

Coherence disruptions in human-chatbot
interaction: towards quantitative approach to
conversation

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Introduction

Recently, there has been a breakthrough in the way we interact with machines¹. We can instruct a computer using natural language². Besides making existing technology an extra step accessible, new ways to use technology appear. Automated interaction alone can solve previously unsolvable problems, such as notably accessing a knowledge base via semantic search³. Until recently a knowledge base would usually be accessed only via fulltext, meaning we would only be able to find information of which we knew a part of the formal encoding. Today, we can search for information simply by asking questions, all thanks to natural language computer interface.

The promise of much practical usage of the current wave of generative AI is ambitious and only brings its fruit slowly, perhaps slower, than was expected⁴⁵. There is talk of a "plateau" in development of the technology powering the current cutting edge inventions⁶. And that is not the only issue

¹D. Sharma et al. "Exploring The Evolution Of Chatgpt: From Origin To Revolutionary Influence". In: *Educational Administration: Theory and Practice* 30.5 (2024).

²G. G. Hendrix. "Natural-language interface". In: *American Journal of Computational Linguistics* 8.2 (1982), pp. 56–61.

³E. Makela. "Survey of semantic search research". In: *Proceedings of the seminar on knowledge management on the semantic web*. Department of Computer Science, University of Helsinki, Helsinki. 2005.

⁴R. Metz et al. "OpenAI, Google, and Anthropic Are Struggling to Build More Advanced AI". in: *Bloomberg News* (2024). Accessed: 2024-12-19. URL: <https://www.bloomberg.com/news/articles/2024-11-13/openai-google-and-anthropic-are-struggling-to-build-more-advanced-ai>.

⁵K. Hu and A. Tong. "OpenAI Rivals Seek New Path to Smarter AI as Current Methods Hit Limitations". In: *Reuters* (2024). URL: <https://www.reuters.com/technology/artificial-intelligence/openai-rivals-seek-new-path-smarter-ai-current-methods-hit-limitations-2024-11-11>.

⁶G. Ritter and W. Lu. "The AI Plateau Is Real — How We Jump To The Next Breakthrough". In: (Dec. 2024). URL: <https://www.emcap.com/thoughts/ai-s-curve-plateau-proprietary-business-data-breakthrough/>.

there is to the current wave of cutting edge AI. To name the most prominent ones:

- high electricity consumption⁷
- unpredictable and broad societal impact⁸⁹

That being said, in context of conversation research, this development in technology promises to make things possible that previously were not. With a partial control of what happens in the conversation and a decent certainty, that our system will simulate human-human conversation to the user, new kind of conversational data is in reach - logs of the human-bot interaction, that could be categorized based on

- which researcher controlled stimulus and
- which participant reaction to given stimulus

they contain.

In the 1960s the relatively recent emergence and adoption of telephone technology allowed for recording and transcribing authentic conversational data. This advancement took place thanks to development in technology which is reminiscent of the current day situation. While human-bot conversational data is arguably less authentic than telephone conversation transcripts, experimental approach can be taken while the human element is present.

This paper's intention is to provide a debate on a metaresearch question - is using generative AI a viable methodology for conversation research? This is done by attempting to develop that very methodology. Proceeding we operate in a frontier, our first steps should be establishing data backed baseline knowledge and assessing possible lines of research.

To understand what something is, it can be fruitful first understanding what that thing is not. One way to understand what makes the unraveling

⁷H. Ritchie. "What's the impact of artificial intelligence on energy demand?" In: *Sustainability by Numbers* (Nov. 2024). URL: <https://www.sustainabilitybynumbers.com/p/ai-energy-demand>.

⁸A Hagerty and I. Rubinov. "Global AI ethics: a review of the social impacts and ethical implications of artificial intelligence". In: *arXiv preprint arXiv:1907.07892* (2019).

⁹M. T. Baldassarre et al. "The social impact of generative ai: An analysis on chatgpt". In: *Proceedings of the 2023 ACM Conference on Information Technology for Social Good*. 2023, pp. 363–373.

text of a conversation a valid one - a coherent one - is obtaining conversational data containing coherence disruptions. This can be done using the discussed technology - it has the capability of conversing in a way that is found generally acceptable by humans and can drift away from the coherent interaction if appropriately instructed to do so.

The data this paper seeks to elicitate and analyse are actual human-chatbot exchanges containing moments which have the potential to be problematic for the human participant to process and follow up on. The line between what a coherent and an incoherent conversation is blurred. It is in no way a binary property of the text of the conversation. The goal is therefore to touch on the gradual divide between them.

While chatbots are evaluated for how natural and error free their way of conversing is, human-human conversation is rarely flawless:

- errors happen
- conversational coherence gets temporarily disrupted

In case of human-human communication, disruptions can however be cured easily.

It used to be (and remains so in legacy systems) that in human-bot communication, disruptions could derail a conversation completely, leaving the bot, who would only rely on surface level textual clues, in the dark.¹⁰ This has become rare with generative AI. Even though it brings a set of its own problems like frequently lacking factuality or the difficulty to handle data responsibly, the cutting edge technology powered conversation systems are

- better capable of understanding and producing relevant answers
- instructed to return to their conversational point of departure

Human-bot communication is often single-purpose. Companies and institutions deploy voice applications to interact with customers and clients, so there is usually a goal to be achieved. The coherence of such conversation can then be described based on whether the goal has been achieved with success and ease. Another common scenario is an open-domain conversation, also known as chit-chat or smalltalk.

¹⁰M. F. McTear. *Conversational AI: Dialogue Systems, Conversational Agents, and Chatbots*. Springer International Publishing, 2020, pp. 43–70.

Some factors that influence coherence in conversational texts, whether in human-human or human-bot exchanges, have been extensively studied.

Namely:

Politeness Brown and Levinson’s work on politeness strategies describes social alignment in smooth interactions¹¹. Politeness strategies, such as using polite language, offering options, or softening potentially face-threatening comments, help to create a comfortable communicative environment. These strategies align with social norms, which people interpret as markers of respect, consideration, or even trust. A failure to employ these politeness strategies, or using them inconsistently, can disrupt conversational coherence. For example, blunt or overly direct responses may be perceived as abrupt or rude, diverting the conversation’s flow or causing discomfort. In such cases, the breakdown of polite norms can lead participants to question intent, hindering effective and smooth communication.

