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Complexity Matching and Lexical Matching in the Conversations of Bilingual Persian-English Speakers

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Abstract: This study focuses on complexity matching and lexical matching to investigate speech convergence in the conversations of bilingual Persian-English speakers in three language conditions namely Persian, English, and mixed in the context of lingua receptiva as an attempt to investigate such matching mechanisms between a Latin-based language and a non-Latin-based language. Complexity matching investigates convergence in terms of the hierarchical temporal structure of human speech while lexical matching explores convergence in terms of the frequency occurrence of the matched lemmas. For this purpose, 14 master's students from the Shahid Chamran University of Ahvaz majoring in English language conversed with one another in dyadic groups in three language conditions each of which had its own topic namely movies, music, and books. In complexity matching, Allan Factor analysis in terms of multiscale clustering of onset events was considered. In lexical matching, the focus was on the distribution of all lemmas and matched lemmas and the possible correlation between the two. The results revealed a gradual increase in Allan Factor log-log plots in relation to the longer timescales that correspond with discourse patterns for complexity matching. For lexical matching, the positive correlation between all lemmas and matched lemmas (r_s = .607) suggested that as participants talked to each other more, they unconsciously tried to match their psychological perceptions with each other more. This suggests that speech convergence is vigorous in both bilingual and monolingual interactions.

Keywords: Bilingual Conversation, Convergence, Hierarchical Temporal Structure, Allan Factor, Lingua Receptiva.

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Introduction

We are living in a world that is constantly evolving and bilingualism is definitely not an exception to this. Interestingly, researchers believe that at least half of the earth's population speaks two languages, (Grosjean & Byers-Heinlein, 2018; Romaine, 2013; Edwards, 2013) and claim that both languages of a bilingual are always active in the mind (Guo & Peng, 2006; Marian & Spivey, 2003; Kroll, Dussias, Bogulski, & Kroff, 2012). This phenomenon can enhance several aspects of human cognitive functions (Bialystok, Craik, & Luk, 2012; Kroll, Bobb, & Hoshino, 2014) especially if learning starts at an early age which leads to achieving a native or near-native proficiency in production and comprehension of both first and second language (Perani et al., 2003). As far as bilingual interaction is concerned, there are many instances when bilinguals speak totally different languages and rely on the linguistic elements of their conversational partners in a conversational activity to comprehend the message. This concept points to the asymmetry between bilingual speakers (Park & Sarkar, 2007) and is referred to as lingua receptiva (LaRa) (ten Thije, 2013). Lingua receptiva is well-investigated in the literature especially by focusing on its characteristics, how it takes place, and how bilinguals and multilinguals use this concept to ease communication exchange (ten Thije et al., 2017; Bahtina-Jantsikene & Backus, 2016; ten Thije, 2013; Bahtina, ten Thije, & Wijnen, 2013). This phenomenon, however, brings researchers to ponder about if the principles that are present in monolingual speech production also exist for bilingual speech production (Schneider, Ramirez-Aristizabal, Gavilan, & Kello, 2020).

Speech alignment (Pickering & Garrod, 2004) or entrainment (Brennan, Kuhlen, & Charoy, 2018) is one of these principles and is defined as the arrangement of produced speech and perceived speech in such a way that they match each other (Schneider et al., 2020). According to the Interactive Alignment Model (IAM) proposed by Pickering and Garrod (2004), interlocutors try to align their speech through multiple levels of linguistic representations in order to achieve a similar or shared situation model and reach what is called "grounding in conversation" (Clark & Brennan, 1991, p. 127). The presence of code-switching (Toribio, 2004) as well as priming (Fricke & Kootstra, 2016), convergence in phonemes (Pardo, 2006), speech pauses (Cappella & Planalp, 1981), syntactic structures (Bock, 1986), and descriptive utterances (Garrod & Anderson, 1987) in bilingual communication show an effort in this regard for both participants in a conversation to try to arrive at a successful interaction.

Throughout the conversation, interlocutors "exhibit linguistic style matching (LSM) on both the conversation level as well as on a turn-by-turn level" (Niederhoffer & Pennebaker, 2002, p. 337). This phenomenon is in relation to open-ended conversations during which interlocutors try to converge their linguistic choices or lexical selections in order to match that of their partner's linguistic representations (Brennan et al., 2018; Brennan & Clark, 1996). Schneider et al. (2020) refer to this concept as "lexical matching" (p. 845). However, research has shown that conversation is more than just a simple and neat turn-taking between interlocutors (Stivers et al., 2009) and it is by nature irregular and not clean in the sense that interlocutors interrupt each other during turns and such turns, in general, do not take place systematically and follow no order (Stivers et al., 2009). So, conversation by nature is complex and occurs on multiple levels between complex systems (Abney, 2016; Abney, Kello, & Warlaumont, 2015; Marmelat & Delignières, 2012; Dubois, 2003). Therefore, the complexity matching hypothesis, a more recently-discovered measure of convergence or alignment in conversation is proposed by Abney (2016) as well as Abney, Paxton, Dale, and Kello (2014) and Abney et al. (2015) which has its roots in statistical mechanics (West, Geneston, & Grigolini, 2008).

Abney (2016) defined complexity matching as "the complexity matching hypothesis for human communication predicts that when the hierarchical structure of communicative patterns matches between two people, information transmission is enhanced" (p. 97). The concept of complexity matching is closely interwoven with a type of structure that is used to indicate nested clusters of such matchings in human speech which is hierarchically structured and temporal, namely "hierarchical temporal structure (HTS)" (Kello, Bella, Médé, & Balasubramaniam, 2017, p. 2; Falk & Kello, 2017, p. 80). Considering such a structure, human speech can be clustered into windows or nests; in other words, human speech consists of "hierarchically nested units" (Kello et al., 2017, p. 2), a phenomenon also known as "nested clustering" (Kello et al., 2017, p. 3) of human speech. As Abney (2016) puts it, "phonemes are nested in syllables, syllables in words, words in phrases, phrases in sentences, and sentences in discourse" (p. 2). Each one of these nested clusters varies from other nested clusters present in a human speech next to each other and such variability, as a result, is indicative of a power law or power laws that exist for complex, non-linear dynamic systems which are hierarchically nested (Mandelbrot, 1983) and human speech is one of those systems (Kello et al., 2017; Abney, 2016). Concerning this, a study by Abney et al. (2014) indicated that interlocutors in a conversational activity attempt to align themselves dynamically on different hierarchical temporal levels by exhibiting similar acoustic onset times (VOTs).

