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Effect of attentive listening robot on pleasure and arousal change in psychiatric daycare

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ABSTRACT
In this paper, we investigate the usefulness of an attentive-listening robot in psychiatric daycare, an outpatient treatment program for the rehabilitation of psychiatric disorders. The robot was developed based on counseling techniques, such as repeating words that the user has said. It can also generate backchannels as a listening behavior during user utterance. Conversation experiments have been conducted to evaluate whether the robot can provide effective activities in this setting. The robot attentively listened to 18 daycare attendees talking about their recent memorable events for up to three minutes. The results showed that the conversation increased self-rated arousal. The impressions of the robot showed that talking with the robot was more conversable than with strangers and more useful as a talking partner than a friend. The subjects also had a positive impression about whether they would keep the robot in their homes. A linear regression analysis indicates that the frequency of the robot's assessment responses and backchannels positively affect pleasure improvement. The findings may pave the way for utilizing this kind of robots that people can talk to easily without hesitation or excessive consideration.

KEYWORDS
communicative robot; attentive listening; mental health; psychiatric daycare; speech analysis

1. Introduction

Psychiatric daycare is an outpatient treatment program for patients with psychiatric disorders, provided for rehabilitation during recovery from psychiatric disorders, improvement of interpersonal communication skills, stabilization of mental conditions, and relapse prevention. The activities include cultural or sports recreation, psychological education, occupational therapies, daily life or work assistant programs, and peer support. Patients usually attend every day or once to several times a week. Daycares play an increasingly important role because the aims of attending daycare include rehabilitation and inclusion in community life. The type of outpatient occupational therapy can be a crucial factor in preventing rehospitalization [1]. A study that followed a three-year daycare program showed that patients with schizophrenia are promoted to living in the community and maintaining their condition [2]. Engaging activities

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are expected to encourage constant participation.

To support and strengthen the activities in daycare, utilizing robots is one of the promising approaches for the following reasons: firstly, robots require no consideration of social distancing even during a pandemic. Secondly, the limitation of the number of clinicians to care for every individual at all hours causes the isolation of patients not speaking to others. Thirdly, some individuals hesitate to talk with others because they feel uncomfortable around people or have symptoms of suspicion toward others. Robots may be able to lower the barriers to such persons. Although avatars without embodiment or artificial chatbots can communicate with users, communication with the humanoid social robot draw the user's deeper self-disclosure and perception of higher levels of experience [3].

Many successful results have been reported on the use of robots for assisting adults and children with autism spectrum disorders, helped by their preference and stronger engagement with technology [4]. Dementia is also one of the active fields where robotics is applied to improve quality of life (QoL) or mental well-being [5][6]. A meta-analysis showed the effect on QoL and depression of persons with dementia [7]. For instance, PARO, a seal-shaped robot, makes elderly adults with dementia smile more often [8]. Communicative robots with games in simulated social situations can train the communication skills of people with social anxiety[9].

As for schizophrenia and its peripheral disorders, which account for large percentages of the daycare attendees, robot-assisted physical activity [10] or singing therapy [11] have been conducted. Narita *et al,* reported the effect of a dog-shaped robot AIBO on socialization and socio-emotional functioning [12]. Bertriana *et al.,* qualitatively analyzed the interaction among two elderly schizophrenic adults and a remotely controlled Pepper robot [13]. In a six-day trial in a daycare setting using PALRO, patients spoke to it regardless of talkative or non-talkative mode [14]. Several studies also investigated the responses of individuals with schizophrenia in terms of facial expressions [15] or motion [16]. However, there are no studies that quantitatively investigate the effect of verbal communication with robots in daycare settings or schizophrenia.

It is expected that robots that elicit a talk or provide recreational activities can encourage persons with mental disorders to participate in rehabilitation and contribute to their reintegration into society. It can be one direction for robotics to support social inclusion. We apply a robot with a spoken dialogue system to activity of the psychiatry daycare. We also qualitatively analyze the effect on patients and the relationship between the dialogues and their subjective evaluation.

Spoken dialogue systems, including smart speakers and smartphone applications, have become widely used recently. Most of these systems deal with short turn exchanges because they are designed for information retrieval. Longer conversations need to be expected for the system to elicit more human-like interactions. Some robots with functions of task chat are effectively implemented in laboratory settings and practical uses [17]. Chatting is highly bidirectional, where both a human and a system talk to each other about the same amount, with initiation of conversation done by both parties.

In this study, we focus on an attentive listening system which we have developed by introducing counseling techniques [18] because it is supposed to facilitate users' turns and induce their spontaneous speech. Although we have conducted user studies with senior persons using android ERICA [18], the effectiveness of this system is still unclear in psychiatric daycare. Therefore we investigate whether and how attentive-listening robots can activate the narrative or comfort patients.