Speech acts Following Austin and Searle’s speech act theories, communication rely on expressing clear intentions and meanings that help build mutual understanding¹²¹³. When speakers convey intentions explicitly through statements, questions, requests, or assertions, it signals to listeners the purpose and direction of the conversation. Effective communication strategies help maintain coherence by ensuring each contribution builds logically on the last. On the other hand, unclear intentions or ambiguous phrasing can create misunderstandings, disrupting the conversation’s flow. Misalignment or mixed signals – such as using sarcasm without cues or making indirect requests without context— can leave listeners uncertain about how to respond, leading to off-track or irrelevant contributions and possibly creating need to address the communication to regain understanding.

Conversational Maxims Grice’s conversational maxims are fundamental to coherent dialogue¹⁴. They suggest that participants should:

- provide truthful information (Quality)
- neither too much nor too little (Quantity)

¹¹P. Brown and S.C. Levinson. *Politeness: Some Universals in Language Usage*. Politeness: Some Universals in Language Usage. Cambridge University Press, 1987.

¹²J. L. Austin. *How to do things with words*. Oxford University Press, 1962.

¹³J. R. Searle. *Speech Acts: An Essay in the Philosophy of Language*. Cambridge University Press, 1969.

¹⁴H. P. Grice. “Logic and Conversation”. In: *Syntax and Semantics: Vol. 3: Speech Acts*. Ed. by Peter Cole and Jerry L. Morgan. Academic Press, 1975, pp. 41–58.

- remain on-topic (Relevance)
- communicate in an orderly, clear manner (Manner)

These maxims encourage effective exchange by setting a standard for contributions that are informative, truthful, relevant, and unambiguous. When violated, such as by giving excessive detail, omitting important context, or straying from the topic, coherence suffers. For instance, irrelevant tangents or over-detailed explanations may confuse the listener as to what is the main focal point of conversation in that moment. This misalignment can leave participants uncertain about the conversation’s direction, ultimately diminishing coherence and the effectiveness of communication.

Sequence Structure The work of Schegloff and Sacks on sequence structure and turn-taking emphasizes that ordered interactions support predictability and continuity in dialogue¹⁵. Turn-taking conventions — where participants follow an implicit sequence of speaking and responding — help maintain the flow by structuring the conversation in a logical order. This sequence structure allows both parties to anticipate when to listen and when to speak, contributing to a well-paced, cohesive exchange. However, interruptions, abrupt changes in topic, or skipping expected responses can disrupt this sequence, introducing unpredictability that can confuse participants. These interruptions fragment coherence by shifting the conversation away from expected responses or structured flow, often leaving gaps in understanding or causing conversational breakdowns.

Message and Topic Interactional linguistics underscores that consistency in message and topic preserves continuity in conversation¹⁶. When speakers stick to a shared topic or make gradual, clear shifts, coherence is maintained because participants know what to expect. Frequent or abrupt topic shifts, however, or sending unclear or conflicting messages, can create disjointed exchanges. For instance, introducing a new topic without closure on the previous one can confuse listeners, leading to a scattered or fragmented interaction. By shifting focus unpredictably or offering unclear messages, coherence diminishes as participants lose track of the conversation’s thread, resulting in exchanges that feel scattered or incomplete.

¹⁵E. A. Schegloff. *Sequence Organization in Interaction: A Primer in Conversation Analysis*. Cambridge University Press, 2007.

¹⁶E. Couper-Kuhlen and M. Selting. *Interactional Linguistics: Studying Language in Social Interaction*. Cambridge University Press, 2017.

While all of the mentioned areas unveil much about the way conversation works, rarely do they concern themselves with the textual dimension of conversation. Most of the mentioned authors (with the notable exception of those operating within the interactional linguistics framework) would hardly be described as linguists, though their works significantly inform linguistics.

The lack of a true interpersonal dimension in human-chatbot communication allows to focus solely on the elements in conversational text, that make it cohesive and coherent or rather those that have the potential to prevent it from being that. The key concepts discussed in this paper are two closely related topics:

Coreference realized by anaphore and topic – what the text is about.

Chapter 1

Theoretical background

1.1 Textual dimension of conversation

The following concepts will be explored individually, in relation to one another and in relation to conversation: text, coherence, cohesion, coreference, anaphora, cataphora, endophora, exophora, topic, entity, and association. While the presented exploration draws on existing literature, it seeks to establish an independent and sustainable framework, rather than strictly adhering to established interpretations.

Text

Text, in its broadest sense, refers to any form of communication that conveys meaning through a combination of signs, symbols, or language¹². These semiotic structures can take various forms, including written, spoken, visual, or even non-verbal modes of expression³. A text can be as simple as a single sentence or as complex as a novel, and it can exist across different mediums, from books and articles to advertisements and digital content. What defines a text is its ability to convey a coherent message or idea, often intended for interpretation by an audience or an addressee. Texts can serve a wide range of purposes, including storytelling, instruction, persuasion, or simply recording

¹J. Hrbáček. *Nárys textové syntaxe spisovné češtiny*. Praha: Trizonia, 1994, p. 7.

²L. Hjelmslev. *O základech teorie jazyka*. Trans. by F. Čermák. 2. doplněné a upravené vydání. Praha: Academia, 2016.

³R. Barthes and S. Heath. *Image, Music, Text*. A fontana original. Fontana Press, 1977, p. 13.

information. Typically text is a structure that is linguistic, produced and perceived as intentional and coherent.

The text of a conversation is specific because it is multiproducer. Another example of a multiproducer text would be a sequence of commercial signs on a busy street. It is the spatial juxtaposition of the signs and temporal juxtaposition of utterances, that make them a text.

Another property of a conversation text is it is negotiated. This is given by its multiproducer and temporal nature. Other types of text which are also negotiated are relatively rare. There are occurrences of debates which take place in written text, whether they are press columns or academic articles, which interact explicitly with each other, making them a negotiation. Such press discourse could however be considered a sequence of text units rather than a single temporarily juxtaposed text. This perspective could hardly be defended in regards to conversation, because its tight temporal coupling and cohesion, making conversation a unique phenomena.

