Doppel Teleoperation System:
Isolation of physical traits and intelligence for personality study

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Abstract

We introduce the "Doppel teleoperation system", which isolates several physical traits from a speaker, to investigate how personal information is conveyed to other people during conversation. With the Doppel system, one can choose for each of the communication channels to be transferred whether in its original form or in the one generated by the system. For example, the voice and body motion can be replaced by the Doppel system while the speech content is preserved. This will allow us to analyze individual effects of physical traits of the speaker and content in the speaker's speech on identification of personality. This selectivity of personal traits provides us with useful approach to investigate which information conveys our personality through conversation. To show a potential of this proposed system, we conduct an experiment to test how much the content of conversation conveys the personality of speakers to interlocutors, without any physical traits of the speakers. Preliminary results show that although interlocutors have difficulty identifying their speakers only by using conversational contents, they can recognize their acquaintances when their acquaintances are the speakers. We point out some potential physical traits to convey our personality.

Keywords: social cognition, android science, human-robot interaction, personality psychology, personal presence

Introduction

Where does personality come from? Do we characterize other people from what they are saying or from how they behave? These issues about personality have been long studied in cognitive psychology. Recent progress has provided us with dimensions of personality to measure human personality (McCrae, Zonderman, Costa, Bond, & Paunonen, 1996) and cognitive models (Brunswik, 1956). Thanks to the establishment of such methodologies, personality studies have been gaining attention not only in cognitive science but also from the viewpoint of design of human-computer/-robot interaction (Fong, Nourbakhsh, & Dautenhahn, 2003; Nass, Moon, Fogg, & Reeves, 1995).

Many studies on personality have been devoted to clarifying what information conveys personality traits of an individual. They have revealed that there exists a strong relationship between physical traits and personality. For example, some studies reported, using criterion measures based on self and peer reports, that a person's appearance, including facial expression (Berry, 1990, 1991; Little & Perrett, 2006) and clothing style (Naumann, 2009), enables other persons to judge the person's personality accurately. While these studies were based on photographs of the face or full-body, other studies have shown that body movement (Kenny, Horner, Kashy, & Chu, 1992) and voice (Scherer & Scherer, 1981; Borkenau & Liebler, 1992) also provide useful information for judging personality traits, especially extraversion.

Although these studies showed several communication channels in which personal traits are presented, the experimental setting was limited to the case where a judge observes a person: there was no conversation between them, although the contents of a conversation would likely be the most informative. A crucial difficulty in examining the relationship between physical traits and personality during a conversation is to isolate physical traits of an individual person from the conversation and to control their effects. Such isolation and control would allow us to investigate not only independent effects of physical traits and personal thought but also mutual interaction among them on identification of personality.

Interactive artificial agents might help us overcome this difficulty since they have been utilized as controllable "humans" to understand the cognitive mechanism of human adults or infants (Itakura, 2008; Yoshikawa, Shinozawa, & Ishiguro, 2007). In this context, some studies have addressed the problems of the behavior and appearance of the agents as contribution to both cognitive science and robotics, using a robot that has a very human-like appearance, called an android (Ishiguro, 2007). While typical androids are controlled as stand-alone agents, a teleoperated android, called a "geminoid", which has a very similar appearance to a living individual (Sakamoto, Kanda, Ono, Ishiguro, & Hagita, 2007; Nishio, Ishiguro, & Hagita, 2007) has been developed as a telecommunication medium to address several issues on telepresence and self-representation (Straub, Nishio, & Ishiguro, 2010). This system enables an operator to have nonverbal and physical interaction, including body touch, gesture and facial expression, as well as verbal one with other people, by operating an android that might have a different appearance from the operator, remotely.

