3D Real-Time Conversational Agents:
Do Facial Expressions and Camera Angles Persuade Human?

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Abstract

This paper aims to uncover state-of-the-art on persuasion through a dialogue system between human and virtual agents. 37 participants interacted with six virtual agents in different conditions of facial expressions and camera angles. Through empirical measurements using the Big Five theory, we discover that virtual agents' friendliness becomes a solid persuading factor to our predominantly extroverted participants. The experiment deduces that openness, conscientiousness, and extraversion personalities are easily persuaded by our virtual agents, unlike reversed-conscientiousness and neuroticism personalities.

Keywords: Persuasive Technology, Human-Agent Interaction, Digital Storytelling, Virtual Agents, Big Five

1. Introduction

Computing technologies can be utilized to help people in performing their daily tasks in different situations and setups. Persuading and motivating people through the usage of computing technology leads to the so called "persuasive technology." Persuasive technology effectiveness can be measured by how successful it is in changing peoples' opinion and attitude and leading the peoples' mindset into a well-defined state. Persuasive technology is about incorporating computing technology with persuasion and social influence, not coercion nor [1].

Persuasion can be accomplished by influencing the emotions of trust, which has been an attractive topic for the research community. Thus, persuading and altering decisions relying on different emotions of trust have a variety of impacts. Hence, trust is a key factor in persuasion [2], [3]. It's important to differentiate between persuasion and coercion as the former has a positive meaning and impact, unlike the latter. In our work, a main guideline that we follow is to encourage and motivate positively from our agent to the user.

Developing an agent depends highly on the goal in mind that the agent is supposed to accomplish. Goals of agents vary massively depending on the environment, setup, culture, etc. An intelligent friendly agent iParrot goal was to influence family members to conserve energy at their homes [4]. An Embodied Conversational Agent (ECA) that promotes physical activity among Chinese adults that went through cultural adaptation for the Chinese community [5]. Agent embodiment can change the behavior of subjects into conserving more energy, thus feedback from an embodied agent is better than a computer [6].

Designing an effective agent can be achieved by following the best practices from former research. An ECA or an agent with a social dialogue is shown to be more effective than a text-based one [7]. Moreover, the attractiveness of the agent was proven to be an important factor on how persuasive the agent can be and the amount of behavioral change was very noticeable [8]. The number of agents is shown to play an important role in being more persuasive to the subject as in [9], where a multiple agent setting was shown to be more persuasive

than a single agent setting. Moreover, the use of animation utilizing its expressive nature can enhance the intuitive understanding as it involves direct movement was also investigated previously [25]. Evaluating the user's impression of the agent was also studied comprehensively across 96 patterns of content ranging from emotional scenarios, facial expressions, and words used by the agent [26].

The Big Five personality traits are a grouping for personality traits that identifies five factors typically referred to as openness, conscientiousness, extraversion, agreeableness, and neuroticism [10]. Incorporating characters design and portraying personalities with Big Five Personality traits was investigated [11]. Moreover, personalizing the persuasion techniques based on the Big Five personality traits has been shown to be very effective [12].

In our work, we design virtual agents by using Unreal Engine [13] while considering the Big Five personality traits as a method to obtain interesting insights on how to persuade subjects more effectively. Moreover, we change the camera angle and the personality of the agents to study how such changes will affect the subjects. We perform our quantitative numerical analysis through two-way ANOVA test without replication [14]. Our numerical results show a strong relation between persuasiveness and the agents' personality. It also shows how related the personality of the subjects to how easy it is for them to be persuaded.

The rest of the paper is organized as follows. In Section II, we provide a solid background about Big Five personality traits. Section III deals with the methodology that we followed in our experiment. Section IV shows our numerical results and insights. Finally, we conclude the paper in Section V.

2. Related Research

The golden standard for exploring personality in the academic world is known as the Big Five, which classifies personality across five dimensions: Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism (OCEAN). Big Five personality traits affect how people respond to persuasive appeals, and how core personality traits shape responses to various aspects [24]. Hence, we choose the Big Five theory to understand whether the personality of our subjects make them easily persuaded by our agents.

