicit persuasion.

Strategy 4: Not using special device

Using a special device is one of the ways to obtain the user's status from a sensor. A special device has a lot of advantages from the aspects of calculation and cutting electric power consumption [15]. On the other hand, a special device also has problems such as disturbing the user [24].

In a case of normal persuasion, using a special device is acceptable. However, in the case of implicit persuasion, having users to carry a special device is not desirable. Therefore, a device equipped with sufficient sensors that a user always carries with himself/herself is a preferable choice.

4.1.4 iDetective design

Conforming to the strategy 4.1.3, the iDetective is a game as a seemingly-not persuasive application and its intention is to encourage its users to walk for their fitness. In the story, the game takes place on the "photo detective school" and users play a role as a student of the school. The photo detective is "a detective who searches for the location a given photograph was taken at". Users will aim at an independent photograph with Zank, who is the head of the photo detective school. Such a setting makes it possible to hide a factor of persuasion and persuade naturally with an agent.

There are two main tasks for users in this game. The first one is to accomplish a mission (i.e. to find a place where a photograph was taken at) and the second one is to submit a request (i.e. to submit a photograph with GPS tag). The purposes of the game are to find the place where a photograph has been taken at and to invite someone to do the same. Thus, user can walk with enjoyment by using this game.

System diagram

The iDetective works as a client with the server communicating via the Internet. In a mobile environment, limited amount of secondary storage and power are available for applications compared with PCs. Storing and transferring large data is not preferable. Therefore, some pieces of information are managed on the backend server and exchanged as lightweight text data as needed. The server program code which is based on CGI was written in Perl and communicates with a client application via HTTP. The server chooses requested operation and processes data essential for the iDetective.

Overall design

Besides persuasive features, we have applied the design strategies listed in the previous section and determined characteristics of the iDetective. Based on these issues, Table 4.1 shows the summary of the corresponding relationships between the design strategies and the iDetective design issues.

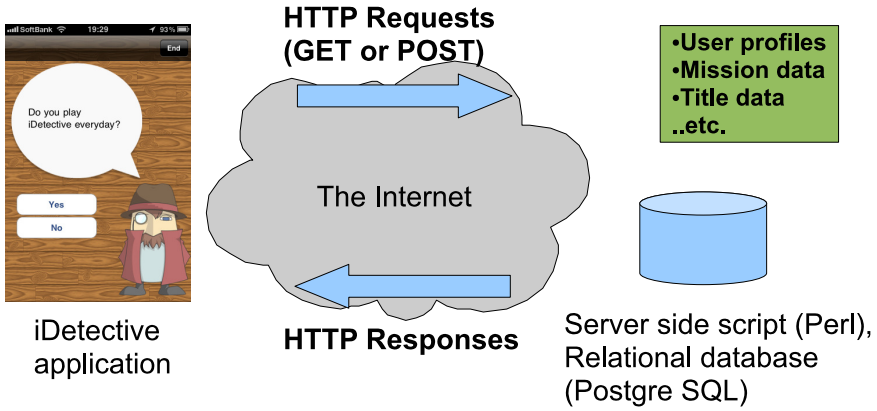


Figure 4.1: The system overview

Table 4.1: The relationship among the iDetective's consciousness stages, the theme of conversation and corresponding processes

Design issue	Strategy
Dialogue	3
Virtual agent	3
Implicit target behavior	1
Game type application	2
Mobile platform	4

Application type As described above, the iDetective is a game application. By adopting the game related features, the iDetective tries to attract its user's attention and persuade them using implicit sensing and feedback through playing the game.

In addition, characters as virtual agents can be introduced to them naturally who make persuasion much less explicit. As games themselves are designed with an intention to entertain its users, the motivation of using them is freer than purpose specific ones such as utility applications. Therefore it is expected to be possible to extend the range of target individuals.

Related work that has already discussed about making use of game techniques exists. According to T. Nakajima et al., three design principles of a persuasive application are proposed as an "ambient lifestyle feedback system" and game-like features are introduced into our daily life in the context of "emotional engagement" [46].

The Virtual Aquarium prototype is an application designed for persuading its users to brush their teeth every day. An accelerometer is installed on a toothbrush and detects the brushing action. The application gives short-term feedback by displaying a cleaner which moves synchronously with the toothbrush and long-term feedback by controlling states of the aquarium such as prosperity of fish inside. This feedback make users feel like keeping the aquarium clean and encourage them durable tooth brushing.

Table 4.2: The relationship among the iDetective's consciousness stages, the theme of conversation and corresponding processes

States	Feedback	Corresponding methods
4	Giving a positive feedback when a user do the behavior	Reinforcement management, Helping relationships
3	Helping a user on having motivation for the behavior	Self-liberation
2	Showing a concrete benefit of taking an action	Self-reevaluation
1	Making the users be conscious about their current status	Consciousness-raising

Mobile platform There are some kinds of smartphone platforms. Taking our evaluation into consideration, we have chosen Apple iPhone[1] because of its unified usability, a large number of users and a good deployment environment and opportunity. At the time when this research is conducted, iPhone is one of popular devices with enough users.

Dialogues

In the iDetective, implicit persuasion techniques have been woven into the dialogues with Zank. There are three types of dialogues, that are "sensing conversations", "feedback conversations" and "chats".

Through the dialogues, the iDetective estimates the current level of the user based on the transtheoretical model and changes the contents of the dialogues according to the estimated level as feedback.

Sensing conversations To determine the stage on which the user is in the transtheoretical model, some questions have to be prepared [54]. However, in implicit persuasion, the sensing has to occur unrecognized by the user and questions have to be implicit. We attempted to obtain approximate levels by modifying the transtheoretical model's criteria and the number of levels suitable for the iDetective. Although there are criteria related to the period of the behavior, the iDetective probes the level of a user without the period attribute since giving questions including the period of the behavior lasting is unnatural. Figure 4.2 shows the flow of the sensing conversations and resulting consciousness levels.

Feedback conversations Feedback conversations are designed using preferable method for each stage based on the transtheoretical model and such methods are used as a main topic of a conversation. The types of methods used for the feedback are listed in Table 7.1.4 according to consciousness levels.

[1] http://www.apple.com

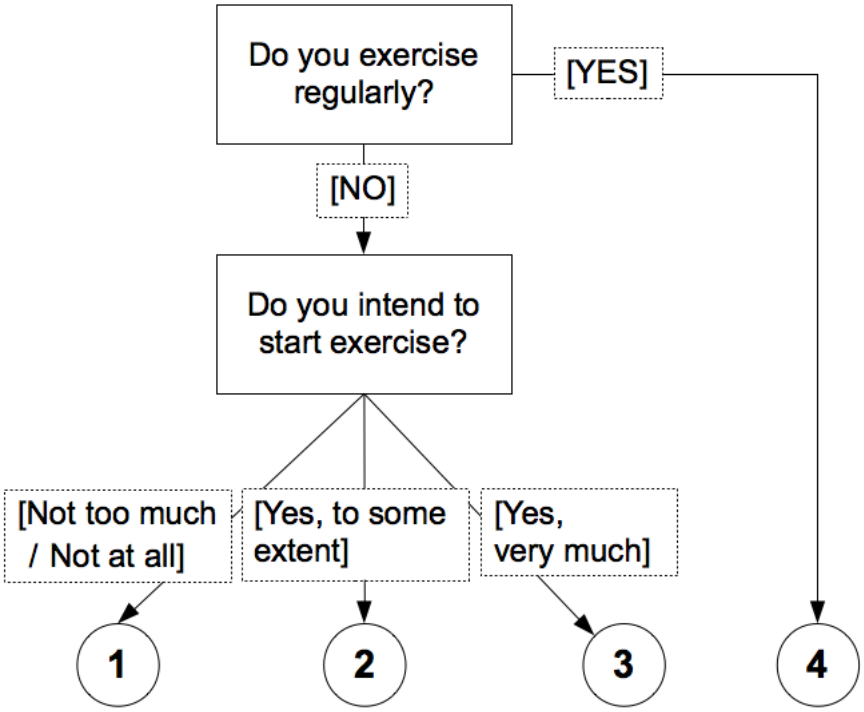


Figure 4.2: Sensing flowchart [72]

Chats Chats have been prepared for making the dialogue less "persuasive-like" and the iDetective more enjoyable by burying the persuasive conversations into the chats. These have been constructed based on trivia and issues of the moment that have not been confined in a specific field.

Each chat has been fetched randomly and can include options from which the user can choose, like the other kind of dialogues.

In order to prevent users from being bored and feeling unnatural, a variety of chats are needed.

Agent

Zank is the head of the photo detective school and a player's boss in the iDetective. From the perspective of his occupation settings, a dignified design can be better. Therefore, it is natural that Zank provides users with information as his students and thus, Zank can persuade implicitly. In addition, to give a user good impression, we adopt simple animation images. According to [19], although an effect of animated agent depends on situations, such agent has possibility of giving a player positive impression. In the iDetective case, Zank grows a mustache and wears a monocle. In addition, Zank has more dignity by speaking in elder manner and sometimes acts stupid in order to make players feel friendly.

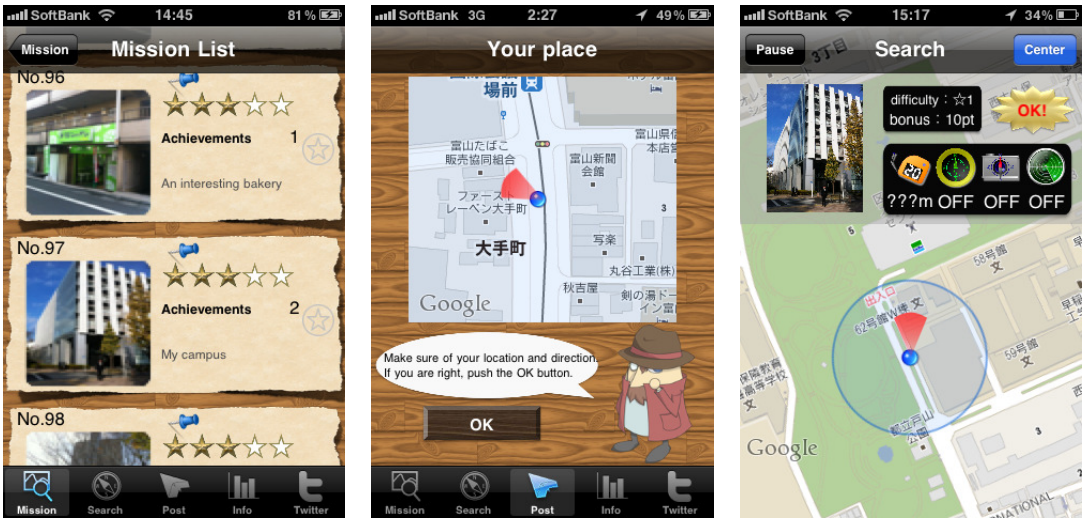
Displaying messages using a virtual agent is one of methods by which a computer communicates with its users. In [60], in order to evaluate the change in the attitude toward exercises, a user study has been conducted using the combination of an agent type (text or agent) with whether or not the conversations is "social". The authors have discussed that the participants have more positive attitude toward exercise through the conversation with an agent [60].

The "social" conversation includes, for example, empathetic statements [60], prompting self-disclosure by the participant [60] and general expressions of interest in the participants [60].

In another related work, to evaluate individual's desire to continue working with agents, four negotiation methods using computer agents are compared. These include *Baseline* (a single audio tone), *Negotiated* (providing users with the ability to delay the start of an interruption), *Forewarn* (providing users with a very brief audio tone 15 seconds before an interruption) and *Social* (apologizing for the interruption, asking how the user is feeling and expressing empathy) [8]. In the results, the participants thought the *Social* method is the most effective.

Functions

This game has six modes, (mission, search, post, information, twitter and conversation). Each mode is represented on the bottom tab bar except for the conversation mode. We give more information on each of the modes below and we do not mention the twitter mode because it is incomplete feature and the use of social networks is one of our future work.



(a) Mission panel (b) Submission panel (c) Search mode

Figure 4.3: Basic features of iDetective

(a) Item panel (b) Ranking panel (c) Conversation mode

Figure 4.4: Persuasive features of iDetective

Mission In this mode, players can select missions. The mission mode shows a mission list to players (Figure 4.3a). This list has missions within 1 km radius and can show entries 10 missions at once. Each mission contains a photograph, a difficulty level, the number of discoveries until now and comments from other "clients" (i.e. players). The distance between the user's location and the goal determines the difficulty level, i.e., the longer the distance is, the more difficult the level is. If the mission is discovered more than 10 times

so far, the difficulty level is decided based on the evaluation of other clients. When the star icon is tapped, the mission is saved to the player's bookmark folder. The player can confirm his/her own bookmarks at any time. After the player selects a mission, the mode is switched to search mode.

Search In this mode, players can receive supports to accomplish a mission which is selected by them in the mission mode (Figure 4.3c). A map is displayed in the full screen, and other information is overlaid on it. The mission photograph is placed on the top left corner. The mission's data (difficulty level, points) and the *OK!* button are placed on the top right. Items are placed below the mission data. The blue ball on the map represents the player's current location, and the red sector represents the player's view. Based on this information, a player can search for a goal location.

If a player has reached the correct location, then s/he can tap the *OK!* button. Whether or not the player has reached the correct location is judged with GPS data obtained from iPhone. When the find button is tapped, the player's location data is sent to the server.

If the player is within a radius of 50 meters from the goal, and if the player's direction is within the range of ± 90 degrees, the player's answer is determined to be correct. If the answer is correct, the player can review the mission. The contents of the review are a difficulty level, a recommendation level, and a comment. When the player finish reviewing, s/he gets detective points. These points can be a main motivation of the game. Thus, transition to the conversation mode occurs. If the user has passed the judgment, detective points are given to him/her and transition to the conversation mode occurs.

Post In this mode, a player can post a mission that other players can challenge. When post tab is tapped, the panel that has a map is shown.

After confirming the current location, the user can start the camera. Players can add comments on the taken picture. When the posted mission is accomplished by others, the player can get detective points. Therefore, the player should post a mission which other player would be interested in, such as beautiful scenery or a good restaurant. After the player has posted a mission, transition to the conversation mode occurs.

Information In this mode, a player can check his/her status and ranking. The contents of the status are accomplishment counts, post counts, detective points, a titles list, an items list(Figure 4.4a) and the player's rank(Figure 4.4b). These pieces of information can be incentive to play the iDetective.

Conversations In this mode, players can have a talk with Zank (Figure 4.4c). There are two conversation styles. One is Zank's one-sided conversation and the other is a question style one given by Zank which the user can choose an answer from options.

The conversation mode can be started by finishing the search mode, the post mode and pushing the conversation button in the information mode. The player can stop and move to the next conversation in the conversation mode at any time if he/she does not want to continue the conversation.

The conversation mode can be ended, or can move on to the next conversation at any time.

4.1.5 User study

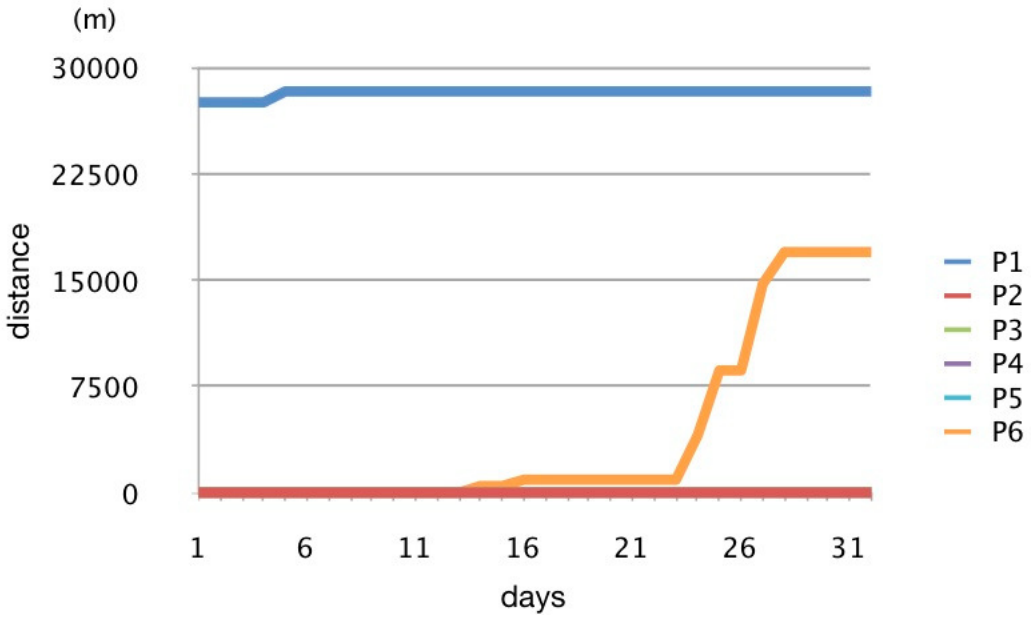


Figure 4.5: The transition of the distance of walking

In order to make sure whether a user accepts the implicit persuasion and whether the iDetective can persuade him/her unconsciously, we conducted a user study to evaluate implicit persuasion. In this user study, we asked participants to install the iDetective on iPhone. At this time, we did not explain our aim to subjects but asked them to simply play our games. Also, we logged the user behavior and took a questionnaire about the iDetective after the user study (however, we could not collect the answer from one user). The study period was 32 days and participants were 6 persons (P1-P6: 4 males, 6 females).

Before the study, we prepared some missions located in user's range of activities. Dummy users were also inserted into the ranking list in advance. In addition to this, we also prepare two feedback conversations, two conversations for sensing and thirteen chats. During the study, we added five-feedback conversations and three chats.

4.1.6 Results and discussion

We describe the results of our user study.

The "implicit" persuasion in the iDetective

Steps of users As a result, the number of mission accomplishments and steps of a few participants increased. Figure 4.5 shows that P1 walked about 28000 m and P6 walked about 17000 m. This data shows that when a user plays the iDetective and achieve missions, the number of steps of the user increases accordingly. For example, the number of missions that the P1 accomplished is one and P6 has accomplished nine missions. P1's data which indicates walking for 2000 m long for each mission was not usual and this result was not accurate.

However, as we have stated above, if users try to accomplish a mission, users need to walk at the same time. Therefore, it is correct that the distance that they have walked increased using the iDetective and our first goal of involving precontemplators was accomplished.

In Figure 4.5, the time when the steps of P6 had stopped (the 28th day) exists and in this point, he had become the "best walker" among players. Many dummy users are placed on the iDetective so as to make it more natural, and their rank cannot change. This indicates that P6 accomplished his own purpose in the iDetective. Therefore, a goal can have an effect on motivations of users in unconscious persuasion.