Although the geminoid system provides us with a way to isolate physical appearance from personality traits, it still transfers not only conversational content but also many other physical traits of its operator such as body movement, facial expression, and speech features. We solve this problem by assuming a speaker who gives content and an operator who acts as a "mediator", which might distort speech features of the speaker as well as control the geminoid's movement. The assumption of the mediator enables us to eliminate physical

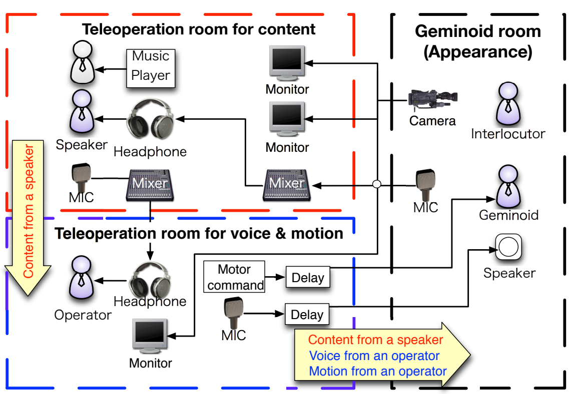

Figure 1: Overview of Doppel teleoperation system. Arrows with yellow show communication channels to be conveyed to the operator or the interlocutor and their sources.

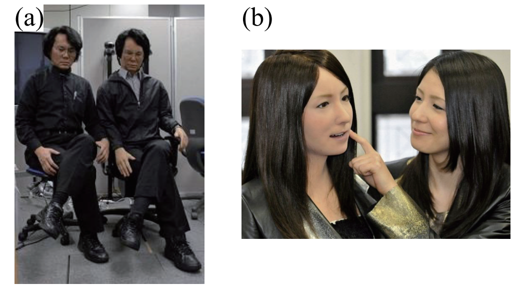

Figure 2: Geminoids. (a) Geminoid HI-1 (right) and the model (left). (b) Geminoid F (left) and the model (right).

traits of the speaker in speech features such as voice sound and accent from the conversation: interlocutors receive the content from speakers and the others from the mediator and the geminoid. As a result, personal information in conversation is separated into physical traits (appearance, body movement, and speech features) and content of speech (personal thought). Such a system to isolate physical traits will allow us to convey some of personal information of the speakers and to replace the others with ones belonging to a geminoid and its operator selectively.

In this paper, we propose a teleoperation system called "Doppel", which isolates several physical traits from conversation. This system allows us to analyze individual effects of physical traits of a speaker and content in the speaker's speech on identification of personality by controlling the physical traits to be conveyed to an interlocutor. To show a potential of the system for investigating how personalities of speakers are conveyed to interlocutors, we report an experiment where identification of the speakers during conversation are tested.

In the rest of the paper, we first describe the proposed system. Next, we report an experiment that we conducted to verify how much content of conversation provides personalities of speakers for their interlocutors. Preliminary results show that although interlocutors have difficulty identifying speakers only using conversational content, they can recognize that they are talking with strangers or their acquaintance. Finally, we discuss what information might provide personalities of speakers for their interlocutors during conversation.

Doppel Teleoperation System

Figure 1 shows an overview of the proposed system, called the "Doppel Teleoperation System". The system is based on the telecommunication system for a teleoperated android and uses a "geminoid" that resembles a living individual (Sakamoto et al., 2007; Nishio et al., 2007). The existing system is used for an operator to communicate with remote people. Unlike a video conference system where we only provide visual and voice information, it is expected to convey the presence of the operator. We extend this system to isolate individual communication channels by separating the teleoperation system into two subsystems: one for a speaker to have a conversation with an interlocutor and the other for an operator to control voice and motion of the geminoid. In the proposed system, the speaker communicates with the interlocutor through the geminoid, hearing what the interlocutor says and talking into a microphone in another room. The operator hears what the speaker says and then repeats the speaker's words in her/his way of speaking in another teleoperation room. Therefore, the system allows us to eliminate physical traits of a speaker during conversation: appearance from a geminoid, vocal information and motion one from the operator, and the content of conversation from the speaker. In the following section, we provide more detailed information about the system.