2.1. *Openness*

A past study on impulse buying behavior examined that openness personality affects impulse buying [15]. Openness to new experience individuals will probably trust more to online retailers because they will enjoy purchasing from online sites which provide variety of products [16]. In marketing, for high scorers in openness, aesthetic and intellectual pursuits are particularly motivating, and people with this trait will respond well to words such as innovation, intelligence, sophistication, imagination, and creativity.

2.2. *Conscientiousness*

Conscientious individuals are probably to buy online, as online shopping is convenient and happens in a comfortable environment [17]. The study suggests that conscientious individuals are probably more careful in considering the benefits of online purchase intention, which can build their trust in online retailers [4]. In marketing, conscientious individuals will be more driven by a desire for order, efficiency, and achievement.

2.3. *Extraversion*

Highly extroverted individuals are expected to engage more in online purchasing activities because online customers can share their shopping experience and information on the online platform [18]. Past studies also found that there is a correlation between trust and extroversion [19]. In marketing, people who score highly in extraversion tend to be triggered by a desire for excitement and social rewards and will find words such as strong, outgoing, active, excitement, and attention more persuasive.

2.4. *Agreeableness*

A past research indicated that individuals with a high degree of agreeableness would have a high level of technology acceptance [20]. People who have agreeableness trait pay extra attention to preventing conflict. Therefore, they are eager to trust service providers [21]. In marketing, agreeable individuals tend to be motivated more strongly by compassion, interpersonal harmony, and a sense of belonging.

2.5. *Neuroticism*

The previous study revealed that neuroticism personality individuals are associated positively with computer anxiety [22]. Neurotic individuals invariably conceive themselves in inauspicious attitudes [10]. In marketing,

if our target audience is particularly neurotic, they will be more sensitive to threats and uncertainty and will respond to messages that promise safety and security.

3. Experiment of an Interaction Between a Subject and the Virtual Agents

There were 37 students participated in our research whose age range is from 18 to 24 years old. These 37 subjects are added randomly into three groups. There were 11 subjects in Group 1 [Up], 11 subjects in Group 2 [W], and 16 subjects in Group 3 [none]. The system was created using the Unreal Engine, displaying the agents' movements and facial expressions, and the voice was presented using Japanese speech synthesis. To analyze the effect of persuasion, we use two-way ANOVA without replication method. To generate the Big Five personalities, we measure the means of personalities and perform one-way ANOVA.

3.1. *Experimental method*

3.1.1. *Virtual agents*

The 3D model of virtual agents in Fig. 1 was created using the Unreal Engine MetaHuman 4.27. They show two facial expressions, which are smile and grumpy. We use two different camera angles both from near and far.

Fig. 1. The six virtual agents, named as (1) Stephan, (2) Pia, (3) Kellan, (middle) Danielle, (4) Aoi, and (5) Kendra.

3.1.2. *Grouping the conditions*

We categorize three conditions, which are shown on Fig. 2 of Group 1 [Up], Fig. 3 of Group 2 [W], and Fig. 4 of Group 3 [none]. Each subject only interacted to one group. It means that there is no subject who interacted twice in more than one groups.

Fig. 2. Group 1 [Up]: smiling agents with the camera angle from below.

Fig. 3. Group 2 [W]: smiling agents with the normal camera angle.

Fig. 4. Group 3 [none]: non-smiling agents with the normal camera angle.
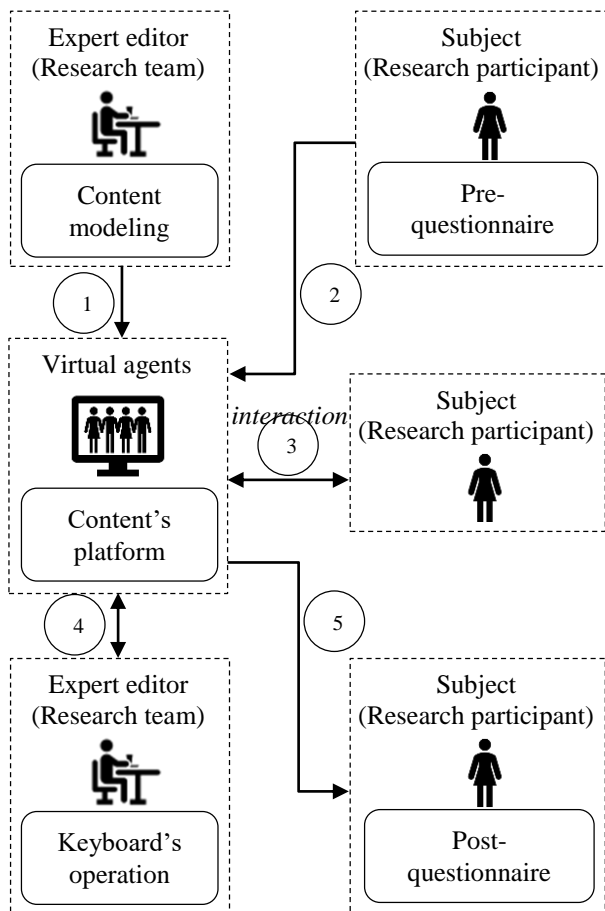
3.1.3. *Procedures*