This issue concerning coupled oscillators and the magnet effect of power-law distributions of dynamic systems has been identified in the related literature (Von Holst, 1973; Gallistel, 1980); however, the investigation of such coupled non-linear systems of oscillators in the speech amplitude of humans in the context of HTS has only recently received considerable attention for further research (see Schneider et al., 2020; Falk & Kello, 2017; Abney et al., 2014). At least one study has been conducted to investigate this issue among monolingual English speakers (Abney et al., 2014) and another one concerning bilingual Spanish-English speakers (Schneider et al., 2020) but no previous study has been conducted among bilinguals whose L1 (i.e., Persian) differs significantly from their L2 (i.e., English). However, the concepts of complexity matching and lexical matching in relation to hierarchical temporal structure (HTS) and the interactive alignment model (IAM) regarding parity in the conversations of bilingual Persian-English speakers were not well-investigated. Therefore, the present study investigated both lexical matching and complexity matching in open-ended conversations, first, in one language, and then in the other language of bilingual Persian-English speakers. The results and findings were compared and contrasted by making use of produced acoustic signals in conversations and also the hierarchical temporal structure of human speech. It is worth mentioning that by referring to the literature, it can be predicated such matchings occur between some languages like English and Spanish (Schneider et al., 2020). However, it is not known to what degree such matchings can show weaker or stronger signs across languages that are more distant like Persian and English, and whether bilingual Persian-English speakers make use of such matchings unconsciously to arrive at an alignment of the situation model (Pickering & Garrod, 2004) in order to achieve a successful point of interaction in conversation or not.

Literature Review

Convergence in Monolingual and Bilingual Conversations

Related to the Communication Accommodation Theory (CAT) proposed by Giles, Coupland, and Coupland (1991), speech convergence implies that when people talk to each other in a conversation, different aspects of their speech often become more similar (Holmes, 2013). In relation to this issue, a number of studies have shown convergence in monolingual and bilingual conversations. Pardo (2013), Pardo (2006), and Pardo, Gibbons, Suppes, and Krauss

(2012) showed the presence of phonetic convergence in monolingual conversations by recording college roommates before the beginning of the academic year and then collecting the recorded samples 4 times during the semester. The result of that study showed that interlocutors converge their speech phonetically during an academic year. Sancier and Fowler (1997) conducted three experiments on phonetic convergence in bilingual conversations to see whether convergence is present in bilingual conversations or not. In the first experiment, they asked Brazilian-Portuguese listeners to see how foreign the pronunciations of a Brazilian-Portuguese speaker would sound to them once before going to the US by staying in Brazil for a few months and once after coming back from the US. In the second experiment, they asked American-English speakers to do the same, seeing how foreign the pronunciations of the same bilingual speaker would sound to them when staying in the US and when coming back from Brazil after a few months of settlement. In the third experiment, they asked if the bilinguals' pronunciation differed from that of native Brazilians and native Americans by trying to measure and compare voice-onset times (VOTs) in order to see if there was a shift in pronunciations as a result of the "ambient language" (p. 428). The results showed that the bilingual used in the experiment would converge her speech to the native speakers of that language under the influence of the situation and that "parallel gestural drifting may occur in stops in both languages because the speaker detects these correspondences" (p. 432). In this respect, Nielsen (2011) has demonstrated that voice onset time (VOT) and frequency of the words used in an interaction can contribute to phonetic convergence in both monolingual and bilingual conversations. A number of studies (Balukas & Koops, 2015; Tobin, Nam, & Fowler, 2017) adopted the approach introduced by Nielsen (2011) to measure phonetic imitation in bilingual conversations. As an example, Tobin et al. (2017) predicted that "Spanish-English bilinguals' voiceless-stop VOTs will accommodate bidirectionally with exposure to different ambient languages" (p. 49) and designed an experiment in this regard including eleven native speakers of Spanish who were asked to listen to twelve English sentences and Twelve Spanish sentences, each of which consisted of at least one of the three voiceless stops [p], [t], [k]. The results of the study were in line with the one conducted by Sancier and Fowler (1997) in relation to phonetic convergence in the ambient language of a bilingual speaker.

Lexical Matching

A number of studies have reported on the presence of linguistic style matching (LSM), i.e., lexical matching, in conversations (Niederhoffer & Pennebaker, 2002; Cappella, 1996;

Chartrand & Bargh, 1999; Garrod & Anderson, 1987; Shepard, Giles, & Le Poire, 2001) some of which are particularly in line with the Communication Accommodation Theory (CAT) proposed by Giles et al. (1991). Building upon Cappella (1996), the words interlocutors use in a conversation vary from each other; however, this variation in word selection is correlated because the language used in a conversation by interlocutors is related, mutual, and shared (Niederhoffer & Pennebaker, 2002). This states that the language interlocutors use to converse with one another is primed (Niederhoffer & Pennebaker, 2002). Research has shown that during a conversation, interlocutors constantly affect each other's behavior both verbally (Chartrand & Bargh, 1999) and non-verbally (Harper, Wiens, & Matarazzo, 1978). However, a conversation is a dyadic or joint action (Abney, 2016; Garrod & Pickering, 2009) during which each interlocutor tries to converge their speech to their partner's style in order to reach communication efficiency and promote social acceptance, the concept of which is referred to as the Communication Accommodation Theory (CAT) (Giles et al., 1991; Giles, Mulac, Bradac, & Johnson, 1987). In this respect, at least two studies (Niederhoffer & Pennebaker, 2002; Ni Eochaidh, 2010) have been done that show the presence of such matching in conversations of both monolingual and bilingual speakers. Niederhoffer and Pennebaker (2002) conducted three experiments in order to see the presence of "linguistic style matching" (p. 341) or lexical matching. The results of the study showed that such a matching is present between L1 speakers and L2 speakers and also between two L2 speakers which states that both L1 speakers and L2 speakers in a dialogue try to match their choices of lexical items to each other so that communication efficiency and common ground are achieved (Giles et al., 1991; Clark & Brennan, 1991). Ni Eochaidh's study (2010) confirmed the same results that interlocutors in a dyadic interaction are affected by the word choices their partners use.

Hierarchical Temporal Structure (HTS)

A number of studies have shown that human speech is hierarchically structured (Kello et al., 2017; Falk & Kello, 2017) and complex (Luque, Luque, & Lacasa, 2015). This states that such a speech can be clustered into windows or nests, a phenomenon also known as "nested clustering" of human speech (Kello et al., 2017, p. 3). Abney (2016) notes that "phonemes are nested in syllables, syllables in words, words in phrases, phrases in sentences, and sentences in discourse" (p. 2). Such nested clusters of speech appear to vary from each other and such variability, as a result, shows the presence of a power law or power laws that exist for complex, non-linear dynamic systems that are hierarchically nested (Mandelbrot, 1983; Kello et al., 2017; Falk & Kello, 2017) and human speech is one of those systems (Abney, 2016). In fact, the presence of such hierarchical structures in human speech as well as the vocalizations of other animals (Falk & Kello, 2017) suggests the existence of some complex processes or mechanics that underlie these conversational activities (Kello et al., 2017). Hierarchical temporal structure (HTS) is present among all acoustic signals, whether vocal or musical (Rohrmeier, Zuidema, Wiggins, & Scharff, 2015; Koelsch, Rohrmeier, Torrecuso, & Jentschke, 2013). This phenomenon can be measured (Abney et al., 2015) as it is considered a non-linear dynamic system (Abney et al., 2014) and all non-linear systems have defining power laws within them (Mandelbrot, 1983).