Appearance:Geminoid

Appearance of a speaker is replaced with the interface between the speaker and an interlocutor. The interface should have human-like appearance to investigate the influence of physical traits on personality identification in human-human interaction. This is achieved by using a geminoid (Figure 2), which resembles an existing individual. Geminoid HI-1 is designed so that its appearance resembles a living male (Figure 2(a)). It has 50 degrees of freedom (DoFs) including 13 DoFs for facial expression. Geminoid F has a similar appearance to a living female (Figure 2(b)). Most of 12 DoFs are used for facial expression.

Both geminoids have two different controllers: a conscious behavior controller and an unconscious one (Sakamoto et al., 2007). While the conscious behavior controller is driven by command from an operator to change behavior of a geminoid based on a set of preprogrammed body motions, subtle expressed motions such as breathing, blinking, and trembling are added by the unconscious behavior controller to maintain the naturalness of the geminoid's behavior. In addition to such semi-automatic control, lip movements of the geminoid are synchronized with those of its operator. This is realized by a facial feature tracking software though the camera in front of the operator.

Content of conversation: Speaker

A speaker decides what a geminoid says, monitoring the conversation between the geminoid and an interlocutor. The words of the speaker to the interlocutor is conveyed not to the interlocutor but to the operator, who hears it in an operation room, through a microphone.

Voice and motion: Operator

The operator controls a geminoid to convey verbal and non-verbal information about a speaker and the operator him/herself to an interlocutor. The operator repeats what the speaker says in the operator's way of speaking in front of a microphone, which is connected to the sound system located behind the geminoid. One might argue for using a system for speech information processing instead of a human operator. Due to the limitations of current technology for speech recognition, we decided to use a human operator.

In addition to conveying the words of the speaker, the operator controls how much s/he provides the interlocutor with physical traits of the speaker such as speed of speaking and accent, and movement. For example, if the operator repeats the speaker's words, mimicking the speaker's way of speaking, speech features of the speaker will help the interlocutor identify the speaker. As a result, the geminoid's voice and movement are presented to an interlocutor as a mixture of verbal information and non-verbal one from a speaker and an operator.

Experiment: personal identification based on conversational content

The proposed system allows us to isolate communication channels from a speaker and design a new experimental setting that is difficult for existing methodologies. As a first step to verifying how we identify personality traits of other persons during conversation, we investigated whether people can identify a person using only conversational content and how much physical traits affect the identification of the person.

In the following experiments, we used geminoid F. To avoid the speaker being identified due to not conversational content but personal information, an operator was asked to replace the speaker's dialect and specific words to identify the speaker (e.g., the speaker's nickname) with standard dialect and general words (e.g., you), respectively though the content of what a speaker said was preserved.

Since it is difficult for ordinary people to make such replacement, we assigned a female actor as the operator. The lip and head movements of the geminoid F were synchronized with ones of the operator, while other body movements and facial expressions were ignored except for eye blinking, which was realized by the unconscious controller. The communication channels and their sources are summarized in Table 1.

Table 1: Sources of communication channels during conversation in the experiments

Channel	Source
Appearance	Geminoid F
lip motion	Operator
Voice sound	Operator
Speaking speed	Operator
Accent	Operator
Conversational content	Speaker

Working hypothesis and prediction

Although physical appearance, motion, and voice include personality traits, content of conversation should also provide much information to identify personality traits because it includes person's thoughts, opinions, and feelings. It will convey more personal information if speakers are acquaintances. Therefore, we verify whether the following hypotheses are established or not.

Hypothesis 1 (H1): people can identify a speaker by using only content of conversation.

Hypothesis 2 (H2): people can correctly identify more speaker by using only content of conversation in case where the speaker is an acquaintance than in case where the speaker is a stranger.

We conducted experiments with two different conditions to verify these hypotheses: *stranger* condition where a speaker and an interlocutor do not know each other and *acquaintance* condition where a speaker and an interlocutor know each other well. We will verify the H1 by evaluating accuracy of a guess of a speaker from among four possible candidates. H2 will be tested through comparison between the accuracy of the guess in the *stranger* condition and one in the *acquaintance* condition.