Coherence

Coherence refers to the logical connections and consistent relationships that make a text easy to follow and possible to understand⁴⁵. It is achieved when the ideas, sentences, and paragraphs within a text are linked together in a meaningful way, allowing the reader to grasp the author's message without confusion. Coherence often depends on the use of transitions, the logical flow of arguments, and the proper sequencing of information. It ensures that each part of the text contributes to the overall meaning, creating a unified whole⁶. Incoherent text can be difficult or impossible to understand, even if the individual sentences are grammatically correct⁷. It is a property of the whole text, but textual elements can be pointed out that contribute to or diminish the given texts coherence. Those elements are however not referred to as 'coherence elements'.

Coherence is a cognitive phenomenon⁸ because it involves the mental processes of interpreting, organizing, and understanding information. When

⁴T. Givón. *Coherence*. John Benjamins Publishing Company, 2020, p. 83.

⁵Hrbáček, *Nárys textové syntaxe spisovné češtiny*, p. 9.

⁶Hrbáček, *Nárys textové syntaxe spisovné češtiny*, p. 28.

⁷Hrbáček, *Nárys textové syntaxe spisovné češtiny*, p. 30.

⁸R. M. Roberts and R. J. Kreuz. "Nonstandard discourse and its coherence". In: *Discourse Processes* 16.4 (1993), pp. 451–464.

reading a text, coherence arises not only from the structure and linguistic cues provided by the author but also from the reader's ability to make connections between ideas based on prior knowledge, expectations, and context. This cognitive interaction between the text and the reader's mind is what makes the content understandable.

In conversation, coherence becomes even more complex, as multiple participants are simultaneously contributing to and interpreting the flow of information. Each individual brings their own perspective and understanding to the interaction, which requires constant negotiation to maintain coherence. Misunderstandings, different backgrounds, and interruptions can disrupt the coherence of a conversation, making it a more dynamic and fragile process compared to written text.

- whether a written text is coherent depends mostly on the reader
- whether a conversation text is coherent depends on an ongoing negotiation

Coherence is a scalar property rather than a binary one. It is however tricky to measure. This paper seeks to explore one possible approach of declaring different levels of coherence disruptions and observing the acceptance rates in participants and correlation between them.

Cohesion

While coherence refers to the interpretative quality of a text, wherein the ideas form a logical and meaningful whole cohesion, focuses on the structural relations within a text, achieved through grammatical and lexical links. It should be seen as an umbrella term covering specific relations within the structure of the text, where cohesive elements can be directly pointed out. While coherent text does not necessarily need to be cohesive, cohesive elements often support it. A coherent text tends to be at least somewhat cohesive.

Halliday and Hasan⁹ developed a detailed framework of cohesion, which includes endophoric references, relating parts of the text to each other, and exophoric references, which point outside the text¹⁰. Endophoric cohesion

⁹M. A. K. Halliday and R. Hasan. *Cohesion in English*. Longman, 1976.

¹⁰Halliday and Hasan, *Cohesion in English*, p. 31.

covers aspects like anaphoric references and cataphoric references¹¹¹². Exophoric references, however, rely on shared context beyond the text itself, requiring readers to use prior knowledge. Their framework highlights how elements of cohesion contribute to textual unity and flow, even if coherence based on meaning is not fully achieved. Following concepts can be considered cohesive elements.

Cataphore and Exophore

In Halliday and Hasan’s framework, cohesion in language is achieved through various devices that connect different parts of a text, forming a unified whole. They classify cohesive ties as references, substitutive forms, ellipsis, and connectors, with anaphoric references being one of the primary ways texts achieve cohesion¹³. When a text element cannot be mapped to a preceding referent, Halliday and Hasan suggest that cohesion is maintained through shared situational understanding, making the reference exophoric. Cataphoric references, though less common, involve elements that look forward in the text, showing intentionality by the author but contributing to cohesion primarily through the eventual resolution of the forward-pointing referent.

In conversation if a seemingly anaphoric text element is not successfully mapped to a preceding textual coreferent the reference can still be understood, because shared context. Such element reaches out of the text with its reference, making it an exophoric one. Cataphore is a related phenomena – a reference which points forward in the text. Such occurrence is relatively rare in written text and even more so in conversation. In fact it is somehow pointless to account for cataphore in a multi-producer text. A cataphore denotes an authors intention to reveal the nature of a referent explicitly after first mentioning them. In conversation, where multiple contributors cocreate given text, and mutual understanding and agreement is the measure of how coherent the produced text is, later realisation of a vague reference does not

¹¹E. Hajičová, J. Havelka, and P. Sgall. “Discourse Semantics and the Salience of Referents”. In: *Journal of Slavic Linguistics* 11.1 (2003), pp. 127–140.

¹²S. Loaiciga, S. Dobnik, and D. Schlangen. “Anaphoric Phenomena in Situated dialog: A First Round of Annotations”. In: *Proceedings of the Fifth Workshop on Computational Models of Reference, Anaphora and Coreference*. Association for Computational Linguistics, Oct. 2022, pp. 31–37. URL: <https://aclanthology.org/2022.crac-1.4/>.

¹³Halliday and Hasan, *Cohesion in English*, p. 68.

contribute to how coherent it is. Regardless, in case of a cataphore, only the referent is a cohesive element, not the cataphore, as it ties back to the previous text, creating bonds across large textual units.

Anaphore, Endophore and Coreference

A common cohesive text element is an anaphore¹⁴. It is a reference inside the text pointing back to a previously mentioned entity. Often it is realised via personal pronouns. Though there are other ways for anaphore to realise. In Czech, anaphoric references often rely on grammatical gender and number, making participial endings essential for identifying the referent. For instance, when a grammatically masculine entity is mentioned, later references might use a participle in the masculine form, such as šel ("he went"), connecting back to it without repeating the noun or using a demonstrative. Demonstratives, such as ten ("that") or tento ("this one"), also frequently serve anaphoric functions, guiding the reader to a previously mentioned subject. Temporal and locative adverbs, such as tam ("there") and tehdy ("then"), also contribute cohesion by indirectly referencing time and place details introduced earlier in the text. These anaphoric elements strengthen textual coherence by reducing redundancy and maintaining flow. The reader identifies coreferential links through these markers, following the cohesive threads without needing explicit repetitions.