Many studies show that human speech is dynamically structured and interlocutors try to converge their phonetic choices to each other in a non-linear way (Pardo, 2006; Sancier & Fowler, 1997; Tobin et al., 2017; De Looze, Scherer, Vaughan, & Campbell, 2014; Nielsen, 2011, Norris, McQueen, & Cutler, 2003). Building upon Norris et al. (2003), for example, Nielsen (2011) mentions that in a conversational activity, interlocutors make use of their lexical knowledge to "dynamically tune their phonemic representations" (p. 133) suggesting that in a dyadic conversation, conversational partners make an attempt to adjust and converge their shared representation of sounds in the words they utter. Kim, Horton, and Bradlow (2011) stated that phonetic convergence or alignment during the initial stages of interaction is "dynamically mediated" (p. 125) implying that interlocutors constantly try to adjust their speech and converge toward each other to have a successful interaction and reach a shared understanding of the topic under discussion. As a result, hierarchical temporal structure (HTS) is an indispensable element of acoustic signals that is present in all vocalizations in nature (Kello et al., 2017) including human speech (Falk & Kello, 2017). This structure is entwined with complex dynamic systems in conversation, i.e., complexity matching, and is used to measure the amount of matching present in the speech amplitude of conversational partners based on their prosodic convergence and interactive alignment (Abney, 2016; Abney et al., 2014; Falk & Kello, 2017; Kello et al., 2017; Pickering & Garrod, 2004).

Complexity Matching

Abney (2016) proposes that human speech is a complex system and when such complex structures that exist in the speech of interlocutors in a conversation match each other, the transmission of information between interlocutors is enhanced. Abney (2016), Abney et al.

(2014, 2015), and Marmelat and Delignières (2012) claim that conversation is a complex activity during which interlocutors try to align themselves according to such existing complexities to ease communication. These complexities are mainly existent in the peak amplitudes of hierarchical temporal structures of human speech (Kello et al., 2017; Falk & Kello, 2017). In this respect, Abney et al.'s (2014) study on dyadic conversations among monolingual speakers showed that interlocutors tried to align themselves dynamically on different hierarchical temporal levels by exhibiting similar acoustic onset times (VOTs) that reflected the existence of "power-law clustering across a range of time scales" (p. 2304). This means that human speech is clustered across multiple time scales (Abney et al., 2014) and each one of these time scales has a power law as a defining feature of its particular relationship with adjacent clusters or nests and their power laws that are present in speech amplitude (Falk & Kello, 2017; Kello et al., 2017). In another study which consisted of 22 volunteers, Marmelat and Delignières (2012) tried to see whether interlocutors converge their speech on such complex levels the findings revealed that the coordination or synchronization between individuals in a conversation is "based on non-local time scales" (p. 137). This non-locality, in other words, the non-linearity of convergence in a dialogue by analyzing the peak amplitudes of human speech through hierarchical temporal structure shows that dyadic conversations are complex (Abney, 2016) and that such dynamic complexities are present at all levels of interaction, from phonetic to semantic to situational levels (Abney, 2016) which is again in line with the Interactive Alignment Model (Pickering & Garrod, 2004). The presence of such complex non-linear systems in dialogues shows that conversations are full of chaos and happen in a chaotic, unpredictable way (Larsen-Freeman, 1997), an example of which includes turn-taking in dialogue that is not predetermined (Sacks, Schegloff, & Jefferson, 1978) and follows no order in any systematic, neat and clear way (Abney, 2016).

The Current Study

As mentioned above, a host of studies have been conducted in relation to the presence of complexity matching and lexical matching in bilingual conversations in the field. However, by reviewing the literature, the relationship between the two concepts, i.e., complexity matching and lexical matching, concerning distant languages like Persian as a non-Latin-based language and English as a Latin-based language has not been explored fully. Hence, the current study aims to investigate whether these two types of matchings are present in the conversations of bilingual Persian-English speakers and if they appear to be present, what relation exists between them as well as how such matchings play a part in the overall degree of convergence in the verbal interaction of the conversational partners as well as an increase in the information exchange of dyads in dialogue to reach a successful point in the dyadic verbal interaction. In this vein, the following research questions are addressed:

1. How do complex systems and power law distributions cause convergence in the verbal interaction of bilingual Persian-English speakers?
2. To what extent do bilingual Persian-English speakers align their speech lexically according to the concept of lexical matching?
3. Is there any relation between complexity matching and lexical matching in the speech of bilingual Persian-English speakers?

Method

Design

The study followed an ex post facto design by focusing on the observation of human behavior. Data collection consisted of structured observation of human verbal interaction in the form of recorded conversations (Phellas, Bloch, & Seale, 2011). Hence, conversations were recorded via structured observation to investigate the presence or absence of complexity matching as well as provide an interpretation in this regard. The English conversations out of all conversations were then transcribed for further analyses to measure lexical matching. As the last step, to see whether the results and findings from complexity matching and lexical matching were related to each other or not, they were compared with one another by focusing on concepts such as convergence, priming, and interactive alignment to pinpoint any possible relation between these two matching mechanisms.

Participants

There were 14 English language students involved in the study (mean age = 25.85; females = 8, males = 6) all of whom were master’s students of English literature (n = 3) and English language teaching (n = 11) from the Shahid Chamran University of Ahvaz (SCU). Participant selection followed a non-probability sampling method and was of a convenience sampling type through which participants were selected based on availability and willingness to take part in the study. All participants reported their native language as Persian. However, in addition to Persian, one participant reported Turkish as her native language and two participants reported

Arabic as their native language as well (n = 2). Some of the participants (n = 4) reported not knowing each other before the experiment. Most of them (n = 10) were either friends or acquaintances. Participants also rated which language they felt most comfortable with on a daily basis. Moreover, 11 participants reported Persian and only 1 participant reported English. All participants reported Persian as their dominant language and English as their non-dominant language. It is also worth mentioning that this study did not aim to generalize the results or findings in any way. Hence, the aim was to merely show the presence of these phenomena, i.e., complexity matching and lexical matching in human speech, and interpret them, not generalize them since convergence may not happen all the time in conversation and different people may even diverge their speech during interaction for different purposes (Holmes, 2013), the notion of which is not within the scope of this study. This explains the number of participants who took part in the study as well. Additional information about the participants' mean age of L2 acquisition as well as the average level of proficiency rated by themselves are given in Table 1.