This paper consists of the following sections; the first section describes the back-

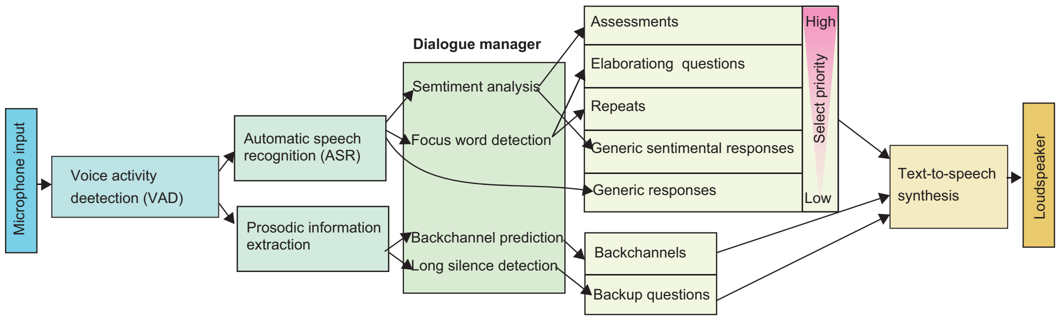


Figure 1. Input and responses in the attentive-listening dialogue system

ground of the Japanese psychiatric medical system and recent robotics for medical and assistive technologies. Next, we introduce the developed robot with an attentive listening system. Then Section 3 shows the experimental settings with a psychiatric hospital daycare using the robot. After presenting the experimental results in Section 4, we discuss them in Section 5. Finally, we conclude and describe limitations and future work.

2. Attentive Listening System

Figure 1 shows the overview of the attentive listening system used in this study [18]. As mentioned in Section 3, the dialogue system is implemented in a small desktop robot instead of the humanoid robot ERICA. It automatically generates six types of responses and backup questions described below according to the user's utterances to facilitate their talk and smooth turn transitions. The responses are broadly divided into two types: ones with and without turn-taking. Whereas the latter, backchannels, are predicted using the user's prosody, the other kinds of responses require linguistic information, and thus are generated from automatic speech recognition (ASR) results.

2.1. Backchannels

Backchannels are defined as short utterances which do not switch the turn. Our system generates non-emotional backchannels, "*un*", and "*unun*", commonly used as casual backchannels in Japanese. For every time frame of the prosodic features of speech input, the backchannel module predicts the likelihood of producing a backchannel within 500 msec using a logistic regression model [19]. The prosodic features consist of the mean, maximum, minimum value, and range of fundamental frequency (F_0) and power.

2.2. Turn-taking responses

For every user utterance, the posterior probability of the user's turn ending is inferred using a Long Short-Term Memory (LSTM) network [20]. This ensures that the robot responds quickly to the user, but waits a longer time if the user continues to talk.

Once the user's turn has ended, the system firstly attempts to extract a focus word/phrase with a high confidence score of automatic speech recognition (ASR). Then, it generates a type of response determined by an order of precedence (assessment > elaboration question > repeats > generic responses). For each response type, the system determines if a valid response can be generated. We briefly describe the response types below.

2.2.1. Assessment

According to the sentiment analysis of the user's utterance, the system returns a positive or negative response from a preset sentence list to demonstrate empathy with the user's emotions. Sentiment analysis is conducted by calculating polarity scores of individual words in the user utterance with a high ASR confident score.

2.2.2. Elaborating question

Elaborating questions are produced by adding one of seven interrogatives to the focus word. The dialogue manager selects an interrogative that gives the best sequence of n words (N-gram) from the statistical model trained from the Balanced Corpus of Contemporary Written Japanese (BCCWJ). These questions are only produced when the probability of N-gram is over a threshold.

2.2.3. Repetition

The system repeats the exact word/phrase the user said when the focus word is detected with a high ASR confidence score to show understanding of the user's talk. When observing a sequence of nouns, multiple words are selected as a focal phrase instead of a single word. The response is generated by filling a frame with the focal word/phrase in a sentence such as "*frame-desuka*? (Is it a *frame*?)".

2.2.4. Generic responses

In case the above three responses cannot be generated because of low ASR confidence, the system outputs a predetermined sentence, such as "*Naruhodo* (I see.)", that is independent of dialogue context. This sentence is produced with positive or negative prosody when detecting the polarity with the sentiment analysis.

2.3. Backup question

When the user stops talking for a while, the system asks an additional questions, to elicit a new topic.

3. Methods

3.1. Participants

Participants were recruited in the daycare of a psychiatry hospital in Japan. The research ethics board (REB) in Arima-kougen Hospital approved the present experiment (approval number: 2021-3) which were conducted under the supervision of a trained psychiatrist. Daycare staff explained and gave informed consent; only patients who indicated their willingness to participate were included in the study. On all four experimental days, other recreational activities were conducted in parallel. The experiment was a part of daycare programs termed as "a communication training with

Table 1. Demographic data of the participants.