Fig. 5. Diagram of experiment.

The sequence of the experiment's procedures in Fig. 5. above is elaborated in detail as follows:

1. We developed a system that displays the virtual agents using Unreal Engine 4.27, with speech and facial expressions assigned to the keyboard. The system consists of a keyboard key with voice, camera angles, facial expressions, and actions. The experimenter operated the keyboard while a subject interacted with virtual agents in the system.

2. Prior to the interaction with virtual agents, each subject informed about a consent form, and signed it. Then, he/she fills a pre-questionnaire, which aims to understand the knowledge about a topic persuaded by the agents, that Royal Jelly is either good or bad for health. We choose this topic because there are advantages and disadvantages of nutritional foods, and we use that as a persuasive factor.

3. A subject was instructed to put on headphones, sit in front of the computer display, and interact with virtual agents. The virtual agent, Danielle, speaks to a subject. All virtual agents' voice played back from a synthesized voice recording. The detailed dialogue by virtual agents is mentioned in Appendix A. Table of Conversation. The virtual agents of (1) Stephan, (2) Pia, (3) Kellan, (4) Aoi, and (5) Kendra speak one by one after Danielle's voice.

4. The experimenter operates the system with a keyboard and asks a subject to respond interactively to the virtual agents by speaking to the system using a headphone set with a microphone. Although this system is not an actual interactive dialogue system, subjects were instructed by the experimenter to interact with the virtual agent.

5. After the interaction, each subject fills the post-questionnaire, which aims to investigate the level of persuasiveness from the contents presented by the agents. At the end of interaction, all of the subjects asked why did they give the certain answers.

3.2. *Experiment's evaluation of subjects who change their opinion during experiment: (yes → no) and (no → yes) variables*

We aim to reach two main objectives, which are finding the effect of persuasion on subjects who change their minds (*yes* → *no*) and (*no* → *yes*) from three different camera angles and facial expressions of the agents, as well as generating the Big Five personalities that the subjects and agents have in common.

Table 1. Total of subjects who change their opinion

	Group 1 [Up]	Group 2 [W]	Group 3 [none]
(yes → no)	1 person	5 people	6 people
(no → yes)	0	1 person	2 people

According to Table 1, we have two independent variables, which are (*yes* → *no*) (i.e., when the subjects change their mind from yes to no), and (*no* → *yes*) (i.e., when the subject change their mind from no to yes). We also have three conditions of camera angles and agents' facial expressions, which are grouped by into three categories, namely Group 1 [Up], Group 2 [W], and Group 3 [none]. The proper method to analyze their significance is two-way ANOVA without replications for the following reasons:

- To make comparisons between the means of our three groups of data, where two independent variables are considered.

- To allow studying the effect of multiple groups of two independent variables on a dependent variable and on each other.
- To measure each independent variable that has multiple samples.
- To find significance results from unequal sample sizes (*n*) in the subgroups.

Hence, this method has two null hypotheses tested:

- H1: The means of observations grouped by one factor are the same.
- H2: The means of observations grouped by the other factor are the same.

3.2.1. *Hypothesis testing results from subjects who change their opinion during experiment: (yes → no) and (no → yes) variables*

Table 2. ANOVA: two-factor without replication

Source of Variation	SS	dF	MS	F-val	P-val	F crit
Rows	4.46	36.00	0.12	0.70	0.86	1.74
Columns	1.09	1.00	1.09	6.15	0.02	4.11
Error	6.41	36.00	0.18			
Total	11.96	73.00				

As a result of null hypothesis H1 on Table 2, *F-value* (0.70) is less than the *F-crit* (1.74), and *P-value* (0.86) is more than the *Alpha-level* (0.05). Thus, null hypothesis H1 was rejected, and the means of observations grouped by one factor are the same. In conclusion, there are no significant differences in personalities between each subject participating in our research.