Table 1. *Mean Participants' Age of L2 Acquisition and their Self-reported Proficiencies for Persian and English*

Age of L2 acquisition and self-reported proficiencies	Persian	English
Age of acquisition	0.71 (0.46)	10.57 (3.81)
Reading Proficiency	9.07 (1.59)	8.28 (1.43)
Speaking Proficiency	9.28 (1.13)	7.0 (1.35)
Writing Proficiency	8.64 (1.64)	6.57 (1.50)
Speech Comprehension Proficiency	9.5 (1.09)	8.07 (1.20)
Mean frequency of use for the non-dominant language	_	42.85% (18.15)
Mean frequency of use for the dominant language	76.78% (24.93)	–

Note. Numbers in parentheses show standard deviations. The self-reported proficiency scores (reading, speaking, writing, and speech comprehension) were calculated out of 10, where 1 indicated no fluency and 10 indicated total fluency. The mean frequency of use for each language refers to how often each language was used by the participants throughout a week for general purposes.

Instruments

The participants were asked questions both before and after the experiment. The pre-experiment questionnaire (Appendix A) asked about participants' demographic information and language history while the post-experiment questionnaire (Appendix B) asked about participants' experience in the experiment. Both of the questionnaires were adopted from Schneider et al. (2020).

Equipment

Two Audio-Technica 2020 condenser microphones as well as one PreSonus AudioBox USB 96 Pre-amp were used as the main equipment. Because of the Covid-19 pandemic, conversations were conducted on Telegram messenger but they were not recorded on this messenger. The Audacity 3.0.2 audio software was used to record the conversations and analyze the speech waves. A few acoustic pads were also used to minimize background noise while recording the conversations by one of the researchers.

Procedure

Before the experiment began, the researcher asked participants 13 questions about their language history and demographic information. Participants were then given 2 to 3 minutes to talk to each other before starting the conversations in order to minimize stress or anxiety. Considering the Covid-19 pandemic, these conversations were conducted in the virtual space on Telegram messenger. The participants were asked to be in a quiet noiseless environment and then engaged in three open-ended five-minute conversations. One microphone was recording the speech of one dyad (left channel) and another microphone was doing the same for the second dyad in the same group (right channel). So, conversations were recorded in stereo. Instructions for each conversation were given before each recording. Conversations were recorded as the participants discussed the chosen topics which were about movies, music, and books.

Once the 5-minute time interval was reached, participants were informed about this in order to get ready for the next topic. Some acoustic pads were used in the place of recording the conversations so that potential background noise was decreased significantly on the part of the researcher. To eradicate even the smallest amounts of background noise on the part of the participants while recording the conversations, a noise profile was first drawn from each recorded sample by using Audacity 3.0.2 audio software. Then the noise reduction filter of 48dB from the Audacity 3.0.2 audio software was applied to all recordings with the sensitivity parameter set to 24 and the frequency smoothing parameter set to 3. These recorded conversations were later transcribed using OTranscribe (https://otranscribe.com). The initial conversation about the first topic was conducted in Persian. The second conversation about the second topic was conducted in English and finally, the third conversation about the last topic was conducted in a mixed situation which means participants code-switched between Persian and English to interact verbally with each other by relying on the concept of lingua receptiva (LaRa). These conversations were used to investigate the presence of complexity matching and lexical matching.

Data Analysis

All of the recorded conversations were saved in *.wav* format but only the conversations performed in the English language condition were transcribed. Later on, each dialogue transcript that belonged to each group was divided into two *.docx* files each of which contained all the sentences uttered by each interlocuter in that particular group. Recordings were also checked for voice quality. If the voice quality was not efficient for the analysis, conversations would be re-conducted on another day to ensure maximum voice quality for both participants in a group. The conversations were also checked to see whether participants made any mistakes or not in the experiment, e.g., code-switching accidentally. Concerning the first question of the study, Matlab R2020b software was used to identify the peak amplitudes of onset events in the speech waves (Schneider et al., 2020) within the context of hierarchical temporal structure (HTS) via some codes that calculated peak events, Hilbert envelope and Allan Factor variance. In this regard, all peaks that fell below a certain threshold in relation to the Hilbert envelope (-30 db in this study) were removed and not included in the analysis.

Allan Factor is a statistical measure used to quantify and show the degree of nested clustering between various power laws or power law distributions present in the dynamic systems of the hierarchical temporal structure of human speech (Abney, 2016; Falk & Kello, 2017). It was originally created to measure neural spike patterns in atomic clocks (Allan, 1966; Lowen & Teich, 1996; Thurner et al., 1997). Allan Factor analysis was originally created to measure the spiking patterns in atomic clocks and was then adopted by Lowen and Teich (1996) to measure neural spiking patterns. So, at its most basic level, Allan Factor analysis is a measure of variability in some type of spike patterns over some duration of time (Lowen & Teich, 1996; Thurner et al., 1997; Kello et al., 2017). Matlab R2020b software was used to identify the peak amplitudes of onset events in the speech waves (Schneider et al., 2020) within the context of the hierarchical temporal structure (HTS) via some codes that calculated peak events, the Hilbert envelope, and Allan Factor variance. In this regard, all peaks that fell below a certain threshold in relation to the Hilbert envelope (-30 dB in this study) were removed and not included in the analysis. These removed peaks could be any variable that was not related to Allan Factor functions and could affect the indication of nested clustering of events in AF log-log plots in such a way that the resultant plots would not yield exact results. In this phase, special attention was paid to *ax*-*ay* pairs in Matlab which correspond to *x* axis and *y* axis for interlocuters in a conversation. After making use of the hierarchical temporal structure (HTS) (Kello et al., 2017; Falk & Kello, 2017) to indicate nested clusters of speech in recorded conversations, some additional codes in Matlab were run again to show Allan Factor (AF) variance in relation to the nested clustering of different conversational events within different timescales in peak amplitudes of the recorded conversations pointing to the mean Allan Factor (AF) functions (Abney, 2016). One way to do this was to feed the spike trains (0 = nonevents; 1 = events) into the AF Matlab functions. From here, estimations of AF functions for each event series would be shown. Such an analysis was conducted to show if the rate of an occurrence or incident of a conversational event within a particular timescale tended to cluster and represent persistence in a range of space and/or timescales (Serinaldi & Kilsby, 2013).

