

Stylistic (A)synchrony in Human-Machine Dyadic Interaction: Investigating Co-Adaptation Through the Lens of Communicative Naturalness

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INTRODUCTION

Naturalness in interaction is generally perceived as a necessary foundation for ensuring spontaneous, fluent and comfortable exchange of information. Though naturalness is a given, more or less, in interpersonal (i.e., human-human) interaction, this is not always the case for human-machine interaction. While large language models like ChatGPT undergo continual improvement, they still tend to fall short of natural “humanlike” communication (Voss & Waring, 2024).

Though a growing number of studies have investigated the factors which affect users’ perceptions of chatbot naturalness (e.g., AbuShawar & Atwell, 2016; Araujo, 2018; Lysova et al., 2025), evaluations remain largely subjective and context dependent (Voss & Waring, 2024). Some (e.g., Atiyah et al., 2019) frame naturalness broadly as the extent to which chatbots can go undetected as machines as they interact with humans, and “tends to be measured against what is expected or normal for humans” (Lysova et al., 2025, Background section, para. 2). Others (e.g., Morrissey & Kirakowski, 2013) have gone further and have identified particular behaviors exhibited by chatbots which influence users’ perceptions of naturalness.

While there is no unified definition for communicative naturalness, it clearly represents an essential construct in shaping how users interact with chatbots, and its significance is further heightened in the context of investigating co-adaptation. In dyadic interaction, interlocutors operate in tandem; each contributes to and is influenced by the other’s linguistic, cognitive, and affective behaviors. Though numerous studies have shown that humans exhibit synchrony across language domains in human-human conversational ecosystems (Kim & Michel, 2023; Larsen-Freeman, 2020), considerably less research has been conducted on how synchrony emerges in human-machine interactions. Existing research in this area has shown that perceived humanness is not a prerequisite for co-adaptation (Branigan et al., 2011; Pearson et al., 2006). Questions remain, however, about which (other) properties of machine-mediated interaction affect the extent and trajectory of synchrony.

Building on this gap, the present analyses sought to understand the role of communicative naturalness in shaping synchrony between a human-machine dyad. Specifically, address the research question “How does co-adaptation unfold in an ecosystem of learner-ChatGPT dyadic interaction?” by investigating the potential role of ChatGPT’s perceived communicative naturalness on the development of stylistic synchrony.

Naturalness Principles for Communication

In their 2024 paper, Voss and Waring propose a framework for operationalizing conversational naturalness, which we adopted for the present analysis. The framework consists of three conversation principles used to evaluate naturalness in spoken communication; these are the emergent, the indexical, and the recipient-design principles, all described briefly below. For the present analyses, these principles were adapted for written interaction.

The first of these naturalness principles, the emergent principle, is concerned with the real-time co-construction of dialogue. Briefly, the emergent principle posits that conversation unfolds through a variety of turn-taking units negotiated in real time by interlocutors. In human interaction, conversation is marked by imperfection and self-repair, as well as openness to multiple possibilities in terms of purpose and direction. Chatbots tend to fail this naturalness principle as productions are characterized by a limited range of purposes (i.e., questioning, informing, and advising). Further, their communication is “perfect,” marked by fully sentential, or even paragraph-length responses. In this way, non-human interaction is nonegalitarian as unlimited conversational space gets taken up by the chatbot.

The second principle, the indexical principle, deals with the contextual nature of conversation and the use of a variety of cohesive elements like anaphora and discourse markers that tie utterances together. Unlike humans, chatbots may not be able to “understand” shared context with their interlocutors, as AI’s “knowledge” relies on pattern recognition derived from limited training data; this knowledge differs fundamentally from knowledge-making processes specific to humans (Curry et al., 2025). At the conversational level, chatbots show that they may not be able to draw information from prior turns or across interactions with their human conversation partners. Chatbots also tend to fail in the opposite direction: though they have trouble accessing information from prior exchanges, productions by chatbots are marked by explicitness in that responses exhibit repetition of their human interlocutor’s nouns and noun phrases. In addition to these naturalness failures, chatbots omit discourse markers that humans would typically include, like *Well* or *So* at the beginning of an utterance.

