Linguistic Adaptation in Conversation Threads: Analyzing Alignment in Online Health Communities

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Abstract

Previous studies of alignment have focused on two-party conversations. We study multi-party conversation in online health communities, which have shown benefits for their members from forum conversations. So far, our understanding of the relationship between alignment in such multi-party conversations and its possible connection to member benefits has been limited. This paper quantifies linguistic alignment in the oldest and the largest cancer online forum. Alignment at lexical and syntactic levels, as well as decay of alignment was observed in forum threads, although the decay was slower than commonly found in psycholinguistic studies. The different pattern of adaptation to the initial post on a thread suggests that specific roles in the online forum (e.g., seeking support from the community) can potentially be revealed through alignment theory and its extensions.

1 Introduction

Linguistic alignment leads conversation partners to adapt their language patterns to match their conversation partners. Such patterns comprise of word choice, sentence structure, and more. For example, if one conversation partner uses passive voice in the conversation, other conversation participants tend to use passive voice at a later point in time. The mechanism of adaptation are better understood now (Bock and Griffin, 2000; Pickering and Ferreira, 2008; Kaschak et al., 2011a; Reitter et al., 2011). The Interactive Alignment Model (IAM) (Pickering and Garrod, 2004) attributes dialogic function to the priming effect; it suggests that adaptation helps people reach mutual understanding. Some recent studies (Reitter and Moore, 2007; Fusaroli et al., 2012) lend empirical confirmation to this thesis.

Repetition effects are not purely mechanistic. They are sometimes moderated in response to situational requirements or framing. For example, they can vary in strength when humans (believe to) communicate with computers (Branigan et al., 2010). Repetition intensifies when the purpose of conversation is to collaborate on a common task (Reitter et al., 2006). Of course, communication between individuals is more than a linguistic event; it is also social. For example, it can be found as a cue to social relationships in film scripts (Danescu-Niculescu-Mizil and Lee, 2011). A more specific aspect of language-based interaction is pragmatic convention in multi-party dialogue, which determines turn-taking, shifts in topic, and more.

One would expect alignment to also occur in social situations involving multiple speakers. The social moderators and functions of adaptation effects, however, are largely unclear. The question we ask in this paper is whether alignment is moderated by the role of a speaker's contribution to the conversation. In this paper, we deal with written interaction only; our data are internet forum conversations.

The first question is whether linguistic adaptation exists in online communities and online groups. Dialogues in threads of online communities are different from previous types of dialogues. Unlike some spontaneous, free-form dialogues, threaded conversations have specific topic. In addition, thread conversations do not have specific tasks. Therefore, we investigate whether dialogues in the threads also exhibit linguistic adaptation, be it as an artifact of mechanistic language processing or because adaptation acts as a social or conversational signal. Adaptation tends to decay over time, although this decay has not been studied in the context of such

slow, asychronuous communication. Therefore, we will characterize the time-scale of dacay. More generally, if alignment exists in forums, is it correlated with the communicative role of a text or the social role of its author?

The contributions of this paper are: (1) an exploratory analysis of linguistic adaptation based on 3,000 conversations threads and 23,045 posts in an online cancer survivor community (`http://csn.cancer.org`). Specifically, we find reliable linguistic adaptation effects in this corpus. (2) We show that properties of conversation threads that are different from regular conversations.

In the following sections, we first survey related work on linguistic adaptation. Then, we describe our data and make preliminary definitions. We then introduce measures of linguistic adaptation. Last, we discuss a set of properties in online thread conversations which are unlike other types of dialogues.

2 Related Work

Linguistic alignment phenomenon in social interaction has been well explored in previous literature. It happens because of multiple reasons. Firstly, it could be due to unconscious linguistic adaptation. Pickering and Garrod (2004) suggests that conversations have linguistic coordination at lexical level. Branigan et al. (2000) and Gries (2005) show that priming effects exist at the syntactic level. However, linguistic alignment could happen consciously by conversation participants. Some literature suggest that people flexibly adapt their linguistic patterns to each other's in order to improve collective performance and social coordination (Healey and Mills, 2006; Garrod and Pickering, 2009).