These removed peaks could be any variable that was not related to Allan Factor functions and could affect the indication of nested clustering of events in AF log-log plots in such a way that the resultant plots would not yield exact results. As for the analysis of lexical matching in relation to the second question of the study, MAXQDA Analytics Pro 2020 software was used to investigate word frequency by taking into account the concept of word lemmatization in only transcribed English conversations in terms of lexical alignment or entrainment. For this purpose, each dyadic conversation was separated into two *.docx* files. Each *.docx* file contained all utterances of each participant in the dyadic conversational activity. Then, both files of each dyad were analyzed against each other to measure the frequency occurrences of all lemmas and matched lemmas for each group. In light of this argument, the minimum number of characters for word frequency analysis was set to 3 in the MAXDictio panel of MAXQDA. It is worth mentioning, however, that Persian conversations were not analyzed in this regard because MAXQDA software did not include any lemma lists in Persian. In this respect, word frequency was explored by focusing on the overall number of lemmas as well as the matched number of lemmas each dyad used in English conversations (Niederhoffer & Pennebaker, 2002).

Before conducting word frequency analysis, lists of English types of words, known as English Stop Lists, that were not intended to be counted were downloaded and later used for the word frequency analysis of transcribed English conversations (derived from https://www.maxqda.com). These English stop lists included single letters and numerals for the English language. As far as the nature of lemmas was concerned, all lemmas with a frequency occurrence of 1 and more than 1 were considered matches. To elaborate on this, only lemmas that were used at least once by both participants in each group during the verbal interaction were investigated. Other lemmas uttered only by one interlocuter and not used by their partner regardless of their frequency of occurrence were excluded from the study as instances of no lexical matching. In this respect, it was assumed that the more lemmas dyads would use over the course of the English conversations, the more likely they would be to match their psychological perceptions with each other unconsciously by means of lexical matching or alignment by using similar or the same types of lemmas. For this purpose, the Shapiro-Wilk test of normality was first conducted and the results lent themselves to non-parametric data.

So, the Spearman test of correlation was then run in SPSS 26 as a final step to investigate the monotonic relationship between the overall number of lemmas and the matched number of lemmas in relation to each dyadic conversation. It is worth considering that in this type of analysis, special attention was given to the spearman correlation (r_s) between the overall number of lemmas and matched number of lemmas because the significance of the correlation is dependent upon the sample size. In other words, the type of correlation (positive and negative) as well as the amount of correlation was important and not necessarily the significance of correlation as significance is greatly influenced by the sample size and it could be expected that our sample size would have a noticeable effect on the p-value. Also, the aim of this analysis as well as the one for complexity matching was not to generalize the results to a wider population by any means. In this respect, such a test of correlation was beneficial to see if there were any correlations between the overall number of lemmas and the overall possible increase of matched lemmas on the part of the dyads as an attempt to match their psychological perceptions of the situation or topic under discussion by matching their speech on a lexical level (Pickering & Garrod, 2004; Garrod & Pickering, 2009).

Results

Mean Allan Factor functions for all conversations

Considering the notions of hierarchical temporal structure, complexity matching, and non-linear dynamic systems, each dyadic conversation was analyzed using Matlab R2020b to pinpoint the presence of complexity matching as well as its interpretation. For this purpose, AF functions in relation to all language conditions for all dyadic interactions were investigated. In this respect, the mean degree of nested clustering in acoustic-onset patterns of recorded conversations is shown as $A(T)$ or Allan Factor variance in relation to a specific window size (T). Concerning this notion, $A(T)$ was calculated for 11 timescales ranging from almost ≈30 milliseconds to ≈30 seconds. While doing the analysis, it was assumed that if events were clustered across timescales or time windows, then Allan Factor variance or $A(T)$ would be more than 1 ($A(T) > 1$). Based on this concept, as timescales become larger, an increase in the Allan Factor variance is observable and this greater variance in Allan Factor functions in relation to each dyadic conversation corresponds with greater clustering of events which points to a higher degree of matching between complex systems with different power law distributions in speech production of the participants (see Schneider et al., 2020). On the other hand, if events are distributed evenly, then Allan Factor variance or $A(T)$ would approximately point to 1 ($A(T) \approx 1$) as AF analysis does not distinguish between periodic events and random events that are distributed evenly (see Schneider et al., 2020; Abney et al., 2014). In relation to this argument, the shorter timescales in AF functions correspond with smaller units of human speech such as syllables and phonemes while longer timescales which are the center of attention here correspond with larger units of human speech such as turns, discourse patterns, sentences, and phrases (see Kello et al., 2017). Figure 1 shows mean AF functions in relation to all dyadic conversations regarding both monolingual and bilingual conversations in three language conditions namely English (blue), Persian (red), and mixed (purple)

The matching observed for AF across the groups was the result of nested clustering of events in the speech amplitude of our participants, and this matching nested cluster of events is called convergence in human speech (Kello et al., 2017; Schneider et al., 2020; Abney et al., 2014). Complexity matching only focuses on these clusters of events in the speech amplitude regardless of the inherent characteristics of languages (see Abney, 2016). This claim has already been firmly established in the literature regarding complexity matching (see Abney et al., 2014, 2015; Abney, 2016; Falk & Kello, 2017; Kello et al., 2017; Schneider et al., 2020; Ramirez-Aristizabal, Médé, & Kello, 2018).

By looking at this figure, it is almost apparent that in all conversations, power law distributions in the speech were being matched with each other. In other words, nested clustering of events is apparent in almost all conversations; however, the intensity of such matchings in relation to nested clustering of events varied a bit in different language conditions. This could be due to several reasons like divergence showing itself in the form of very short pauses or even as an interlocuter's lack of interest to take part in a conversation momentarily as a result of which turn-taking in longer timescales would be affected, and the transmission of information would be influenced.

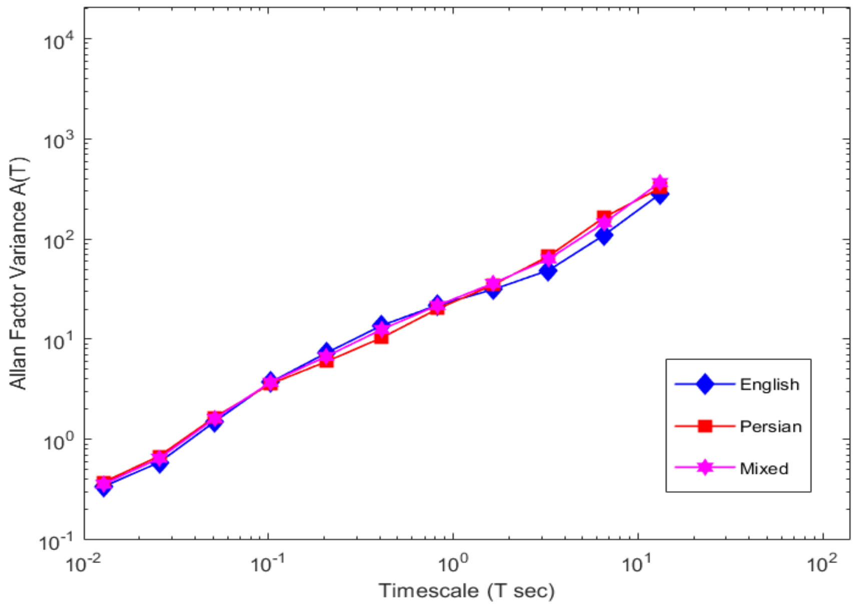

Figure 1 *Mean Allan Factor (AF) Functions for each Language Condition representing the Mean amount of Nested Clustering (i.e., HTS) across different Timescales (≈30 ms to ≈ 30 s)*