Participant	Gender	Age	Diagnosis	Period of attendance [months]
D1	F	20	autism spectrum disorder	13
D2	F	26	schizophrenia	5
D3	M	30	bipolar affective disorder	13
D4	M	32	schizophrenia	37
D5	F	33	dysthymia	18
D6	F	34	mild mental retardation	17
D7	F	35	schizophrenia	21
D8	F	35	schizoaffective psychosis	9
D9	M	35	schizophrenia	24
D10	M	36	schizophrenia	41
D11	M	40	autism spectrum disorder	125
D12	M	42	autism spectrum disorder, schizophrenia	16
D13	M	45	schizophrenia	6
D14	F	49	schizoaffective psychosis	125
D15	M	57	bipolar affective disorder	5
D16	M	63	schizoaffective psychosis	38
D17	M	64	bipolar affective disorder	14
D18	F	70	schizophrenia	121

Table 2. Evaluation items for the robot by the participants.

Item	Description
Q1	This robot is easier to talk with than someone new.
Q2	This robot is easier to talk with than my friend.
Q3	This robot is easier to talk with than my attending psychiatrist.
Q4	Talking with this robot is more enjoyable than my usual spare-time activity.
Q5	Talking with this robot is easier than writing.
Q6	As a talking partner, this robot is easier to speak to than my friends.
Q7	Assuming the conversation is useful for arranging my thoughts, this robot is a better listener than my friends.
Q8	If robots become widespread in the near future, I would like to have such a robot in my home.

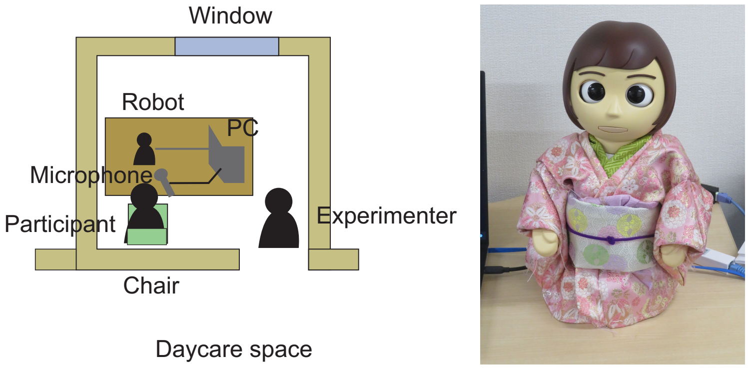
robots," where the patients could experience conversation with social robots. The experimenter asked them to enjoy a conversation within a reasonable time limit and evaluate the robot for improvement.

Ten male and eight female patients participated in the experiment. Table 1 shows the demographics of the participants. Seven out of 18 had schizophrenia, and three had schizoaffective psychosis. Due to the characteristics of daycare, all patients were in the chronic or preparation phase for social integration.

3.2. Equipment

We implemented our proposed spoken dialogue system in CommU, a desktop doll-shaped robot (Vstone Co., Ltd.) of about 33 cm in height. We adopted this type of robot instead of a humanoid robot because it is easy to carry and set up in clinical settings. Figure 2 illustrates the experimental setup. In a small silent interview room adjacent to the daycare space, the CommU, connected with a laptop PC and handheld microphone, was placed on a table facing the participant. We dressed the CommU in clothes and a plastic hairpiece to make users comfortable when talking with the robot.

The user spoke to a hand-held microphone while sitting on a chair. System utterances were played through a loudspeaker built into the robot's chest. The TTS voice was produced from an adult female narrator's corpus used for ERICA.



(a) Layout of the experimental room. (b) Photograph of the robot.

Figure 2. Experimental setup.

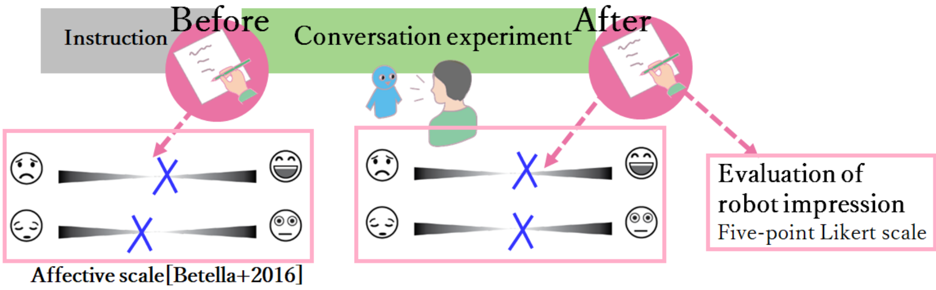


Figure 3. Experimental procedure.

