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Alignment and task success in spoken dialogue

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ABSTRACT

Task-solving in dialogue depends on the convergence of the situation models held by the dialogue partners. The Interactive Alignment Model (Pickering & Garrod, 2004) suggests that this convergence is the result of an interactive alignment process, which is based on mechanistic repetition at a number of linguistic levels. In this paper, we develop two predictions arising from the theory, along with two methods to quantify the known structural priming effects in the full inventory of syntactic choices found in text and speech corpora. (a) Under a rational perspective, we expect increased repetition in task-oriented dialogue compared to spontaneous conversation. We find within- and between-speaker priming in a corpus of spontaneous conversations, but stronger priming in task-oriented dialogue. (b) The Interactive Alignment Model predicts linguistic adaptation to be correlated with task success. We show this effect in a corpus of task-oriented dialogue, where we find a positive correlation of long-term adaptation and a quantifiable task success measure. We argue that the repetition tendency relevant for the high-level alignment of situation models is based on slow adaptation rather than short-term priming. We demonstrate that lexical and syntactic repetition are reliable and computationally exploitable predictors of task success.

Introduction

Humans appear to be remarkably efficient communicators in light of the computational complexity of natural language. Dialogue poses many challenges: interlocutors have different viewpoints, linguistic preferences and knowledge states. What may help is that we are copy cats rather than creators; we prefer to adapt our language rather than to go against the grain. The *Interactive Alignment Model* (IAM, Pickering & Garrod, 2004) posits that such mutual adaptation is easier than careful selection of information and targeting of the message in dialogue. The IAM suggests that basic priming effects at lower processing levels (lexical, syntactic) reinforce alignment at higher ones (e.g., semantic, pragmatic), leading to linguistic adaptation and grounding of situation models during speaker interaction. Priming occurs when memory retrieval is biased by previous context; in this case, priming refers to a tendency to choose linguistic constructions that have been used shortly beforehand.

The IAM assumes that this repetition of linguistic choices is not just an artifact of general memory retrieval properties, but instead is a mechanism (alignment) by which interlocutors build a common understanding of the situation, enabling them to successfully communicate without keeping track of one another's linguistic idiosyncrasies. According to the IAM, repetition is a heuristic that helps establish common ground unless the situation requires more careful monitoring and modeling of one's interlocutor's state of knowledge.

The success of our interactions varies. The success of task-oriented dialogue depends on communication and is quantifiable, allowing us to test the IAM by linking it to

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alignment. In this paper, we correlate priming at levels of sentence structure (syntax) and word choice, the problem-solving objective of the dialogue, and success.

Hypotheses

Humans align their linguistic choices at several representational levels. At a low level, phonetic reductions occur in jointly understood words (Bard et al., 2000). An example of adaptation at a higher level of representation involves dialogue partners that develop coherent situation models, as in Garrod and Anderson's (1987) *Maze Game* study. The task was designed to elicit a coordinated communication system between participants. They found that speakers tended to make the same semantic and pragmatic choices as in the utterances they had just heard. As the games proceeded, participants developed a common description scheme for positions in the maze.

However, the full causal cascade from lower-level priming to high-level alignment has not yet been observed. Specifically, the hypothesized correlation between the two, and ultimately successful communication, has eluded empirical verification.

In this paper, we focus on implicit linguistic decisions: the basic mechanics of communication implemented in syntactic structure, as opposed to the high-level strategies speakers use to describe aspects of a task, or the more explicitly controlled lexical choices. *Syntactic priming* occurs when speakers show a tendency to prefer one phrase structure over an available alternative shortly after having used this structure or having heard an interlocutor use it (Bock, 1986). Verbatim, lexical repetition is known to increase the strength of priming (Gries, 2005; Hartsuiker, Bernolet, Schoonbaert, Speybroeck, & Vanderelst, 2008; Pickering & Branigan, 1998). This *lexical boost* is a crucial effect for the IAM, as it shows propagation of alignment from lower to higher levels of representation.

Thus far, there is only limited evidence for the occurrence of structural adaptation outside of carefully controlled laboratory settings. As we will see, speakers also adapt in situated, realistic dialogue. For example, consider this excerpt from the Map Task corpus (Anderson et al., 1991; McKelvie, 1998), a dataset that we will use extensively in this study. One speaker (*g*) is giving directions for another one (*f*) to follow on a map:

f: *from the mill wheel and up to the abandoned cottage to the right* ***like a tick shape*** *it'd be s–* ***[the shape of a tick]*** *from the*

g: *no*

g: ***[the shape of a] [like an oval shape]*** *from the caravan park you start just above the caravans*

Here, *g* first sets out to repeat the latest syntactic construction (*the shape of an oval*), but proceeds to use an alternative one (*like an oval shape*) in its repair, mirroring his interlocutor's first syntactic choice (*like a tick shape*). The spontaneous syntactic choice is a direct repetition, but would be ungrammatical if completed (*the shape of a oval*). Both of *g*'s expressions reflect structural repetitions rather than plausible alternatives to describe an oval-shaped path. This example of repetition reflects not only syntactic, but also lexical choices. A quantitative model of priming should cover such cases, but also repetitions that occur outside of lexically or semantically similar contexts. In our study, we are concerned with implicit (syntactic) effects. We therefore measure priming of syntactic phrase-structure rules, whereby word-by-word repetition (topicality effects, parroting) is explicitly excluded.

We examine the IAM from a functional perspective, and derive two groups of testable hypotheses. The first examines *syntactic priming in task-oriented dialogue*, while the second adds a functional perspective by showing a *correlation between adaptation and task success*.

Our first hypothesis concerns the mechanisms of priming. Syntactic priming is claimed to be a mechanistic effect, though this does not necessarily mean that it is automatic and agnostic to contextual influence. According to some cognitive architectures (Anderson & Lebiere, 1998), priming effects are the result of working memory activity. From a functional and rationalist point of view, the enhancement of communication by priming suggested by the IAM could have led to an architectural configuration where the demands of the dialogue situation drive syntactic priming. For instance, syntactic representations may be temporarily associated with semantic ones. Topics determine semantics held in working memory, and so, meaning is typically clustered rather than randomly mixed. In line with this, theories of dialogue have suggested clustering of topics, and coherence of topic structure (Grosz, Joshi, & Weinstein, 1995; Grosz & Sidner, 1986). Given any syntactic-semantic associations, syntactic structure may tend to cluster as well.

We hypothesize that there is a tendency for dialogue partners to repeat syntactic structure within brief time windows, and that they do more so in task-oriented dialogue than in spontaneous conversation. Regardless of the underlying mechanisms, the IAM seems incompatible with the inverse hypothesis: less priming in task-oriented dialogue.

In the first set of experiments (1–2), we look at short-term priming effects and whether speakers implicitly use increased short-term adaptation in situations where they may benefit from it.

The second hypothesis is derived from the IAM's core idea connecting low-level priming to high-level mutual understanding and task success. Adaptation itself is difficult to manipulate in naturalistic human–human dialogue. However, we expect observable variation in adaptation levels.

The IAM predicts that task-oriented dialogues that exhibit more syntactic adaptation between the interaction partners will ultimately yield more task success. We test this prediction in Experiments 3–4. We conclude with an experiment that uses machine learning techniques to demonstrate that both syntactic and lexical alignment can be exploited to predict task success (Experiment 5).

We will refer to several different variants of syntactic adaptation. *Adaptation* denotes an increased amount of re-use of decisions compared to expected repetition occurring by chance. *Short-term priming* is short-lived adaptation, which disappears after a few seconds. *Long-term adaptation* is adaptation that is enhanced by repeated