An anaphoric element is by definition also endophoric. It points inside the text it appears in. By definition an anaphoric element has a referent, which occurs earlier in the text. These two elements are then coreferent. As such they also share an identical exophoric reference – they point outside of the text.

In conversation, many aspects of which are subject to negotiation, also specific coreference relations can be questioned¹⁵. The reference realised by one communication participant may be unclear to the other resulting in a repair request coming from another participant. In conversation analysis, Sacks's concept of repair traditionally addresses misunderstandings related

¹⁴A. Nedoluzhko. "Rozšířená textová koreference a asociální anafora (koncepte anotace českých dat v pražském závislostním korpusu)". PhD thesis. Prague: Univerzita Karlova, Filozofická fakulta, Ústav českého jazyka a teorie komunikace, 2010.

¹⁵S. Loaiciga, Simon D., and D. Schlangen. "Reference and coreference in situated dialogue". In: *Proceedings of the Second Workshop on Advances in Language and Vision Research*. 2021, pp. 39–44.

to intentions and actions, loosely drawing on frameworks like Austin's and Searle's speech act theories. From this perspective, repairs often target interpretative gaps about what a speaker intends to do with their utterance. However, viewed from a broader, more abstract level, what is called repair triggers can extend beyond intentions alone, encompassing issues on the textual level as well. For instance, an nonassignable anaphora — a reference that lacks a clear antecedent — may lead to a repair request, thereby showing how textual ambiguities prompt interactional responses. This approach expands the causes of repair in conversation, integrating elements of reference and interactional misalignment, where a structural aspect of the language itself can become a repairable issue in the communicative exchange.

Topic

Topic is what a text is about. That makes topic very complicated to define. Among others, some issues with topic and annotating it in text are:

- A text can and typically does cover multiple topics
- Different framing will produce different topic annotations of text
- The span of a topic section can be impossible to delimit within text.
- Topic annotation is by its nature always more text, so even it can be annotated for topic. making topic annotations recursive. One cannot therefore achieve a definite topic description of a text.

Despite all these complications, topic cannot be ignored in conversation research as it is deeply intertwined with the aforementioned concepts. Topic progressions across text are realised via anaphore and association and tightly interact with coherence. An appropriate amount of time has to be spent on a given topic unit, enough information has to be said about a given topic in order for it to be possible to move on or add another one in the conversation. Closure has to be provided in order for a topic to be done. Transitioning from one topic to another has a potential to disrupt coherence, if the association between the topics is too distant. A divergence in topic has to be justified.

Association

Association is a textual realization of an isotopic relation¹⁶. By their exophoric properties, referents exist in a semantic web of relationships. Similarly to coherence, associative relationships are a cognitive phenomena. They come to exist when they are perceived. While association is a cohesive element it is difficult to formalize the way it can and has been done with anaphoric text relations. It is however a major factor in a coherence of text as in some cases a text can only rely on association in its coherence.

Entity

An entity is an exophoric referent, descriptions of objects, people, events etc¹⁷. Words or text elements which can be referred to by an anaphore will be called entities. Since a phrase containing an anaphore typically adds more information about the referent the new information must be semantically compatible, in other words association has to be possible between the referent and the added information. Entity also has to do with topic. In text topic can be represented by a single or multiple entities. Coreferent words will be regarded as a single entity. It can serve to partially map a topic distance in the texts chronology.

1.2 Interactional dimension of conversation

In terms of introduced background, conversation is a text which is produced by multiple producers This complicates things:

- Conversation is an interactive process, distinct from static text, which is created collaboratively.
- Conversational content is continuously negotiated by participants, who continuously adapt one another.

Due to its temporal and cooperative nature, conversation allows for:

¹⁶T. Koblížek. *Interpretační sémantika. Úvod do textové teorie Francoise Rastiera*. Univerzita Karlova v Praze, Filozofická fakulta, 2015.

¹⁷D. Ayuso. "Discourse entities in Janus". In: *27th Annual Meeting of the Association for Computational Linguistics*. 1989, pp. 243–250.

- Overlaps in speech,
- Swift corrections of minor errors,
- Multiple layers of perspective, including:
 - Each participant’s personal viewpoint,
 - Each participant’s perception of others’ viewpoints,
 - Each participant’s understanding of the shared conversation as it’s being co-created.

each of these perspectives can desynchronize resulting in misunderstandings. Humans however are excellent at correcting misunderstandings this is because under regular circumstances, people cooperate.

The Cooperation Principle, introduced by philosopher H.P. Grice, suggests that participants in a conversation typically work together to achieve effective communication. Grice proposed that, to ensure this cooperation, speakers follow four conversational maxims. In practice, people may not always follow these maxims but they do so in ways that still rely on shared expectations of cooperation. Even when misunderstandings arise, humans naturally engage in conversational repair, using their social intuition and mutual cooperativity to clarify intention and realign perspectives.

Contemporary conversation research can be understood to draw from conversation analysis. Modern conversation research traces its roots to conversation analysis, a field pioneered by sociologists Harvey Sacks and Emanuel Schegloff in the 1960s. They sought to understand the structure and social rules of everyday interactions, focusing on the patterns and norms that govern turn-taking and response. Thanks to recordings of phonecalls, transcripts could be qualitatively analyzed. This research has led to coining new terminology.

Adjacency pair

Adjacency pairs describe sequences of two related utterances by different speakers¹⁸. These pairs are characterized by their predictable and reciprocal nature, where the first part sets up the expectation for a specific type of

¹⁸H. Sacks. *Lectures on Conversation*. Ed. by G Jefferson. Oxford: Basil Blackwell, 1992, p. 188.

response. Common examples include greetings('Hi' → 'Hello'), questions and answers ('What time is it?' → '3 PM'), or offers and acceptances/declines ('Would you like some coffee?' → 'Yes, please' or 'No, thank you').

Sequence structure

Sequence structure refers to the organization of conversational turns into coherent patterns or sequences. It describes how interactions are shaped by predictable structures, such as adjacency pairs. These sequences provide order and meaning to conversations, guiding participants in understanding when and how to respond. Schegloff¹⁹ emphasized that sequence structure is central to the social organization of talk, as it allows participants to manage and negotiate interaction effectively.