This, however, was not a steady phenomenon and was, in fact, a dynamic which means that such occurrences of scarce pauses or lack of interest in taking part in the conversations were temporary and dyads attempted to collaborate with their conversational partners to make up for this phenomenon. It is worth mentioning that this type of verbal behavior happened totally unconsciously and dyads were not aware of doing this deliberately. As dyads talk to each other more, timescales (*T sec*) became larger and longer timescales (*T sec*) were formed. This phenomenon, as shown in Figure 1, caused an increase in the time windows (*x axis*) as a result of which a gradual increase in Allan Factor variance (*y axis*) became apparent. This gradual increase in AF variance in relation to all dyadic conversations corresponds with greater clustering of hierarchical temporal structure (HTS) in these dyadic conversations. In other words, this means that as the interlocutors in the study engaged in the conversations more, information transmission was improving gradually. As a result, a gradual, non-linear increase in the matching of complex systems in all conversations becomes apparent. In this respect, the nearly straight line in Figure 1 shows approximately similar nested clustering of events (i.e., HTS) across timescales as dyads engaged in the conversational activity. As shown here, while the interlocutors were engaging in the conversations more, power law distributions in relation to dynamic systems of the hierarchical temporal structure were becoming more aligned with each other. This concept has to do with the presence of fractals and attractors for non-linear dynamic systems.

In larger timescales that correlate with phrases, sentences, and discourse patterns, more variance in AF functions is observable. The rate of occurrence of these instances regarding complexity matching tended to represent persistence in a range of timescales (≈30 milliseconds to ≈ 30 seconds) and this persistence is representative of power law clustering as a result of which complex systems in the speech of the participants became more aligned and a nested clustering of events became apparent in hierarchical temporal structure (HTS), the phenomenon of which can be justified by an increase in AF variance (*A(T)*). Figure 1 shows that in general, by calculating the mean Allan Factor functions for all recorded conversations, complexity matching takes place irrespective of language conditions or language proficiency. The roughly straight line shows that as timescales expand and become larger, variance in Allan Factor functions (*A(T)*) also increases. This increase is representative of one power law (Allan Factor functions) increasing as a result of another power law (timescales) pointing to a monotonic relationship between the values.

Lexical Matching and Word Frequency Analysis

To investigate whether dyads matched their choices of lexical representations with each other or not, the frequency of lemmas in each transcribed English conversation was investigated separately. Table 2 shows the thirty most frequent lemmas used by two conversational partners in one of the English conversations. In this respect, lemmas that are used by both interlocutors (frequency occurrence >1 for each participant) are bolded and used for further investigation. Lemmas that are not bolded (frequency occurrence = 0 for one of the participants) are excluded from the analyses. Each occurrence of a lemma for both participants is an unconscious attempt by each participant to align their lexical representations to that of their conversational partner.

Table 2. *Twenty most Frequent Lemmas Used by Two Participants in One of the English Conversations*

Lemmas	Frequency	Participant A	Participant B
you	20	12	8
music	17	12	5
the	14	6	8
that	10	6	4
think	10	6	4
and	9	3	6
can	8	4	4
see	7	1	6
about	5	1	4
all	5	4	1
part	5	1	4
people	5	4	1
be	4	2	2
but	4	4	0
even	4	1	3
have	4	4	0
human	4	1	3
nation	4	4	0
tone	4	2	2
why	4	4	0

Shapiro-Wilk test of normal distribution

After counting the overall number of lemmas in each conversation as well as the matched number of lemmas for each dyadic conversation, the Shapiro-Wilk test of normality was run in SPSS 26 to see whether the data were distributed normally or not. As shown in Table 3, the data lent themselves to non-parametric scales for further analyses ($p > 0.05$). Figure 2 shows the monotonic relationship between the overall number of lemmas and the matched number of lemmas in a scattered plot respectively.

Table 3. *Shapiro-Wilk Test of Normality*

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
All Lemmas	.245	7	.200	.879	7	.221
Matched Lemmas	.238	7	.200	.901	7	.335

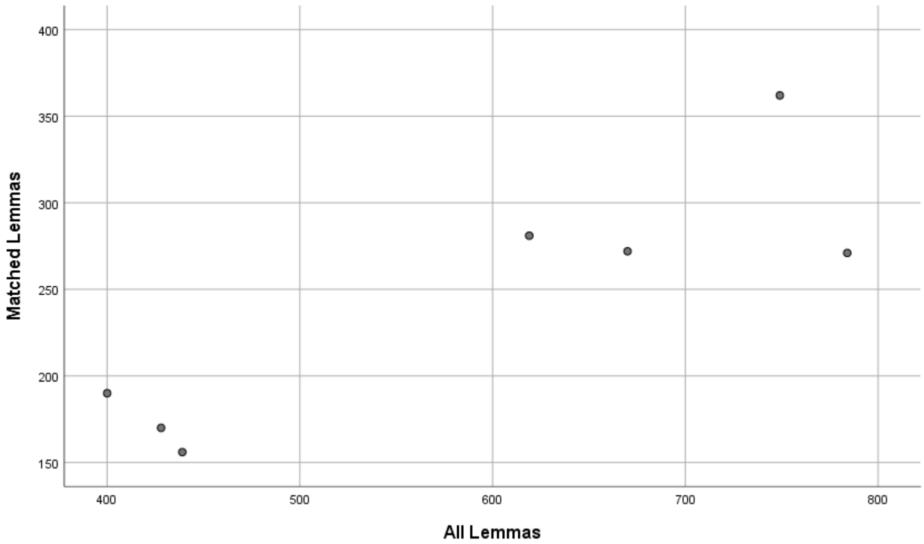

Figure 2. *Monotonic Relationship between all Lemmas and Matched Lemmas*

Spearman's Correlation Coefficient

This monotonic relationship between the variables shows that as one variable increases, so does the other one. As a final step to measure the degree of correlation, spearman's correlation coefficient test was run in SPSS 26. The results of the test are shown in Table 4.