The result of the implicit persuasion According to the participants' answers to the question "Were you aware of the true goal that the iDetective encourages you to walk more?", all of participants chose "No". They did not realize that the iDetective has been designed for persuading users to walk more. This indicated that implicit persuasion using the iDetective was successful. In addition to this, we received feedback that the conversation mode was an attractive feature. Therefore, the iDetective's persuasive design can be valid.

The implicit sensing In Figure 4.6, the consciousness level of P6 moves in higher levels. This indicates the effect of persuasion with the iDetective. But the answers to the question "How did you feel when you answer questions?" has shown that the user has a curiosity about how responses from Zank change when the user chooses another option.

In this user study, the server received the consciousness levels for each of the five days. However, in this period, frequent conscious level changes were unlikely. Therefore, the reason why conscious level changed in those days was curiosity of the user. The cause of curiosity was the conversation mode itself.

The contents of the conversations were available for each selection which has been displayed in the conversation mode. This system has been introduced to attract users, but this affected the sensing of consciousness levels. Therefore, a further discussion is needed for the precise sensing of the level of consciousness.

Effect of a virtual agent As Figure 4.7 shows, the number of participants who had positive impressions (acceptable, reliable and cool) of the agent was larger than the number who had negative or neutral impressions. In addition, Figure 4.8 shows that the agent itself

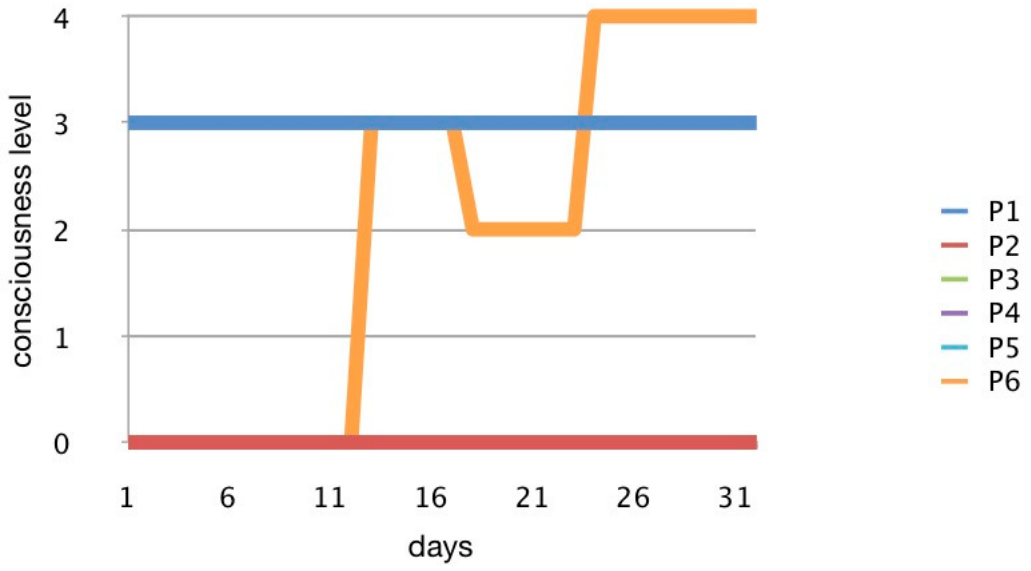


Figure 4.6: The change of consciousness levels

and the conversations were attractive features. That is, the conversation mode can be a valid and entertaining function.

However, the impression of a virtual agent varies among individual users. The impression of an agent is not always positive and can depend on the users' cultural and social background [17]. In the work by Cramer et al., the agent was "invisible" (i.e., not embodied) and was socially expressive where the messages consisted of more emphatic phrases and their result indicates the importance of considering the combination of the expression of a conversation and the context in which the conversation occurs [17]. If an application is internationalized, such cultural and individual differences would have to be considered.

In addition, an agent must give users suitable expectation of its ability. That is, an agent affects intention of using an application [67]; therefore, an agent must be perceived as helpful regarding tasks in the application. As Figure 4.7 shows, the agent in iDetective was perceived almost positive. Although the agent played a limited role in the current version of game, trade-offs between usability and expressiveness.

Features to attract users Figure 4.9 shows the use counts of each participant (P1-P6). The conversation mode was used by P1 and P6. However, they often ended the conversation using the "end" button (cancellation of the conversation). The same conversation could be repeated because the number of prepared conversations was less than the number of times a user used the features. As the topics of conversations were determined randomly, the possibility of the repetition of a same topic increased when the use of the conversation mode increased. The repetition of a conversation can bore users, and then their curiosity

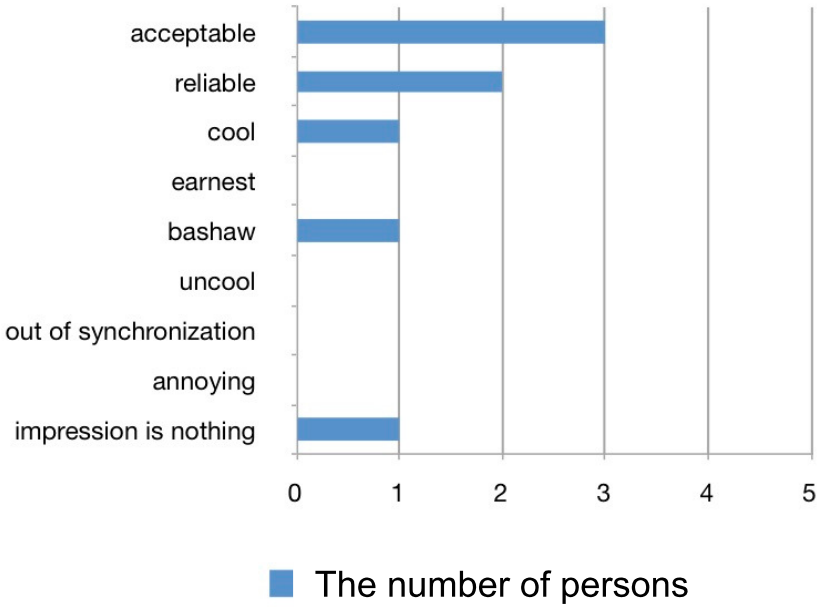


Figure 4.7: Answer of the question "How did you feel about Zank?"

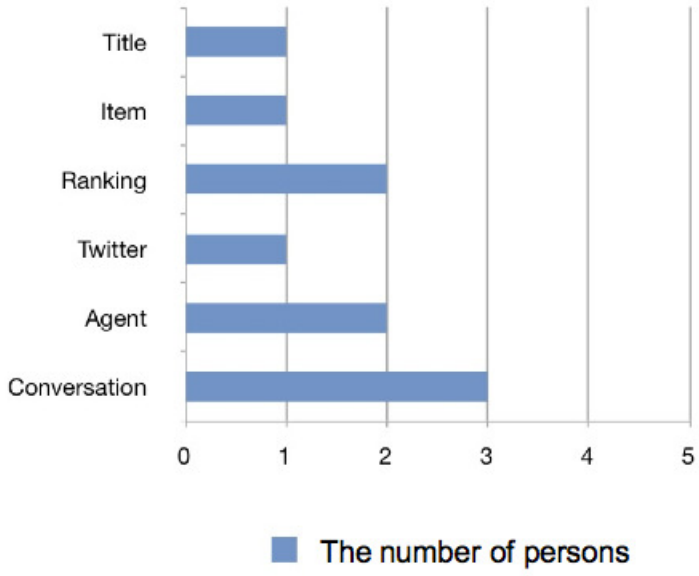


Figure 4.8: Attractive features for the participants

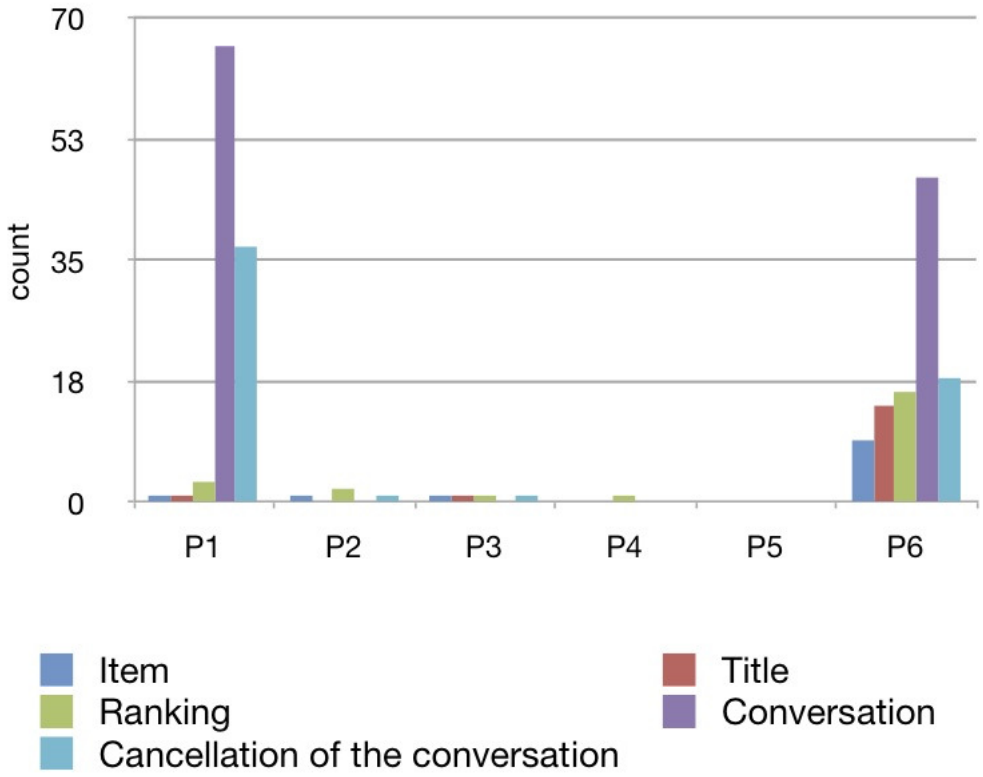


Figure 4.9: Use status in iDetectives

reduces the accuracy of implicit sensing. That is, a user can choose the option of a question from an agent regardless of his/her actual behavior stage.

Advantages and disadvantages of game Serious games can "violate" a user's voluntary behavior [41], while the definition of play includes voluntary (i.e., a form of freedom) aspects [31]. In implicit persuasion, the game itself provides players with entertainment and addictiveness along with "practical features". In our case, an agent can give useful information related to health issues to a user; however, a sophisticated conversation generation technique is needed. For example, topics can be automatically retrieved from articles, tweets or blog posts.

Figure 4.10 shows the screens most used by each participant. This result implies that the info screen which includes additional information such as points and ranks, was less important for participants. In the experiment, it could be difficult for iDetective to motivate participants to compete with each other because the number of participants was small. In addition, the degree of fun of the game itself must be considered.

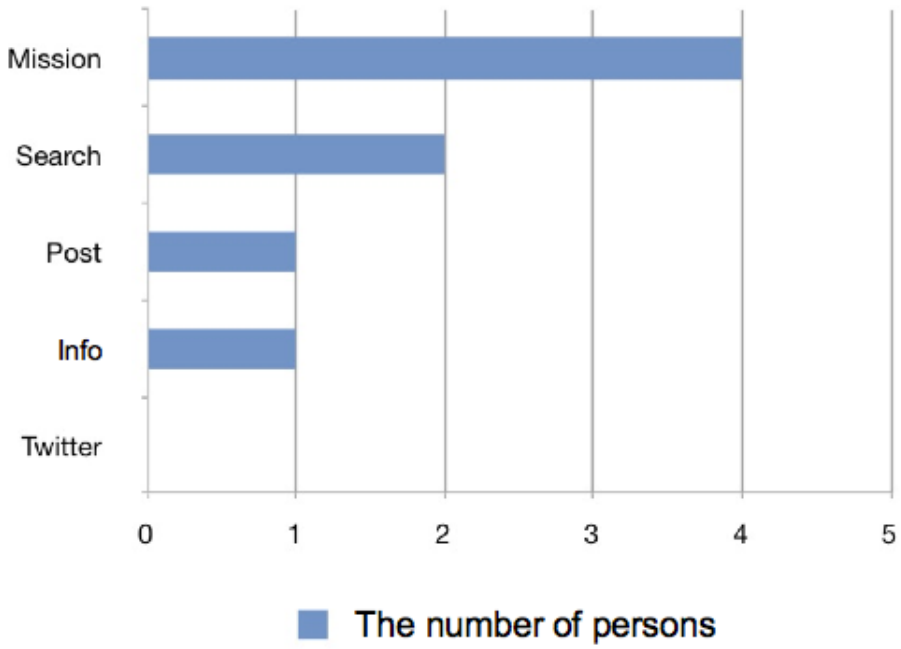


Figure 4.10: The most used screen

4.1.7 The general "implicit" persuasion strategies

The acceptance of an application embedded implicit persuasion

As for the answers to the question "How do you think of existing a designer's intent hidden into an application?", we have found that there was no user who has had poor impression from the iDetective. The reason is that our purpose in the iDetective was to persuade users to walk more, which was "good" and healthy for users. If our purpose would be harmful for users as a result, users would feel uncomfortable. In order to persuade individuals implicitly, the selection of a target behavior is important.

Berdichevsky et al. have proposed the disclosure principle and stated that designers of persuasive technologies should disclose their motivation, methods, and expected outcome [6]. They also have mentioned the exception when the disclosure significantly undermines the ethical goal [6].

The iDetective does not persuade explicitly and it might be a problem. However, in the iDetective case, a use of the conversations with the virtual agent who plays a role of a persuader depends on the user's will. The walking behavior can be assumed to be ethical because the iDetective supports a user's walking behavior as a health keeping behavior and the participants had positive impression of it.

Not using special devices

Due to the nature of implicit persuasion, we cannot persuade individuals implicitly using a special device. We chose a smartphone as a general device because it can be carried anywhere and anytime, and be used in daily life.

This generality can contribute to increasing ability of a user to activate behavior. Fogg suggests that people are resistant to behaviors that require effort [22]. Thus, required effort can be lowered by being available on easily accessible devices.

On the other hand, as a generalized device, certain optimizations must be needed. In the case of iDetective, the conversation script data were retrieved as a set of several scripts to reduce the number of network communications.

Interactions with a virtual agent

Persuasion using interactions with a virtual agent can be applied to many kinds of computer systems other than games. Many topics can also be given to users. If a user becomes interested in conversations with the virtual agent, s/he would try to interact with it actively and thus much more information can be given to him/her.

4.1.8 Ethical issues

We always have to consider ethicalness of target behavior when we decide whether the fact of persuasion is buried into other "innocent" features completely. According to Berdichevsky, a golden principle has been proposed [6]; and taking this principle into consideration, the creators of a persuasive technology should not choose a target behavior which is not acceptable for themselves. Otherwise, another intermediate solution can be considered. For some consciousness levels of users, an application gives them a choice whether the functions of the persuasion are turned on.

4.1.9 Summary

We have discussed implicit persuasion based on TTM as a mean of persuading users who are not aware of the problematic behavior to extend the range of target users. We defined the implicit persuasion and specified the design strategies to develop an implicit persuasive application.

We also developed the prototype system named iDetective by applying the strategies and conducted a user study to confirm its implicit persuasive effects and possibilities. The iDetective encourages implicitly users to walk using game settings, and feedback and sensing have occurred through the conversations with a virtual agent.

As a result of the user study, players of the iDetective participated the story of the game and walk more and more simultaneously as we proposed in the design strategy. At the same time, the implicit persuasion did not give users bad impression and a virtual agent can be effective because participants also have had comfortable feelings for the agent. However, from ethical aspects, an impression of implicit persuasion can vary according to the purpose of persuasion or the scale of the user study.

Chapter 5

Case Study 2: Intention Adjustment

In this element, we mention two case studies. The first case study is related to a user's attitude to persuasion and boredom. We have referred to relationship between users to examine the possibility of reduction of boredom and improvement of impression of persuasion. The second case study includes discussion of balancing between fictional representation and real world attributes. We used a prototype table tennis application, which refers to a real world activity, incorporating feedback generated by a computer.

5.1 IA1: Social desirability and conversations

In this research, we focused on the existence of other individuals. With this condition, we attempted to improve the problem that an individual does not respond to the questions based on their real opinion or situation. In addition, we will also discuss a design strategy of persuasive computer systems and possibility of further study in the aspect of this problem. We will use a sentence "answering just by curiosity" describing an answering behavior which is not according to their real opinion or situation **when the authenticity of the answer significantly affects the precision of functionalities of a computer system, especially persuasion**. Still, curiosity is not always "evil" in the use of a computer system; for example, entertainment oriented software such as games can be played by the user's curiosity.

In a term of the relationship with others, an individual has a notion of what is "correct" or what is acceptable by society and this can become a bias which is called *social desirability*. For example, A. Joinson has discussed relationship between anonymity and *social desirability* [32]. In addition, *the presentation of self in everyday life* [26] theory describes that an individual attempts to manage his/her impression given to others.

Based on these theories, we proposed a hypothesis that an individual may answer to a question according to his/her actual opinion or current situation in a condition where the answer can be known by other members in a group consists of his/her acquaintances. The reason of this hypothesis is that making an individual's answer be revealed to others can reduce anonymity and the effect of *social desirability*. Besides, an individual can attempt to manage impression of him/her more in a group consists of acquaintances than strangers

because acquaintances know each other and cannot pretend. Under this hypothesis, we developed a web-based application on which an individual can have conversations with an agent and conducted a user study using this application in order to examine whether an individual's answer changes according to the existence and the relationship with others.

In practice, if a computer system can obtain its user's real opinion or status in qualitative form, such system can assist activities of its users precisely giving them supportive information in order to achieve a certain behavior. For example, if a computer system can obtain whether its user are interested in exercise, the computer can provide him/her with information such as an advantage of exercise and encourage him/her to have exercise actually.

5.1.1 Anonymity and social desirability

A. Joinson has mentioned the possibility of the Internet as a new form of psychological research such as questionnaire [32]. He has conducted a user study in order to examine the use of the Internet-based questionnaire and existence of anonymity in terms of self-consciousness, social-anxiety, self-esteem and *social desirability*. Each participant was assigned one of two groups; the Internet-based questionnaire was used in one group and the paper-based questionnaire was used in the other group. As a result, in an aspect of *social desirability*, anonymous group with internet-based questionnaire had lowest *social desirability*.

In the case of our research, the method of presentation is different from questionnaire and an agent gives individuals questions. That is, they are presented by the graphical agent during certain periods and same question can be shown to an individual repeatedly.