Linguistic alignment has been found in written communication as well, which is close to our work. Danescu-Niculescu-Mizil et al. (2011) examines conversations in a Twitter corpus, showing convergence of Linguistic Inquiry and Word Count (LIWC) measures. This result confirms that linguistic alignment exists in written online social media. Furthermore, in Huffaker et al. (2006); Scissors et al. (2008); Backstrom et al. (2013) also show that people adjust their linguistic style, such as linguistic features, in the online written chatroom and online community. Also, priming effects at syntactic level (Gries, 2005; Branigan et al., 2000) have been explored in several written dataset settings (Pickering and Ferreira, 2008).

In order to quantify the linguistic alignment phenomenon, researchers have introduced several quantitative measures. Several methods evaluate repetition of linguistic events, such as the use of words, syntactic rules or a small set of expressions (Church, 2000; Reitter et al., 2006; Fusaroli et al., 2012). These approaches typically test whether linguistic alignment is due to linguistic adaptation or intrinsic repetition. Moreover, linguistic feature similarity (Stenchikova and Stent, 2007; Danescu-Niculescu-Mizil et al., 2011) is also widely used to measure linguistic adaptation precisely.

3 Online Health Communities

Online health communities (OHC) typically include features such as discussion boards where cancer survivors and their caregivers can interact with each other. Support and information from people with similar cancers or problems is very valuable because cancer experiences are unique. Therefore, an online community for cancer survivors and caregivers enables them to share experiences related to cancer, seek solutions to daily living issues, and in general support one another (Bambina, 2007) in ways that is not often possible with other close family, friends or even health care providers. Benefits to cancer survivors who have participated in an OHC are reported in the literature. Studies of cancer OHC have indicated that participation increases social support (Dunkel-Schetter, 1984; Rodgers and Chen, 2005), reduces levels of stress, depression, and psychological trauma (Beaudoin and Tao, 2008; Winzelberg et al., 2003), and helps participants be more optimistic about the course of their life with cancer (Rodgers and Chen, 2005). The support received from other OHC members help cancer patients better cope with their disease and improve their lives both physically and mentally (Dunkel-Schetter, 1984). Further understanding about these benefits has been provided by computational text analysis and machine learning methods, which enable fine-grained analysis of the sentiments of individual posts in the discussion forum of cancer OHC Qiu et al. (2011). It has been shown that those who started a thread in a cancer OHC often

show a more positive sentiment in their posts later in the thread, after other OHC members provided replies Qiu et al. (2011); Portier et al. (2013). However, the potential relationship between alignment theory and these benefits of cancer OHC has not been explored. This motivates us to study the alignment of posts on a thread to the initial post that starts the thread.

4 Data Description and Preliminary Definitions

The data used in this study stem from the Cancer Survivor's Network (CSN) (`http://csn.cancer.org`). The CSN is the oldest and the largest cancer online community for cancer survivors, which includes cancer patients, and their friends and families. CSN has more than 166,000 members (Portier et al., 2013). Members in CSN present their concerns, ask questions, share their personal experience and provide social support to each other through discussion threads. Similar to other online communities, CSN threads consist of an initial post followed by a sequence of reply posts ordered by time. A thread could be represented as a sequence of post, $< P_1, P_2, \cdots, P_i, \cdots, P_n >$. In order to better explain the problem, we show some properties of a post in the thread.

Absolute Position: Given a post P_i in a thread, the absolute position of post P_i is *i*

Relative Position: Given a post P_i in a thread with n posts, the relative position of P_i is *i/n*

We construct the CSN corpus by randomly sampling 3,000 threads from CSN between 2000 and 2010. Using Stanford's CoreNLP tool (Klein and Manning, 2003), we generate the syntactic structure of the text in each post. In order to calculate linguistic adaptation, we convert every syntactic tree into structure rules in phrases (Reitter et al., 2006). The data distribution of CSN corpus is shown in Figure 1.

5 Measures of Linguistic Adaptation

Following previous work, we implement *Indiscriminate Local Linguistic Alignment* (Fusaroli et al., 2012) at the levels of syntax and lexicon. In general, indiscriminate local linguistic alignment measures the repetition of language use in the target post repeating prime posts. LILA, as defined, is a normalized measure of the number of words that occur in both the prime and the target.