The final principle, the recipient-designed principle, says that each turn in human conversation is crafted for a particular interlocutor and moment. This requires that speakers pay close attention to and monitor the unfolding of conversation on a moment-by-moment basis. AI chatbots may not show full monitoring of their conversation partner’s prior response, such that their responses are not designed for that particular turn. Chatbots generally also fail to demonstrate contiguity, addressing questions in the order they were asked, rather than addressing the more recent question first.

ANALYTIC APPROACH

The human-machine interactional data selected for this forum were iteratively coded in an approach mirroring that of Voss and Waring (2024). The conversation was first reviewed for instances of “natural” and “unnatural” productions by ChatGPT. These were cases where both authors mutually agreed that the chatbot’s production read as particularly “human” or “nonhuman,” respectively. Following this more intuitive approach, the framework provided by Voss and Waring was applied such that the moments identified in the first round of analyses were coded according to their adherence to or violation of the three naturalness principles. The two interlocutors’ writing styles were coded over the course of the exchange to understand the effect

of naturalness on stylistic synchrony. Coding focused on speakers' (1) tone (i.e., formality and politeness markers, including the presence or absence of discourse markers and contractions), (2) syntax and mechanics (i.e., grammatical accuracy, punctuation, spelling, and capitalization), and (3) language use (i.e., presence or absence of interactional moves such as greetings and closures).

FINDINGS

Early in the exchange, there is a high degree of stylistic synchrony; both the learner and the chatbot assume a polite, formal tone. ChatGPT, in particular, establishes a formal register and a didactic tone: in turn 1, the chatbot asks the learner to share what they learned in that day's class so that it can better help them. Both participants at this early stage in their exchange demonstrate grammatical and mechanical accuracy, marked by proper mechanics, including proper capitalization and spelling, and adherence to grammar rules.

This early synchrony coincides with the chatbot's adherence to the indexical principle: initially, ChatGPT indexes the context "shared" with the learner, using "we" to create a shared frame of reference and positioning itself and the human as co-participants in a communal learning environment (see ① in Figure 1). Despite this initial success, evidence of explicitness appears in the exchange not long after, as ChatGPT fails to employ conversational "tying" elements: in turn 5, ChatGPT responds to the learner's question by repeating specific language and strings of text produced by the learner in the prior turn (see ② in Figure 1). This breach of naturalness may signal early divergence in style initiated by the learner, starting with their failure to capitalize the first letter of the question in turn 6.

FIGURE 1
Indicators of Naturalness in Exchanges Across Week 1, Turns 1-6

Turn	Interlocutor	Text	Indicators of (Un)naturalness
1	ChatGPT	Hello! Welcome to the main exercise. Can you please tell me what you learned in class so that I can help you better?	
2	Student	Today I learned about data commentary for scientific writing. Data commentary is an essential skill for writing a good paper. It has some purposes such as to highlight the research data, to support the author opinion with the data, and to compare and evaluate different data sets.	
3	ChatGPT	Yes, that's a great summary of what we talked about in class today! Would you like to expand on anything or ask any questions?	① +I – ChatGPT includes language indicating shared experience and knowledge of classroom instruction
4	Student	Is it important to position ourselves as author in the data commentary?	② -I – There is some early evidence of explicitness from ChatGPT, marked by the repetition of words and phrases produced by the learner, rather than use of anaphora
5	ChatGPT	Yes, it is important to clearly identify yourself as the author in the data commentary. This helps to establish your authority and credibility as the researcher or scholar who conducted the study or analyzed the data. ...	
6	Student	what is the typical organizational flow in the data commentary paragraph?	

Note. "+" indicates presence of naturalness principle; "-" indicates violation of naturalness

principle. I = indexical.