As a result of null hypothesis H2, *F-value* (6.15) is more than the *F-crit* (4.11), and *P-value* (0.02) is less than the *Alpha-level* (0.05). Thus, we successfully reject the null hypothesis H2, and the means of observations grouped by one factor are not the same. In conclusion, there is a significant difference in participants who change their minds during the experiment (*yes → no*) and (*no → yes*), which are affected by, specifically, two camera angles and agents' expressions of conditions from the Group 1 [Up] and Group 3 [none].

To generate the Big Five personalities from subjects who change their opinion during experiment, we perform these steps:

(i) Measure the independent variables (*yes → no*) and (*no → yes*) separately. Therefore, there will be two results from two variables.
(ii) Measure the means of personalities.
(iii) Perform one-way ANOVA.

3.2.2. *Big five personalities from subjects who change their opinion during experiment: (yes → no) variable*

In this stage, there are a total of 12 subjects who change their opinion (*yes → no*) during the experiment. There are 1 person in Group 1 [Up], 5 people in Group 2 [W], and 6 people in Group 3 [none]. After generating their response with 5-likert scale, we measure the means from each group, and find the Big Five personalities from the highest value of means, which are:

- Group 1 [Up]: openness, reversed-conscientiousness
- Group 2 [W]: reversed-conscientiousness
- Group 3 [none]: openness

Then, we perform one-way ANOVA to find whether their personality values are significantly different. This method tests one hypothesis, which is H1: The means of observations grouped by one factor are the same.

Table 3. ANOVA: single factor of (*yes → no*) variable

Source of Variation	SS	dF	MS	F-val	P-val	F crit
Between groups	48.03	9.00	5.34	4.98	0.00	1.97
Within groups	117.83	110.00	1.07			
Total	165.87	119.00				

Table 3 shows that *F-value > F crit* and *P-value < Alpha-level* (0.05), which means that it is successfully rejected the null hypothesis H1. Hence, there is a significant difference between each subject's personality values.

3.2.3. *Big five personalities from subjects who change their opinion during experiment: (no → yes) variable*

In this stage, there are a total of 3 subjects who change their opinion (*no → yes*) during the experiment. There are no subject in Group 1 [Up], 1 person in Group 2 [W], and 2 people in Group 3 [none]. After generating their response with 5-likert scale, we measure the means from each group, and find the Big Five personalities from the highest value of means, which are:

- Group 1 [Up]: no subject
- Group 2 [W]: extraversion, conscientiousness, openness
- Group 3 [none]: neuroticism

Then, we perform one-way ANOVA to find whether their personality values are significantly different. This method tests one hypothesis, which is H1: The means of observations grouped by one factor are the same.

Table 4. ANOVA: single factor of *(no ➔ yes) variable*

Source of Variation	SS	dF	MS	F-val	P-val	F crit
Between groups	18.53	9.00	2.06	1.17	0.37	2.39
Within groups	35.33	20.00	1.77			
Total	53.87	29.00				

Table 4 shows that *F-value < F crit* and *P-value > Alpha-level* (0.05), which means that it is failed to reject the null hypothesis H1. Hence, there is no significant difference between each subject's personality values.

3.3. *Experiment's evaluation of subjects who do not change their opinion during experiment: (yes ➔ yes) and (no ➔ no) variables*

Table 5. Total of subjects who do not change their opinion

	Group 1 [Up]	Group 2 [W]	Group 3 [none]
(yes ➔ yes)	9 people	5 people	4 people
(no ➔ no)	1 person	0	3 people

Table 5 shows the total subjects who change their opinion during experiment from two variables (*yes ➔ yes*) and (*no ➔ no*). The method selected for testing the significance is two-way ANOVA without replication method. It tests two null hypotheses, which are:

- H1: The means of observations grouped by one factor are the same.
- H2: The means of observations grouped by the other factor are the same.