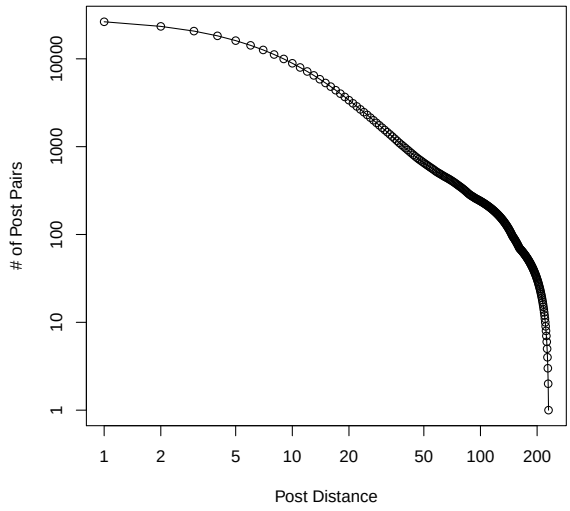

Figure 1: The distribution of posts based on post distance.

The normalization factor is the product of the length of the prime and the length of the target.

Alignment has been demonstrated for syntax and lexicon, ranging from controlled experimentation to broad-coverage naturalistic text (e.g., Bock, 1986; Gries, 2005; Ferreira and Bock, 2006; Reitter et al., 2006). In this paper, we present primarily exploratory analyses that emphasize minimal filtering and data processing. While some priming effects discussed in the literature indeed require careful post-hoc control using many explanatory variables, the phenomena we discuss are evident with exploratory, early-stage methods.

5.1 Indiscriminate local linguistic alignment at the lexical level

Lexical Indiscriminate Local Linguistic Alignment (LILLA) measures word repetition between one or more *prime* post and a *target* post. The prime always precedes the target. LILLA, in our implementation, can be seen as the probability of a word occurring in a single location, given it occurred in a prime period. Formally,

$$\text{LILLA}(target, prime) = \frac{p(target|prime)}{p(target)} \quad (1)$$

$$= \frac{\sum_{word_i \epsilon target} \delta(word_i)}{length(prime) * length(target)} \quad (2)$$

$$\delta(word_i) = \begin{cases} 1 & \text{if word}_i \in \text{prime} \\ 0 & otherwise \end{cases} \quad (3)$$

where length(X) is the number of words in post X, and target post is any post following the prime post. The distance between the two posts is measured in posts. In different experiment settings, we focus on certain prime posts, such as the first post of a thread, or all posts written by a certain author.

To sum up, LILLA is measured as word repetition conditioned on the word having been primed in a previous post. A high value of LILLA indicates an increased level of linguistic alignment. Alignment at the lexical level can have a number of underlying causes, including lexical priming, but also simply topicality of the posts. Therefore, it is important to also inspect indiscriminate local linguistic alignment at the syntactic level.

5.2 Indiscriminate local linguistic alignment at the syntactic level

Here, we consider a priming effect of syntactic structure, which shows users' implicit linguistic adaptation. Similar to Reitter et al. (2006), our cancer survivor network corpus was annotated with phrase structure trees; unlike in previous work, we do so using a parser (from the Stanford CoreNLP package (Klein and Manning, 2003)). Each post is encoded as a series of syntactic rules. *Indiscriminate local linguistic alignment at the syntactic level* (SILLA) measures the repetition of syntactic rules in the target post. Similar to our experiments in lexical repetition, prime posts will vary in different experimental settings.

5.3 Alignment and Adaptation

In this paper, we distinguish *alignment* and *adaptation*. Alignment is the general adoption of words, phrases, syntax, and any linguistic representation that was heard, read, spoken or written previously. Adaptation is a special case of alignment: here, speakers permanently adjust their linguistic preferences, or they *learn* from their linguistic experiences. Alignment can be due to a memory effect (e.g., priming), while adaptation may alternatively be the result of speakers discussing a topic. When they do, they are more likely to use the same words. Both alignment and adaptation may decay over time.

