

# Research Statement

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The goal of my research is to develop a computational and experimental understanding of the cognitive process underlying language comprehension and production, especially the capability of producing fluent dialogues for effective communication. I am particularly interested in modeling human dialogue from various perspectives: the distribution of information content among interlocutors; the mutual alignment/adaptation of linguistic elements between interlocutors at multiple representation levels. Combining these aspects together, I hope to achieve a unified perspective that better explains how language is produced and comprehended in dialogue settings.

My approach draws on methods from computational and corpus linguistics, psycholinguistics experiments, statistical inference, and machine learning. All together, my recent work and future trajectory focus on three general directions, which I will review below.

## Information density in dialogue

Human communication in the form of natural language can be analogized to the communication system in Information Theory (Shannon, 1948), where the most efficient way of communication is to keep the entropy rate constant. This principle holds to written language at the character and word levels (Genzel and Charniak, 2002; Genzel and Charniak, 2003), and also extends to the level of syntactic choices (Jaeger and Levy, 2006). As summarized by the theory of *uniform information density* (UID) (Jaeger, 2010), people avoid sudden changes in the information content of linguistic elements. In our recent work, we systematically examined whether the general principle of entropy rate constancy (ERC) holds true to spoken dialogue (which is missing in existing literature), and we found that ERC indeed applies to dialogue as a whole system, but not necessarily to the separate individual interlocutors who contribute information differently (Xu and Reitter, 2016b; Xu and Reitter, 2016a). Basically, the information contribution from interlocutors fluctuates in a complementary manner, and forms a convergence temporal pattern within the topicality units in dialogue (Xu and Reitter, 2016b).

We explain this new pattern of information density by casting dialogue as an information exchange system where the participants maintain a partially shared context and their own distinct contexts (Xu and Reitter, 2017b). We have also found empirical evidence that the interactive alignment model (IAM) (Pickering and Garrod, 2004) may explain the effect (Xu and Reitter, 2017b). Lastly but not exhaustively, we deem that the process of building common ground (Clark and Brennan, 1991) is analogous to the information convergence pattern. Therefore, the information-theoretic perspective of dialogue has the potential to unify some existing theoretic frameworks of human dialogue.

Pushing along this line of work further, we have examined the extent to which the relative information contribution of dialogue partners can act as a key to successful communication. We use spectral analysis techniques to extract the frequency domain features of utterance information series from task-oriented dialogues, which turned out to be significant predictors of the task success (Xu and Reitter, 2017c). We conclude that the

strategic distribution of information density across interlocutors, i.e., the proper timing of producing information, is relevant to effective communication, which is not captured by existing computational approaches of dialogue studies.

## **Linguistic alignment and information density**

Conversation partners align with each other at various levels of linguistic representations, including phonological characteristics, speech rate, word and syntactic decisions etc (Pickering and Garrod, 2004). Alignment is stronger for less expected, lower-frequency linguistic elements (Jaeger and Snider, 2013; Reitter, Keller, et al., 2011). Our preliminary work extend the previous studies by showing that the lexical alignment between dialogue interlocutors is not just observed within the scope of dialogue, but also happens within shorter discourse units, i.e., topic episodes (Xu and Reitter, 2017b)(c.f. Reitter and Moore, 2014). Moreover, interlocutors diverge in lexical choices at the beginning of a topic episode, and later become aligned as the topic develops, which suggests that interlocutors can no longer rely on the previously achieved aligned lexicons, and has to rebuild the alignment when new information is continuously introduced into the dialogue (Xu and Reitter, 2017b). Therefore, there is a close relation between linguistic alignment and the information density of linguistic structures, which could be estimated at the lexical, syntactic, or other levels. It is an important direction for my future work.

One of my recent ongoing work explores whether the linguistic accommodation behavior, which has been largely attributed to higher level factors (e.g., social power etc.) by previous studies (Danescu-Niculescu-Mizil et al., 2012; Noble and Fernández, 2015), can actually be explained by lower level cognitive mechanisms, such as the primitive and automatic alignment that is sensitive to the information density of the content (Xu and Reitter, 2017a). Here, we are not denying the effect of social status on language use (which has been thoroughly studies in socio-linguistics), rather, we are exploring alternative explanations, especially for communication scenarios where social status is not explicitly established, e.g., the ubiquitous online communities etc.

## **Structural priming and working memory**

Structural priming can be viewed as a special case included by the general concept of linguistic alignment. It refers to the phenomenon that a syntactic structure (e.g., dative structure, active/passive structure, etc.) is more likely to be used again if it is encountered (read or heard) in preceding content. It has been an important topic of psycho-linguistics for decades (since Bock (1986). For a detailed meta-review, see Mahowald et al. (2016)). We intend to use the paradigms in structural priming studies to explore the relationship between linguistic alignment and information density, so that more experimental evidence can be obtained as an augmentation to our corpus-based studies.

So far, our preliminary results are affirmative in the correlation between structural priming and lexical information, and we found that the perspective of working memory capacity best accounts for our observation. Some basic thought is that in the priming phase where lexical and syntactic information is encoded into working memory, there is a competition mechanism between them, while in the later production phase, the choice of syntactic structures is also limited by the working memory span imposed by the comprehension task. By introducing working memory into the explanations, I hope to achieve a better unification in our understanding of linguistic alignment at different levels. Of course, more fine-grained experiment designs and supportive corpus-based investigation will be the next step for my future work.

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