Topic shading

Topic shading, as discussed by Sacks²⁰, refers to the subtle way in which a conversation naturally shifts from one topic to another while maintaining coherence. Instead of abruptly changing the subject, speakers introduce a related idea or concept, gradually steering the discussion in a new direction. This process allows for smooth transitions in dialogue, helping participants maintain engagement and avoid confusion.

Dis/preferred answers

Preferred answers, according to Sacks²¹, are responses in conversations that align with social norms and expectations, making interactions smoother and more cooperative. In conversation analysis, preferred answers typically follow the format or intent of the preceding question or statement. They contrast with "dispreferred" answers, which might include refusals or disagreements and often require additional explanation or mitigation to maintain social harmony.

¹⁹E. A. Schegloff. "On the organization of sequences as a source of 'coherence' in talk-in-interaction". In: *Conversational Organization and its Development*. Ed. by B Dorval. Ablex, 1990, pp. 51–77.

²⁰E. A. Schegloff and H. Sacks. "Opening up Closings". In: *Semiotica* 8.4 (1973), pp. 289–327.

²¹Sacks, *Lectures on Conversation*, p. 410.

Conversational repair

Conversational repairs refer to how participants address and resolve problems in understanding, hearing, or speaking during interactions²². These issues, can occur at any point in a conversation. Repairs are classified into self-repair, where the speaker corrects their own error, and other-repair, where a different participant addresses the issue. They can further be classified into self-initiated repair and other-initiated repair.

As a descendant of conversation analysis interaction linguistics has emerged, building on its insights to examine language use in social contexts. It broadens the focus to study not only verbal exchanges but also multimodal cues like gestures, gaze, and intonation, analyzing how these elements contribute to meaning. Interaction linguistics aims to understand the dynamic aspects of conversations, such as how topics shift and how sequences of speech acts unfold, reflecting the fluid nature of human communication.

1.3 Disruptions in conversation coherence

While the question of what makes for a coherent text is too broad, the answer to what makes for a coherent conversation can be somewhat easier to answer. Because conversation participants negotiate understanding, it is up to them, when a conversation is and is not coherent to describe what a coherent conversation is, it is worth pursuing the moments, when the conversation stops flowing with ease. Such moments can be called coherence disruptions. A coherence disruption is a complex phenomena as

- it penetrates through some or all of mentioned perspectives on an on-going conversation
- it can't be evaluated in a binary fashion

There are different degrees to which a conversation coherence can be disrupted:

- if a participant suddenly starts speaking in an a way that can hardly be considered interaction due to its irrelevance or

²²E. A. Schegloff, G. Jefferson, and H. Sacks. "The Preference for Self-Correction in the Organization of Repair in Conversation". In: *Language* 53.2 (1977), pp. 361–382.

- if the utterance simply is not grammatical or understandable, while the conversation has been compromised and becomes incoherent, it has more to do with incoherent written text, because the incoherence is encapsulated on the level of a single utterance

Roberts²³ Discusses various types of incoherent text. He exemplifies so called giberish as incoherent text that is absent of structural relations. On the other hand he discusses experimental theater or literature as a type of text which is assumed to be coherent in the sense that there is an intention behind it but contains little to no structural relations. Lastly he mentions a so called "schizophrenic discourse" as a speech that is not assumed to be coherent even if it has structural relations to it. In any case Roberts definitively states that coherence is assumed and is therefore a receptive phenomena. The incoherence Roberts discusses is considerably different from when the source of incoherence stems from the structure of the conversational text or relationship between different utterances - this is when another participant assesses, they are simply speaking leading a different conversation perhaps with a differing intention or that they are conversing under differing set of circumstances which manifests formally in the linguistic fabric of the conversation - its text. All that despite everyone included being cooperative.

1.3.1 Sources of incoherence in conversation

Schegloff shows how incoherence arises when people interpret sequence structure differently, namely in terms of which turn is seen as an answer to which previously occurring turn. In his example, the participants misread each other's intentions, leading to confusion about how their turns fit together. They each project different expectations for how the conversation should unfold, which causes misaligned sequence structure interpretations. When this happens, they turn to brief metacommunication — comments about the conversation itself to try to clarify and re-align their understanding. Schegloff illustrates how these efforts to "repair" the misalignment are central to managing and resolving incoherent moments in conversation.

Coherence disruptions are also discussed in linguistic literature. Hrbáček's approach to coherence and cohesion in text distinguishes the two concepts, noting how they often interact but can also be independent. He highlights that while cohesion involves grammatical or lexical links that make sentences

²³Roberts and Kreuz, "Nonstandard discourse and its coherence".

flow together, coherence relies on the logical and meaningful progression of ideas. This means that a text could be cohesive - using connectives, repetitions, and consistent lexical choices - yet lack coherence if the sequence of ideas doesn't make logical sense or follow a clear progression. Conversely, a text may be coherent in its narrative flow without relying heavily on cohesive devices. In Czech linguistics, the distinction between *téma* (theme) and *réma* (rheme), as used by Daneš, underlines the role of topic progression. Hrbáček illustrates this by discussing examples where a story progresses logically from one point to the next while being incoherent despite being clear about its topic structure due to never coming back to a previously mentioned topic.

Two kinds of phenomena are at hand when it comes to ways in which conversation coherence can be disrupted - topic shifts and nonassignable anaphore. While not unique to conversation both take on specific forms in it worth looking at.

Topic shifts

When conversations shift abruptly from one topic to another, it can create confusion for the conversation partner. They might find themselves trying to reconnect to the previous discussion or wondering how the new subject relates. This can lead to misunderstandings as the transition can feel jarring.

One interesting question is, how do we determine when a topic has run its course? What common traits do conversations share when a subject is truly exhausted? Perhaps observing transcripts could reveal repeating patterns in topic progression or sequence structure.

Moreover, what makes for a smooth transition between topics? Is it related to the cues participants give each other, or perhaps the context of the discussion? How do we navigate the flow of conversation and what indicates a natural shift versus a disruptive one?