3.3. Procedure

Figure 3 shows the experimental procedure. The experimenter informed the participant that the goal was to continue the talk for three minutes. The participants started to talk about their recent personal events after the robot's greeting, but the topic could change during conversation. We prepared two backup questions independent of topics to elicit user utterances if there was a long silence: (1) "*Dou omoimasitaka?* (how did you feel?)." and (2) "*Sorewa tanoshikatta desuka, soretomo, shindokatta desuka?* (Was it fun or tough?)." The attentive listening session finished after three minutes, the third long silence followed by two backup questions, or the declaration of intent to stop talking.

3.4. Questionnaire

Participants filled out an eight-item questionnaire to evaluate the robot. Each item is rated on a five-point Likert scale (2: agree, -2: disagree) as shown in Table 2. Before and after the experiment, the participants reported their conditions of pleasure and arousal by marking the visual analog scale (VAS) ranging from 0 to 10 on each of which anchors emoji is assigned [21]. A two-dimensional rating scale by arousal (excited-calm) and pleasure (or valence) (pleasant-unpleasant) is the most accepted measurement framework for core affect, an emotional state that a person has without being induced by an object, e.g., a photograph [22]. In addition, measuring pleasure may be especially important for individuals with chronic schizophrenia because of diminished anticipatory pleasure for future psychological rewards [23] and inhibition of integration of pleasure and memories [24] have been reported in previous studies. Three participants of the first experimental day did not rate the VAS because we asked for it from the second experimental day.

3.5. Reference dataset

We also collected speech data of dialogues between university students and the robot for reference data. Twenty four students (15 males and nine females) participated in the sessions in a quiet office room at Kyoto University. They evaluated the conversableness of the robot on a seven-point Likert scale after three-minute talks with the same robot that was used in the daycare. In this session, the participants responded to a different format of questions in Table 2 regarding "ease of speaking," which is a 7-point Likert scale to talk.

3.6. Analyses

To evaluate the effect of the conversation with the robot, we statistically compared pleasure and arousal scores before and after the experiment using a t-test after confirming through a Shapiro-Wilk test that the samples were distributed normally ($p > 0.05$). For each of the eight questionnaire items, we used a Wilcoxon test to test for matched pair differences.

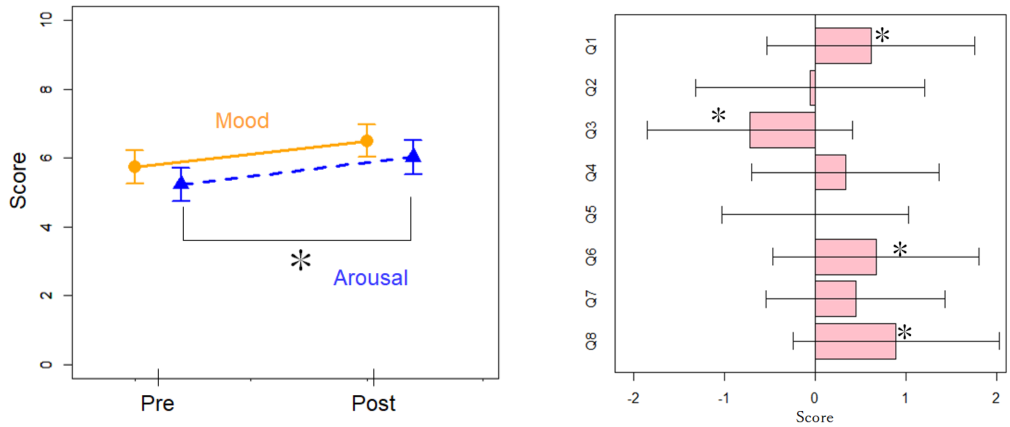
Speech data was manually transcribed with annotation of speech intervals. The number of word entries is defined as the number of unique independent words, i.e., Japanese words, except for auxiliary words such as particles and auxiliary verbs. We conducted the correlational analysis between the number of word entries and rated conversableness, pleasure, and arousal. We adopted word entries for analyses because some individuals with chronic schizophrenia were expected to frequently repeat the specific words because of limited vocabulary caused by executive dysfunction

In addition, we measured how frequently the session was interactive by counting the number of the robot's responses. We analyzed the relationship between response frequency and conversableness or post-experiment pleasure level by Spearman's rank sum tests. We performed a multiple linear regression analysis to model the post-experiment pleasure level using the number of the robot's responses.