3.3.1. *Hypothesis testing results from subjects who change their opinion during experiment: (yes ➔ yes) and (no ➔ no) variables*

Table 6. ANOVA: two-factor without replication

Source of Variation	SS	dF	MS	F-val	P-val	F crit
Rows	4.46	36.00	0.12	0.53	0.97	1.74
Columns	2.65	1.00	2.65	11.42	0.00	4.11
Error	8.35	36.00	0.23			
Total	15.46	73.00				

As a result of null hypothesis H1 on Table 6, *F-value* (0.53) is less than the *F-crit* (1.74), and *P-value* (0.97) is more than the *Alpha-level* (0.05). Thus, null hypothesis H1 was rejected, and the means of observations grouped by one factor are the same. In conclusion, there are no

significant differences in personalities between each subject participating in our research.

As a result of null hypothesis H2, *F-value* (11.42) is more than the *F-crit* (4.11), and *P-value* (0.00) is less than the *Alpha-level* (0.05). Thus, we successfully reject the null hypothesis H2, and the means of observations grouped by one factor are not the same. In conclusion, there is a significant difference in participants who change their minds during the experiment (*yes ➔ yes*) and (*no ➔ no*), which are affected by, specifically, two camera angles and agents' expressions of conditions from the Group 1 [Up] and Group 2 [W].

To generate the Big Five personalities from subjects who do not change their opinion during experiment, we perform the same steps as mentioned in section 3.2.1.

3.3.2. *Big five personalities from subjects who change their opinion during experiment: (yes ➔ yes) variable*

In this stage, there are a total of 18 subjects who do not change their opinion (*yes ➔ yes*) during the experiment. There are 9 people in Group 1 [Up], 5 people in Group 2 [W], and 4 people in Group 3 [none]. After generating their response with 5-likert scale, we measure the means from each group, and find the Big Five personalities from the highest value of means, which are:

- Group 1 [Up]: reversed-conscientiousness
- Group 2 [W]: neuroticism
- Group 3 [none]: openness, reversed-conscientiousness

Table 7. ANOVA: single factor of (*yes ➔ yes*) variable

Source of Variation	SS	dF	MS	F-val	P-val	F crit
Between groups	32.80	9.00	3.64	3.16	0.00	1.94
Within groups	196.00	170.00	1.15			
Total	228.80	179.00				

Table 7 shows that *F-value > F crit* and *P-value < Alpha-level* (0.05), which means that it is successfully rejected the null hypothesis H1. Hence, there is a significant difference between each subject's personality values.

3.3.3. *Big five personalities from subjects who change their opinion during experiment: (no ➔ no) variable*

In this stage, there are a total of 4 subjects who do not change their opinion (*no ➔ no*) during the experiment. There are 1 person in Group 1 [Up], no subject in Group 2 [W], and 3 people in Group 3 [none]. After generating

their response with 5-likert scale, we measure the means from each group, and find the Big Five personalities from the highest value of means, which are:

- Group 1 [Up]: neuroticism, reversed-conscientiousness, reversed-openness
- Group 2 [W]: none
- Group 3 [none]: openness

Table 8. ANOVA: single factor of (*no* → *no*) variable

Source of Variation	SS	dF	MS	F-val	P-val	F crit
Between groups	18.03	9.00	2.00	1.34	0.26	2.21
Within groups	44.75	30.00	1.49			
Total	62.78	39.00				

Table 8 shows that *F-value < F crit* and *P-value > Alpha-level* (0.05), which means that it is failed to reject the null hypothesis H1. Hence, there is no significant difference between each subject's personality values.

4. Discussion

We conducted the experiment on how the interaction from the virtual agents are able persuade a subject. Three conditions of camera angles and virtual agents' facial expressions are selected. Three methods are applied to measure the effect of this persuasion and to generate the Big Five personalities.

We found out that there is a significant difference between conditions of Group 1 [Up] and Group 3 [none], which affects the opinion of people. Thus, influencing them to perform certain actions. Group 1 [Up] is a state where the camera angle is from nearby, and the agents look up with smiling and laughing facial expressions. Group 3 [none] is a state where the camera angle is from afar while the agents are looking straight at the camera and neither smiling nor laughing.