Table 4. *Spearman's Rho (r_s) for all Number of Lemmas and Matched Number of Lemmas*

Correlations			
		All Lemmas	Matched Number of Lemmas
	Correlation Coefficient	1.000	.607
All Lemmas	Sig. (2-tailed)	.	.148

Spearman's rho		N	7	7
	Matched Number of Lemmas	Correlation Coefficient	.607	1.000
		Sig. (2-tailed)	.148	.
		N	7	7

As shown in Table 4, a positive correlation exists between the overall number of lemmas in each dyadic English conversation and the matched number of lemmas in those conversations ($r_S = .607$). However, this moderate correlation is not significant ($p = 0.148$) due to the sample size. Concerning this, what is more important for the analysis of lexical matching in this study was the possible correlation between the overall number of lemmas and matched number of lemmas uttered by the participants. However, it may be worth mentioning that the current p-value ($p = 0.148$) might be interpreted as leaning toward significance which might imply that a larger sample size would lead to a significant p-value. This positive correlation shows that as dyads talked to each other more over the course of English conversations, they came to use similar lemmas, i.e., lexical choices, more frequently. This increase in using more similar or the same lemmas can happen as an unconscious decision on the part of both participants in a dyadic conversation to match their psychological perceptions of the situation under discussion.

Relation between Complexity Matching and Lexical Matching

As shown earlier, both complexity matching and lexical matching took place in the dyadic conversations. However, there may not be a direct relationship between complexity matching and lexical matching considering that very different methods of analyses were used for each type of matching and such results may not lend themselves appropriately for a direct comparison. However, the results implied that there was a monotonic relationship in both analyses, i.e., Allan Factor (AF) variance and word frequency analysis. The results also showed that the degree of occurrence of both of these phenomena was a bit affected by the degree of familiarity in some of the conversations in this study. Nevertheless, this lack of familiarity was not a critical variable in the sense that it did not affect the nature and presence of these phenomena. Also, this lack of familiarity can be a characteristic of natural conversations in daily life. Complexity matching then was observed in all language conditions between the interlocutors who knew each other before the experiment (friends or acquaintances) and those who did not. It also took place between speakers and within speakers irrespective of language conditions (Persian, English, and Mixed) and language proficiency as an attempt to enhance their information transmission. Lexical matching was also apparent in the dyadic English interactions as a result of participants using the same lemmas frequently to have aligned psychological perceptions.

Discussion

The current study investigated the presence of complexity matching in the conversations of bilingual Persian-English speakers and attempted to provide an interpretation and analysis of the extent to which lexical matching occurred in these conversations. Concerning this, the outcomes of the analyses are compared and contrasted with the literature as well in an attempt to provide a general picture of the results by providing theoretical arguments. Complex patterns were apparent both between two participants and within one participant because such dynamic structures of human speech (i.e., HTS) are unique to each person and can adapt themselves to their surroundings (Fuchs, 2014). In this case, such surroundings included the speech of conversational partners as they talked to each other. From this point of view, it can be argued that complexity matching was present in the speech of all language conditions. This phenomenon then can point to the presence of inter-person convergence and intra-person convergence in each participant. As far as inter-person convergence is concerned, the participants in the study converged their speech toward each other unconsciously as an attempt to converge their speech on different hierarchical patterns of speech. On the other hand, intra-person convergence also took place as a result of complexity matching within each participant. This claim can be justified by saying that the hierarchical structures of each one of the participants were unique, and during the time, complex patterns of their speech were aligning or adapting themselves to each other. They also changed in relation to the nature of prosodic features of language that are unique to each person including pitch and intonation pattern.

So, while the participants were talking to each other, inter-person convergence was taking place and intra-person convergence was also in action on smaller scales for each person individually. From this perspective, intra-person convergence took place in the hierarchical temporal structure of pitch and intonation patterns of the participants and these suprasegmental features of human speech constituted the way words, sentences, phrases, and discourse patterns were uttered in larger timescales which corresponded to inter-person convergence. However, it is worth mentioning that the log-log plots were not used for showing the presence of intra-person convergence as the nature of Allan factor analysis indicates that it may not be the best tool to investigate suprasegmental features of speech (Schneider et al., 2020; Kello et al., 2017). Accordingly, this intra-person convergence as a result of the presence of complex patterns in prosodic features of language suggests that complexity matching captures the hierarchical temporal structure (HTS) of human speech collectively as a whole in relation to each particular longer timescale. In other words, speech style as a feature of longer timescales that takes place in discourse patterns and turns is the crucial factor that can affect complexity matching as a whole in each dyadic conversation and not individual words or any other linguistic factor in this regard (see Schneider et al., 2020; Abney, 2016). So, complexity matching occurred regardless of the language conditions as it is the speech style and not the individual phonemes and words from a language that can affect the transmission of information and complexity matching.

The results of the study in relation to lexical matching showed that as the participants came to talk to each other more, they tended to use lemmas that were produced in the dyadic English interaction more frequently. In this sense, the results of the study in relation to lexical matching in English conversations were in line with previous studies of the same type (see Cappella, 1996; Niederhoffer & Pennebaker, 2002) suggesting that during the conversational activities in the English language condition, the participants mostly used lexical items adopted by their conversational partners to some extent more frequently and this adaptation to the frequent lemmas used in the English interaction correlated positively with the overall number of lemmas during this dyadic activity. In other words, as the participants talked to each other more in English, they used more frequent lemmas and the frequency occurrence of these shared lemmas between the interlocutors in each group had a positive correlation with the overall number of lemmas pointing to a monotonic relationship between these two variables. There were, however, English conversations in which the frequency occurrence of shared lemmas was low or less than other English conversations in the study. This could be because of a temporary lack of interest in the subject or an act of divergence on the part of an interlocutor for any reason. This positive correlation means that the participants tried to align their lexical choices over the course of the conversation to arrive at similar or the same psychological perceptions. According to Costa, Pickering, and Sorace (2008), it can be suggested that this phenomenon happened unconsciously and involuntarily. In other words, as shown by the positive correlation between the overall number of lemmas and the matched number of lemmas in dyadic English conversations, the participants in each group used the same lemmas to refer to an object or explain a concept or point repeatedly to have similar choices of lexical items which would cause alignment at the lexical level.

It is worth mentioning that, considering the concept of the interactive alignment model (Pickering & Garrod, 2004), lexical matching suggests that in a dyadic conversational activity, interlocutors may come to use the same or very similar lexical choices or patterns overtime to reach grounding in communication (Bortfeld & Brennan, 1997; Clark & Brennan, 1991) irrespective of whether those words are among the frequent words used in that language or not. In addition, during the conversation, interlocutors did not have the time to think about the frequent words used in English so that they can use those words in such a way that we could say such matchings have occurred deliberately by the participants' awareness of the most frequent words in English. Costa et al. (2008) state that alignment can happen either linguistically which is mostly automatic or non-linguistically which is mostly non-automatic. A linguistic way to alignment refers to any way of alignment that leads to alignment of the situation model which stems from the alignment of linguistic representations at lower levels (Costa et al., 2008), an example of which includes lexical matching (Bortfeld & Brennan, 1997; Brennan & Clark, 1996). So, because the focus of the current study was on linguistic ways of alignment on different levels of linguistic representations (Pickering & Garrod, 2004), all occurrences of lemmas were automatic and not intentional or deliberate. In this vein, lexical matching can be a type of interpersonal synchrony (Paxton & Dale, 2013) whereby interlocutors unconsciously try to match their choices and representations of lexical items to possibly increase the verbal interrelatedness among themselves (Bernieri & Rosenthal, 1991) leading to a potential effect in their verbal interaction (Bernieri, Reznick, & Rosenthal, 1988). In this regard, Pennebaker and King (1999) state that the language and the lexical choices used by interlocutors in a conversational activity are representative of their feelings and thoughts which themselves reveal individual differences.