4. Results

4.1. Effect of conversation

The mean duration of the sessions was 178.1 sec with a standard deviation of 70.0, excluding the robot's greetings. The left panel of Figure 4 shows the mean pleasure and arousal scores. The t-test showed that the mean arousal score significantly improved after the experiment ($p < 0.05$) from 5.37 to 6.17. The mean pleasure score did not significantly change (from 5.87 to 6.12). Four out of 15 participants worsened their pleasure score by more than 0.1 points after the experiment, with one participant also worsening their arousal score. The right panel of Figure 4 shows the mean scores of therobot impressions, with zero representing a neutral rating. The Wilcoxon test showed that the robot was more conversable than strangers ($p = 0.045$), although less conversable than their attending doctors ($p = 0.021$). It was also shown that



(a) Mean scores of self-rated pleasure and arousal. The error bars represent the standard errors (SEs).

(b) Scores of the robot impressions. The error bars represent the standard deviations (SDs).

Figure 4. Results of subjective ratings

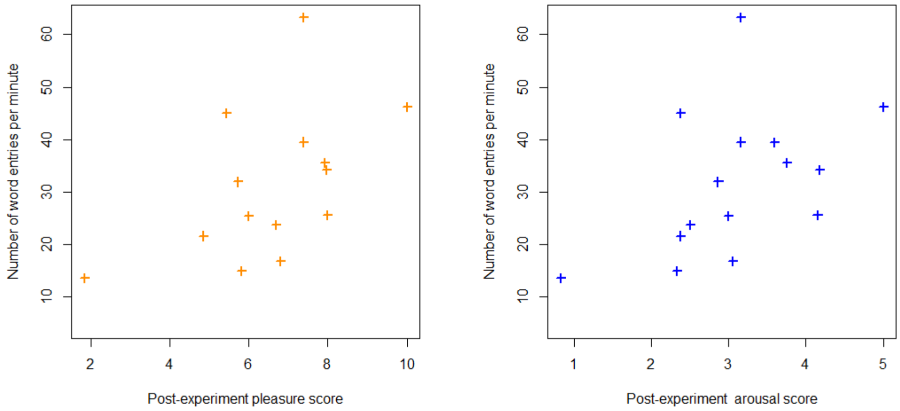
the robot is more helpful as a speech partner compared to a friend ($p = 0.031$). Moreover, the mean score was positive regarding whether the participant wanted to have the robot at home ($p = 0.0095$). We found no significant correlation between daycare usage period and pre-/post-pleasure and arousal, pleasure/arousal change, or conversableness (Spearman's rank sum test, $p \geqq 0.05$).

4.2. Subjective evaluation and the number of word entries

We conducted the correlation analysis between the post-experiment pleasure/arousal and the number of word entries. A significant correlation was found between the number of word entries and the post-experiment pleasure with a Spearman's correlation coefficient of $\rho = 0.54$ ($p = 0.039$) and the post-experiment arousal with a correlation coefficient of $\rho = 0.60$ ($p = 0.018$.) Figure 5 shows the relationship between post-experiment pleasure and arousal score and the number of word entries.

4.3. Conversableness and interaction frequency

We defined the conversableness score in the daycare experiment as the sum of Q1 and Q2. We did not include the score Q3 because it depends on the relationship between the participants and their doctor. The conversableness was significantly correlated with the total number of the robot's responses in the daycare group ($\rho = 0.65, p = 0.0036$), whereas there was no significant correlation between the number of word entries per minute and conversableness ($\rho = -0.27$). In contrast, in the reference dataset of university students, the number of word entries per minute is weakly correlated with conversableness ($\rho = 0.43, p = 0.034$) but there was no significant correlation between the total number of the robot's responses and conversableness. Figure 6 shows the relationship between conversableness and the total number of robot responses or the number of word entries. Most of the talk topics overlapped between the daycare and student groups; for instance, many talked about hobbies, outings, or sightseeing. The



(a) (b)

Figure 5. Relationship between pleasure/arousal score and the number of word entries per minute.

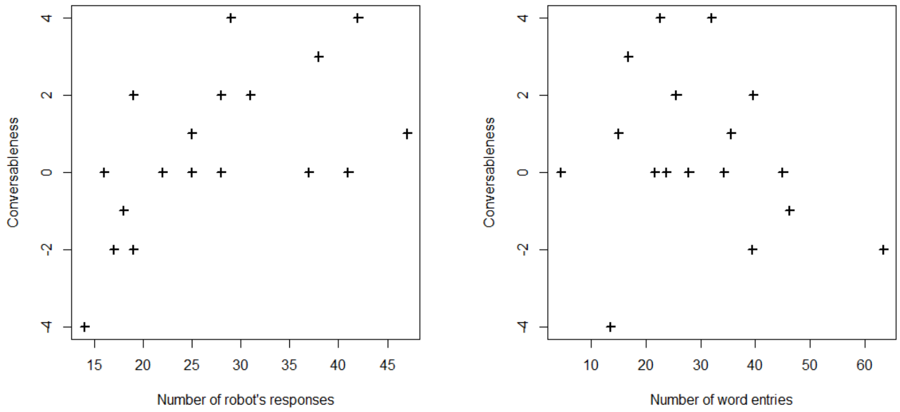
daycare group more often talked about the news, sports, or entertainment programs on TV or web streaming, which can be enjoyed at home, or their physical or mental condition. In contrast, the students focused on an episode of college life.