Nonassignable anaphore

nonassignable anaphore is closely tied to topic progression. Currently established topic or topics help assigning anaphore and determining between an anaphore and an exophore. Even if an anaphoric device is not assignable, and the reference is presumably an exophoric one, The reason for employing this reference must be relevant to an established topic. In conversation meaning of demonstratives is to be negotiated. If an anaphores assignability

causes confusion, chances are it is caused by one of the following

- there are no relevant assignment candidates
this situation can be understood as a vague or unjustified exophore
- there are multiple equally relevant candidates
- candidate has occurred in the conversation text too long ago
can be understood as an abrupt return to previously established topic

1.3.2 What do people do about coherence disruptions?

In conversation, coherence disruptions often prompt participants to employ strategies to maintain understanding and flow. Schegloff suggests that people manage these disruptions through interactive repair or inference. Interactive repair often involves explicitly addressing misunderstandings or clarifying intentions, often by rephrasing or asking questions. Interactive repair refers to immediate, collaborative corrections within dialogue, where one speaker might correct the other or themselves to enhance clarity. Inference and pragmatic reasoning, the most seamless methods, allow participants to fill gaps based on context and social cues, helping conversations continue smoothly without explicit repair.

Dingemanse and Enfield²⁴ echoes this from a cognitive perspective, highlighting how inference and pragmatic reasoning are particularly effective. Participants rely on shared understanding and contextual knowledge to interpret ambiguous statements. Together, they use both explicit (metacommunication and repair) and implicit (inference and reasoning) methods work to restore coherence.

It needs to be noted however that both interactive repair and reasoning are deployed in a number of other contexts other than conversation coherence disruption. Inference takes place constantly²⁵. Each of those moments could be hardly considered a coherence disruption. There is however always potential for it, particularly via unclear or nonassignable anaphore or abrupt unjustified topic shifts. Repair and metacommunication also takes place in a mutually informed and synchronized interaction. It is for example deployed

²⁴M. Dingemanse and N. J. Enfield. “Interactive repair and the foundations of language”. In: *Trends in Cognitive Sciences* 28.1 (2024), pp. 30–42.

²⁵H. Garfinkel. “Studies in ethnomethodology”. In: Routledge, 2023, pp. 209–261.

when it is revealed that the interaction participants intentions or opinions differ.

These uses of interaction management are however hardly possible to analyse on a textual level since they do not cooccur with coherence disruptions. What can be observed are – as mentioned above – troublesome anaphoric references and topic progressions.

Chapter 2

Methodology

2.1 What are chatbots?

A chatbot is a dialog system powered application simulating conversation with a user. An attempt to make a machine converse with a human user requires capturing the essence of human speech. What the essence speech is and what capturing it means are not defined and some definitions of what essence of speech is require specific definitions of what capturing it means. (Semantics and DialogueSchlangen, David2015) .. In case of the history of chatbots, the essence of speech is partially achieved via mimicking it. The intention was to have a user interact with a chatbot that would communicate so well that the user would be convinced this is a another human they are talking to. Whether just that has been achieved would be measured by a so called turing test proposed by Alan Turing in 1950¹

Initial attempts at making a computer converse were rule-based² What that means is the content of the chatbot utterances would be predetermined and there would be a decision tree that would decide what to say next. In the early days as well as often times in modern day systems string matching would be used to analyse user input.

ELIZA³ is regarded as a milestone what it was, it pretended to be a

¹A. M. Turing. “Computing Machinery and Intelligence”. In: *Mind* 59.236 (1950), pp. 433–460.

²Sacks, *Lectures on Conversation*, p. 43.

³J. Weizenbaum. “ELIZA a Computer Program for the Study of Natural Language Communication Between Man and Machine”. In: *Commun. ACM* 9.1 (Jan. 1966), pp. 36–45.

therapist hiding behind general phrases doctor authority

as long as interaction frame is strictly defined and the robot has some level of authority in it the rule-based approach can work granted, it requires a lot of manual design and constant maintenance but it is used nowadays

Machine learning moved things forward in many ways Fuzzy matching allowed for close matches without the necessity to predefine the exact sequence of characters. IBM Watson uses classifiers built on examples⁴ structure remains rule based reasoning about these rules is decided to a large degree by classifiers

The recent breakthrough pushed another thing in the mainstream it is now possible to generate near natural speech this gives the possibility to just let the conversation be taken over by one answer generator this way we lose tight control over what it does though For some use cases like open domain conversation or accessing knowledge base that is not an issue.

And so currently chatbot interface text generators are very prevalent. In 2024 this technology is now closer to beating the Turing test than any other model or approach before it⁵ by having 54% of participants thinking they are talking to a human. While Eliza convinced 22% of participants, actual humans only convince 67% of participants.

Turn taking in chatbot interactions

Even if the Turing test is passed, really fitting simulation of conversation can only be achieved if the low-level conversation mechanisms are simulated, like turn taking⁶.

As established in previous chapter, turn taking is a crucial aspect of conversation. The way participants distribute who is to talk explains exhaustively the difference between a structure of the text of conversation and a single-producer text. The mechanism of turn taking differs between actual human conversation and an interaction between a chatbot and a user.

⁴D. Ferrucci et al. “Building Watson: An Overview of the DeepQA Project”. In: *AI Magazine* 31.3 (July 2010), pp. 59–79. DOI: 10.1609/aimag.v31i3.2303. URL: <https://ojs.aaai.org/aimagazine/index.php/aimagazine/article/view/2303>.

⁵C. R. Jones and B. K. Bergen. *People cannot distinguish GPT-4 from a human in a Turing test*. 2024. arXiv: 2405.08007 [cs.HC]. URL: <https://arxiv.org/abs/2405.08007>.

⁶A. Raux and M. Eskenazi. “Optimizing the turn-taking behavior of task-oriented spoken dialog systems”. In: *ACM Trans. Speech Lang. Process.* 9.1 (May 2012).

Interaction between chatbot and user typically take place in a strict fashion where both participants, human and virtual, have unlimited time to come up with the next answer. While the chatbot should be optimized to answer as fast as possible, the user has as much time as they need until fallback.