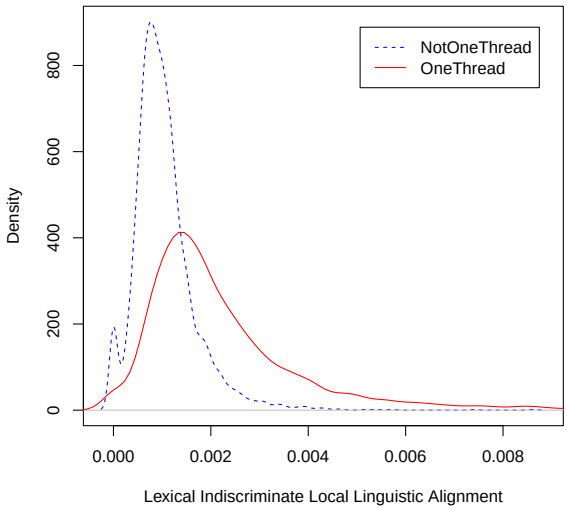

Figure 2: Distribution of lexical indiscriminate local linguistic alignment compared to a control (NotOneThread).

6 Linguistic properties of conversation threads

In this section, we will set up four experiments to show the alignment properties of conversation threads. For simplification, we will only consider replies whose post distance is less than 100 (data distribution shown in Figure 1).

6.1 Linguistic alignment

We assume that there is a constant level of random indiscriminate local linguistic repetition in human language, both lexically and syntactically.

We designed a post-hoc experiment to test whether linguistic alignment effect is due to linguistic adaptation or intrinsic repetition in human language, following methodology to measure long-term adaptation developed in Reitter and Moore (2007). We split each of 3,000 threads into two equal-size (by posts) halves. Out of the resulting 6,000 thread halves, we produce pairs combining any two sampled thread halves.

We define the binary OneThread variable, indicating whether a pair consists of material from the same thread, or if it consists of a first half from one thread, but a second half from another thread. This allows us to contrast repetition within and between threads. If linguistic adaptation exist, linguistic repetition at the lexical and syntactic levels between the two halves of a pair will be

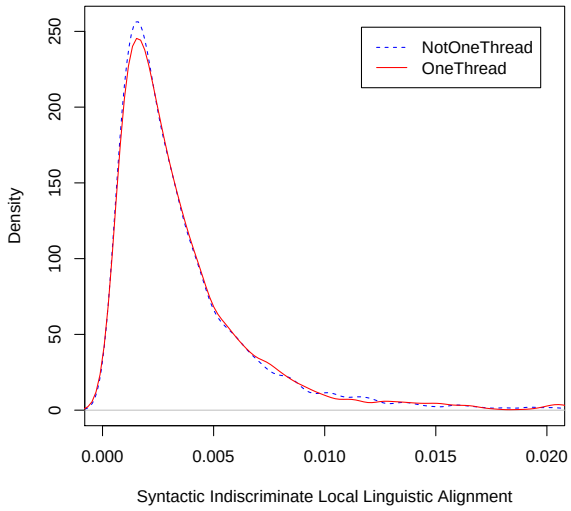

Figure 3: Distribution of syntactic indiscriminate local linguistic alignment compared to a control (NotOneThread).

more common if OneThread is true.

Figures 2 and 3 show that linguistic repetition in the same thread is greater than the control (repetition between different threads) (Wilcoxon-test $p_{LILLA} < 0.001$, $p_{SILLA} < 0.001$). However, despite the statistical difference, it is obvious that there is a strong lexical alignment effect, but much less syntactic alignment. As a result, we conclude that at least some linguistic repetition in the online conversation is due to linguistic adaptation. Again, at the lexical level, we would expect some of this repetition to be due to the preferred repetition of topical words; at the syntactic level, this is unlikely to be the case.

6.2 Linguistic Adaptation Decays

Strong syntactic repetition has been shown to diminish within seconds (Reitter et al., 2006). Precisely, given an use of a syntactic construction at one point in time, the probability of this construction being used again is strongly increased for the first seconds, but decays rapidly towards its prior probability. In our experiment, we replicate the decay of linguistic repetition at the larger scale of forum threads. From a psycholinguistic perspective, one would expect only a relatively weak effect, given that syntactic short-term priming is often short-lived (Branigan et al., 1999). However, there is also weaker, slow, long-term persistence (Bock and Griffin, 2000), which can even be cumulative (Jaeger and Snider, 2007; Kaschak et al., 2011b). The messages in such forums are written at a much larger timescale than the priming models and short-term priming lab experiments investigate.