Throughout the exchange, ChatGPT also produces increasingly detailed, well-organized, formal paragraphs. In turn 11, for instance, ChatGPT responds to the learner's question, "where can I find some example of good data commentaries including their data examples?" with a multi-paragraph bulleted answer. Structured and explicit responses such as these are atypical of "natural" inter-human conversation, and they contrast with the more variable turn-construction patterns produced by the human interlocutor in this interaction. As such, this represents another early violation by ChatGPT—this time, of the emergent principle. The effect seems to be that, as the exchange progresses, the human contributions gradually diverge in style and mechanics from their initial turn, and importantly from their interlocutor's contributions: Their utterances become shorter, less polished, and begin to lack punctuation. The conversation concludes with a brief "Ok thank you for today," from the learner, followed by ChatGPT's characteristically positive and polite farewell: "You're welcome! Don't hesitate to reach out if you have any further questions or concerns. Good luck with your scientific writing!" While both interlocutors employ a closing, the difference in tone is clear: ChatGPT, as always, is upbeat, formal, and didactic, while the learner is notably cool and informal.

Over the course of the next few weeks, the learner and ChatGPT continue to show a more or less consistent stylistic pattern. Communicative goals are met through functionally complete turn-taking units and a consistent question-and-answer structure, with ChatGPT providing detailed and well-structured information in response to users' requests—and, in this way, maintaining its prescribed role to function as a helpful adviser. However, a clear shift becomes evident in week five; beginning in turn 6, the human interlocutor's productions become increasingly informal, marked by the appearance of a spelling error ("stucture" in turn 4) and discourse markers ("hmm" in turns 6 and 12 and "so" in turns 10 and 14). This contrasts with ChatGPT's consistently formal style, marked by the absence of contractions and a strict adherence to well-formed, fully sentential and formulaic utterances.

This marked shift in style coincides with a series of violations of naturalness principles on the part of ChatGPT. In turn 6, the learner notes that ChatGPT's suggested organization for the introduction section of a scientific paper differs from the structure taught in class; this signals that there is a perceived lack of shared context (see ③ in Figure 2). Despite ChatGPT's persistent attempts to repair its "incorrect" responses, its repeated failure to integrate the corrections over the course of the interaction in turns 9 and 13 point to its inability to index the human's contributions from prior turns. These violations of the indexical principle are further exacerbated by the chatbot's subsequent violations of the emergent principle: ChatGPT maintains strict adherence to "perfect" fully sentential and formulaic language (see ⑦ in Figure 2). Even as it fails in its foundational job to inform (Voss & Waring, 2024), ChatGPT continually tries to maintain this role, asking the learner if they have any further questions that it can answer. The roles are brought to a head as the human begins to assert epistemic authority; they continue to quiz ChatGPT to determine if it has integrated the corrections (see ⑥ in Figure 2).

FIGURE 2
Indicators of Naturalness in Exchanges Across Week 5, Turns 5-16

Turn	Interlocutor	Text	Indicators of (Un)naturalness
5	ChatGPT	Yes, the three moves in an introduction for a scientific paper are: 1. Establish the research territory 2. Summarize the state of the art 3. Introduce the research gap or a research problem to be addressed in the paper.	
6	Student	hmm, but in our lecture the third move is to introduce the statement of purpose , including list of research questions, principle findings, contributions, and outline of the paper structure	③ -I – There is perceived lack of shared knowledge by student, evidenced by questioning of ChatGPT's response
7	ChatGPT	Yes, you're right! I apologize for the mistake, it was my oversight. The third move of an introduction in a scientific paper is indeed to introduce the statement of purpose, which includes a list of research questions, principle findings, contributions, and an outline of the paper's structure. Thank you for correcting me. So, did you have any other questions or things you'd like to discuss regarding writing scientific introductions, or did you feel like you learned everything you need to know about it?	④ +E – Some evidence of self-repair from ChatGPT
8	Student	the research gap and a research problem should be the second move	
9	ChatGPT	I apologize for my mistake again. You are right. The second move is to introduce and summarize the state of the art, while the third move is to introduce the research gap or research problem. Thank you for correcting me. Do you have any other questions or things to discuss about scientific writing?	⑤ -I – ChatGPT fails to incorporate the student's corrections, signifying that it is not integrating information from prior turns
10	Student	so, what are the three moves for writing an introduction in a paper?	⑥ -E – Even as it fails in its foundational role to “inform” (Voss & Waring, 2024), ChatGPT continually returns to this role. This brings interlocutor roles to a head, where human begins to assert epistemic authority and role change
11	ChatGPT	The three moves for writing an introduction in a scientific paper are: 1. Establishing research territory or context 2. Summarizing the state of the art 3. Introducing the research problem or a research gap, or the statement of purpose which outlines the aim of the study, research questions, principal findings, contributions, and the overall structure of the paper.	
12	Student	hmmm, introducing the research problem or a research gap should be on the second move	
13	ChatGPT	I apologize for my mistake earlier. You are correct. The second move is to introduce the research problem or the research gap, while the third move is to outline the aims of the study, research questions, principal findings, contributions, and paper structure in the statement of purpose. Thank you for bringing this to my attention.	
14	Student	so, what are the three moves?	
15	ChatGPT	The three moves for writing an introduction in a scientific paper are: 1. Establishing research territory or context 2. Introducing the research problem or a research gap 3. Outlining the aims of the study, research questions, principal findings, contributions, and paper structure in the statement of purpose.	⑦ -E – ChatGPT adheres strictly to “perfect” format; it consistently produces fully sentential and formulaic turns
16	Student	yes, you are correct	