5.1.2 System design

We have developed a web-based application where users can talk with the virtual agent. We will explain the purpose of this application first, and describe details of it. Our application is named *Agent System* and this system has an iDetective-like conversation feature. Unlike the iDetective, the device on which the Agent System runs do not have to be mobile device because we intend to discuss the effect of more general conversations under existence of other individuals. In addition, we can recruit more participants than the iOS application's case because the Internet and web browser is common and the system requirements are less limited.

This application simulates a persuasive application which encourages a user to exercise. The main difference of the conversation feature compared to the iDetective is that a part of choices which a user makes is disclosed to other users. Thus the effect of observation by other individuals can be examined using this system.

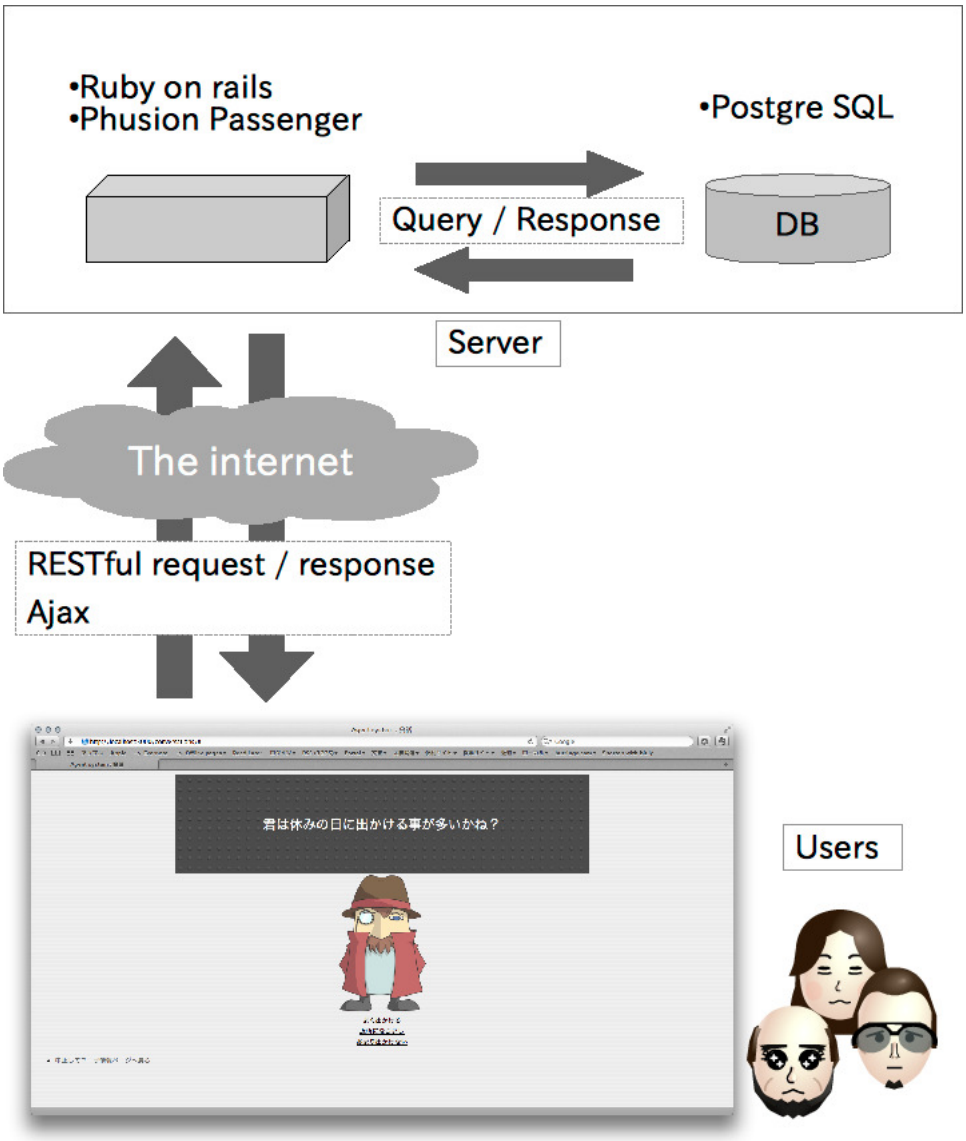


Figure 5.1: DC: System overview

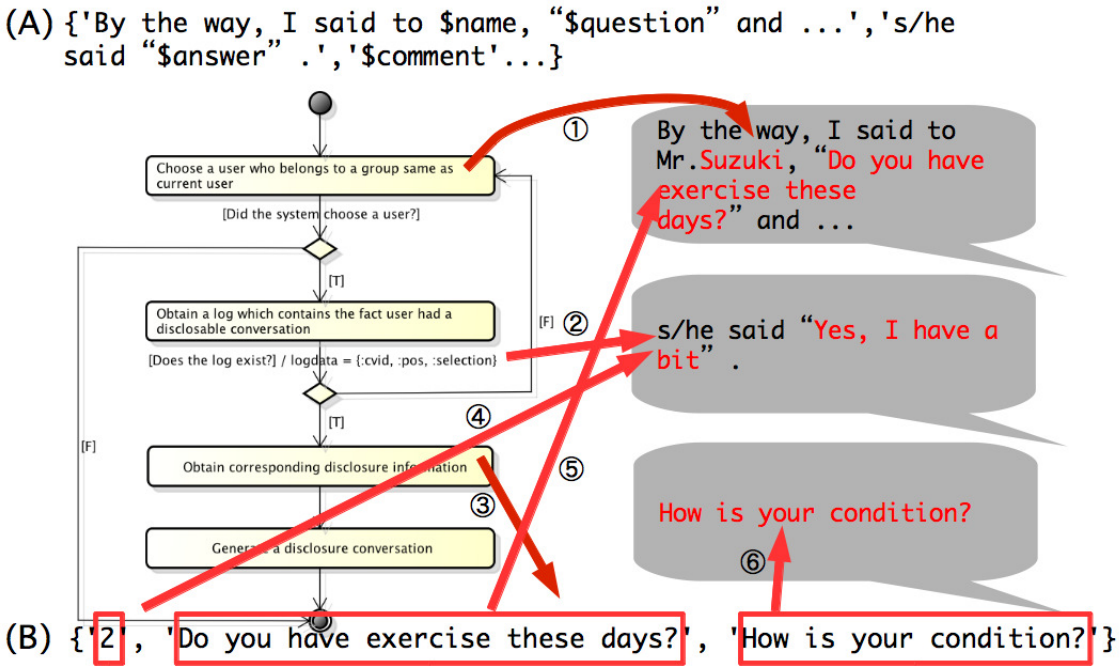


Figure 5.2: DC: Conversation generation

System diagram

Conversations

n the Agent System, conversations are divided into seven categories and each conversation has a special type number (Table 5.1). This type number is used as a filter when a user starts a conversation and the system chooses a conversation to show. For example, a *disclosure conversation* will not be presented to a user who belongs to the "unknown group" and will not know an answer of others. The types of conversations same as the iDetective are also included in these categories. However, we prepared *feedback conversations* only for future use and we did not implement the persuasive future based on the *transtheoretical model*.

Also, the format of conversations is similar to the one in [72] except for the *disclosure* data to generate *disclosable conversation* and subtle representations of data which controls a flow of a conversation. One conversation consists of steps which represents a frame with a piece of scripts and associated options.

Initial conversation This conversation is presented to users who have logged in to the system for the first time. On this conversation, the agent not only introduces himself and explain an overview of the Agent System but also intends to obtain the user's current behavior using a conversation same as the form of the sensing conversation.

Disclosure conversation The *disclosable conversation* informs other members of the one individual's selection out of options in the conversation and such type of conversation has *disclosure* data which will be used for composing *disclosure conversation*. The difference between *disclosure conversation* and *disclosable conversation* is important. The former is a special type of conversation which becomes a template of texts and is shown to individuals with strings from the *disclosure* data are embedded. On the other hand, the latter is a conversation which has *disclosure* column data regardless of conversation types and gives this data to the composition process of the *disclosure conversation*.

The *disclosure conversation* which reveals a user's answer to others is composed by a process shown in Figure 5.2 and this type of conversation itself is a template whose parts prefixed with '$' are replaced with proper data (A). First, the system attempts to select another user randomly whose group is same as the current user who is about to be presented the *disclosure conversation*. If another user was found, the system obtains his/her name (path ①) and inspects into log data generated by that user which represents that the user has had a *disclosable conversation* before. Next, if such log was found, the system extracts the number of option which was chosen by the user and this will be used for determining a label text corresponding to the option. At this point, the data in the *disclosure* column can be obtained (path ③ and B) and this data consists of three parts; the number of step which has the option in the data obtained in the former step, a text label of conversation which represents a question and an additional comment sentence. The reason for the existence of the second item is that the form of sentences in the conversation does not always fit into the template; therefore, we need to prepare optimized version of the sentence embedded naturally. Using the *disclosure* data, all of variable parts of the template are replaced and the *disclosure conversation* is completed (path ②, ④, ⑤ and ⑥).

Sensing conversation A conversation which asks a user whether s/he is engaged in the behavior regularly has a type 2 and a form of this type of conversation has succeeded to the one of the iDetective; that is this conversation is composed based on the Figure 4.2.

Level conversation The target behavior-related conversations are typed according to a part of stages of the transtheoretical model shown in the Table 7.1.4. We reduced them to four stages excluding the *Maintenance* stage and mapped to the response of the type 2 conversation. We prepared this conversation for future use and we did not implement the persuasive feature based on the *transtheoretical model*.

A part of these conversations was succeeded from the feedback conversations in the iDetective or offered by Y. Funabashi. Sources of the conversation were web sites such as All about[1], and many other literatures.

Chatting The function of this type of conversations is same as that of the iDetective.

[1] http://allabout.co.jp/gm/gc/389424/

Figure 5.3: DC: Facial expressions

Agent

An appearance of the agent and a form of a conversation are almost same as the one in the iDetective. However, we did not show a name of the agent whereas the name of the agent was "Zank" in the iDetective. The agent has originally been designed by Y. Haga with five types; besides we made new face types by modifying the original one. As a whole, the agent can present 8 kinds of expressions (Figure 5.3) and the behavior of the agent consists of a sequence of these still images. In addition, all interactions with a user are text-based; outputs are shown at a frame above the agent and inputs from a user are a multiple-choice form.

User interface

Each user has their own user page when they login to the Agent System. The target behavior is shown at the top part of the user page and a user can enter a conversation from this page. According to Prochaska et al., understanding what an individual can do when s/he improve a problematic behavior is important and behavioral criteria of fifteen behaviors are specified [54]. In this research, persuasion based on the transtheoretical model is not a main issue; however, we adopted this feature as a pre-study of transtheoretical model based persuasive application.

When a user enter the conversation page and start a conversation, user can go through a sequence of texts presented from the agent (Figure 5.4).

5.1.3 User study

We conducted a user study in order to examine the effect of existence of another individual when a user interacts with a virtual agent. We recruited 21 individuals; however, one participant had retired during the study and the total number of participants had become 20 (17 males and 3 females). They consisted of 18 Japanese, 1 Chinese and 1 Thai. They

Table 5.1: Conversation types

Types	**Names**	**Descriptions**
0	Initial	Presented just after the first login
1	Disclosure	Informs other users of one individual's answer
2	Sensing	Obtains a user's current behavior
3	Level1	Given to *precontemplation* user
4	Level2	Given to *contemplation* user
5	Level3	Given to *preparation* user
6	Level4	Given to *maintenance* user
7	Chatting	Shows topics not related to the target behavior

(a) Q&A-style display (b) Normal style display

Figure 5.4: DC: Displays in the Agent System

Table 5.2: The actual groups of participants

	Acquaintances	Strangers
Known	1-1_1, 1-1_2	2-1_1, 2-1_2
Unknown	1-2_1, 1-2_2	2-2

Table 5.3: Criteria of determining relationship with the other members ("I" represents one member and "he" or "she" represents one of the others)

Acquaintances	**Strangers**
S/he is so intimate that I communicate with each other frequently	I do not know him/her at all
I meet him/her at your workspace or laboratory or house	I have only heard about him/her not knowing each other directly
	I used to communicate with each other long ago but not now

were asked to agree with personal information policy and conditions of the user study in advance; and a more detailed agreement page was shown after the first login.

They were divided into four triad-groups (Table 5.2) randomly according to the criteria shown in Table 5.3. The participants were confirmed the relationship with other members in the group in advance. In this research a common target behavior to which a participant will be persuaded was exercise. The participants were asked to converse with the agent freely for ten days and fill up a questionnaire on the last day. The questionnaire includes questions about the agent, conversation and attitudes of participants. These questions will be shown in section 5.1.4. Although the entire questionnaire was conducted in Japanese, the sentences are translated to English and simplified in this study.

As described the previous section, main activities such as logging in and starting a conversation were recorded to the *logs* table.

5.1.4 Results and discussion

In this section, we will show the numbers of conversations of the participants and describe a tendency. Next, we will discuss the data derived from the *Agent System* and results of the questionnaire that we conducted at the end of the user study.

The number of conversations

Figure 5.5 shows how many times a user has started and finished a conversation. If a user escape from the conversation page after the user has started a conversation, the number of

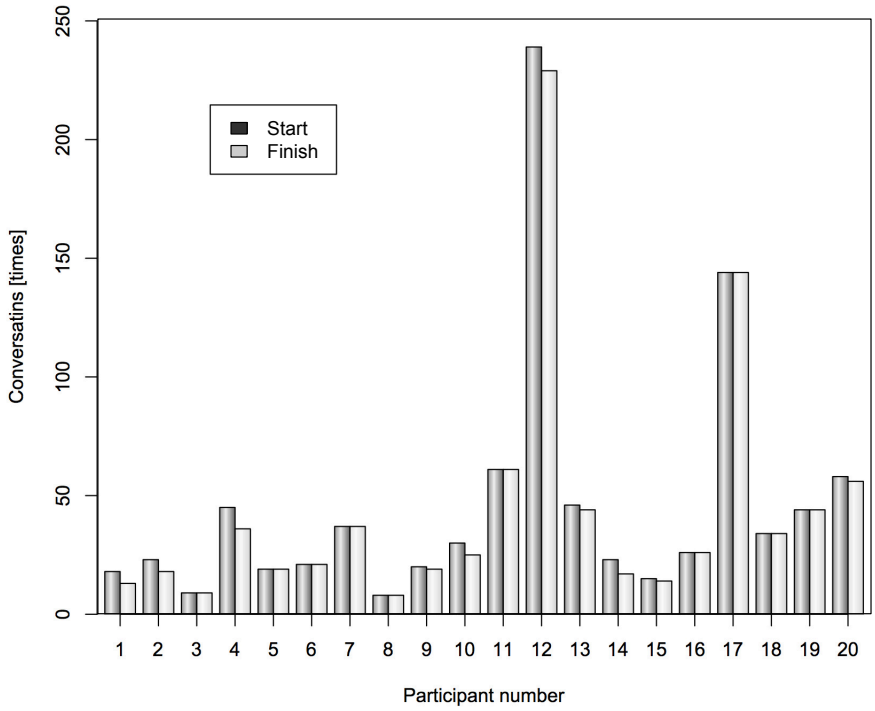


Figure 5.5: DC: Begin / finish logs

starts become more than ends. From this figure, 10 participants had escaped in the way of conversations; however, we cannot find the relationship between the total numbers of conversation and the numbers of escapes.

The effectiveness of our hypothesis

11 participants answered that they began to respond to the conversations by their curiosity when they got bored in both topic conditions (Table 5.4) whereas Figure 5.6 shows that 17 or 16 participants in each conditions respectively, responded to the conversation by their real opinion or status.

From the results of the questionnaire, boredom in the conversations had more affected on the individuals' behavior than the existence of other members. In the exercise-related conversation's case, for example, although 17 participants out of 20 have chosen an option according to their real opinion or status, one of the problems common to the iDetective was that the number of conversation was limited and run out earlier. If a persuasive feature which persuades individuals to provide the application with his/her real opinion or status works, this feature can be applied to the more general case where the fact of the persuasion is more explicit to users. However, a more precise evaluation under the condition where

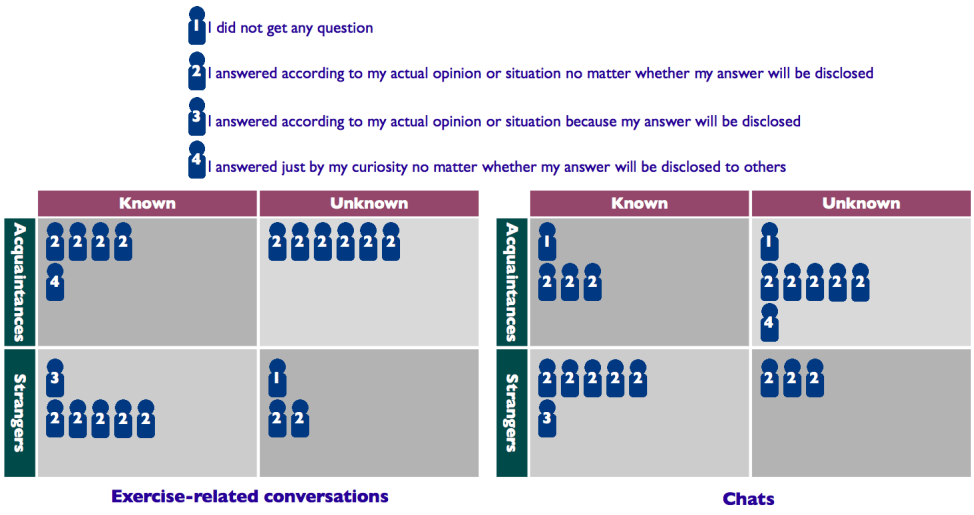


Figure 5.6: Participants' attitudes from the aspect of topics of conversations

Table 5.4: The effect of boredom on the response to the conversations (both topic conditions)

Item	**Choices [person(s)]**
I did responded by my real opinion or situation, until I got bored	11
Whether I got bored or not did not affect my response	7
I did not get bored	2

the boredom is decreased is needed.

In addition, the form of the sensing conversation was also limited and such conversation can be presented to the users multiple times. Instead of frequent use of sensing conversation, the system can combine with the sensing conversation and data obtained from sensors such as an accelerometer. If a user actually starts a target behavior, the stages can be evaluated using such sensors without asking the user directly.

The difference between the Agent System's case and the iDetective's case

As for the Agent System's case, we examined detailed attitudes toward responding to the conversations. That is, even if an individual responds by their real opinion or situation at first, s/he can start to answer by curiosity when they get bored. On the other hand, in the iDetective's case, we found only the existence of the problem. In both cases, those who responded to the conversations just by the curiosity existed; however, we have examined possibility of disclosure of an individual's answer to others in conversations and such

Table 5.5: "How did you feel about that your answer is disclosed to others?"