“Research in sociolinguistics, psycholinguistics, and conversational analysis has revealed that turn-taking is a mixed-initiative, locally coordinated process, in which a variety of verbal and nonverbal cues such as eye gaze, body pose, head movements, hand gestures, intonation, hesitations, and filled pauses play a very important role. We continuously produce and monitor each other for these signals and can coordinate seamlessly at the scale of hundreds of milliseconds across these different channels with multiple actors.”⁷

People are capable of producing and picking up clues that indicate opportunities for turn taking flawlessly. There is a some way ahead for robots in this regard whether it is figuring out the correct time to start speech⁸⁹ or actually creating a system that will be able to produce such behavior¹⁰¹¹. This research field has the potential to push conversation technology closer to true conversation simulation.

2.2 Convform

An exploration has been carried out using a custom tool called Convform¹².

At its core Convform is a computer program which accepts a configuration, user input and context and determines next chatbot answer. Other than that it offers a collection of utilities to help design and run chatbots.

⁷S. Andrist et al. “Turn-Taking and Coordination in Human-Machine Interaction”. In: *Ai Magazine* 37 (Dec. 2016), pp. 5–6.

⁸G. Skantze. “Turn-taking in Conversational Systems and Human-Robot Interaction: A Review”. In: *Computer Speech & Language* 67 (May 2021), pp. 101–178.

⁹A. Gravano and J. Hirschberg. “Turn-taking cues in task-oriented dialogue”. In: *Computer Speech & Language* 25.3 (2011), pp. 601–634.

¹⁰G. Jonsdottir and K. Thórisson. “A Distributed Architecture for Real-Time Dialogue and On-Task Learning of Efficient Co-Operative Turn-Taking”. In: Oct. 2013, pp. 293–323.

¹¹F. Gervits et al. “It’s About Time: Turn-Entry Timing for Situated Human-Robot Dialogue”. In: *Proceedings of the Special Interest Group on Discourse and Dialogue*. 2020. URL: <https://hrilab.tufts.edu/publications/Gervits2020Sigdial.pdf>.

¹²A. Maršík. *Convform*. <https://github.com/almarsk/convform>. 2024.

Participant facing chat interface

In order to handle the inputs, convform provides a chatting environment for the participants to interact with a chatbot. The convform environment differs from a usual chat log because it does not display the entire history the conversation. In attempt to simulate spoken conversation it only displays the last chatbot response. This way the participant has to rely on their memory in taking part in the conversation. Other than that the participant may enter their next response and send it. They are also instructed to end to conversation by a red button if the chatbot behaviour is "unnatural" (nepřirozené) After the conversation is over whether it has been ended by the user or the chatbot, there is a questionnaire which asks the participants to rate how "natural" the conversation was and mark and comment on utterances in the now fully displayed conversation.

Conversation design tool

Lets admin user create chatbots and define their behavior the behavior can be defined by string matching rules or prompts it is capable of working as a statemachine or a single state it provides a level of control over references within the design

Testing and debugging of various conversation contexts

while designing chatbots it is necessary to be able to simulate various situations to fine tune various possible scenarios that might occur in the conversation. To achieve this, there must be a way to encode required context to convform. The convform chatbots use a conversation status (CStatus) object to represent their current understanding of the conversation. It contains information about the history of the conversation which in conjunction with the configuration file and user input helps determine the next response. The configuration file is static CStatus changes automatically User input comes from the user. This conversation status can simulate any possible conversation context from the chatbots perspective For testing and debugging specific contexts, convform allows admin user to tweak the conversation status

Accessing the conversation data

Lastly convform naturally includes a convenient way to read user interactions and browse associated conversation status objects

2.3 Conversation design in theory

Designing the behavior of a dialog system is referred to as conversation design¹³¹⁴. It is not the course of any one conversation that is being designed here but rather as many possible ways any conversation could go for a given use case. Conversation design as a profession is deeply connected with the rule-based approach that has been used in ELIZA. Maintaining all the possible utterances and rules under which they would be uttered in commercial dialog systems has proven to be a responsibility large enough to generate jobs.

A conversation designer operates between the business logic and use case of the dialog system the clients, customers or users interacting with the system and the developers maintaining the system.

2.3.1 Rule-based approach

In order to be able to design a rule-based dialog system, one needs to be able to encode the following:

- The possible utterances, that the dialog system can produce - "the mouth"
- Rules under which the next utterance will be chosen - "the ear"

If the conversation is supposed to be a state machine e.g. it needs to be able to use different sets of rules under different contexts in the conversation. This way a dialog system can be context aware to a degree. A conversation design of this sort can be displayed as a diagram. Then a way to maintain context of conversation is also necessary. This context needs to encode rules

¹³Š. Kološová. "Konverzační design: principy designu hlasového robota pro přirozenou komunikaci s lidmi". Diplomová práce. Praha: Univerzita Karlova, Filozofická fakulta, Ústav informačních studií - studia nových médií, 2022.

¹⁴McTear, *Conversational AI: Dialogue Systems, Conversational Agents, and Chatbots*.

to choose an immediate ruleset which helps determine the next utterance. This principle is a simplification of how people decide what they will say next in conversation.

Pros and cons

This approach to designing a dialog system has been the standard for decades. It offers a granular control over how a conversation should go. In case of the state machine variant it allows to guide the user through a relatively complex process. It however suffers from how unpredictable the user can be. It is up to the conversation designer to cover all the possible ways of answering which not only is hardly possible but also poses a necessity to parcel the spectrum of possible answers which can generate conflict when a user input semantically spans across multiple determined categories. This issue is even stronger while using the string matching approach, because there the string literal can decide about the following dialog system answer as if meanings and their speech representations were a one-to-one map, which they are not. Even if a certain meaning is included in a ruleset, the system might not grasp the meaning and react in an incoherent way. With the state machine the distribution of various rules across various rulesets requires big effort. Extending the capabilities of a rule-based dialog system hardly scale and tend to have regressions. In case of dialog systems relying on user input by speech transcription the text input processed by the system is not guaranteed to represent what the user actually said. In conclusion rule-based approach to conversation design provides control over the dialog system behavior but tends to be inflexible.

2.3.2 Statistically driven approach

Some of the issues tied to rule-based systems are resolved using another approach. Especially in recent years the breakthroughs in the field of speech generation have been significant () allowing for letting the dialog system play a bigger role in what is being said next. In its simplest form, it is possible to just let the answer be generated "end-to-end". The user input is sent to a model which generates an answer. It has been convincingly shown that this technology has the capability of reacting in a flexible way to much of what is being thrown at it (). While not perfect () this technology is capable of staying on topic (), mirroring () and other things that make for a coherent

conversation.