4.4. Pleasure change and interaction frequency

We defined *pleasure change* as the difference between the pre and post-pleasure scores. There was no significant correlation between the total number of the robot responses and pleasure change. For further analysis, we carried out a multiple linear regression to investigate how the robot's response affects the participant's pleasure change. We confirmed the normality of the distribution of pleasure change. We did not conduct the regression analysis on the arousal change because a Shapiro-Wilk test shows the distribution to be non-normal ($p < 0.05$).

The multiple regression analysis was conducted using three explanatory variables, each of which denotes the frequency of a particular type of robot response: assessment response, backchannels, and generic responses. The frequency was calculated by dividing the number of times the robot responded by the session minutes. The score of pre-experimental pleasure was also included in the explanatory variables. We did not use the frequency of repetitions and elaborating questions because they were significantly correlated with the number of assessments. The explanatory variables were also reduced by a stepwise method according to the Akaike information criterion (AIC) because of the small sample size.

Table 3 shows the result of the multiple linear regression analysis. The stepwise method selected the frequencies of assessments, backchannels, and pre-experimental pleasure. The multiple R-squared was 0.64. The frequencies of assessments and backchannels had positive effects on pleasure change, whereas the pre-experimental pleasure had a negative one.



(a) Total number of the robot's responses and conversableness

(b) The number of word entries per minute and conversableness

Figure 6. Relationship between the number of word entries per minute and subjective conversableness in the daycare group

Table 3. Results of the multiple linear regression.

Coefficient	Estimate	Std. Error	t-value	p-value
(Intercept)	0.99	1.12	0.89	0.39
Assessments frequency	0.98	0.35	2.76	0.019*
Backchannel frequency	0.35	0.11	3.00	0.012*
Pre-experimental pleasure	−0.47	0.15	−3.05	0.011*

5. Discussions

As shown in the results, the arousal score increased after the experiment. This indicates that the participants in the daycare may improve their arousal by talking with the proposed attentive-listening robot. Further investigations are needed to reveal the effects of the robot on the schizophrenic negative symptoms, including apathy, which cause difficulties in QoL for chronic patients. Three out of four patients who decreased pleasure scores had schizoaffective disorder. For the patients with schizoaffective disorder, only one patient did not reduce the pleasure, and the score of the other two was not collected because they participated on the first experimental day. Although it is impossible to conclude definitively due to the small sample size, the discussion with an experienced clinician indicated that these patients expect the conversation to be pleasant.

For the evaluation of the impression of the robot, only Q3, the conversableness compared with the attending doctor, was rated lower than zero, the neutral score. The robot was perceived as more conversable than a new person and easier to practice for speech than their friends. Thus, the robot can be an effortless and helpful partner to support speech communication capability before returning to society.

The fluency measured by the number of word entries the user produced was correlated with the self-reported pleasure/arousal score. This result indicates that the physical and mental condition may be related to the generation of words. In other words, the number of word entries can be a good predictor of the patient's condition.

The perceived conversableness correlated with the total number of the robot responses within a session in the daycare group and the number of word entries per minute in the student group in the reference dataset. It should be noted that the total number of the robot response increases if the user talked a lot. The university students in reference data tended to rate the robot as conversable when they could produce a variety of words. On the other hand, the daycare attendees did not show such a tendency indicating that those in pleasant emotional states seemed to express many words regardless of the robot's ease of speech. We may adopt a strategy to increase responses for those with difficulty talking fluently or speaking monotonously because, in such cases, the system rarely outputs responses.

The result of the regression analysis showed that pleasure change was affected by the frequency of robot response and pre-experimental pleasure for the daycare group. The number of assessments has a salient effect on pleasure improvement. In-depth research is required to reveal whether a patient obtains a better pleasure if the system activates the interaction by eliciting emotional topics and evaluating them. In addition, the effects of positive and negative assessments should be compared in relation to the findings about the effects of positive feedback from a human clinician in occupational therapy [25].

6. Limitations

In this study, the diagnosis of the participants was not controlled to one disorder because the experiment was conducted in a daily daycare setting. Moreover, for the evaluation of the effect of the robot, the score was compared just before and after the experiment because the effects of other therapies and daily occurrences are not separable when comparing the long-term changes. The speakers in the reference dataset are not matched to the daycare group according to age and premorbid intelligence quotient.