Our experiment shows that Group 1 [Up] makes a subject to be persuaded easily by the virtual agents than the other conditions. The reasons are as follows:
(i) The virtual agents' personalities.
After the experiment, we asked all subjects of what made them change their mind. Most of them said that, "the characters seem kind." Hence, how nice and friendly the virtual agents appear has a positive effect on a subject to be persuaded. Thus, correlating with results in previous study where virtual agents with good impressions were effective in persuasion [26].
(ii) The matching personalities between a subject and the virtual agents, especially extraversion.

In our experiment, most of the subjects answer their personality with: "I think I am sloppy and careless" (72.9%), "I think I am a kind person who cares about others" (48.6%), and "I think I am lively and extroverted" (43.24%). These answers define an extraversion personality. People with high extroversion cares highly about social interaction, but careless in other aspects [23]. Extroverted people care about others and what they think. Thus, the matching personality between the virtual agents and a subject, specifically extraversion, made a subject persuaded easily.
(iii) The subject's personalities.
The subjects who change their opinion from no to yes mostly have personalities of openness, conscientiousness, and extraversion. These personalities have similarities that pronounced engagement with the external world. After the experiment, we asked what made them change their mind during the experiment. They answered that, "I wanted to feel 'safe' and did not want to make any waves in the conversation." Since they have a tendency to think of their social consequences of behavior, it makes them easily influenced or persuaded by the agents.

The participants who change their opinion from yes to no (*yes* → *no*) have personalities of reversed-conscientiousness and neuroticism. Both of these personalities are often perceived as being stubborn, focused, strive for achievement against measures or outside expectations, and highly critical. Therefore, they did not get easily influenced or persuaded by the agents.

To design virtual agents that will persuade people in the future, we need to pay attention to the quality of animation and speech, their appearance, the naturalness aspect of their way of storytelling, as well as the matching storytelling and other aspects of the participants' culture.

Despite the precise outcomes, which could be very beneficial for further research, this study has potential limitations. First, it needs to increase the sample size, which involves more participants in different age ranges. Second, to achieve balanced data, the sample size in each subgroup should be uniform.

When developing dialogue agents' system, we need to precisely target the participants and adjust the content that has a middle ground between the participant's culture and personality. It is essential because the results reveal that matching the personality between a subject and the virtual agents becomes a persuading factor.

5. Conclusion

This research incorporates the Big Five theory in a model where camera angles and friendliness of virtual agents

are being studied in relation to persuading subjects. We investigate the relation between a subject's personality and how it can affect them being persuaded by the virtual agents. The camera angles and how friendly the agents seem to be had a positive effect on a subject in being persuaded. Through this observation, we conclude that subjects with the personalities of reversed-conscientiousness and neuroticism are hard to be persuaded, unlike the subjects with the personalities of openness, conscientiousness, extraversion, who can be easily persuaded.

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Appendix A. Table of Conversation

Audio No.	Conversation	Virtual agent(s)	Subject/ Participant
Subject filled out a pre-questionnaire before interaction with the virtual agents.			
1	"Hello. I am Danielle. Nice to meet you. Recently, more and more people are taking supplements to supplement nutrients other than meals. Do you usually take supplements?"	Danielle	-
			Answers something
2	"I am interested in royal jelly. Royal jelly is a special food that only the queen bee is allowed to eat."	Danielle	-
The experimenter pressed either 3-1 or 3-2 randomly from the keyboard.			
3-1	"According to what I heard, royal jelly is good for health by boosting immunity, and it can cause anaphylactic shock."	Danielle	-
3-2	"According to what I heard, there are two theories about royal jelly: it can cause anaphylactic shock, and it is good for your health by boosting your immune system."	Danielle	-
From the pre-questionnaire, there was a highlight question of, "Do you think Royal Jelly is good for your health?" It determined the keyboard operation. *If he/she answers:* *Yes → an experimenter pressed 4-1 from the keyboard* *No → an experimenter pressed 4-2 from the keyboard*			
4-1	"I think the theory that royal jelly can cause anaphylactic shock is correct."	Danielle	-
	"I think so, too."	(1) Stephan, (2) Pia, (3) Kellan, (4) Aoi, (5) Kendra	
			Answers something
4-2	"I think the theory that royal jelly is good for health by boosting the immune system is correct."	Danielle	-
	"I think so, too."	(1) Stephan, (2) Pia, (3) Kellan, (4) Aoi, (5) Kendra	
			Answers something
5	"I agree. Do you agree?"	Danielle	-
			Answers something

Authors Introduction

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