Item	**Choices [person(s)]**
I cannot accept the disclosure no matter kinds of questions	1
I cannot accept the disclosure as for the questions querying my knowledge	3
I cannot accept the disclosure as for the questions querying my opinion or situation	3
I do not mind the disclosure as for the questions described above	13

method can be accepted by individuals in this research.

Ethical issues

A group whose all members had not experienced the disclosure did not exist whereas 4 out of 12 participants who belong to the *Known* group could not have the *disclosure conversation*.

Further, we asked attitudes toward disclosure of individual's answer regardless of the actual encounter with the *disclosure conversations*. The results are shown in Table 5.5.

As Table 5.5 shows, 13 participants did not mind the disclosure and if our method works effectively choosing the target behavior carefully, the system can encourage the users to answer according to their real situation or opinion. However, according to Berdichevsky et al. the creators of a persuasive technology should not choose a target behavior which is not acceptable for they themselves [6] and this is called golden principle. That is, a designer of the system still has to choose target behavior or contents of disclosure carefully. For example, our method cannot be used with conversations that extract personal data.

Anonymity of the captology

According to [21], computers allow anonymity where they can obtain sensitive information from individuals or help individuals to experiment new attitudes and behaviors. Thus, an individual can act as a different kind of person in the computing environment. In addition, results of a user study in the research on anonymity and *social desirability* [32] have described that anonymity can reduce *social desirability* and individual can answer the questionnaire by their real opinion.

However, asking questions by weaving them into conversations with an agent is different form of interaction with an individual. In addition, the anonymity in the questionnaire can be considered the relationship between examiner and examinee; on the other hand, our *disclosure conversations* focus on the relationship between examinees.

Table 5.6: "How was the impression of the agent?"

Item	**Choices [person(s)]**
Good	12
No opinion	7
Bad	1

Moreover, the main topic was exercise and we did not intend to ask sensitive question for an ethical reason. With the ethical consideration, although significant differences between the acquaintances-setting and the strangers-setting was not found under the both conditions of topics of the conversations, our user study has room for considering the effect of *the presentation of self in everyday life* [26] and encourage individuals to answer by real opinion under the not-anonymous condition.

Difference between kinds of an application

If functions of an application vary, attitude of a user can also change according to such diversity of applications. In this research, because the Agent System was designed as an experimental persuasive application, the user can only have a conversation with the agent. However, in the aspect of practicality, a kind of an application can be, for example, utility software such as anti-virus, web browsers or a game. Thus, a choice of the user can lead to significant effect on him/her or others in some kinds of applications such as security related software whereas in the case of applications, which are developed for an entertainment such as games, a user can easily choose an option as s/he likes.

The effectiveness of the agent

As Table 5.6 shows, one of participants had a bad impression. We also asked reasons for not choosing the "good" option in the questionnaire. As we foresaw, the scarcity of the number of the conversations was the most frequent reason among the replies. Another opinion was related to the representation of the agent such as the use of animation or audio. A participant who had chosen the "Bad" said that what the agent speaks was selfish and he seemed not to establish trust with the agent.

Although the impression of the agent was almost favorable, preferences of an appearance or a character of an agent can depends on cultures [17] or individuals. One of the participants said that the age of the agent was too old to talk about daily topics such as exercise. In addition, related work has discussed the design of an agent including appearances. For example, the reality of the agent does not affect the persuasion however an individual can be more persuaded by different gender of an agent [76].

Still, in the realm of robotics, according to M. Mori, an individual's familiarity increases as human likeness increases until the likeness reaches to the minimal point called *uncanny valley* [43].

Considering these theories, when we design an agent, the appearance of the agent can be important matter. However, the design accepted all of cultures and individuals is difficult and we have to examine effectiveness of the agent in terms of reality, genders, characters and many other criteria.

In addition to the appearance, behaviors of an agent are another issue. The agent, which was used in the Agent System was based on sequences of still images and it was not animated. According to D. M. Dehn and S. V. Mulkin, depending on situations, an animated agent has possibility of giving positive impression to a user [19]. Therefore, we can consider animating the agent including nonverbal behaviors such as gestures or eye contacts. Especially in a web-based application, we can realize such animation by not only implementing programmatically but also using certain image format such as GIF animation.

Change of an attitude of an individual according to kinds of a conversation

We examined attitudes of participants toward questions which are given by the agent in two conditions. That is, we examined the difference between attitude toward exercise-related conversations and toward chat (i.e. not-exercise-related ones).

As a result, except for those who had not encountered the Q&A-type conversations under one of the conditions, no significant difference between these conditions was detected (Figure 5.6). In this case, conversations that were not related to the exercise did not include sensitive topics and materials used for the composition of the conversation were not based on interests of the participants. As future work, we can focus on a difference between topics which is based on an individual's interest and ones which is not.

As the other type of question, we asked the difference between impressions of the *disclosure conversations* inquires knowledge of an individuals and current status or opinion (Table 5.5). However, most of the participants did not mind the disclosure in the range of question this system presented. Therefore, we can use the *disclosure conversations* which are not sensitive to an individual.

5.1.5 Summary

We have described a persuasion using a virtual agent and the possibility of constructing relationship between individuals and computers. The main problem was that the existence of those who chooses an option just by their curiosity and in a situation where the response from the user affect functions such as persuasion, such curiosity can decrease the precision of the behavior of the system.

To cope with such problem, we focused on an effect of other individuals because an individual has a bias called *social desirability* and also can be affected by anonymity. In addition we developed web-based application where an individual can have conversations with the agent. This application can disclose answers to a part of conversations by one individual to others.

As a result of a user study, asking the participants to converse with the agent freely, most of the participants have chosen an option according their real situation or opinion

regardless of the existence of other participants. At the same time, they have responded to the conversation just by curiosity when they are bored with the conversation. On the other hand, *disclosure conversations* were accepted by most participants and there is a possibility of further study changing the conditions and adopting other theories.

5.2 IA2: Virtuality adjustment

Computer user interfaces are developing interaction styles that are more complicated than traditional devices such as mice and keyboards. For example, a 3D user interface (3D UI) [10] enables a user to interact with computers in a style more similar to real world actions than a command line interface (CLI) or graphical user interface (GUI). As another example, the natural user interface (NUI) [55] proposed by Reuterberg et al. augments the interactions between physical objects and virtual worlds generating feedback from inputs including audiovisual information.

Users can now control computers using their body movement. For instance, the Wii Remote enables a player to play a game by body movements because the Wii Remote includes an accelerometer in addition to traditional buttons and communicates wirelessly with the game console. The Microsoft Kinect does not require the use of any physical controller in hand at all, allowing the players to interact with computers using gestures. Thus, game consoles for home use also accept a variety of controllers, and players can control games in more natural ways.

However, the existence of interactions produced by a physical object has a room for exploration. For example, Yamabe et al. proposed augmented traditional games mentioning auxiliary information like physical and social interactions provided by traditional games [69]. On the other hand, Sodhi et al. developed an interaction style enables users to experience tactile sensations without physical devices [63]. Regarding the existing work, balancing between physical and virtual interactions is needed. Freeman et al. discussed the implications of introducing a physical controller to a gesture-based game, and the effects of the use of a physical controller on the play of a gesture-based table tennis game [23].

In this study, we examined another way for balancing between reality and virtuality in gesture-based application software. Besides, we propose design implication for adjustment between reality and virtuality in the gesture-based application. Examining aspects not limited to enhancing reality can benefit interaction design of gesture-based computer applications. This balance leads to two possibilities: use of tactile feedback other than producing reality, and complemental effect by different modality on mismatch between perspectives and tasks.

Especially, we focused on a motion video game. Games can be easily combined with certain degree of unreality (e.g. staging and fun) and not always have to conform to real world situations. In this research, we specified two parameters in an aspect of assisting player action in both the virtual and real worlds of a game. This aspect is distinct from both prop fidelity and interaction fidelity. The parameters were perspectives (first and third -person) and feedback (tactile and visual), which relate to the virtual world and the real world, respectively. Using these parameters, we experimented with the effect of

a physical controller on the user's performance and impression using a table tennis game designed using different combinations of perspective and feedback. The developed table tennis game is played with a physical controller that simulates a racket.

5.2.1 Related Work

As partially described in the previous section, the possibility of introducing physical controller to a motion-based application has been discussed. Freeman et al. introduced physical controllers in a motion based table tennis game [23]. In their experiment, two types of conditions called "fidelity" were specified, and the performance of the player under each of the two fidelities was examined. One type of fidelity was prop fidelity, which is related to the type of object used as a controller: racket, stick or none (the player's hand). The other type of fidelity was interaction fidelity, which is the type of measurements that can be reflected in the gameplay: velocity, position or a combination of the two. Velocity and position were obtained by sensors attached to a controller or hand and by a Kinect sensor.

Interaction methods incorporate with tactile sensation in a free space are discussed in multiple aspects. Sodhi et al. proposed a user interface which can deliver tactile sensation in mid-air [63]. This system can launch a chunk of air from canon-like devices, and these devices can track user's hands, head and body. This method has an advantage in operation without any physical device on a body. On the other hand, our purpose is to examine another route in a design space exploiting an attributes provided by physical object.

On the other hand, Lindeman et al. explored interaction methods in a 3D space using feedback as 2D representations. They explained that haptic feedback is sometimes impractical because of physical constraints [39]. They introduced the notion of clamping. Clamping means restriction of a movement in a 2D virtual space as if a physical surface exists [39]. Burns et al. proposes the MACBETH method which complements unnaturalness caused by discrepancy between physical and virtual world [13]. Whereas their work focused on the improvements of virtual representation when haptic feedback is not utilized, our focus is discussing possibilities of haptic feedback as another modality assuming the existence of a physical controller and feedback.

5.2.2 Prototype concept design

Home video game controllers are becoming diverse. Video game consoles for home use have been growing in popularity because of their increasing performance and convenience compared to arcade games, which are limited to a specific location.

Still, arcade games have an advantage in terms of the availability of specialized controllers for specific scenarios [38]. The emergence of NUI game controllers introduced variety of interactions with video games. Traditional home game controllers with limited mechanical switches, such as buttons and joysticks, are problematic due to the complexity of gameplay. Advances in machine power have enabled more sophisticated expressions, and stories have become complicated. The complexity of gameplay can prevent a game from being accepted by a broad range of players beyond veterans and rabid fans [38].

We focused on the following properties for a targeted game type (TGT):

1. A physical controller can be introduced naturally (refer to real-world activities)
2. Users can take advantage of both body movements and a physical controller

We chose a game type based on the TGT to discuss adjustment virtuality and reality.

Game types

We have chosen table tennis while we recognized multiple candidates for a prototype game referring to arcade games which incorporate body movements.

1. Sports (e.g. soccer, basketball, golf)
2. Driving / cruising (e.g. racing cars, heavy equipments)
3. Fighting
4. Dance
5. Music (e.g. percussions)
6. Fishing
7. Others (e.g. comedy)

Among them, the table tennis was suitable for the type of games targeted in this research from three aspects. First, table tennis is an activity which involves a racket as a physical item in hand and a racket can be easily mapped to a game controller. A user assumes usage of newly encountered things generating a mental model [48]. Mental models are constructed by, for example, experiences, trainings and learnings. Thus we have chosen an existing activity as a theme. Second, body movements of a player are involved during game play; therefore, a prototype game can incorporate gesture input naturally, instead of buttons or joysticks. Lastly, both first and third -person perspective can be incorporated by the game.

Interaction parameters

We adopted a parameter for the real world and the virtual world respectively. That is, perspectives and tactile sensation are introduced to balancing between reality and virtuality.

Perspectives in a Video Game Many studies have discussed perspectives in GUI video games. As discussed by Richard Rouse III, in games with a first-person perspective, the player sees the game world through the player-character's eyes. Thus, players are more immersed in the game and might even think they are actually in the game world [57]. In addition, in shooting games with a first-person perspective, the player can see the hand of the player-character or the weapons. This visibility increases proprioception [42] and enables the players to perform more precise operations such as sniping.

By contrast, in the third-person perspective, the player's sense of immersion is significantly less because third-person games provide the player with a suitable distance not only between the player and the player's character but also between the player and the game world. Hence, the third-person perspective is appreciated in action games in which the player-character moves around the game world [25][59].

Bateman et al. researched the effect of differences in perspective in driving games [5]. They set participants a task to traverse the track as quickly and accurately as possible with four types of perspectives: *first person, third-person-low (at an angle of* $15°$*), third-person-high (at an angle of* $60°$*) and overhead.* The overhead perspective was associated with significantly worse performance than the other three views, with no significant difference among any of the other views.

The overhead perspective is also called the *god-like aerial perspective* and is often used in management and strategy games. Because these games provide the most distanced and abstracted view, the sense of presence or immersion in the game world is less than in other perspectives [25].

From these related work, perspectives as a virtual-world parameter can affect operability of a game and staging. We did not adopt a head-mounted display (HMD) for presenting first-person perspective because of the difficulty of operation in the body-movement-based situation.

Tactile Sensation Pielot et al. [51] have proposed a way to overcome the problems arising from the traditional audio and visual feedback of a GPS navigation device by employing tactile feedback and have developed a mobile navigation application called the "Pocket Navigator", which introduces vibration patterns to represent direction and distance. The tactile feedback is based on tactons [11] proposed by Brewster et al.

Pocket Navigator indicates the distance from and direction to a destination using tactons comprising two pulses. The direction of the destination relative to the user's current orientation is indicated by the length of each pulse. If the destination is to the left of the user, the first pulse is longer; when the destination is on the right side, the second pulse is longer. The distance from the destination is represented by the duration between pulses.

Their experimental results suggest that a user can navigate effectively with tactile feedback. Three conditions of navigation styles were examined in the experiment: a map, tactile feedback and both together. Tactile feedback was as effective as maps because the differences in the number of landmarks found by users and the times required to reach the destination were not significant.

We have chosen tactile sensation (vibration feedback) as a message for a player instead

Libraries	Unity 4.2.2f1
	ZigFuOpenNI1.01b
	ZDK_Unity40_1.1_trial
Development environment	Unity, Xcode
Languages	C++, Unity script, C#

Table 5.7: Development Environments

of endowing reality in the game world such as expressing collision. In addition to tactile feedback, sound feedback can be adopted; however, sound feedback can be additional stimulus besides game sounds.

5.2.3 Experiment

We first describe the experimental game application and parameters, and specify the hypotheses. Last, we explain the methods of the experiment.

System design

Our system is roughly divided into two parts. One is the *UI part*, which creates all the visual effects of the game. This part draws the image of the apparatus in the game and the player-character model, which is connected with the movement of the player as captured by the Kinect. The other part is the *physical controller management part*, which provides the player with tactile feedback and receives the data wirelessly from the sensor attached to the physical controller.

These two parts use socket communication. The *UI part* sends the direction of a missed ball to the *physical controller management part*, while the *physical controller management part* sends the acceleration value of the sensor to the *UI part*. Figure 5.7 shows the development environments.

UI Part The *UI part* draws 3D models such as the player-character, the ping-pong ball, the table and the racket, and it enables the operation of the player-character by tracking the bones of the player using the Kinect. This part is implemented in Unity. The physical simulation and collision detection were primarily processed by Unity, but a ball sometimes did not rebound after colliding with the racket, and thus we wrote the program to prevent this case.

The function of displaying visual feedback is also implemented in the *UI part*. Four transparent lozenges are mapped to the four directions (up, down, left, right) in the game. Visual feedback is presented by blinking the lozenge that corresponds to the direction of a ball missed by the racket. Those lozenges move in conjunction with the racket in the third-person perspective mode and are fixed ahead of the player-character in the first-person perspective.

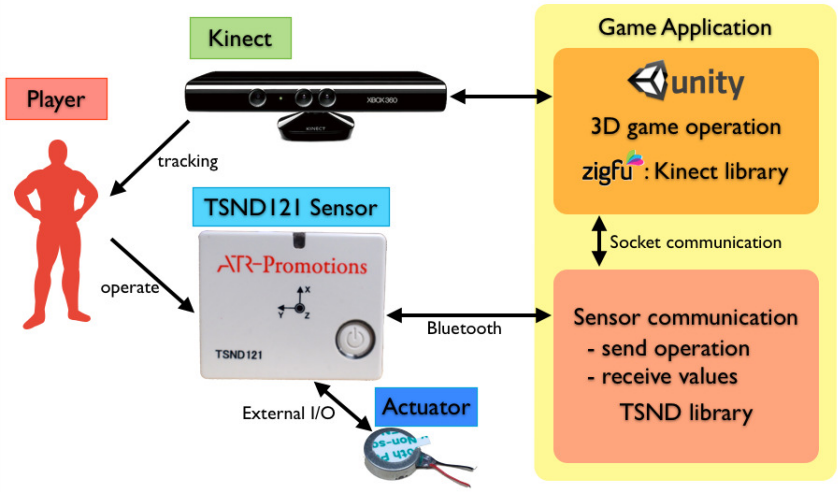


Figure 5.7: System Architecture

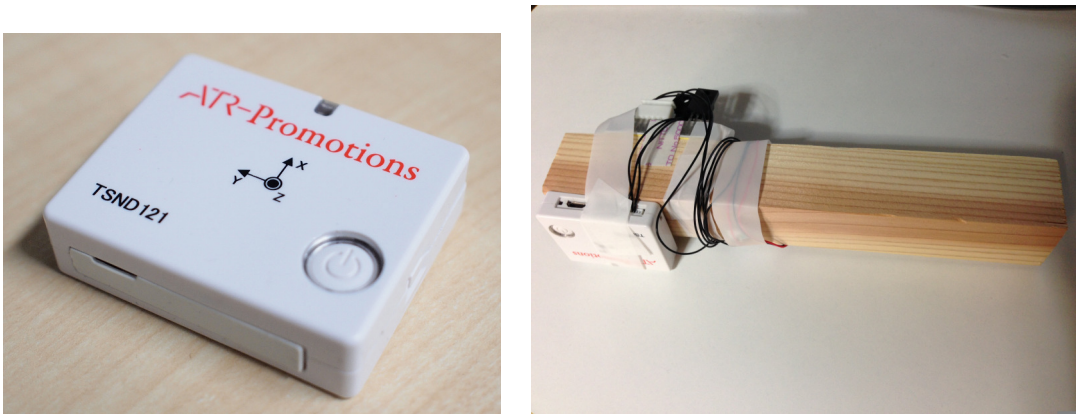
Two sockets are arranged to communicate with the *physical controller management part*. One sends the identifier representing the direction in which a ball missed. The other receives the acceleration value data from the sensor attached to the physical controller.

Physical Controller Management Part The *physical controller management part* communicates with the physical controller via Bluetooth modules to send commands to and receive measurement values from a sensor. This part is written in C++ and includes the sockets needed for communicating with the *UI part*. Vibration patterns are defined in this part and used by a command to drive a motor when a symbol corresponding to one of the four directions arrives.