Participants

Since the geminoid F has a female physical appearance, only female participants were recruited to eliminate the possibility that gender difference makes it easier for an interlocutor to guess actual speaker. Seventy-six Japanese females participated in the experiment. We made nineteen pairs of two persons who do not know each other for the *stranger* condition while there were nineteen pairs of close friends for the *acquaintance* condition. We assigned one of each pair as a speaker and the other as an interlocutor. The average age of all participants was 25.3 (SD = 6.7).

Procedure

A subject as an interlocutor was asked to chat about a given topic with a speaker and to guess the speaker from among four possible speakers: the parted subject as a speaker (S_s), the model of the geminoid F (S_g), the operator of the geminoid F (S_o), and the assistant of an experimenter (S_a). The last three persons were fixed through all experiments and we confirmed that the interlocutor did not know them. The model and operator of the geminoid F have never been selected as actual speaker in the experiment. Therefore, the selection of S_g or S_o by the interlocutor is assumed to be caused not by conversational content but by other physical traits of the geminoid F and the operator. It is implied that, while her/his guess was based on the appearance of geminoid F if the interlocutor selected S_g, s/he guessed from the movement and voice of the operator if the interlocutor selected S_o.

Each experiment consisted of six three-minute sessions. An experimenter selected a topic to be discussed and actual speaker from between S_s and S_a before each session. The topic was chosen from two different kinds of topics: common topics and delicate ones. The common topics were the topics which people have more chance to talk about (e.g., "how do you want to enjoy your life after your retirement?"). Some topics were related to personal histories such as Christmas gift that speakers got as a child or personal preference such as favorite type of man. The delicate topics were about what people have less chance to discuss (e.g., "should we revoke elder persons' driving licences to obviate car accidents?"). The selected speaker was told to discuss the given topic through the geminoid with the interlocutor while the person who was not selected was told to listen to music with headphones so as not to hear the conversation between the actual speaker and the interlocutor. Three consecutive selections of the same speaker were avoided not to make the interlocutor recognize the speaker because of long conversation.

Before each experiment starts, each possible speaker was asked to talk about two different topics provided by an experimenter. The talk was videotaped for two minutes per topic. An interlocutor watched the videos of all talks to discern personalities of all speakers. After that, she was asked to rate their personalities with the Japanese Property-Based Adjective Measurement questionnaire (Hayashi, 1978), which has high correlation between its three components and the extraversion, openness and agreeableness components of the Big Five Model (McCrae et al., 1996).

After rating the personalities of all speakers, the interlocutor was led to the experimental room where the geminoid F was located. The operator and speakers (S_s and S_a) were separated into different rooms, respectively. After a brief explanation about the specifications of geminoid F, the number of sessions and the duration of each session, the experimenter informed the interlocutor that actual speaker could change for each session. It was also noted that the geminoid was controlled by the operator whom the interlocutor saw in the video and she would talk based on her own thought or what one of the other speakers was saying. During a session, the actual speaker and the interlocutor asked each other questions about a given topic and responded to each other. After each session concluded, the interlocutor was asked to guess who the speaker was and to provide the reason for her guess. She also rated personality of the speaker with the questionnaire (Hayashi, 1978). After the experiment finished, the interlocutor was debriefed about the experiment.

Table 2: Average of accuracy rate of guessing in *stranger* condition and *acquaintance* condition

condition	accuracy rate
stranger	0.28
acquaintance	0.31
total average	0.29

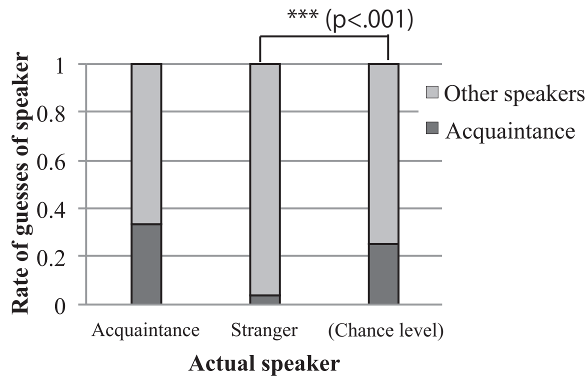

Figure 3: Rate of guesses on each actual speaker in acquaintance condition.

