Adaptive Psychological Distance in Japanese Spoken Human-Agent Dialogue: A Politeness-Based Management Model

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Abstract

While existing spoken dialogue systems can adapt various aspects of interaction, systematic management of psychological distance through verbal politeness remains underexplored. Current approaches typically maintain fixed levels of formality and social distance, limiting naturalness in long-term human-agent interactions. We propose a novel dialogue management model that dynamically adjusts verbal politeness levels in Japanese based on user preferences. We evaluated the model using two pseudo-users with distinct distance preferences in daily conversations. Human observers (n=20) assessed the interactions, with 70% successfully distinguishing the intended social distance variations. The results demonstrate that systematic modulation of verbal politeness can create perceptibly different levels of psychological distance in spoken dialogue, with implications for culturally appropriate human-agent interaction in Japanese contexts.

1 Introduction

The advancement of communication robots designed for frequent human interaction has accelerated significantly in recent years. By integrating human-like traits, these robots or agents are expected to become more approachable and relatable, facilitating broader adoption (Cassel and al., 2003.) (Häring and al., 2011.). With the advent of generative AI, robots can now understand and respond to human speech more effectively. However, understanding implied meaning, which is a cornerstone of human communication, remains challenging for AI.

A critical yet understudied aspect of implied meaning is psychological distance, which plays a fundamental role in relationship development and maintenance. This concept has been extensively studied in psychological research, particularly through the lenses of personal space and politeness theory (Brown and Levinson, 1987) (Hall, 1966). Although previous studies have explored personal space and politeness in robot interactions, there has been limited investigation into robots' active management of psychological distance during ongoing conversations (Huttenrauch and al., 2006) (Tomoki and al., 2017), especially in Japanese language contexts where politeness levels are deeply embedded in linguistic structures.

Traditional approaches to politeness have primarily relied on Brown and Levinson's (1987) framework, which conceptualizes politeness as strategies to mitigate face-threatening acts. However, more recent theoretical developments by Locher and Watts (2005) have shifted focus toward "relational work", emphasizing the dynamic and contextual nature of politeness rather than inherent linguistic features. Similarly, Culpeper's (2011) contributions to understanding impoliteness have broadened the theoretical landscape. Our work integrates these perspectives while addressing the specific linguistic features of Japanese politeness.

Therefore, the present study addresses this gap by designing and implementing an internal model that enables robots to modulate psychological distance through linguistics behaviors grounded in an integrated politeness theory framework, with specific application to Japanese language interaction.

2 Proposed System

Our system enables robots to converse at the psychological distance preferred by users through an internal state variable D that governs the selection of conversation strategies based on politeness theory. This value evolves through extended interactions, triggering corresponding adjustments in conversational approaches. The

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Strategy	Japanese Example	English Translation	Notes
NPS: Be conventionally indirect	もし宜しければ、お名前を教えていただけますか？	If it's not too much trouble, could you please tell me your name?	honorific form and conditional
NPS: Question, hedge	少しお時間をいただけないかもしれませんが...	I was wondering if I might possibly have a moment of your time...	Multiple hedges and honorific form
NPS: Give deference	山田様、ご意見をお聞かせいただけますか？	Mr. Yamada, would you honor me with your opinion?	honorific title and humble request form
PPS: Notice, attend to Hearer	新しい髪型いいね！似合ってるよ。	Nice new haircut! It really suits you.	Direct compliment with casual ending
PPS: Exaggerate	すごーい！あなたの考えは天才的だよ！	Wow! Your idea is absolutely genius!	Elongated expression and enthusiastic tone
PPS: Use in-group identity markers	ねぇ、これどう思う？	Hey, what do you think about this?	casual speech pattern and familiar address

Table 1: Overview of some NPS and PPS in Japanese with English translations.

system maintains individual *D* values for each user, allowing for personalized distance calibration in Japanese dialogue contexts.

Given the complexity of accurately inferring users' preferred psychological distance in real-time, we initially validate our approach using pseudo-users with predetermined distance preferences. This controlled setup enables systematic evaluation of the model's effectiveness.