In the experiment, we split a thread into a sequence of posts. Given a target post P_j, the prime post is one post in the subsequence of posts $< P_1, \cdots, P_i, \cdots, P_{j-1} >$. We calculate LILLA and SILLA of posts for prime-target distances below 100. We will use the same method in this and following experiments.

Figures 4 and 5 show that LILLA and SILLA drop as the post-distance between a target post and a prime post in the thread increases. Comparing syntactic and lexical decay, we note that the slope of LILLA's decay is stronger than that of SILLA's decay. Both two measurements imply that linguistic alignment decays over time, by "utterance" (for some definition of utterance), or by post. These results parallel standard results from the priming literature. Surprisingly, for forum threads we find this effect at a much larger scale than in one-on-one spoken dialogue.

6.3 Linguistic adaptation to the initial post

So far, we have largely replicated a known alignment effect for the case of written communication in the online forum. There are some properties of the forum communication that allow us to investigate a number of open questions pertaining to alignment in multi-party dialogue. The main question concerns the function of alignment. Is it more than an artifact of low-level memory effects (priming)? Does it, as Pickering and Garrod (2004) have argued, contribute to mutual understanding? Or is it, beyond that, a mechanism to express or establish social relationships? If alignment is not just a purely functional phenomenon, but also carries pragmatic weight or social functions, we would not expect it to be blind to the role of the author of the source (prime) post.

In a self-help online discussion forum, the role of the initial post differs from that of other messages. The initial post raises an issue generally, or it poses a concrete question. In this experiment, we test whether initial posts in the thread are more important than other replies

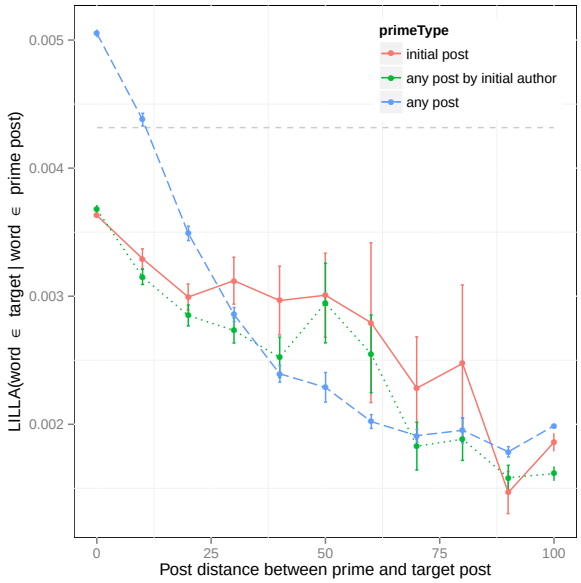

Figure 4: **Lexical** indiscriminate local linguistic adaptation to any post, the initial post and the posts from the initial author of the thread. The light gray horizontal line shows the mean LILLA to any post in the thread. Error bars: standard errors. (The dashed horizontal line shows the prior, which is large due to the large number of many short threads.)

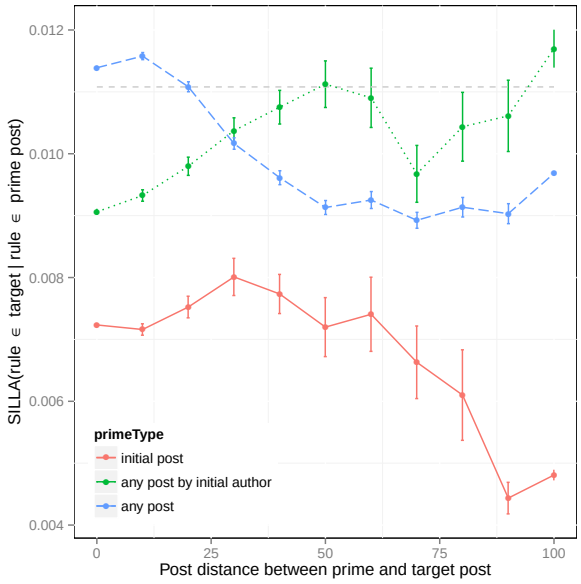

Figure 5: **Syntactic** indiscriminate local linguistic adaptation to any post, the initial post, and the posts from the initial author in the thread. The light gray horizontal line shows the mean SILLA to any post in the thread.

in online conversations. That is, given an initial post, does linguistic alignment still decline with increasing post distance between the initial post and the reply post in the online discussion thread? Also, is linguistic alignment to the initial post higher than that to any post?