Note. “+” indicates presence of naturalness principle; “-” indicates violation of naturalness principle. I = indexical; E = emergent.

Later in the exchange, the chatbot goes on to violate the recipient-designed principle by failing to show contiguity in turn 23; here, ChatGPT addresses two consecutive questions sequentially, providing relatively long and structured responses (see ⑧ in Figure 3) for both. After this turn, the human interlocutor provides a terse “okay thank you”; their response lacks punctuation and proper mechanics. This is in stark contrast to the chatbot’s extensive and well-formed turns throughout the week’s exchange.

FIGURE 3
Indicators of Naturalness in Exchanges Across Week 5, Turns 22-25

Turn	Interlocutor	Text	Indicators of (Un)naturalness
22	Student	typically, how many words are in an introduction? should we also include related work into it?	⑧ -RD – ChatGPT responds with a lack of contiguity, where the questions are answered in the order they’re asked, rather than latter-first
23	ChatGPT	The length of an introduction can vary based on the specific requirements of the journal or publication you are submitting to.... In addition, related work can be included in the introduction, usually as part of the second move where you summarize the state of the art....	
24	Student	okay thank you	
25	ChatGPT	You're welcome! Do you have any other questions or topics you would like to discuss related to scientific writing?	

(End of exchange)

Note. “+” indicates presence of naturalness principle; “-” indicates violation of naturalness principle. RD = recipient-designed.

The learner’s reaction to the series of naturalness breaches in Week 5 appears to permeate the conversations in the subsequent weeks. Across Weeks 6 and 7, the exchange is marked by the human interlocutor’s consistently informal style; sentences become progressively fragmented and often omit capitalization and punctuation (See Figure 4). Conversations end abruptly following ChatGPT’s last explanatory response. The human no longer offers thanks, and ChatGPT’s customary closing statement is missing, in contrast to earlier interactions. By the final week, the learner no longer builds well-formed questions, despite having shown that they know how to construct questions in earlier exchanges. ChatGPT, meanwhile, continues to rely heavily on its role as an informer and advisor, maintaining a consistently formal and academic tone. Its responses are structured in complete, well-organized—if unegalitarian—blocks of text; these responses provide elaborate and often prescriptive explanations (see ⑩ in Figure 4). ChatGPT dominates the exchange, almost as if following a predetermined script. In this way, the chatbot continues to fail to engage naturally; here, it shows a clear violation of the emergent principle. In some of the final exchanges between the learner and chatbot, ChatGPT produces a complete duplication of scripted language across turns (see ⑨ in Figure 4), thereby delivering a final naturalness violation, here of the recipient-designed principle.