This alignment causes convergence as a result of which grounding in the interaction takes place (Clark & Brennan, 1991). Once grounding happens, successful interaction is achieved (Garrod & Anderson, 1987; Bortfeld & Brennan, 1997). In this respect, the interactive alignment model assumes that interlocutors align themselves on various levels of linguistic representations (Pickering & Garrod, 2004). It is also mentioned that alignment at one level of linguistic representation enhances alignment at other levels of linguistic representation (Pickering & Garrod, 2004; Garrod & Pickering, 2009). In this sense, to provide an account of complex systems and lexical choices in relation to Pickering and Garrod's (2004) Interactive

Alignment Model (IAM), it can be argued that as the participants interacted with each other more in the conversations, different dynamic patterns in their speech started adapting to each other in terms of both intra-speaker features like pitch and intonation (prosodic features of speech) and inter-speaker features like speech style and discourse patterns. Therefore, the idea is that prosodic features were nested in words and words were nested in sentences and sentences were nested in discourse patterns to form speech style variations which could cause inter-speaker convergence. In this respect, speech style can roughly be taken as the alignment of the situation model in relation to Pickering and Garrod's (2004) Interactive Alignment Model (IAM) by saying that if the participants of the study align themselves at smaller features of the language like suprasegmental features, then this could cause them to finally align their speech style (i.e., alignment of the situation model). This is exactly what happened as captured by AF log-log plots for all recorded conversations.

As far as lexical matching is concerned, the participants' choices of lexical items in the English language condition became more aligned by using more frequent lemmas produced during this dyadic interaction. This increase in using the same lemmas causes alignment in lexical representations of the participants in each group. This lexical alignment then can enhance the alignment of semantic representations of the interlocutors in the study which would finally lead to the alignment of the situation model which is in line with Pickering and Garrod's (2004) Interactive Alignment Model (IAM). So, this would bring about both of the participants in each group aligning their psychological perceptions of the topic they were discussing to each other. Hence, aligning lemmas by means of lexical matching causes alignment of the situation model (Pickering & Garrod, 2004) where grounding in communication takes place (Clark & Brennan, 1991) as a result of which conversation would be a successful interaction and information transmission would be enhanced. Taken together, lexical matching caused convergence by saying that the participants in the English language condition of the study aligned their lexical representations to each other in each group. In addition, complexity matching also showed the presence of dynamic systems and hierarchical temporal structure in the speech of the participants by capturing moments of alignment that were representative of discourse patterns, turns, and speech style variations. Such representations in longer timescales were being aligned in terms of between-speaker factors. In other words, the intra-person convergence from smaller timescales together formed convergence in relation to the larger timescales of speech production, and these larger timescales were captured by AF functions in the log-log plots.

Conclusions

To conclude, the present study investigated complexity matching and lexical matching to explore convergence in bilingual Persian-English speakers. In addition, the occurrence of complexity matching in longer timescales was investigated in a comprehensive manner in relation to the interactive alignment model. It was also intended to see the extent to which the bilingual English-Persian speakers had a tendency to re-use more frequent lemmas perceived and produced in the dyadic English conversations. For these purposes, evidence for the existence of complexity matching was provided by focusing on AF log-log plots which also provided some additional information about shorter and longer timescales. As for lexical matching, a positive correlation was observed between all lemmas used by each dyad and the matched number of lemmas in terms of frequency occurrence in the English language condition. However, the results and findings of the present study from this small sample could not be generalized to a wider population. Also, predicting the behavior of non-linear systems over a suitable number of bilingual participants to generalize the results was not possible either. Considering the presence of these matching mechanisms, conversation analysts can investigate alignment in relation to the existence of complex patterns of human speech. Secondly, the findings can also be beneficial for researchers who are interested in the behavior and presence of non-linear dynamic systems in the context of human speech perception and production and how these dynamic mechanisms can cause convergence among bilingual speakers. Altogether, it can be said that both complexity matching and lexical matching are robust phenomena in the conversations of the bilingual participants involved in the study. Both complexity matching and lexical matching as tools to investigate speech convergence can reflect on some principles in relation to social interaction as well as some shared processes of bilingual language interaction including shared-syntax account.

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Appendix A: Pre-Experiment Language History and Demographic Information Questionnaire

1. Student ID:

2. Gender:

3. Age:

4. Do you have any hearing problems? If yes, what are they?

5. What is your native country/ies?

6. What is your native language(s)?

7. What language is spoken in your household?

8. At what age(s) did you start to learn each language, and for how many years?

9. What would you consider to be your primary second language?

10. What language are you most comfortable using on a daily basis?

11. On a scale of one to ten, with ten being the highest level of confidence, please mark your proficiency in the following areas:

a. English reading

1 2 3 4 5 6 7 8 9 10

b. English spelling

1 2 3 4 5 6 7 8 9 10

c. English writing

1 2 3 4 5 6 7 8 9 10

d. English speaking

1 2 3 4 5 6 7 8 9 10

e. English speech comprehension

1 2 3 4 5 6 7 8 9 10

12. On a scale of one to ten, with ten being the highest level of confidence, please mark your proficiency in the following areas:

a. Persian reading

1 2 3 4 5 6 7 8 9 10

b. Persian spelling

1 2 3 4 5 6 7 8 9 10

c. Persian writing

1 2 3 4 5 6 7 8 9 10

d. Persian speaking

1 2 3 4 5 6 7 8 9 10

e. Persian speech comprehension

1 2 3 4 5 6 7 8 9 10

13. Estimate, in terms of percentages, how often you use your dominant language and other languages per week (in all weekly activities combined, circle which range best applies):

Dominant language:

0% 0–25% 50–75% 75–100%

Second language:

0% 0–25% 50–75% 75–100%

Appendix B: Post-Experiment Participant Experience Questionnaire

1. Have you ever met your partner before today? If so, are you just acquaintances, or friends?

2. On a scale of 1 to 5, how easy was the conversation in which you both spoken English, with 5 being the easiest?

1 2 3 4 5

3. On a scale of 1 to 5, how easy was the conversation in which you both spoke Persian, with 5 being the easiest?

1 2 3 4 5

4. On a scale of 1 to 5, how easy was the conversation in which you spoke two different languages, with 5 being the easiest?

1 2 3 4 5