2.1 Definition of Psychological Distance *D*

Our model quantifies psychological distance *D* as the inverse relationship between shared information and interpersonal similarity, building on Yamane's model (available only in Japanese). To accommodate individual user preferences, we introduce a personality multiplier. The psychological distance D is calculated as:

$$D = \frac{personality}{\sum_{k=1}^{n} sim_k} \quad (1)$$

In this equation, *n* represents the amount of shared information, while sim_k represents information similarity, ranging from 0.1 to 1, computed via cosine similarity of text vectors. The personality parameter ranges from 1 to 5, allowing for individual variation in distance preferences.

It is important to clarify that although our mathematical formulation incorporates concepts related to physical distance from proxemics theory (Hall, 1966), *D* specifically measures psychological distance on an abstract scale.

Unlike physical distance measured in meters, psychological distance in our model represents the perceived social-emotional space between interactants, which manifests through linguistic choices and conversational strategies. The formula allows us to quantify this abstract concept for computational implementation.

2.2 Conversation Strategy Selection

The model employs conversation strategies derived from politeness theory's Face-Threatening Act (FTA) framework. While traditional FTA calculations consider psychological distance (D), power difference (*P*), and imposition (*Rx*), our implementation focuses specifically on distance perception through *D*. From the five traditional politeness strategies, we concentrate on the two most relevant for everyday conversation in Japanese: Positive Politeness Strategies (PPS) and Negative Politeness Strategies (NPS). In Japanese linguistic and cultural contexts, NPS generally corresponds to greater psychological distance, as they involve formal language patterns, honorifics, and indirect expressions that signal respect and deference. Conversely, PPS typically signals closeness through casual language, shared expressions, and direct communication styles. This relationship between politeness strategies and psychological distance is particularly pronounced in Japanese, where the language has grammaticalized politeness levels (Ide, 1989). Examples of NPS and PPS in Japanese are provided in Table 1, along with their English translations to illustrate the differences.

The system calculates *D* at conversation topic boundaries and determines the ratio of NPS to PPS strategies for subsequent utterances. These ratios are based on predefined thresholds aligned with personal space theory, as illustrated in Table 2. For values of D below 0.45, the system employs a highly informal approach with an NPS:PPS ratio of 0:5. As D increases through the ranges of 0.45 to 1.20 and 1.20 to 3.60, the formality gradually increases, with NPS:PPS ratios of 2:3 and 3:2 respectively. For D values above 3.60, the system adopts a highly formal stance with an NPS:PPS ratio of 5:0.

These specific ratio values were determined through preliminary studies examining the correlation between perceived psychological distance and the distribution of politeness strategies in Japanese conversation samples. The thresholds correspond to significant transition points in perceived distance based on linguistic features.

2.3 Dynamic Adjustment of Distance

Our model dynamically adjusts the personality parameter to modulate D, thereby adapting the psychological distance to match user preferences. The system analyzes the ratio of NPS to PPS strategies in pseudo-user utterances at topic boundaries to identify the user's preferred D range. When a mismatch is detected between the user's and robot's D ranges, the system calculates an adjustment value that shifts the robot's D to the maximum value within the user's preferred range. For the uppermost D range, which lacks a defined limit in Table 2, we reference proxemic theory of personal space which establishes a maximum public distance of 7.6m. Given the challenges in extracting precise psychological distance information from natural utterances, we pre-generate pseudo-user responses based on their assigned D values, using the relationship between D and conversational strategies outlined in Table 1. The adjustment value r is formally defined as:

$$r = \frac{u_{max}}{D} \quad (2)$$

where (u_{max}) represents the maximum value of the user's preferred D range.

2.4 Utterance Generation

The utterance generation process utilizes GPT-4o in two distinct phases. First, it creates base conversational scenarios that establish the fundamental interaction structure. Subsequently, it performs strategic modification of utterances to reflect intended NPS/PPS ratios. This two-phase approach ensures both coherent dialogue flow and appropriate social distance signaling.