Physical Controller The physical controller (Figure 5.8b) has two functions: to detect the tilt angles of the controller and to provide the player with vibration feedback. A TSND121 sensor (Figure 5.8a) developed by ATR-Promotions[2] and an external circuit including a vibration motor are attached to the controller. The form factor of the controller is approximately 30 mm (W) × 200 mm (H) × 75 mm (D).

We used a TSND121 sensor (Figure 5.8a) developed by ATR-Promotions to implement the two functions. TSND121 is a Bluetooth-enabled sensor developed to measure a person's movements. This sensor has the proper functions for our experiment and is suitable for working with the controller in terms of size and weight. The weight of the sensor is approximately 22 g and the form factor is 37 mm (W) × 46 mm (H) × 12 mm (D). In addition, this sensor has multiple sensors including an accelerometer and a gyro sensor and external I/O ports that can be used for additional devices.

[2]ATR-Promotions, Kyoto, Japan (http://www.atr-p.com)



(a) TSND121 Sensor (b) Controller

Figure 5.8: Physical Controller

A vibration motor is connected to the external I/O ports of the sensor, and the motor can thus be driven by an external transistorized switching circuit when the signal from the port becomes "1" (5 V).

Parameters of the experiment

We specified two parameters related to a motion video game incorporating a physical controller: the perspectives in the virtual (game) world and the type of feedback that reflects the events of the game.

Perspectives Perspectives represent how the player sees the world in the game. We prepared two perspectives in the game: the first-person perspective and the third-person perspective. The first-person perspective is similar to human eyesight and the body, except for the right arm of the virtual table tennis player, is thus invisible in the game. The third-person perspective includes a larger viewing range and corresponds to the view of a camera located behind the virtual player.

In the *UI part*, perspectives are expressed by adjusting the camera position and viewing angle in the 3D environment. Perspectives can be switched quickly using a checkbox when a condition is changed.

Feedback During play in the experimental game, the participants received feedback indicating the direction of a missed ball relative to the location of the racket at that time. This feedback was in the form of either visual or tactile feedback (vibration).

The tactile feedback was designed based on the tactons proposed by Brewster et al. [11]. Tactons can be constructed using multiple characteristics such as amplitude and frequency. Tactons can be structured to deliver abstract messages to communicate complex concepts nonvisually [11].

Identifier	Perspective	Feedback
1-Vis	First-person	Visual
1-Vib	First-person	Vibration
1-N	First-person	None
3-Vis	Third-person	Visual
3-Vib	Third-person	Vibration
3-N	Third-person	None

Table 5.8: Conditions

We believed that tactile feedback could reduce the load of recognition tasks in a game involving many visual representations. We designed simple tactons to represent the direction of a ball missed by the virtual racket. The vibration patterns consisted of the duration and number of vibrations (Figure 5.10). The vibration durations were varied enough to recognize the difference in their lengths, and the absolute length of time was not specified.

For comparison, we also implemented visual feedback. Visual feedback was provided to the participants by a blinking diamond-shaped area corresponding to the direction of a missed ball (Figure 5.9).

Hypothesis Based on the parameters described above, we formulated hypotheses for the result.

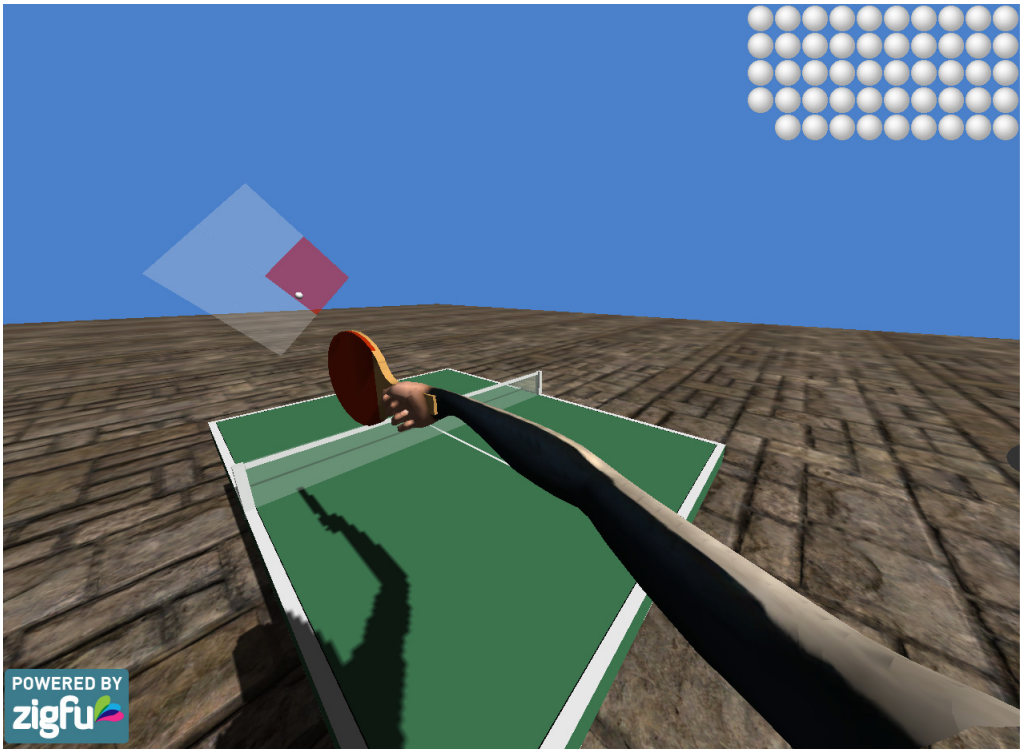
H1 The first-person perspective increases the hit rate of the player compared to the third-person perspective Although the type of game is different, referring to Rouse Ⅲ's work [57], users can hit a ball more precisely in the first-person perspective than in the third-person perspective. As a result, the first-person perspective can increase the hit rate of a session.

H2 Vibration feedback can reduce the load of a player while also supporting play Tactile feedback can be delivered through channels other than vision. That is, games can overload the player with visual information, and tactons can therefore provide hints and facilitate more precise hits by the player without making the player feel too busy.

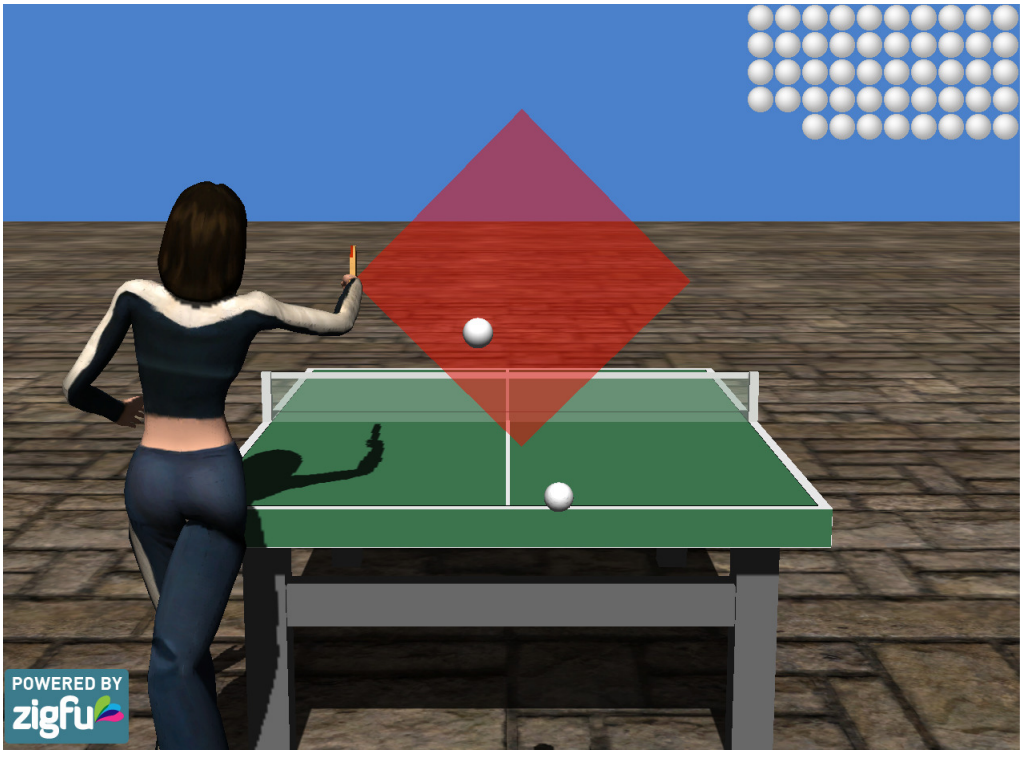
User study

We experimented with six feedback and perspective conditions to compare the performance of play, ease of use and understandability. Nine right-handed male participants ranging from 18 to 22 years of age (one participant's age was unknown) were recruited and asked to play the table tennis game under the 6 conditions.

Conditions The conditions consisted of combinations of two perspectives and three feedback types. The perspective was first or third person and the feedback type was visual, tactile (vibration) or no feedback (Table 5.8). The participants experienced all of the con-



(a) First person



(b) Third person

Figure 5.9: Visual Feedback

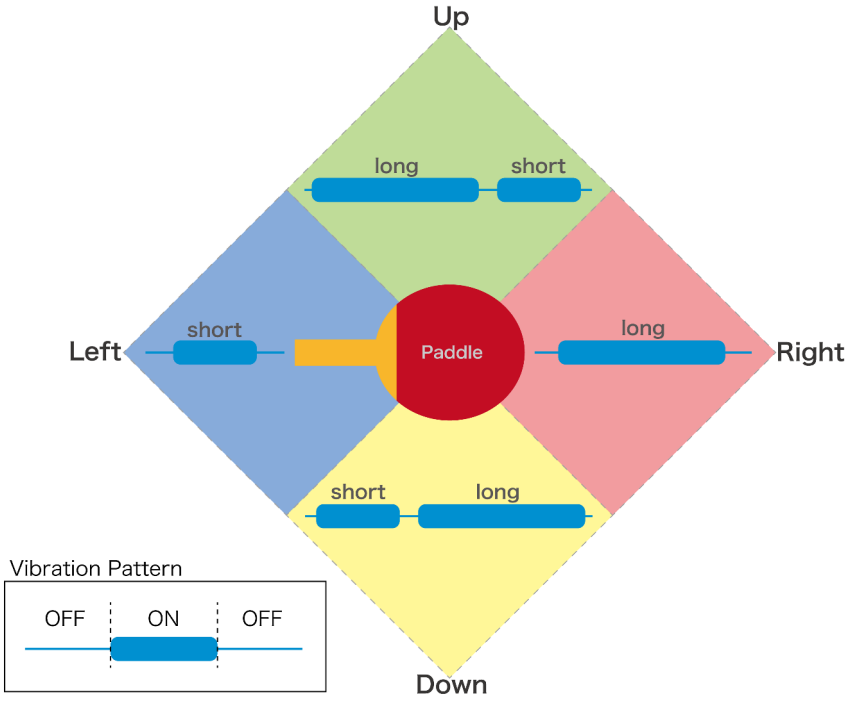


Figure 5.10: Vibration Feedback

Session1	Session2	Session3	Session4	Session5	Session6	Participants [persons]
1-Vis	1-Vib	3-N	1-N	3-Vib	3-Vis	1
1-Vib	1-N	1-Vis	3-Vis	3-N	3-Vib	1
1-N	3-Vis	1-Vib	3-Vib	1-Vis	3-N	2
3-Vis	3-Vib	1-N	3-N	1-Vib	1-Vis	1
3-Vib	3-N	3-Vis	1-Vis	1-N	1-Vib	2
3-N	1-Vis	3-Vib	1-Vib	3-Vis	1-N	1

Table 5.9: The number of participants and corresponding order of conditions

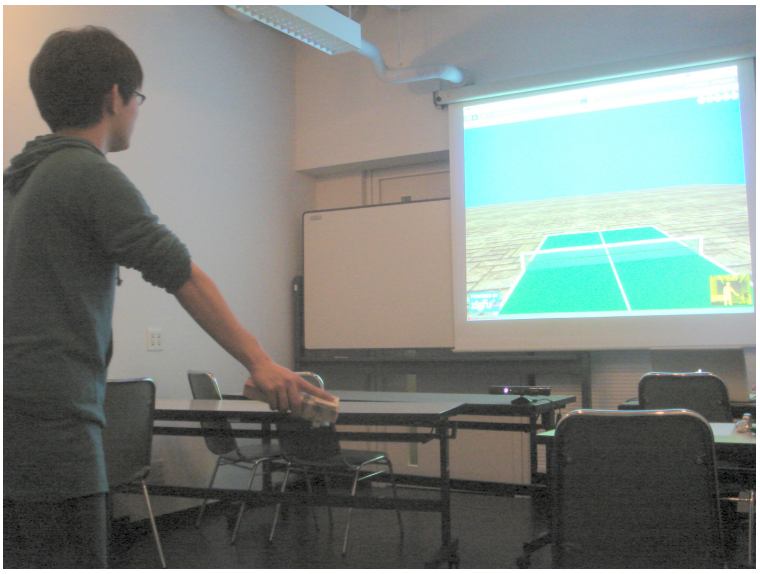


Figure 5.11: Experiment

ditions in order (Table 5.9) according to an incomplete counter-balanced measures design [62].

Procedure This experiment consisted of three parts. In the first part, the participants were instructed in the manner of play and given important notices. After the introduction, the participants encountered at least 10 balls in each perspective (first and third person) as a training session for the game. This number of balls was increased for participants who had trouble.

The main session was the second part of the experiment (Figure 5.11). The participants' task was to attempt to hit 20 balls traveling from the launcher in front of the character in each session. Although no score system existed, the number of hits was recorded internally. After each session, the participants were asked to fill out the part of a questionnaire corresponding to the condition they had just finished. When a problem related to the

Condition	1-Vis	1-Vib	1-N	3-Vis	3-Vib	3-N
Mean	3.125	3.250	3.000	2.667	3.222	3.222
Median	3	3	3	3	4	3

Table 5.10: The Mean and the Median Operability Score for Each Condition

Condition pair	1-Vis/1-Vib	3-Vis/3-Vib	1-Vis/3-Vis	1-Vib/3-Vib	1-N/3-N
p-value	0.7514	0.3023	0.3596	0.9508	0.6127

Table 5.11: Condition Pairs and p-values of t-tested Operability Scores

behavior of the game occurred, the session was retried, and the total number of balls was increased. However, we considered 20 balls with as little noise as possible.

In the third part, after the previous two sessions were complete, the participants were asked to complete the remaining parts of the questionnaire.

5.2.4 Results

We investigated the effect of each condition on operability and understandability during play. In the questionnaire, we asked the participants to rate the operability of the experimental game (represented as "operability") and the understandability of presentation in the game (represented as "understandability").

Figure 5.12a shows the results of the operability ratings and Figure 5.12b shows the understandability ratings. The cited sentences from the participant's open-ended answers were translated to English, and "Pn" represents "Participant#n"

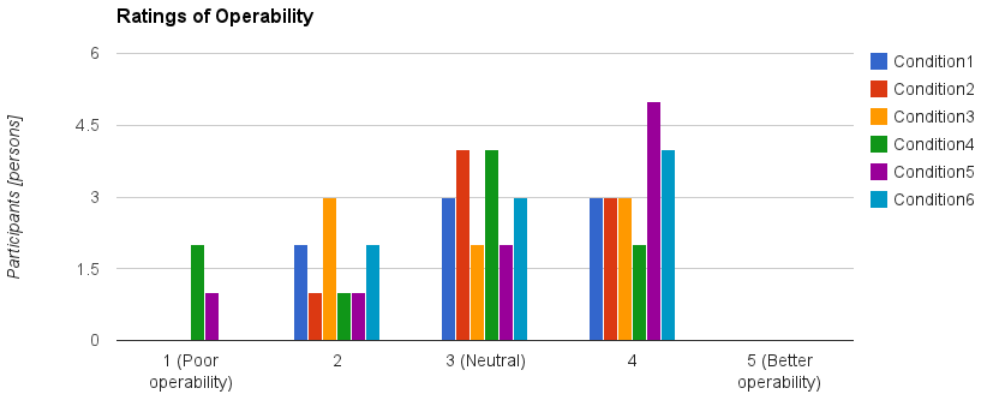
Table 5.11 shows p-values of t-tested condition pairs. The 1-Vis/1-Vib and 3-Vis/3-Vib pairs are used to examine difference between the visual and the vibration feedback. The 1-Vis/3-Vis, 1-Vib/3-Vib and 1-N/3-N pairs are for difference between first and third -person perspectives.

Performance

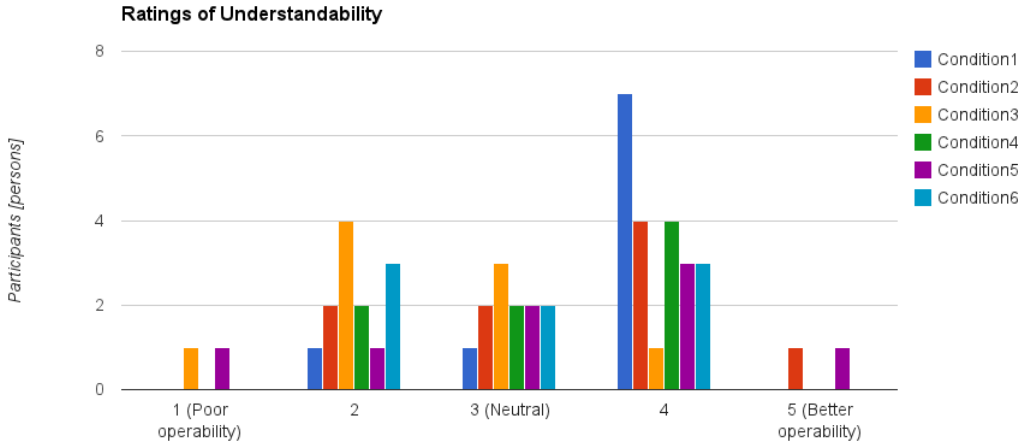
Figure 5.13 shows the hit rates for each condition. No specific relationship between the hit rates and conditions was identified. In addition, although some participants who mentioned habituation during the game, higher hit rates were not observed for the later conditions.