Figure 4 plots lexical alignment (LILLA). We can see that lexical alignment is present for the initial post as well, but not more so than in general. In fact, the absolute level as well as the decay of LILLA to the initial post is weaker than that of LILLA to any post in the thread.

To distinguish linguistic adaptation from more general alignment effects, we also test syntactic alignment, SILLA. Figure 5 plots this measure. SILLA shows a different story compared to LILLA. It shows that syntactic adaptation takes place (and decays) for all posts, but that there is less, if even initial anti-alignment with the posts from the initial author. The results may be supported by properties of conversation in internet threads. In an online community, initial posts generally raise questions. Different sentence types (e.g., questions) may be used by someone seeking help. So, alignment with the initial post may seem to decay after post 25, but also shows more variance (due to fewer data-points).

In sum, both measurements suggest that linguistic alignment takes place with general material presented before the target text, and that repetition probability does decrease over time or linguistic material (posts) as theoretically predicted. We do not see evidence for a strong social role of alignment.

6.4 Linguistic adaptation to the author of the first post

As the previous experiment showed, lexical alignment to the initial post decays over time. There is no evidence that alignment with the initial post is related to its informational role in the thread. However, is alignment affected by the social role taken on by the author that asks the initial question? In other words, do writers align more with posts from the initial author than with others?

Figure 4 shows that LILLA drops gradually when prime posts are restricted to the initial author. Lexical alignment to the initial author behaves similarly to alignment with the initial post. At the lexical level, repetition of material

provided by the initial author or initial post does not drop as rapidly as it does for general material, and it starts at a lower level. Further investigations will be needed to better understand the alignment effects and the slow decay with the thread-initiating post. For example, further analysis is needed to investigate whether the slow decay is related to the support function the community provides to the thread initiators. Syntactic alignment (SILLA, Figure 5) suggests weaker alignment effects for the initial author and the initial post. Further investigations will also be needed to study the syntactic alignment of replying posts to early reply posts. If such alignment exists, it provides further insights about the leadership role in the community (Zhao et al., 2014).

This finding result may be supported by properties of online support communities. Specifically, the author of the initial post is the person that would like to receive support from other community members. People who reply provide support to that initial author. Therefore, replies in the thread are likely to have expressions different from those used in the initial post and by the initial author.

7 Conclusion

Motivated by analyzing linguistic adaptation behavior in online communities, we provide a descriptive analysis that qualifies linguistic alignment at both the lexical and syntactic levels. A novel observation is that we find reliable linguistic adaptation in online communities. We replicate the temporal, logarithmic decay, but we found it at a much slower pace or larger scale than psycholinguistic work has done in experiment or corpus studies.

The distinction we make between syntactic and lexical alignment has implications for the possible mechanisms behind the adaptation effect. A writer's lexical choices are influenced by topic, while syntactic composition happens implicitly, i.e., without (conscious) attention. Topics do not remain the same during a conversation: they shift throughout the thread. This clustering of topics can create alignment and decay but as far as permanent adaptation is concerned there is nothing but the illusion of it.

Our study provides some insight into properties of linguistic alignment particularly in thread-based discussions. Different from regular dialogues, the initial post and the author of the initial post may have a special role in such dialogues. We see differences in lexical and syntactic alignment. We assume that these are likely due to conversational properties rather than underlying cognitive processes.

This phenomenon provides an interesting angle to study online communities as well as linguistic alignment from the perspectives of communication and psycholinguistics.

Following these exploratory studies, we plan to measure *discriminate* alignment next. Here, priming spans across semantic relationships rather than only word identity (Swinney et al., 1979). Also, a next step would be to build a model that can quantify alignment (or even adaptation) and relate it to the factors pertinent to the discussion and the community, such as network measures and an individual propensity to align.

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