Threshold of D	**Ratio of NPS/PPS**
$0.00 < D \leq 0.45$	NPS:PPS=0:5
$0.45 < D \leq 1.20$	NPS:PPS=2:3
$1.20 < D \leq 3.60$	NPS:PPS=3:2
$3.60 < D$	NPS:PPS=5:0

Table 2: Threshold of D and conversational strategies.

Consider the neutral utterance "Kai, What would you like for breakfast?" When applying NPS, it transforms into "If you don't mind, could you please let me know your breakfast preferences?" This version emphasizes social distance and formality. Conversely, when applying PPS, it becomes "Would you prefer toast and coffee, or is there something else you'd like to try?" This version creates a more intimate, casual interaction style.

In Japanese, these distinctions are even more pronounced due to the language's grammaticalized politeness levels. The neutral question "朝ごはん何が食べたい？" (What do you want for breakfast?) becomes "もしよろしければ、朝食のご希望をお聞かせいただけますでしょうか？" (If it's not too much trouble, could you please tell me your breakfast preferences?) with NPS, and "トーストとコーヒーでいい？それとも他に食べたいものある？" (Is toast and coffee good? Or is there something else you want to eat?) with PPS.

3 Experimental Evaluation

3.1 Overview

To evaluate our proposed model, we designed a controlled experimental protocol utilizing two pseudo-users with distinct *personality* parameters (1 and 5). These values were selected to represent contrasting tendencies in psychological distance adaptation: the lower personality value facilitates rapid reduction in psychological distance D, while the higher value maintains greater distance stability throughout interactions. We developed two parallel conversation scenarios, corresponding to interactions between the robot and pseudo-users 1 and 2, respectively. To ensure experimental validity and isolate the effect of personality on psychological distance modulation, we standardized the information similarity between both pseudo-users and the robot system.

The experimental design enabled human participants to evaluate both the naturalness of the dialogue management system and their perception of psychological distance variations between the two conversation conditions.

This study was conducted with approval from the Research Ethics Committee of the Organization for Promotion of Advanced Science and Technology, Kansai University (approval number: 24-91). All participants were volunteers and received gift cards valued at 1000 JPY as compensation for their time.

3.2 Experiment Protocol

The experimental protocol employed a virtual cohabitation paradigm consisting of 10 interaction scenarios. Each scenario comprised 10 alternating utterances equally distributed between the robot and pseudo-user systems, maintaining conversational balance. The experimental interface, illustrated in Figure 1, presented these scenarios in a controlled virtual environment with participant-paced progression. We recruited 20 participants (age range: 20-29 years) to evaluate the dialogue interactions through two complementary assessment instruments. The primary questionnaire (Table 3) assessed conversation quality using a five-point Likert scale anchored by “agree” and “disagree” for two key metrics. A secondary comparative questionnaire (Table 4) elicited both quantitative evaluations of the two conversation conditions on a five-point scale and qualitative insights through open-ended response.

The conversational scenarios covered everyday topics such as meal planning, weekend activities, and campus navigation. The robot character was framed as a home assistant robot designed to provide companionship and practical support.

3.3 Results

Analysis of participant responses revealed strong support for the naturalness and effectiveness of our dialogue management system. For Q1, which assessed conversational naturality, all participants (100%) indicated agreement or strong agreement for both conversation conditions, suggesting successful reproduction of natural dialogue patterns across different psychological

Figure 1: System UI.

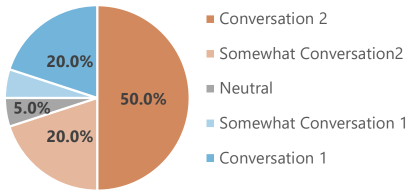

Figure 2: Results of Q3

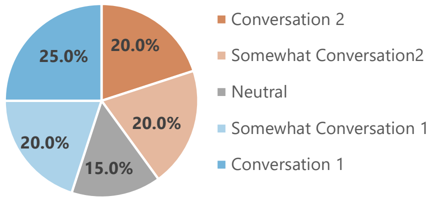

Figure 3: Results of Q4

Q1	To what extent did the robot demonstrate natural conversational capabilities in its interaction with the pseudo-user?
Q2	How did you perceive the evolution of psychological distance between the robot and pseudo-user throughout the conversation?