Operability

Table 5.10 shows the mean and median scores for each condition. For the mean score, condition 1-Vib (first person, tactile-feedback) scores had the highest values (3.250), followed by conditions 3-Vib (third person, tactile-feedback) and 3-N (third person, no-feedback) at 3.222. With the exception of the no-feedback conditions (1-N, 3-N), the mean scores for the first-person perspective mode were higher than those for the third-person perspective



(a) Operability



(b) Understandability

Figure 5.12: Ratings

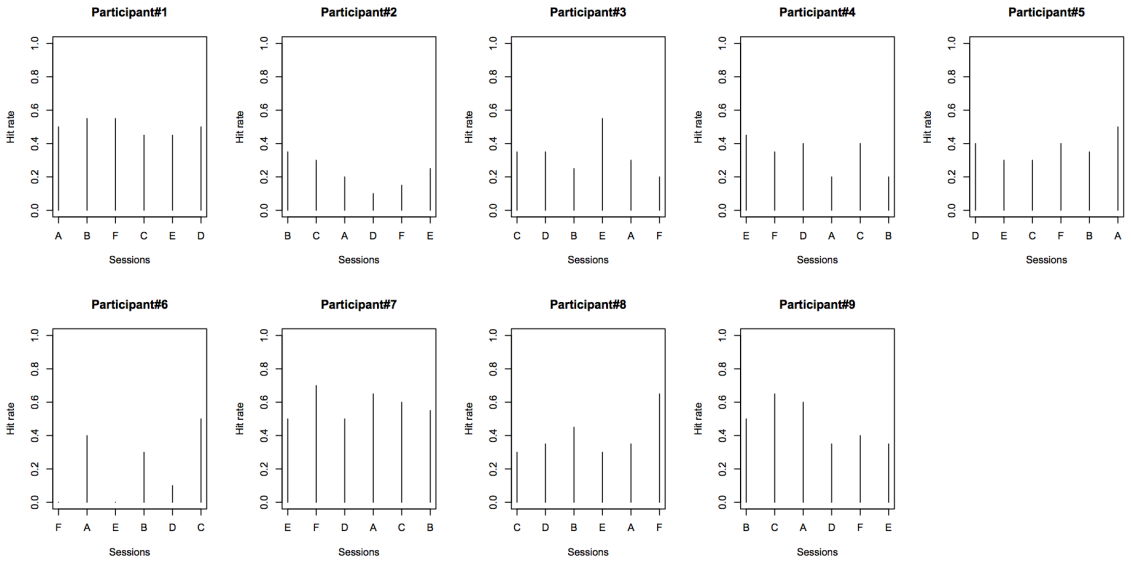


Figure 5.13: Hit Rates

mode. For the median score, only condition 3-Vib scored "4", and all other conditions scored "3".

Among the first-person perspective conditions, the most common score was "3" (Neutral). In the condition 1-N, identical numbers of subjects scored "2" and "4". As observed in Table 3, the mean score of the condition 1-Vib was highest at 3.250.

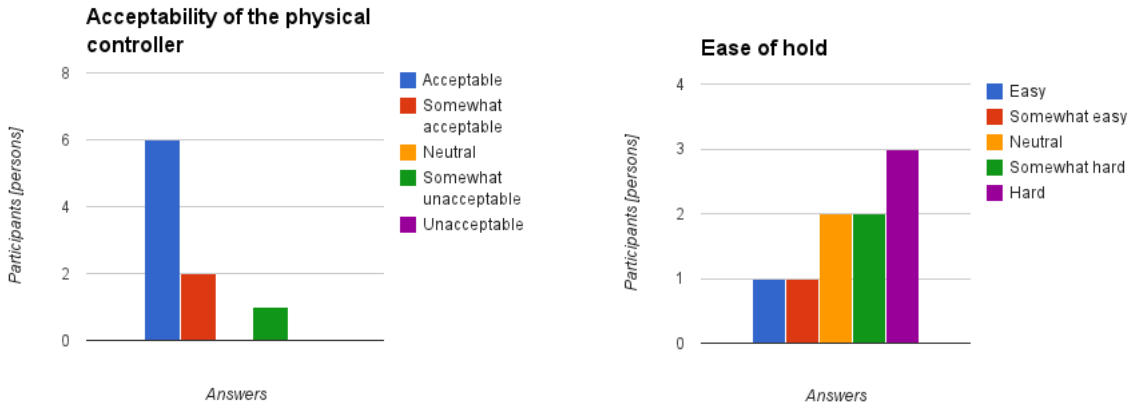
As for the third-person perspective conditions, scores in the condition 3-Vis was varied. The most common score was "3"; three subjects scored "1" or "2", while two subjects scored "4". In the condition 3-Vib, five subjects scored "4", which demonstrates that they felt that the tactile-feedback mode was most operable in the third-person perspective. Finally, the mean score in the condition 3-N was the same as that in condition 3-Vib (3.222).

As described in hypothesis H1, we expected that the first-person perspective would be more appreciated than the third-person perspective because players can generally become good at precise manipulation in the first-person perspective [25]. However, there were little differences between the first and third -person perspectives (1-Vis/3-Vis, 1-Vib/3-Vib and 1-N/3-N pairs in the Table 4).

Feedback

In this section, each type of feedback was compared to other combinations, and the necessity of a physical controller was considered.

Visual feedback Five participants left positive comments about the visual feedback, although no clear tendency among the conditions in which the visual feedback was incor-



(a) Acceptability (b) Ease of hold

Figure 5.14: Impression of the Controller

porated could be identified. For example, Participant # 5 said that he could confirm the points through which the ball had passed. Conversely, other participants said that the visual feedback was unclear.

Vibration The simplicity and the inexperience with tactile feedback suggest the little difference between the visual and tactile feedback (The 1-Vis/1-Vib and 3-Vis/3-Vib pairs in the Table 5.11). The number of scores greater than or equal to four points was higher than the number of two-point scores under all conditions that incorporated vibration feedback. Conversely, three participants' comments suggested a problem with the feedback. For example, one comment was, "It is difficult to understand the meanings of the vibration feedback immediately", while another stated, "Faster responses are desirable for the vibration feedback". Although these comments may contradict hypothesis H2, a player can still accept tactile feedback.

Physical Feedback Needs Figure 5.14 shows the acceptability and ease of use of the physical controller.

The limitation of the manner in which the controller was held suggests a negative effect on the participants' impression. For ease of use of the controller, five of the nine participants indicated "Hard" or "Somewhat hard" (Figure 5.14a). The cause of this limitation was mainly technical issues, such as the recognition precision of Kinect and the shape of the controller.

The combination of a gesture-based game and a physical controller suggests the possibility of use, in agreement with the work by Freeman et al. [23] The existence of the controller was accepted more often because eight of the nine participants chose "Acceptable" or "Somewhat acceptable" (Figure 5.14b).

Presentation

The participants gave three opinions about the presentation of the game.

The first opinion was that recognizing the distance from the player-character to the ball was rather difficult. This problem may have arisen because grasping the length of the player-character model's arm takes time.

The second opinion was that aiming for the ball was difficult because of the fading of the racket and the hand of the player-character when the participants moved the hand back in the first-person perspective mode.

This problem might have been due to the reduction in proprioception [42] as the hand of the player-character become invisible to the participants. Pointing the camera at the ball as the ball approaches the player-character instead of fixing the direction of the camera could solve this problem.

The third opinion was that the image of the player-character often obscured the emerging point and the trajectory of the ball.

Although there are isometric and linear third-person perspectives [16], we adopted a linear third-person perspective and set the camera behind the player-character so that the direction between the player-character and the table was the same as the direction between the player and the screen. As a result, the ball was hidden when it was between the camera and the player-character.

Two countermeasures to this problem are possible. One is to have the player move from side to side to secure a wide view until the ball emerges. The other is to make the player-character model translucent.

5.2.5 Limitations

We had technical and presentation issues that can affect the usability. From the comments provided by participants, we describe limitations in our prototype application.

Firstly, the representation in the game had unnaturalness. Due to the representation of perspectives, some users had difficulties in aiming balls. For example, the racket and the hand of the player-character were hidden when the participants moved the hand back in the first-person perspective conditions. This problem might have been due to the reduction in proprioception [42] as the hand of the player-character become invisible to the participants. Pointing the camera at the ball as the ball approaches the player-character instead of fixing the direction of the camera could solve this problem.

Secondly, although there are isometric and linear third-person perspectives [16], we adopted a linear third-person perspective and set the camera behind the player-character so that the direction between the player-character and the table was the same as the direction between the player and the screen. As a result, the ball was hidden when it was between the camera and the player-character. Two countermeasures to this problem are possible. One is to have the player move from side to side to secure a wide view until the ball emerges. The other is to make the player-character model translucent.

In addition, the mapping between actual orientation of the controller and 3D representation in the game was affected by noises. This problem was caused by the Kinect's

misinterpretation of the player's wrist and hand when the player's wrist was pulled ahead of the hand. This problem also occurred when the TSND121 sensor attached to the controller rotated such that either the roll angle or the pitch angle was greater than 90 degrees. In that case, the player-character's wrist behaved strangely.

5.3 Design Implications

We will describe design implications for gesture-based applications based on the results described in the previous section.

5.3.1 A combination of modalities can be exchangeable

From the results in acceptability of the physical controller, a part of assistances for user movement can be migrated to another modality such as haptic one. In a motion video game which incorporates physical gestures, holding the posture of the player-character and the game objects (e.g. a racket) stable is more difficult than in conventional mouse-, keyboard- and gamepad-input games.

When a vibration pattern is used for conveying messages instead of expressing reality, the learning time must be considered. Brewster et al. [12] have examined the recall rate of earcons, which support traversing the file system hierarchy. The participants had 5 minutes to memorize the earcons on their own. Although the modality of earcons and tactons differs, carefully designed tactons can be learned quickly [11]. In our case, the process of learning tactons was simplified. That is, the participants were given a limited time interval for learning, but the length was not fixed and depended upon the participant's decisions. In addition, the participants were asked to view a diagram illustrating the tactons' vibration patterns instead of learning through actual gameplay.

Still, a player tends to make rapid-discrete movements at a shorter viewing distance [5]. Thus, our participants might not have had sufficient time to estimate the trajectory of a ball due to the short time interval between appearance of the ball and attempting to hit it. Hence, some participants could not behave as they expected.

5.3.2 Freedom in perspectives can enable the flexible virtual experience

The results from player operability impressions suggest the potential of versatile expressions in an application. For example, Morrison and Ziemke [44] explained the existence of responses coupled with perceptual information called "emotion" in the third-person perspective. Thus, certain games can be designed by incorporating either of the perspectives suitable for the production.

When visual perception can tolerate difference between virtual and real worlds, virtual experiences can be flexible reducing degradation of performance of a user. For example, Kohli et al. explored "discrepancy" in the mapping between a virtual object and a physical display in terms of hand movements [36]. They developed a system which incorporates with a motion tracking of a user's finger and a head-mounted display for presenting a virtual

environment. They have shown that the discrepant condition can yield performance as well as the one-to-one condition.

5.3.3 Summary

To explore the balance between physical and virtual aspects, we focused on perspectives in the game and feedback. These properties correspond to virtual and physical characteristics. We developed a prototype table tennis game incorporating a physical controller that simulates a table tennis racket and asked participants to play the game under each of the conditions.

Based on the results of our experiment with the table tennis prototype, we have formulated design implications for gesture-based application. First, "a combination of modalities can be exchangeable". That is, a part of feedback can be migrated as another modality. The second implication is that "freedom in perspectives can enable the flexible virtual experience", suggesting the potential of versatile expressions in an application.

Chapter 6

Case Study 3: Preference-Based Internalization

We describe two case studies in this chapter. The first case study is related to the relationship between user's preference of an agent and impression of persuasion. In this study, we let a part of users choose his/her favorite agent and converse with the agent. The main focus of second case study is interaction between an object and a user. We used personification of a daily object and present it as an agent.

6.1 PBI1: Persuasion from favorite agents

Whether a user credits a computer or not also influences on outcomes of persuasion from the computer; for example, B. J. Fogg have described credibility in persuasion [21]. We will use "trust" as the same meanings of "credibility". According to B. J. Fogg, "trust" can be used as both "credibility" and "dependability" depending on contexts. Besides, these words can be distinguished by replacing "trust" with "believability" and check if the replaced word matches the meaning of the sentence [21]. Thus, when users provide their information or have an important transaction believing computers, we can use the word "trust" as the meaning of "credibility".

Credibility can be used as a clue of whether one can believe computers or other individuals. For example, credibility which is called *surface credibility* is one of four types of credibility described in [21]. This kind of credibility comes from first impression of surface traits such as appearance [21].

A room for discussion of making users' impression of computers better in an aspect of credibility still exists. Attempts of giving users favorable impression have existed and the discussed agents have varied from text-based to graphical ones (for example, [7] has summarized related work). In addition, a computer system which user can choose and interact with his/her favorite agent also exists [33]. However, a comparison between the case an agent can be chosen by a user and an agent is fixed regardless of a user's preference can give a profound aspect. That is, if the agent just meets a user's preference or a character

from a user's favorite anime or games, s/he is expected to interact with the agent with eagerly by enhanced persuasive effect.

In our research, we examine a degree of persuasiveness of conversation with an agent considering two cases. One case is that a user can choose an agent according to his/her preference and the other is that a user can not choose his/her favorite agent.

We constructed an agent system using existing software and conducted an experiment using our system. In the experiment, we asked male participants who belong to one of four groups combining two different conditions to talk with a female agent; after the conversation, we interviewed them about the talk with the agent.

Based on the results of the experiment, we will also discuss an effectiveness of reflecting preferences of a user to selection of an agent; in an aspect of designing credible persuasive computer systems which incorporate with agents.

6.1.1 Related work

In this section, we introduce related work on an agent and discuss the relationship with our case.

An appearance of an agent

Zanbaka et al. have examined effect of gender and appearance of a virtual agent as a persuader [76]. In this research, an experiment has been conducted where three kinds of agents persuade users about the same topic. One agent is a picture of a real person (human), another is a CG based human-like agent (virtual human) and the other is a CG based not-human-like agent (virtual character).

As a result, a user has been more persuaded by an agent with different gender than with same although significant effects of appearance and gender on persuasion did not exist. In addition, although users had positive impression toward the virtual agents, a virtual character can be perceived as bolder than other types of an agent.

Affiliation need

Katagiri et al. have mentioned a need to establish and maintain affinitive relationships with others, called as affiliation need. They have examined construction of relationship between an agent and a user based on affiliation need using an exhibition guidance system incorporates with an agent [33]. With this system, a user can receive explanations and recommendations of exhibition transferring an agent from his/her portable device to an information terminal besides the exhibition.

A user can choose his/her favorite agent out of nine kinds of agents. An agent tells the user that it will wait for him/her at the exhibition which has been recommended by the agent after the fourth visit to exhibitions. If the user goes to the recommended exhibition, the agent appreciates him/her; on the other hand, if the user does not, the agent complains about it. The study has confirmed whether these reactions of the agent induce affiliation need from the user and affect later behavior of the user.

Consequently, the result has showed that those who had visited more than four exhibitions had changed their behavior after the fourth visit. In this experiment, participants have been divided into two groups and asked to walk around the exhibitions using the guidance system. Each member of one group finished after four visits of exhibitions while a member who belongs to the other group was able to visit more than four exhibitions. Although they have said that they need more participants in order to obtain statistically clearer results, they concluded that the interaction from the agent had had an effect on behavior of a user.

6.1.2 Prototype design and materials

We conducted an experiment in order to examine how will a user responds to an agent when we let them choose their favorite agent. Before the study, we constructed a conversation system which incorporates with an agent and interacts with users. We will describe details of this system in this section.

System diagram

Figure 6.1a shows an overview of our conversation system. A user can have an oral conversation with a virtual agent which can speak in synthesized voice. An appearance of an agent and speech were presented in a wizard-of-oz style. More precisely, an agent was controlled by gestures of the researcher using a Kinect and the each sentences of speech were stepped by key input on a shell.

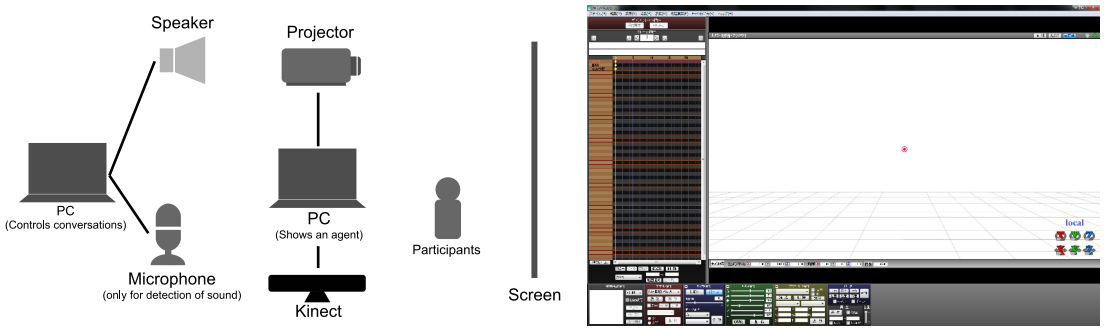
An agent and the speech components were deployed on different computers separately because of the difference of operating systems. An agent was controlled via a PC on which Microsoft Windows 7 was installed and the speech was generated on a virtualized Debian Linux (Squeeze) environment of another computer.

Agent

An agent was a 3D character which has been generated by software which is called as MikuMikuDance (MMD) [1]. The MMD has been originally developed a software tool to enable authors to generate a music video using 3D virtual character with synthesized vocal and music notes; the appearance of the MMD is shown in Fig. 6.1b. We chose a Kinect to control behaviors of an agent by gestures using a plugin[2] instead of programming numerically.

We used 3D character models bundled with books which were published by Shinyusha featuring the MMD. Such models have been provided by many people sometimes based on anime characters or games and they can be loaded to the MMD.

[1] http://www.geocities.jp/higuchuu4/index_e.htm
[2] http://www.xbox.com/ja-JP/kinect



(a) An overview of the conversation system (b) An appearance of the MMD

Figure 6.1: System overview

Conversation

The speech of an agent was synthesized by OpenHRI [3]. This software is a collection of components for Human Robots Interaction including speech synthesis and recognition. We used the speech synthesis feature based on Open JTalk[4], which is supported in the OpenHRI.

We prepared a component which receives text input from a shell and command speech related components in order to generate synthesized speech. The OpenHRI provides each features such as speech recognition or speech synthesis as components. These components can be connected to each other graphically via an input port and an output port using RT System Editor which was installed on Eclipse.

Our speech generator consists of components shown in Fig. 6.2. We prepared the *ConsoleIn* component in order to receive keyboard inputs and provide the next component with keywords so as to control a flow of a conversation manually because we adopted wizard-of-oz style instead of speech recognition as a conversation management method. This component was written by Python and based on sample code which is provided on OpenHRI's web site. The conversation was managed by the *SEAT* component using state transition model and each states correspond to statements which an agent speaks at once. It receives text keywords and executes commands associated with the keyword. In our case, the command was sent to the *openjtalkrtc* component and then speech sounds generated from the speech script were emitted via *pulseaudiooutput* to the speaker.