Large language models

The main component that is responsible for this way of simulating conversation at this level of flexibility are so called large language models (). These models, powered by advanced neural networks, have revolutionized the field of natural language processing. Among the most influential architectures are transformers, which enable these models to handle vast amounts of text data and capture complex patterns of meaning, context, and grammar. They use their training data to generate the next most probable token.

and then it takes also its output and predicts the next probable output
llms for other things than conversation

The Generative Pre-trained Transformer family of models, exemplifies the capabilities of LLMs.

Researched in - exponential improvements over short period of time.
including ChatGPT, presented in ... ()

These systems are trained on diverse datasets containing billions of words, allowing them to generate coherent and contextually relevant responses across various topics. This flexibility has made them increasingly mainstream, being integrated into tools for writing, education, customer service, and more.

Nowadays there are multiple publicly available LLM services.

Unlike traditional rule-based systems, LLMs rely on deep learning techniques to process and predict language, enabling them to understand nuanced queries and provide human-like responses. This adaptability has set new standards for conversational AI, making it a valuable resource in numerous industries.

Prompt engineering techniques

The rapid advancement of LLM technology has outpaced research into optimal interaction strategies. Understanding how to engage effectively with these systems has been a developing area (), which illustrates both their power and their novel nature. The foundational idea is: an LLM might perform nearly any task if prompted correctly.

The quality of the task differs significantly task to tasks in reality, but the anything is possible approach has proven to break new grounds when leveraging LLMs' capabilities.

Over time, researchers and practitioners have developed techniques for crafting effective prompts to optimize outputs. The simplest approach is known as "zero-shot" prompting, where a user poses a direct question or request without additional context. However, zero-shot prompting may not always yield the desired depth or accuracy. It is common for the model to "misunderstand" the assignment and generate tokens so that it will "confuse" itself and lead to generated answer in a completely irrelevant direction.

More sophisticated strategies include "few-shot" prompting, where examples are provided to guide the model's response style or focus. This way there is a reference for the structure of the answer and there is a protection to the answer leading somewhere it is not meant to. Since analogy is a task LLMs are doing really well in () framing the task as an analogy can help improve the output significantly.

Another very prevalent way that has proven to improve the performance of LLMs is a so called chain-of-thought (CoT) prompting. It encourages the model to articulate its reasoning step-by-step, enhancing logical accuracy. There are many ways to achieve this, but the primary one is a few-shot approach where a description of the logic is explicitly described. The model is then prompted to produce a similar chain of thought (hence the name) and end the answer with the sought after information.

This principle can be further improved by chaining several LLM calls and having one evaluate the previous one. Such strategy has been used for the GPT o1 which has proven to surpass other models in available metrics ().

Pros and cons

Using large language models as core component of dialog systems brings resolution to many issues rule-based systems introduce.

An LLM powered dialog system is flexible in understanding the user input. The user input is processed in a way much more sophisticated than the shallow string-matching approach. While the classifier approach is a lot more capable to understand, it is still forced to choose a predefined answer, whereas an LLM has the capability to tailor an answer for every input. It can do this in a way that would be very hard to come up with especially in advance with the help of a conversation designer, leveraging the fact that LLM is primarily a text generator and only functions as a component in a dialog system. It can be relatively well controlled as it can accept complex instructions as to how to behave and these instructions can be tuned in

runtime.

Systems of this sort however introduce their own set of problems. The biggest issue are so called hallucinations (). Factuality is a challenge for LLMs overall. Being programs that are to output text no matter what, there have been instances of asking them questions, that do not have a correct answer (). It has been shown, that LLMs have an issue knowing that they do not know something. Recognizing that is the case requires an extra level of reasoning that is an object of research as of recently ()[dark matter of ai]

Since these models are their own agents, us humans also need them to be ethically aligned with us (). That can prove challenging since a lot of ethical problems exist, that do not have a simple answer. Alignment however means that an LLM must always side with humans. This is an ongoing research field which has been making some troublesome observations recently with the most intelligent models available ().

Even if all the programming and training is done to the most benefit of humans, information technology is susceptible to be broken by malicious action. In case of LLMs we talk of so called jail breaks (). LLMs being trained on vast amount of data, they hold knowledge that can be illegal or unethical to spread like steps to create explosives for example. The typical examples of jail breaks are ways to manipulate the LLM to give out this information which under regular circumstance it would not give.

With all this in mind, how much of a responsibility do we want to allow LLMS to have? Considering the direction our civilization is going in LLM powered technology is expected to be making decisions that will affect people on a daily basis. Hopefully that will not happen before the challenges of alignment and hallucinations are solved.

As far as open domain conversation simulation goes, LLM powered chatbots are relatively safe though there are cases of dangerous or tragic situations especially for vulnerable individuals ().

This is why for dialog systems that are supposed to achieve anything else on top of the conversation itself, if they are meant to be powered by LLMs, a regulating structure needs to be placed on top of the LLM.

2.3.3 Hybrid approach

An interesting next step that could be done on the contact surface of conversation design and LLM development is a hybrid system that would allow a conversation designer to have the dialog system interact with a user in the

required way including passing through a state-machine like process while keeping the flexibility of an LLM.

- analysis prompt
- master prompt
- prompt component
- hardcoded ?
- issues - speed
- convform

2.4 Conversation design in practice

conversation design in Convform ..

State

Intent

Conversation style

(Robo-Identity: Exploring Artificial Identity and Emotion via Speech Interactions)

- default mode
- Inquisitive
- Relaxed

Prompting

Entity recognition (New or Old? Exploring How Pre-Trained Language Models Represent Discourse Entities)

Anaphorization

(Annotating anaphoric phenomena in situated dialogue) but here we try to generate it instead

2.4.1 Stimuli

shallow anaphore

deep anaphore

how its done ..

topic mentioned in the meantime ..

nonassignable anaphore

hardcoded ..

prompting ..

2.4.2 Ending the conversation

2.4.3 Data

the nature of elicited data .. therefore to process the data ..

Attempting to replicate a situation using conversation design

Quantitative analysis

Qualitative analysis

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