Evaluation

The performance of an interlocutor was evaluated with how often an interlocutor guessed right on actual speaker. Due to limited space, the analysis of personalities rated by interlocutors with the Japanese Property-Based Adjective Measurement questionnaire is not reported here.

Result

Table 2 shows average accuracy rates of guessing actual speaker for two conditions and total average across subjects. Although the total average rate is slightly higher than the rate expected by chance (0.25), no significant difference was found between them ($p = 0.13 > .05$ by binomial test). This result indicates that it is hard to guess who is talking from conventional content, rejecting our first hypothesis. We also tested the second hypothesis by comparing average accuracy rates between two conditions. However, there was no significant difference between them ($p = 0.85 > .05$ by Wilcoxon test) although the rate in the *acquaintance* condition is slightly higher than one in the *stranger* condition. This result suggests that the difference between two conditions does not support the our second hypothesis.

In the *acquaintance* condition, an interlocutor talks with not only an acquaintance but also a stranger (i.e. the assistant). If she identifies their acquaintances more correctly than the stranger, the second hypothesis is supported within the *acquaintance* condition. Therefore, we compared performance of guessing the actual speaker when the acquaintance is the speaker with one when the stranger is the speaker in the *acquaintance* condition.

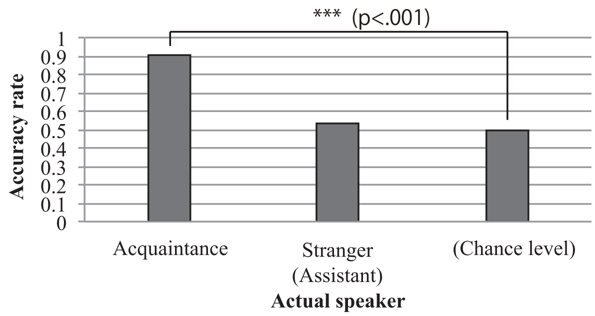

Figure 4: Accuracy rates of guessing on different actual speakers in the acquaintance condition.

Figure 3 shows the rate of guesses of speakers on each actual speaker in the acquaintance condition. The left bar in the figure shows the rate for acquaintances as actual speaker while the middle bar represents the one for the stranger (S_a) as actual speaker. The bar on the right shows the rate in case where the guesses occurred by chance. The black part in each bar stands for the rate of guesses of acquaintances. As we can see, the guessing performance for acquaintances as actual speakers is slightly higher than the rate expected by chance. However, there was no significant difference between them ($p = 0.17 > .05$ by binomial test). Interestingly, the guessing performance is significantly different when the stranger was the actual speaker ($p = 0.00 < .001$ by binomial test). These results indicate that, while it is hard for the interlocutors to identify acquaintances as the actual speakers, they can recognize that the actual speakers are not their acquaintances.

The results shown in Figure 3 suggest that our second hypothesis is not supported. However, the low accuracy rate of the acquaintances might be caused by the strong conservative bias of the interlocutors when making judgment of actual speaker as their acquaintances. To distinguish accuracy from bias effects, we computed A' and B'' scores (Grier, 1971) from hit rate (i.e., the rate of the guess of the acquaintance given acquaintances as actual speakers) and false-alarm rate (i.e., the rate of guess of acquaintance given the stranger as actual speaker). The scores showed that the interlocutors are sensitive to their acquaintance ($A' = 0.80$) though they have strong conservative bias against guessing their acquaintances ($B'' = 0.70$). Both scores were higher than ones in case of guessing the stranger (S_a) as actual speaker ($A' = 0.54, B'' = 0.036$). In fact, it was revealed that the interlocutors identify their acquaintances significantly when we calculate the accuracy rate given that the interlocutors answered that speakers were their acquaintances. Figure 4 shows the accuracy rates of guessing the actual speakers in *acquaintance* condition. As can been seen, the guessing performance for their acquaintances as actual speaker is much higher than the performance expected by chance. Actually, there was significant difference between them ($p = 0.00 < 0.001$ by binomial test). We cannot find such difference for the guessing performance for the assistant as actual speaker (see the middle bar in Figure 4). These results imply that the interlocutors identify their acquaintances as the actual speaker, supporting the second hypothesis.