Table 3: Questionnaire items related to impressions of conversation

Q3	Between the two conversations, which interaction exhibited a more pronounced reduction in psychological distance?
Q4	Which conversation demonstrated a level of psychological distance that would be optimal for you?

Table 4: Questionnaire items related to impressions of conversation

distance settings. The perception of dynamic psychological distance adaptation (Q2) garnered similarly strong support, with 90% and 95% of participants indicating agreement or strong agreement for Conversations C1 and C2, respectively, demonstrating the system's capability to convey decreasing psychological distance over time.

Comparative analysis between the two conversation conditions yielded additional insights into the system's effectiveness. As illustrated in Figure 2, 70% of participants perceived a more pronounced reduction in psychological distance in Conversation C2 compared to C1, validating the intended differential effects of our personality parameter settings. To assess the statistical significance of this finding, we conducted chi-square tests on the distribution of responses. For Q3, the distribution significantly differed from chance ($\chi^2(4, N=20) = 13.50$, $p < 0.05$), confirming that participants could reliably distinguish between the two psychological distance conditions.

However, responses to Q4 (Figure 3) revealed substantial individual variation in preferred psychological distance, highlighting the importance of adaptability in dialogue systems.

Qualitative analysis of open-ended responses provided deeper insights into the perceptible differences between conversation conditions. Participants who successfully discriminated between the two conditions identified several key distinguishing features: conversational vivacity, linguistic style and lexical choice, and degree of conversational initiative. These observations align with our theoretical framework linking personality parameters to observable conversational behaviors.

3.4 Discussion

The universal positive response to Q1 demonstrates that our approach to dynamic psychological distance modulation preserves conversational naturalness while implementing sophisticated politeness-based adaptations. The strong positive responses to Q2 further validate that our implementation of variable politeness strategies successfully conveys gradual psychological distance reduction, supporting the theoretical foundation of our approach.

The convergence of evidence from Q2, Q3, and qualitative responses substantiates the model's capability to create distinguishable psychological distances through systematic manipulation of politeness strategy ratios. Particularly noteworthy is participants' recognition of variations in linguistic patterns and conversational initiative, indicating successful operationalization of politeness theory principles in modulating perceived psychological distance. These findings demonstrate that our computational approach to politeness strategy selection creates perceptible and meaningful variations in conversational dynamics.

However, the significant interpersonal variation in preferred psychological distance revealed by Q4 underscores a critical consideration for dialogue system design. This heterogeneity in user preferences extends beyond the traditional focus on creating uniformly friendly interactions, highlighting the necessity for adaptive distance management in human-agent dialogue systems. Our model's capacity for dynamic distance adjustment addresses this requirement, though future research should explore additional mechanisms for rapid adaptation to individual user preferences.

These findings also demonstrate the relevance of integrating both traditional politeness theory (Brown and Levinson, 1987) and more recent "relational work" perspectives (Locher and Watts, 2005). While our computational model operationalizes Brown and Levinson's strategies, the dynamic adaptation mechanism reflects Locher and Watts' emphasis on the contextual and negotiated nature of politeness. This integration provides a more comprehensive theoretical foundation for politeness management in human-agent dialogue.

4 Conclusion

This work introduces an adaptive politeness-based model for managing psychological distance in human-agent dialogue. Our experimental evaluation through simulated cohabitation scenarios demonstrates the model's effectiveness in maintaining natural conversation while creating perceptible variations in psychological distance. The results validate both the technical feasibility of our approach and its ability to accommodate diverse user preferences for social distance in dialogue interactions.

Future research will focus on enhancing real-time psychological distance estimation, validating the model with human users in naturalistic settings, and implementing the system in physical robot platforms. These advances will contribute to the development of more sophisticated and socially aware dialogue systems that can sustain meaningful long-term interactions with users.

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