FIGURE 4
Indicators of Naturalness in Exchanges Across Week 7, Turns 8-11

Turn	Interlocutor	Text	Indicators of (Un)naturalness
8	Student	in which part of the paper should be put in a presentation?	
		When preparing a presentation based on a scientific paper, it's important to focus on the key findings and main points of the research. The presentation should be structured in a way that is clear and easy to follow, with a logical flow of information.	⑨ -RD – There is a duplication of scripted language across turns by ChatGPT
9	ChatGPT	Typically, the presentation should include an introduction that provides background information and context for the research, followed by a brief overview of the methods used in the study. The main focus of the presentation should be on the results and findings of the research, which can be presented in the form of graphs, tables, or other visual aids.	
		It's also important to discuss the implications of the research and how it contributes to the field. Finally, the presentation should conclude with a summary of the main points and a call to action or next steps for future research.	⑩ -E – Production is dominated by ChatGPT, such that communication does not feel egalitarian
		In terms of which parts of the paper to include in the presentation, it's generally best to focus on the most important and relevant information, rather than trying to cover everything in the paper. This may involve selecting key figures or tables to highlight, or summarizing the main points of the discussion section.	
10	Student	how about poster?	
11	ChatGPT	When preparing a poster based on a scientific paper, the focus should be on presenting the key findings and main points of the research in a visually appealing and easy-to-understand format...	

Note. “-” indicates violation of a naturalness principle. RD = recipient-designed; E = emergent.

DISCUSSION AND CONCLUSION

In this paper, we were interested in understanding the effect of ChatGPT’s ability to exhibit communicative naturalness on the synchrony of style between a human-machine dyad. Over the course of the exchange, the data suggest that violations of conversational naturalness shown by ChatGPT in the human-machine interaction may have inhibited stylistic co-adaptation. Whereas there was early stylistic synchrony between interlocutors in terms of their grammatical accuracy and overall tone, with both participants adopting a more formal and polite register, violations by ChatGPT seemed to trigger divergence in stylistic features, such that by the end of the exchange, the two participants varied greatly in style. While the chatbot’s productions were consistently formal, polite, and grammatically accurate, marked by both the presence of greetings and closings and the absence of discourse markers, the learner increasingly exhibited informal stylistic features; in stark contrast to the chatbot, their use of correct grammar and mechanics waned. Late in the exchange, the learner also introduced the use of discourse markers, and in the final two weeks of the conversation, they went so far as to abandon all conversational closings. These findings point to a bidirectional lack of stylistic synchrony, where both human

and machine fail to adjust their communication style in response to one another. The outcome is two very distinct and divergent conversational styles by the end of the seven weeks.

Though ChatGPT's adherence to principles of communicative naturalness motivated the investigation of stylistic synchrony in the exchange, the learner proved central to understanding the observed asynchrony. Their role in the stylistic divergence is twofold.

First, because ChatGPT relies on a dynamic, pattern-based, and context-aware neural network to adjust its style, minimal or incomplete input from the human makes accurate stylistic adaptation difficult. Accordingly, the AI defaults to the safest option: a general-purpose, neutral conversational style (OpenAI, 2025). That is, stylistic co-adaptation in human-machine interaction emerges from the interaction itself and is primarily driven by the human user's input. In this dataset the learner's productions tended to be fairly sparse—typically just a few tokens long. As a result of the limited input by the participant, ChatGPT does not have an abundance of language to adapt *to*, and so defaults to its operating guidance and assumes a “neutral” conversational style, characterized by longer, grammatical, more formulaic productions. With few cues available, the chatbot is limited in its ability to infer or understand the human's communicative preferences.

Second, the learner shows little modification to their style in response to the chatbot and, as such, functionally leads the *asynchrony*. In addition to providing little input for the chatbot to respond to, the learner also fails to adopt elements of ChatGPT's style and does not otherwise engage with its stylistic or discursive choices. Accordingly, ChatGPT cannot recalibrate its output to the learner, reinforcing a static, default interactional pattern. These factors seem to work together to constrain the interactional feedback loop necessary for co-adaptation to take place.

The results of this analysis underscore the important role *both* participants play in shaping co-adaptation; synchrony emerges through interaction rather than through a unilateral imposition on the part of just one partner. Interlocutors work together to co-construct meaning in dyadic interaction such that each contributes to and is influenced by the behavior of the other. While ChatGPT's inability to observe principles of conversational naturalness was the focus of this investigation into linguistic synchrony, and may have played a considerable role in the general lack of co-adaptation seen in the dataset, it is clear that the user, too, was central in shaping effective and natural human-machine communication. In short, co-adaptation in these contexts is not the responsibility of the chatbot alone, but is instead an emergent phenomenon resulting from the co-construction of the conversation by both human and machine.

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