We chose a female voice because all of the character models we had prepared were female and we used the same voice for all characters. The conversations are constructed partially based on social dialogue [60]. For example, we used "empathetic statements" (line 3 in Fig. 6.3b) and "prompting for self-disclosure by the participant" (line 5 in Fig. 6.3b).

The microphone was used only for indicator of sound levels because the researcher attempted not to hear the speech of a participant in order to let them talk without pressure.

[3] http://openhri.net/?lang=en
[4] http://open-jtalk.sourceforge.net

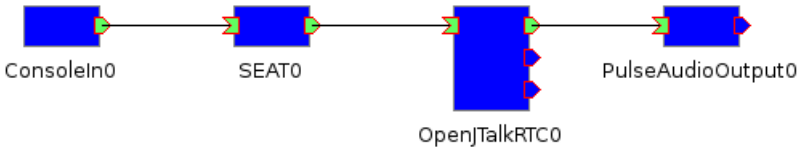


Figure 6.2: A system diagram of conversation system

6.1.3 User study

An experiment consists of three parts. These parts include a pre-questionnaire, a conversation session with an agent and an interview.

Participants and tasks

We recruited 6 participants (5 Japanese, 1 Chinese) and divided into four groups according to two conditions (Table 6.1). One condition is whether a participant can choose his/her favorite agent from the book (A) or not (B); the other is whether s/he has a specific favorite character, game or anime regularly (1) or not (2). As the table 6.1, we named each groups as combination of an alphabet and a number; for example, the group whose members do not have specific preference (2) and they can select their favorite agent (A) is group A-2. One participant could not fully understand the content of the conversation and we inquired mainly the impression of the agent and imaginary-based opinion.

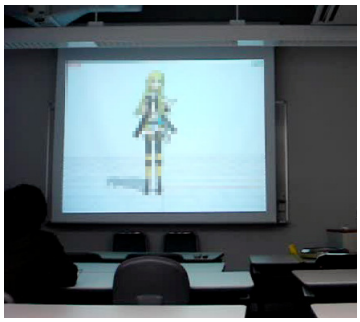
Gender of the participants was unified to be male so as to exclude an effect of difference of participants' gender. All of the agents were female and according to Zanbaka et al., female speakers are more persuasive toward male participants than male speakers [76].

In the main study, each participants had conversations related to exercise with an agent (Fig. 6.3a). The conversations took place in Japanese and look like Fig. 6.3b as an English translated form.

Table 6.1: Groups of the participants (the unit is [person(s)])

	(A) [person(s)]	(B) [person(s)]
(1)	3	1
(2)	1	1

During the conversations, the researcher heard music via earphones in order to hide the details of the participants' talk letting them talk more naturally.



(a) A conversation session

A: An agent / **B**: A participant
***** or **--** : variable parts
Sentence no. from 13 to 16 are conditional branch

1. A: Hello, my name is --. Nice to meet you.
2. B:*****
3. A: Thank you for coming all the way here. I'm glad to see you.
4. B:*****
5. A: What is ** san's hobby?
6. B:*****
7. A: That's great! Please tell me more next time!
8. B:*****
9. A: I like music. I often listen to especially classical music.
10. A: Well, let me move to the main topic. Today I'd like to talk about exercise, all right?
11. B:*****
12. A: By the way, do ** san exercise regularly? Say, walking, cycling...
13. B: 1. Yes, 2. Sometimes, 3. Not so much
14. A1: Really? Then you must be healthy!
15. A2: Well, do you walk or ride a bike? I heard that your brain become active if you change your route to different one. You may come up with new idea.
16. A3: Well, do you know this story? Your brain becomes active if you have some exercise. You may be able to refresh your mind and spend comfortable time if you exercise weekend.
17. B:*****
18. A: Come to think of it, exercising reduces your stress and improves depressed feelings.
19. A: Exercise is surprisingly good for mental side. Have you refreshed when you get some exercise?
20. B:*****
21. A: I also started to walk as refreshment these days.
22. A: And then, I'm becoming fond of walking where I haven't been to and I found a nice cafe the other day.
23. B:*****
24. A: Oh, sorry, I have to go out. Although I can talk with you for short time, I will appreciate if you remember what I said.
25. B:*****
26. A: See you again!
27. B:*****

(b) The script of conversations

Figure 6.3: Conversations with an agent

Interview

Participants were asked to give an open-style interview with the researcher about the conversation and the agent after the conversation. In the interview, we firstly asked participants to tell us about the entire conversation freely and then we interviewed them according to following topics.

- How did you feel about the conversations with the agent?
  - The length and timing
  - The voice of the character
  - The manner of speaking
  - The gesture
- Did you really like the agent? Why?
- Did you have a interest with the exercise? Why?
- Do you have a favorite character?

6.1.4 Results and discussion

In this section, we will show the result of the experiment and discuss them. We will use fragments derived from comments of participants and these are edited for explanation.

Conversation with an agent

From the results of the experiment, five participants felt the speech of an agent was unnatural. Such perception relates to all of or a part of the timing, the voice quality and the manner of speaking. For example, longer time lags or overlaps between speech of a participant and an agent have occurred. This was mainly because of manual conversation control without hearing the participant's talk. Besides, according to four participants, intonations of the speech was "machine-like". One participant could not understand the pronunciation enough.

Synthesized voice can have a negative effect on credibility of an agent with less reduction of persuasive effect. However, if we can increase credibility of agents using characteristics such as a visual appearance or a personality, negative effects of synthesized voice can be reduced. As for perception of synthesized speech, Stern et al. have compared synthesized speech and human speech. Their results have shown that synthesized speech was rated less knowledgeable and truthful. However, in terms of the persuasion, a significant difference between human speech and synthesized speech did not exist [65].

Favorableness of an agent

In an aspect of the favorableness of an agent, a significant difference between the groups was not found. One of members of the group A-1 said that "Although I am not fun of a specific character, the agent which I have selected was favorable". On the other hand, a member of group A-2 said that "I did not feel especially about the agent". These results suggest that users' regular preference does not significantly affect the immediate favorableness of an agent. We still have to examine other characteristics such as a personality and a voice of an agent in order to reduce unnatural impression from a user.

Other comments from four participants suggested the possibility of positive impression by a selectable character. We asked the participants how they thought that they can choose their favorite agents; as for those who are in group B, we asked them to imagine the situation. In addition, we also asked them what they think if an agent of our conversation system were replaced by their "regular" favorite characters of games, anime or any other media. Comments we received were "I am not feel like talking with the agent if she were not my favorite", "Choosing from many agents was difficult. But if I could not choose an agent, she may make me less impressed" and "I did not have special feelings toward the agent this time, but I may listen to my favorite character more". On the other hand, one of members of group B told us that he will have same feelings even if he could choose his favorite agent.

Persuasiveness of an agent

Two participants were affected by the agent's persuasion. Both of them had chosen "I do not exercise regularly" on the pre-questionnaire about exercise. One participant said that "I have got to know new facts about exercise and I may remember them and exercise someday". On the other hand, four participants were not persuaded. The comment of such participant was "I will not change my behavior unless I start a conversation with an agent on my own will".

This result suggests relationship between a topic of a conversation and participants' current exercise behavior have to be considered while the experiment with significant number of participants is expected. Specifically, we did not assign the participants to a group according to exercise behavior of them; in addition, the conversation which we have prepared contained same persuasion for all participants except for a conditional branch on lines from 13 to 16 in Fig. 6.3b.

Each option of the questionnaire about exercise can refer to a behavior model. According to Prochaska et al., behavior can be divided into five stages from *precontemplation* level to *maintenance* [54]. Among these stages, precontemplation is a stage for those who do not intend to change their behavior and contemplation is for those who are seriously considering changing their behavior. In addition, different processes of change are needed in order to move from one stage to another smoothly. For example, giving information about a target behavior to a precontemplation or contemplation individual is *consciousness-raising*. Informing participants of positive aspect of exercising can be consciousness-raising for those who answered "I do not exercise regularly" to our questionnaire; however, not to those who exercising regularly.

6.1.5 Summary

We discussed an effect of letting a user choose his/her favorite agent on behavior of the user. In addition, we also conducted an experiment constructing an agent system with which a user can have a conversation to examine the effect of a favorite agent.

In the study, we divided participants into four groups according to two conditions. One condition was whether a participant can choose his favorite agent and the other condition was whether a participant has a "regular" favorite characters, game or anime in his/her daily life.

As a result, making an agent selectable by a user according to his/her preference has a possibility of increasing credibility of an agent system. However, we still have to adopt personalities, voices and the contents of conversations to the appearance of an agent in order to reduce unnatural feelings from participants.

6.2 PBI2: Personification

Due to the advance in computer technologies, the physical world in which we live is coming closer to the virtual worlds generated by computers or media. For example, information can be superimposed onto the real world using a head mounted display (HMD), and people

can see their achievements in exercising using a pedometers and a smartphone. Computers can add additional value to our daily lives by enabling users to have new experiences that could not be realized only in the physical world in which they live. Therefore, we focus on computers that can provide users with awareness of a specific issue in their daily life with a certain amount of "unreality".

A computer application can incorporate a virtual character (agent), and an agent often adopts nonverbal behaviors such as facial expressions or gestures. Their functionalities including visual characteristics and behaviors have been discussed by researchers in the past. Although the design of an agent sometimes refers to human characteristics, people often treat lifeless items as if they are living entities (Ethopoeia [47]) though they do not seem to be living things.

In contrast, people occasionally introduce life-like characters as real-world objects in a personified form. Ranging from classical examples such as fables and mythology to the happy / sad mac icon were shown according to the condition by 1980s and 1990s personal computers released by Apple Computer (the icons are described in [52]), we can encounter various characters. Mascot characters or famous characters from games or anime are occasionally associated with products, services and organizations. Thus, virtual-world scenarios can be carried into the physical world.

Using bi-directional characteristics that bridge the gap between the physical world and virtual worlds, a room for the design spaces of user interfaces exists. In this case study, we discuss the possibility of a virtual agent representing a personified object. The motivation of using a personified agent as a user interface is the emotional effect and expressiveness for virtual representations. Cafaro et al. reported that users form a certain impression of a virtual agent based on behaviors even within a time as short as 12.5 seconds [14]. Virtual agents can also be combined with entertainment. For example, serious games are games whose primary goal is education [41], and they can provide different aspects of issues by using a game user interface [41].

6.2.1 Related work

The existing work attempts to add agency to a physical object. For example, Barakonyi et al. proposed an AR Puppet [4] as an assistant for users. This framework proposed new input and output modalities to make physical objects interactive, and to collaborate with virtual characters. The main difference with our study using Fairy Agent is that we are focusing on the impression of personification of daily objects and the possibilities of applying a personified agent to a user interface.

Kodama et al. proposed an agent as a mediator between a smart environment and a user [35]. The agent can behave as though it moves between appliances and then executes user-requested tasks. This behavior is based on Practical Magic [37] and suggests the possibility of the regulation of disbelief in autonomy by producing the perception of covering tasks instead of smart environment. Although this type of agent can be considered as a personified form of an environment, our focus is mainly on the characteristics of an object, where different agents are supposed to exist in each object, not just in the smart one.

6.2.2 Prototype design

We developed a prototype application named Fairy Agent [75]. Fairy Agent consists of two software components: a client and a data provider. The client corresponds to an application running on a smartphone. This client obtains the data needed to show an agent from the data provider. Therefore, the client does not have to hold all of the data that exists on the data provider at once (Figure 6.4).

Users can roam with an Apple iPhone running the Fairy Agent. A user can interact with an animated agent superimposed onto an object by using touches (Figure 6.5). Wearable devices such as smart glasses could be another option; however, they require special operation methods other than touch display. Although interacting with an object via touch can be a better experience, we did not adopt this method because of the variety of object shapes and ways of interaction.

System diagram

The client runs on a smartphone (iPhone) and shows personified agents to a user according to marked objects in the camera sight. MetaioSDK[5] is used to implement the presentation of a personified agent (Figure 6.5). Personified agents can be animated during the interaction with users.

A user interacts with an agent using a touch display. An agent shows utterances in a balloon on the screen so that a user can proceed with messages from agent touching on a button. Wearable devices such as smart glasses could be another option; however, they require special operation methods other than touch display. Although interaction using touch of an object can be a better experience, we did not adopt this method because of the variety of object shapes and ways of interaction.

Specific terms Relationships between data are shown in the diagram. The data provider sends the required data to the client in response to requests. The “house” represents a residence of an agent and the ”location” represents a specific set of houses. Each combination of an agent 3D model, a script, and a house can be changed for each user.

6.2.3 Materials

Materials are essential for the presentation of personified agents. We use the term “house” to refer to the residence of a personified agent and a house corresponds to an object.

A house includes three types of data: 3D model data for an agent, a message script and a marker. As an entry point of appearance of an agent, we used an image marker (e.g., Figure 6.5). When a marker is recognized, an agent is superimposed on the marker as a 3D character. Users can interact with the agent using text messages from the agent.

Users and places are also defined to handle different users and rooms. Based on this information, each user can have an individual house configuration. This flexibility is prepared for future extensions.

[5] http://www.metaio.com/products/sdk

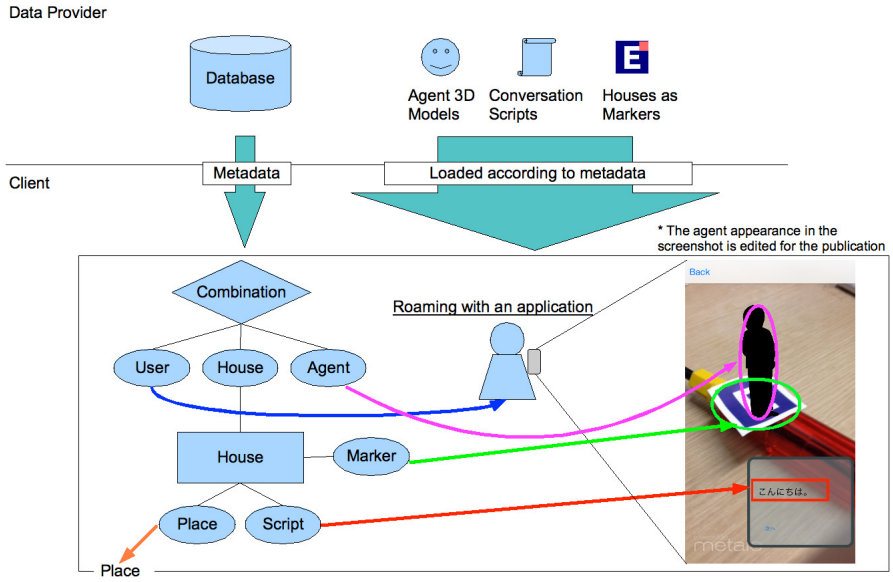


Figure 6.4: Relationships between data and Fairy Agent

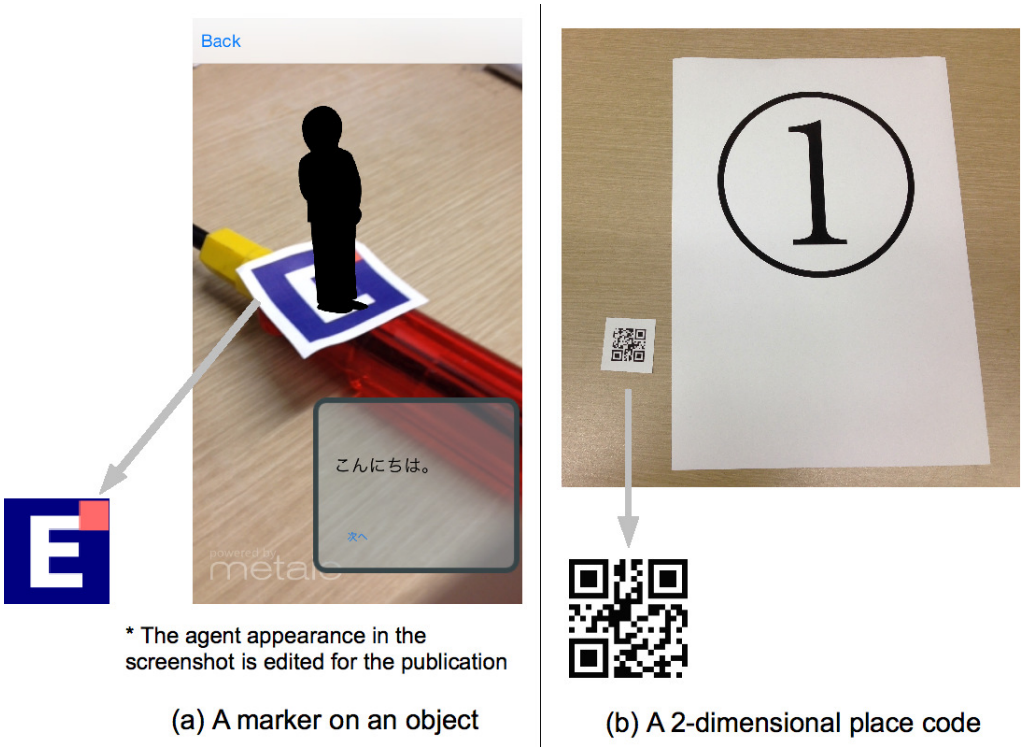


Figure 6.5: A personified agent superimposed onto an object (a: The agent is saying "Hello") and a location marker (b)

Figure 6.6: Objects

6.2.4 Hypothesis

We formulated a hypothesis to examine the degrees of personification.

- H1: An agent that is visually associated with specific keywords gives people a sense of personification

The existing work reports that products and brands are associated with human personality [2]; moreover, perceived personalities have influence on consumer preference [28]. Based on the existing work, H1 means that an object could have associated keywords. Then, when an agent has similarities in terms of the keywords, a user could perceive a sense of personification by finding a similarity between an object and an agent.

We focused on the associated occupation of an object instead of basic visual properties, such as shape or color, because an agent has clothing and because the clothing can thus effectively represent the occupation.

6.2.5 Surveys

In this section, we describe surveys involving participants. We designed two types of questionnaires related to the relationship between an object and an agent, and one task-based study using a Fairy Agent.