Table 3: Selection probability of possible speakers

speakers	selection probability
the model of geminoid F	0.285
the operator	0.241
the assistant	0.263
the subject as a speaker	0.206

We also calculated probabilities of guessing each possible speaker as the actual speaker to test how much physical traits can affect the identification of speakers (Table 3). Although the probabilities of selecting the geminoid model or the operator are slightly higher than that of selecting subjects as speakers, we were able to see no significant difference among them. This might imply that no physical trait is much stronger than others when several traits are presented.

Discussion

The results revealed that it is difficult for people to identify a person without her/his physical traits: physical appearance, body movement, and speech features. In fact, after the experiments, some interlocutors reported that they felt as if the geminoid had another new personality, not one of possible speakers. Even though some results did not support our hypotheses, the results gave us fruitful insights. Especially, it is interesting why it was easy for the interlocutors to recognize that actual speaker is not their acquaintances. Exclusion of some physical traits presented in the experiment will reveal what information provides interlocutors with enough information to make the judgment.

The accuracy and response bias scores suggested that the low accuracy rate of guessing acquaintances might be caused by the conservative bias of the interlocutor for the guess. This finding was supported by the high accuracy rate of guessing when the interlocutors guessed their acquaintances as the actual speaker as shown in Figure 4. Since our second hypothesis was partially supported not between conditions but in the acquaintance condition, further verification is needed.

The accuracy rates shown in Table 3 tell us that there is no significant effect of physical traits on personal identification. This might implies that the identification of personality during conversation results from mutual interaction among physical traits and conversational content. The investigation of such interaction seems difficult for existing approaches because they needs to extract single modality from all modalities and exclude the others. Our system is useful for such investigation because it allows us to examine not only single effect of the physical traits and conversational content but also the mutual interaction among them by controlling the presented information selectively. We will conduct experiments with different combinations of physical traits to investigate how physical traits and conversational content interact with other traits as a future work.

One concern in this system is the influence of the geminoid on interlocutors' judgment. Previous studies have reported that people respond to an android as they respond to a human if it shows human-like behavior (Shimada & Ishiguro, 2008). Since we designed the geminoid so as to resemble human in appearance and movement, it is expected that the subjects consider the geminoid as a "human". However, it is well-known as uncanny valley (Mori, 1970) that even small lacks of human likeness affect human perception of androids. Therefore, how human likeness of androids affect human judgmental process should be addressed in the future.

We should point out that the interlocutors still extracted some physical traits of their speakers through conversation even though we tried to eliminate this possibility in the conversation. More precisely, they used some speech features to guess actual speakers: timing of speech, duration of speech, and expression of feedback to the interlocutors' comments like "Really?", "Exactly", and "No way!". In addition, it turns out that interlocutors might use speed of speech and accent to guess actual speakers in preparatory experiments. A detailed investigation of physical traits including such speech features is also valuable as future work.

Conclusion

We introduced the "Doppel teleoperation system", which isolates several physical traits from conversation, to investigate how personal information is conveyed to other people during conversation. With the Doppel system, one can choose for each of the communication modalities to be transferred whether in its original form or the one generated by the system. This will allow us to analyze individual effects of physical traits of the speaker and content in the speaker's speech on identification of personality. We tested how much content of conversation conveys the personality of speakers for interlocutors, without any physical traits of the speakers. Preliminary results showed that although interlocutors have difficulty identifying their speakers only by using conversational content, they could recognize that they were talking with their acquaintances. We hope that this system helps us understand our cognitive mechanism of our personality.

Acknowledgments

This research was supported by Grant-in Aid for Scientific Research (S), KAKEN (20220002) and JST, CREST. HS thanks M. Shimada for valuable comments.

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