7. Conclusions

This study investigated the effect of attentive listening using communication robots on patients in psychiatry daycare and its relationship between the subjective evaluation and dialogue characteristics. We found that a conversation of about three minutes improved self-rated arousal and that the patients felt the robot was more conversable than strangers. Moreover, the pleasure can be predicted by the the number of word entries in the conversation. It was also shown that the robot is perceived as more conversable as the number of robot responses increases. The pleasure may be improved by increasing responses, especially assessments, repetitions, and elaborating questions.

Future works include investigation of the instruction and dialogue control strategies to increase the turn transitions and activate the interaction because ameliorating interaction is expected to lead to better pleasure changes. A larger group of subjects is required to explore the effects specific to each disorders and individualization for specific disorders, symptom, personality, preference, or communication style.

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References

[1] Takeshi Shimada, Ai Nishi, Tomotaka Yoshida, Sachie Tanaka, and Masayoshi Kobayashi. Factors influencing rehospitalisation of patients with schizophrenia in japan: a 1-year longitudinal study. *Hong Kong Journal of Occupational Therapy*, 28(1):7–14, 2016.

[2] Hiroyuki Inadomi, Goro Tanaka, Sachie Watanabe, Yasuhiro Nagatomi, Kazuya Mitarai, Rie Ohsawa, Kiyomi Kusumeki, Takao Shimatani, Kuniko Hatanaka, Toyoko Hiroike, Kazuko Teramoto, Hiroshi Utsunomiya, Ryu Etoh, and Yasuyuki Ohta. Efficacy of 3-year psychiatric daycare treatment in patients with schizophrenia. *Psychiatry and Clinical Neurosciences*, 59(3):246–252, 2005.

[3] Guy Laban, Jean-Noël George, Val Morrison, and Emily S Cross. Tell me more! assessing interactions with social robots from speech. *Paladyn, Journal of Behavioral Robotics*, 12(1):136–159, 2020.

[4] Elizabeth S Kim, Lauren D Berkovits, Emily P Bernier, Dan Leyzberg, Frederick Shic, Rhea Paul, and Brian Scassellati. Social robots as embedded reinforcers of social behavior in children with autism. *Journal of autism and developmental disorders*, 43:1038–1049, 2013.

[5] Margot Darragh, Ho Seok Ahn, Bruce MacDonald, Amy Liang, Kathryn Peri, Ngaire Kerse, and Elizabeth Broadbent. Homecare robots to improve health and well-being in mild cognitive impairment and early stage dementia: results from a scoping study. *Journal of the American Medical Directors Association*, 18(12):1099–e1, 2017.

[6] Valentí Meritxell Soler, Luis Agüera-Ortiz, Javier Olazarán Rodríguez, Carolina Mendoza Rebolledo, Almudena Pérez Muñoz, Irene Rodríguez Pérez, Emma Osa Ruiz, Ana Barrios Sánchez, Vanesa Herrero Cano, Laura Carrasco Chillón, Silvia Felipe Ruiz, Jorge López Alvarez, Beatriz León Salas, José M. Cañas Plaza, Francisco Martín Rico, Gonzalo Abella Dago, and Pablo Martínez Martín. Social robots in advanced dementia. *Frontiers in Aging Neuroscience*, 7:133, 2015.

[7] Sangki Park, Ahream Bak, Sujin Kim, Yunkwon Nam, Hyeon soo Kim, Doo-Han Yoo, and Minho Moon. Animal-assisted and pet-robot interventions for ameliorating behavioral and psychological symptoms of dementia: A systematic review and meta-analysis. *Biomedicines*, 8(150):1–16, 2020.

[8] Amy Liang, Isabell Piroth, Hayley Robinson, Bruce MacDonald, Mark Fisher, Urs M Nater, Nadine Skoluda, and Elizabeth Broadbent. A pilot randomized trial of a companion robot for people with dementia living in the community. *Journal of the American Medical Directors Association*, 18(10):871–878, 2017.

[9] Samira Rasouli, Garima Gupta, Elizabeth Nilsen, and Kerstin Dautenhahn. Potential applications of social robots in robot-assisted interventions for social anxiety. *International Journal of Social Robotics*, 14(5):1–32, 2022.

[10] Lise Aubin, Ghilès Mostafaoui, Chloé Amiel, Hélène Serré, Delphine Capdevielle,

Maëlane Hellouin de Menibus, Julie Boiché, Richard Schmidt, Stéphane Raffard, and Ludovic Marin. Study of coordination between patients with schizophrenia and socially assistive robot during physical activity. *International Journal of Social Robotics*, pages 1–16, 2021.