Survey: Object-Image questionnaire

In this survey, we aimed to specify common keywords from seven objects (six objects are shown in Figure 6.6 (X)). Nine male participants whose ages ranged from 22 to 25 were recruited. In each question, a picture of an object was shown to each participant, who was then asked to complete the questionnaire with keywords from three aspects: associated

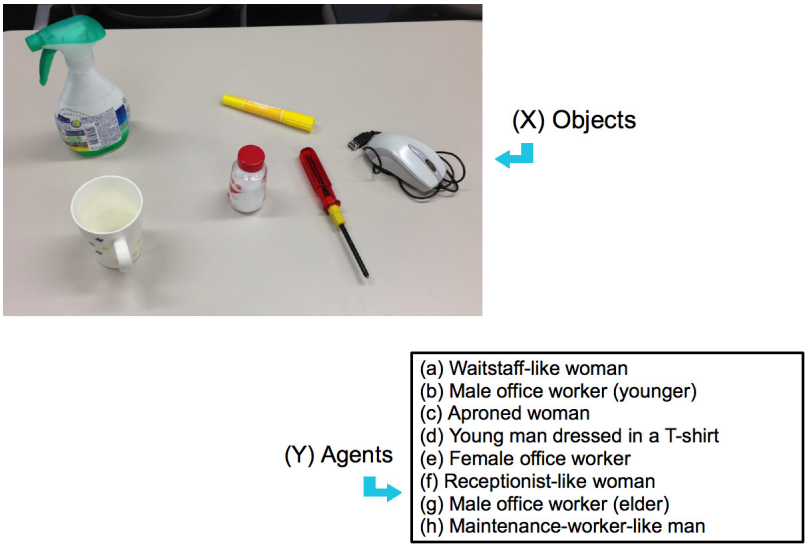


Figure 6.7: Objects and Agents

occupation, associated personality and others. Keywords were collected separately from among the three types and categorized by similarity. As a result, common keywords were extracted from each categorized set.

Survey: Agent-Image questionnaire

Based on the previous survey, we chose 3D models whose appearance were associated with a keyword. For example, when "an office worker" was a common keyword for a telephone, a model whose appearance reflected that of an office worker was chosen. For an object whose keywords had little in common, we chose a model based on at least one keyword from the result of the previous survey.

Six participants whose ages ranged from 22 to 23, were recruited. They consisted of four males and two females and they were different people from those included in the previous survey. Participants were asked to choose 3D characters that could be associated with each object. 3D characters were chosen based on keywords in advance. The descriptions of the agents are shown in the Figure 6.7 (Y). The criteria of and reasons for their decisions were also obtained. The results were collected and the most popular 3D characters were chosen for the task-based study.

Task-based study

This study aims to examine the perception of personification in the physical environment by incorporating a specific task. Seven participants, whose ages ranged from 21 to 24, were recruited. They consisted of four males and three females.

Table 6.2: Conditions

Conditions	Marker locations	Set of agents
Sp-Uq	Separated	Unique
Sp-Uf	Separated	Unified
At-Uq	Attached	Unique
At-Uf	Attached	Unified

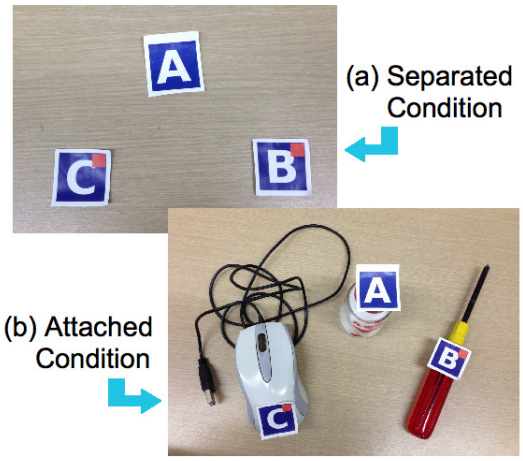


Figure 6.8: Conditions

Conditions We prepared four conditions from a combination of two sets of an agent visual characteristics and two types of marker locations (Table 6.2). Marker locations consisted of "Separated", where all markers were affixed to a fixed place, and "Attached" where each marker was affixed on each object (Figure 6.8). Conditions for sets of an agent visual characteristic consisted of "Unique" where different agents based on keywords were allocated, and "Unified" where the same agent was allocated to all objects. Each participants proceeded with the same tasks in four conditions in a randomized order.

Task Participants were asked to roam about with a Fairy Agent and find an agent's "house". When they activated an agent, the agent began to generate utterances in the balloon on their phone screen.

The agent asked each participant to put each object in its "original" location. The "original" locations were specified by number cards associated with a two-dimensional code, as shown in the Figure 6.5 (b). Participants could choose one of two actions: to act as the agent asked or to skip the request from the agent. When they would bring an object to its "original" location, they could then make the FairyAgent confirm the completion of the task by reading the two-dimensional code. An example of translated utterances is shown in the Figure 6.9.

After completing the tasks under the four conditions, we asked participants to fill out a questionnaire comparing each condition.

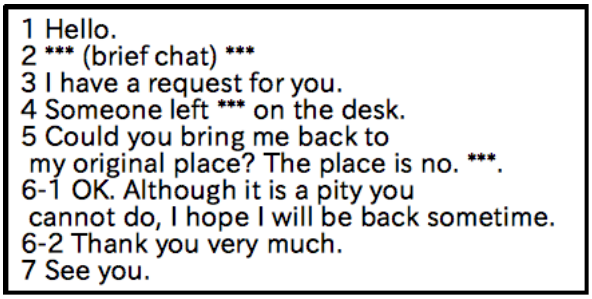


Figure 6.9: Conversation script translated to English ("***" can be varied, 6-1,2 are conditional branches)

6.2.6 Results and discussion

Based on the surveys described above, we show the collected data from each survey and then discuss them, especially in regards to both perception of personification and persuasive effect aspects.

Survey: Object-Image questionnaire

Collected keywords were grouped; common ones are specified in Table 6.3. Keywords with an asterisk represent ones selected by the researcher among minor keywords.

Table 6.3: Categorized keywords (each keyword is translated into words with close meanings)

Object	Occupation
Telephone	Office workers, telephone solicitors
Bottle of salt	Cooks, housekeepers*
Air refresher	Janitors, housemaids*
Computer mouse	Programmers, office workers
Screw driver	Carpenter, factory workers
Yellow marker pen	Artists*, teachers*
Mug	Cafe waitstaff, computer geek

Survey: Agent-Image questionnaire

The results of the Object-Image questionnaire were collected, and the one selected by most participants was chosen (Table 6.4). The alphabet characters in Table 6.4 correspond to each agent in Figure 6.7 (Y). The yellow marker pen was marked as N/A because it was not common among participants.

Table 6.4: Candidates for agents

Object	Character
Telephone	b, e, f, g
Bottle of salt / Air refresher / Mug	c
Computer mouse	b, g
Screwdriver	h
Yellow marker pen	N/A

Task-based study

We collected comments from participants via a web-based questionnaire after the sessions.

Comparison between marker locations, and sets of agents Some comments from participants suggested that the "attached" conditions helped participants understand the relationship between an agent and an object regardless of "unique" or "unified" agents. However, with a "unified" agent, a "separated" one can be more suitable than an "attached" one being perceived as a reception personnel. The results suggested the possibility of "unique" and "attached" agent for the improved experience.

Perceived role of agents Among the comments from participants, "unique" agents in the "attached" condition (condition At-Uq) suggested the perception of personification. For example, one participant said that agents were like a fairy or personification. In condition Sp-Uq, for example, agents were perceived as helpful things to remember a target object, occasionally instructing participants to move objects.

Persuasive effect Six participants received increased motivation to complete the task in condition At-Uq. One participant did not like some of the utterances from the agent; therefore, his motivation depended on his particular agent. The brief chat segment of each conversation differed among agents; however, under the "unified" agent conditions, different sentences could be uttered by the same agent. On the other hand, troublesomeness and unnaturalness were found in some comments in the other conditions.

Conformance with the hypothesis From the results, the "attached" condition with a "unique" agent suggests the possibility of persuasion using a personified agent. This result can lead to conformance with H1 in regards to the perception of personification. Although an associated image in terms of occupation was the focus of this study, other properties could also be included. For example, common colors or (product) personalities could be added to affect personification.

6.2.7 Group work

In addition to the discussion above, we arranged a group work to collect ideas for personification. The main purpose of this group work was to specify essences of personification of

nonliving objects. The group work was divided into two parts. This kind of findings can be utilized for designing personified agent.

Participants

Ten participants from our laboratory attended the group work. The participants consist of seven males and three females; and all participants were Japanese. They includes participants of previous studies described in the previous sections. They are paired with another participant and then each participant is supposed to discuss themes with the partner.

Task1: essence of personification

In the first part, we discussed the main features of personified (anthropomorphized) characters referring to existing examples. We asked participants to enumerate characters, for example, game characters which they know and consider the favorite or not-favorite point. First of all, we asked each participant to enumerate existing personified characters from multiple aspects: official ones, not-official ones, favorite ones, and not-favorite ones. Next, participants were asked to discuss the the main elements for personification and favorite / not-favorite attributes of the characters.

Task2: personification of familiar daily objects

We have chosen two daily objects: a camera tripod and a box of tissue paper. We asked participants to choose one or both of them and designing personified characters and its personalities. During the task, participants can generate a 3D model using SIMS3[6] or sketch an image of the personified agent.

Before the task, we announced example aspects to the participants: genders, ages, hair style, clothes and accessories. Also, other types of an aspect can be accepted.

Findings and discussions

We extracted clues regarding preferences and perception of personification in the Task1. In addition, we asked participants to explain the process of personification of the daily objects in the Task2. The Figure 6.5 shows the sentences extracted from the discussion in the Task1 and new aspect of personification in the Task2.

Resemblance to, or consistency with an original entity to which a personified agent refers includes contexts or episodes around the entity. That is, “effective personification” can be derived from natural translation of, for example, an original image, a history, and uniqueness.

The keywords from the Task2, we find new keywords for personification process. For example, one participant mentioned a function of a tripod. The personified character can have a camera as a friend because a tripod supports a camera. As another example,

[6]http://www.thesims3.com

Table 6.5: Extracted sentences of attributes for personification from the group work

Task	Subject	Keywords
Task1	Personification	Resemblance to, or consistency with an original entity
	Preference	Unreal abilities, effect of learning, desire, commonness
Task2	Considered aspects	Functions, weight, an attribute of a user

another participant said that a personified character, which derived from a box of tissue paper, catches a cold because of an image of those who blow their nose.

If a character is used as an agent for supporting user's daily life, its functionality is a concern. Considering the successful design of an anthropomorphic character, Yamada states that the level of reality of appearance should not surpass the level of functionality [70].

Certain amount of incompleteness can be accepted with affection [49]. Owada discussed combination of the scenario of a character and an electric appliance (iRobot Roomba[7]). Roomba sometimes sweeps a room in a less sophisticated manner and this can be incompleteness [49]. He pointed the similarity of a hero/heroine of a story and the behavior of Roomba [49].

As these discussions, we can adjust an expectation by a user to an agent combining a fictional stories and general visual attributes such as a color, an accessory, and many other type of features.

6.2.8 Summary

In this case study, we have conducted surveys and a task-based user study of the perception of personification from an agent as a representation of an object as well as possibilities for persuasion. In the task-based user study, we used a prototype application named Fairy Agent and then asked participants to use the Fairy Agent in four conditions.

The results suggest the possibility of persuasion using a personified agent. As a future direction, a personified agent superimposed onto an object could incorporate other persuasive strategies.

In addition to the three studies, we also arranged a group work for inspecting elements for perception of personification. As a result, multiple aspects can be introduced to personification; however, an original entity as a reality must be carefully weaved into the design of a character.

[7] http://www.irobot.com/For-the-Home/Vacuum-Cleaning/Roomba.aspx

Chapter 7

Discussion

In this chapter, we mention more generalized strategies than case studies along with the relationship between each research question and modeled problems.

7.1 Design implications

Based on the case studies we have described in the previous chapters, we formulate design implications for developers of persuasive applications. These implications are also described the scenario in the section 3.3.

7.1.1 Adaptive communications between virtual agents and a user

Persuasion methods should be designed considering a current behavior state of each user. For precontemplation users, an application can incorporate implicit persuasion. In the scenario, the application was a location-based game and Doe can "play" a persuasive application.

Utterance by a virtual agent can be changed according to a user's current behavior status referring to existing behavior models such as TTM [53]. Scripts for utterances can be assembled using theories suitable for behavior models, for example, TTM incorporates processes (e.g. [53], [54]). In addition, utterance should be varied time to time.

7.1.2 Unobtrusive sensing and persuasion

In the scenario, agents support Doe by utterances during the play. The utterances can be chatting not related to the target behavior, or questions about the target behavior.

Sensing is needed for modeling of user behaviors and the behaviors should be sensed carefully enough not to impose obtrusive impression to users. Sensing can be based on readings from sensors or answers from users to a question presented by a virtual agent. In the TTM case, a set of questions to estimate behavior stages is proposed [54]; therefore, sensing process can be transformed to utterances from an agent based on models and theories.

7.1.3 Adjustment between reality and virtuality regarding real world problems

The reality can consist of a target behavior and existing activities. Target behavior can be included to utterances by an agent or functions of an application; in addition, existing activities can be utilized to provide a user with mental models of an application. The virtuality can be introduced referring to existing stories, pop cultures, and preferences of a user.

For example, exercising is a target behavior in the scenario and utterances from an agent can present exercising-related topics. The style of an application can be in a style of an existing game; that is, Doe may understand what it is easily if he has got used to games.

Fictions and other types of unreality can be utilized for affecting user preferences and interests. If users have a reality regarding a target behavior or a problem related to the behavior, they may be interested in the topics. According to ELM [50], the central route is derived from, for instance, the personal responsibility and relevance, and this kind of behavior change can be persistent. Virtual agents have the possibilities of influence users with the unreal expression.

7.1.4 Handling boredom

Utterances of a virtual agent should be generated automatically and attributes of an agent should be customizable. For example, the iDetective designers referred to Table as a guideline and then construct topics on exercising fitting them to the guideline.

Boredom can prevent users from using an application continuously. Handling boredom during the use of an application must be considered until a user move from the precontemplation stage to more "persuaded" stage such as the contemplation or preparation stage, in the TTM term.

7.1.5 Options to customize

Customization of a virtual agent can be introduced. For example, let a user choose his/her favorite one, or change an attribute of a virtual agent. Although this implication overlaps partially with the previous one, this one focuses on the possibility of collaboration with another type of media. Combining customization with storytellings in existing games or anecdotes worlds enables a user to enter the world of a persuasive application easily without understanding a context from the beginning.

7.2 Solutions for each modeled problem

We review how did our case studies addressed problems mentioned in section 1.1. Table 7.1 shows the relationship between case studies described in the previous chapters and modeled problems. Table 7.2 shows principal research questions in each case study and corresponding modeled problems which are addressed by the questions.

Table 7.1: Relationship between case studies and modeled problems

Modeled problem \ Case study	AP1	IA1	IA2	PBI1	PBI2
P1		◯	◯	◯	◯
P2	◯	◯		◯	◯

Table 7.2: Research questions and findings or implications

Case study	**Research question**	**Modeled problem**
AP1	How can a user be persuaded implicitly?	P2-1
IA1	How does a user respond to questions from agents when observers exist?	P1-1, P2-2
IA2	How much is the virtuality accepted?	P1-2
PBI1	Can an agent preferred by a user be persuasive?	P1-1, P2-2
PBI2	Can a user be affected by personified nonliving objects as personified virtual agents?	P1-1, P2-2

7.2.1 P1: Short-term use of an application

The case study IA1 discussed an effect of boredom and social desirability. This discussion started from the question whether a user respond by their real opinion or not under the condition where his/her answer revealed to other users. In the experiment, although the boredom still existed and the users did not always respond to a question from an agent, most participants did not have negative impression of informing other users of a response when the questions is ethically acceptable.

In the case study IA2, the acceptable range of assistances by a computer is not always real manner was examined and was related to problem P1. If a persuasive application introduces acceptable unreality, persuasion can be crafted not to be so annoying that a user ceases using the application and to take advantage of rich range of expression of persuasion.

We discussed whether a user's favorite agent can reduce the boredom of a user compared to a fixed one regardless of the preference in the case study PBI1. For example, this discussion suggests the possibility of encouragement of the continued use of a persuasive application by game and anime characters liked by users.

Lastly, the discussion in the case study PBI2 suggests the possibility of addressing the boredom of a user using personification. That is, when a user can choose a favorite agent as a personified daily objects, interactions with them can be diverse; and thus the attribute

can affect the reduction of boredom.

7.2.2 P2: Resistance to persuasion

The target in the case study AP1 was introducing an implicit (unobtrusive) persuasion and sensing strategy even for a user on the precontemplation stage of TTM. As a result, although the participants were not aware of the implicit persuasion, sometimes they did not respond to the sensing question from an agent by real opinion because of the limited variation of conversations.

The case study IA1 includes a question whether a user responds to the questions by an agents seriously. This question linked to an aspect of providing a user of interest or responsibility on a target behavior.

In the case study PBI1, we discussed based on the hypothesis that a user's favorite agent obtains more credibility by a user than a fixed one. When a user feels the agent "credible", the utterances by the agent can be received seriously. That is, an agent is not perceived as a liar or a joker but a useful source of information and facts.

The case study PBI2 mentioned the possibility of empathy for a daily object which was not considered as a lovable thing previously and this topic is related to the problem P2-2. This type of empathy can encourage a user to recognize the importance and value of target behavior. For example, a persuasive application whose target is to persuade users to save energy can present agents as personified electric appliances.

Chapter 8

Conclusion and Future direction

We have proposed the Tailorable Persuasive Agent (TPA) framework, a framework for long-term persuasion with a virtual agent. In this chapter, we conclude the dissertation and mention the future direction of this research.

8.1 Conclusion

We have defined problems of persuasion using an agent as modeled problems; and then, we proposed three elements of TPA framework: Adaptable Persuasion, Intention Adjustment, and Preference-Based Internalization. We explained each element and described scenario of application developed using TPA.

Secondly, we described case studies which supports the three elements. Based on the case studies, we discussed relationship between each modeled problem and each case study. Moreover, we also described design implications for developing persuasive applications for long-term behavior change. These implication are intended to handle the modeled problems: short-term use of an application and resistance to persuasion.

8.2 Future direction

In addition to problems mentioned in the previous parts, some aspects are yet to be discussed.

8.2.1 Cultural difference

The preference of attributes for designing agents should be discussed from a multiple-culture or multiple-generation aspect. For example, a game character on a package design is known to be changed suitable for a country in which the game is sold [1]. A visual or nonvisual attributes for a virtual agent should be adjusted according to countries or districts where the persuasive agent is used.

We have surveyed 11 designs for an assistant agent suitable for Finnish elderly people [73]. We specified criteria for the evaluation, for example, kindness, trustfulness, child or adult, and compared them.

8.2.2 Handling boredom

One of ways to prevent a user from being bored with utterances by a virtual agent is to generate utterances dynamically. For example, Matsuyama et al. collected web pages related to a specific topic for an utterance by a robot [40]. If a virtual agent can collect webpage data for variable keywords dynamically, a part of text data can be allocated to each persuasive utterance of the agent.

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