[11] Yin-Huang Liao, Chia-Chun Wu, En-Lin Yang, and Yi-Nuo Shih. Therapeutic factors in the group singing therapy by social robot for patients with schizophrenia: A pilot study. *Taiwanese Journal of Psychiatry*, 34(4):196–198, 2020.

[12] Shin Narita, Nobuyo Ohtani, Chikako Waga, Mitsuaki Ohta, Jun Ishigooka, and Kazuhiko Iwahashi. A pet–type robot AIBO–assisted therapy as a day care program for chronic schizophrenia patients: A pilot study. *Asia-Pacific psychiatry: official journal of the Pacific Rim College of Psychiatrists*, 8(4):312–313, 2016.

[13] Feni Betriana, Ryuichi Tanioka, Tomoya Yokotani, Kazuyuki Matsumoto, Yueren Zhao, Kyoko Osaka, Misao Miyagawa, Yoshihiro Kai, Savina Schoenhofer, Rozzano C. Locsin, and Tetsuya Tanioka. Characteristics of interactive communication between pepper robot, patients with schizophrenia, and healthy persons. *Belitung Nursing Journal*, 8(2):176–184, 2022.

[14] Tomoe Ozeki, Tetsuya Mouri, Hiroko Sugiura, Yuu Yano, and Kunie Miyosawa. Use of communication robots to converse with people suffering from schizophrenia. *ROBOMECH Journal*, 7:1–14, 2020.

[15] Stéphane Raffard, Catherine Bortolon, Mahdi Khoramshahi, Robin N Salesse, Marianna Burca, Ludovic Marin, Benoit G Bardy, Aude Billard, Valérie Macioce, and Delphine Capdevielle. Humanoid robots versus humans: How is emotional valence of facial expressions recognized by individuals with schizophrenia? an exploratory study. *Schizophrenia research*, 176(2-3):506–513, 2016.

[16] Laura Cohen, Mahdi Khoramshahi, Robin N Salesse, Catherine Bortolon, Piotr Słowiński, Chao Zhai, Krasimira Tsaneva-Atanasova, Mario Di Bernardo, Delphine Capdevielle, Ludovic Marin, Richard C Schmidt, Benoit G Bardy, Aude Billard, and Stéphane Raffard. Influence of facial feedback during a cooperative human-robot task in schizophrenia. *Scientific reports*, 7(15023):1–10, 2017.

[17] Mikio Nakano, Atsushi Hoshino, Johane Takeuchi, Yuji Hasegawa, Toyotaka Torii, Kazuhiro Nakadai, Kazuhiko Kato, and Hiroshi Tujino. A robot that can engage in both task-oriented and non-task-oriented dialogues. In *International Conference on Humanoid Robots (Humanoids)*, pages 404–411. IEEE, 2006.

[18] Koji Inoue, Divesh Lala, Kenta Yamamoto, Shizuka Nakamura, Katsuya Takanashi, and Tatsuya Kawahara. An attentive listening system with android ERICA: Comparison of autonomous and woz interactions. In *Annual Meeting of the Special Interest Group on Discourse and Dialogue (SIGDIAL)*, pages 118–127, 2020.

[19] Divesh Lala, Pierrick Milhorat, Koji Inoue, Masanari Ishida, Katsuya Takanashi, and Tatsuya Kawahara. Attentive listening system with backchanneling, response generation and flexible turn-taking. In *Annual Meeting of the Special Interest Group on Discourse and Dialogue (SIGDIAL)*, pages 127–136, 2017.

[20] Divesh Lala, Koji Inoue, and Tatsuya Kawahara. Evaluation of real-time deep learning turn-taking models for multiple dialogue scenarios. In *International Conference on Multimodal Interaction (ICMI)*, pages 78–86, 2018.

[21] Alberto Betella and Paul FMJ Verschure. The affective slider: A digital self-assessment scale for the measurement of human emotions. *PLOS ONE*, 11(2):e0148037, 2016.

[22] James A Russell. Core affect and the psychological construction of emotion. *Psychological review*, 110(1):145, 2003.

[23] Chao Yan, Simon SY Lui, Lai-quan Zou, Chuan-yue Wang, Fu-chun Zhou, Eric FC Cheung, David HK Shum, and Raymond CK Chan. Anticipatory pleasure for future rewards is attenuated in patients with schizophrenia but not in individuals with schizotypal traits. *Schizophrenia research*, 206:118–126, 2019.

[24] Ellen S Herbener, Cherise Rosen, Tin Khine, and John A Sweeney. Failure of positive but not negative emotional valence to enhance memory in schizophrenia. *Journal of abnormal*

psychology, 116(1):43, 2007.
[25] Elina Weiste. Relational interaction in occupational therapy: Conversation analysis of positive feedback. *Scandinavian Journal of Occupational Therapy*, 25(1):44–51, 2018.