Are You More 'In Sync' With Another Person When Extraverted?

Master Thesis – Developmental Psychology

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Abstract

Objective: Speech synchronization in dyadic conversations was investigated and its potential relationships with the personality trait Extraversion and post-interaction outcomes.

Method: 112 undergraduate students filled in self-reports on personality traits before the dyadic interactions (International Personality Inventory Pool, IPIP-NEO-120, Johnson, 2014). Afterwards, participants had a conversation of 15 minutes in same-gender dyads that were composed of both individuals scoring High in Extraversion (E+) or Low in Extraversion (E-). Furthermore, the participants filled in other self-reports after the conversation on: Affect (International Positive and Negative Affect Schedule Short Form I-PANAS-S, Thompson, 2007), Perception of the Interaction (adaptation from Cuperman & Ickes, 2009) and Interpersonal Closeness (Aaron et al., 1992). The self-disclosure paradigm was used during the conversations (adaptation from Aaron et al., 1997). Audio Streams of speech were used to extract speech and silence segments. Windowed and lagged cross-correlation (WLCC), Linear Mixed-Effects Models (LMM) and Generalized Linear Models (GLM) were used to process these segments and to test for the post-interaction outcomes.

Results: Extraverted dyads exhibited stronger speech synchronization in an Argumentative conversation; similarity in personality was connected to stronger speech synchronization, and extraverted individuals and speech synchronization predicted the perceived enjoyment of the dyadic interactions.

Keywords: Speech synchronization, dyadic interaction, Extraversion, post-interaction outcomes, windowed and lagged cross-correlation, linear mixed-effects model

Are You More 'In Sync' With Another Person When Extraverted?

As human beings, we daily encounter social interactions. These interactions are complex and dynamic processes due to the great extent of variations of behavior within and between people (Wang & Hamilton, 2012). Interpersonal synchronization has developed as a research area trying to explore and understand the underlying processes in such social interactions (Ayache et al., 2021). In this study, the aim is to gain insights into the effects of the personality trait Extraversion on interpersonal synchronization of speech and post-interaction outcomes, specifically perceived enjoyment and affect valence, between young adults in conversational settings, since most research in this field has primarily focused on the nonverbal aspects of synchronization.

Definitions of Interpersonal Synchronization

The classical definition of interpersonal synchronization refers to patterned and synchronized behaviors in social interactions that may be similar or occur (nearly) simultaneously (Bernieri & Rosenthal, 1991). As this research area grows, discrepancies arise in defining the term '*synchronization*' to be employed henceforth. On one hand, interpersonal synchronization may manifest as *'mimicry',* observed in actions like scratching the head (Bernieri & Rosenthal,1991). On the other hand, interpersonal synchronization can also refer to *interactional synchronization* (Bernieri & Rosenthal,1991), characterized as temporal alignment, encompassing synchronized patterns in speech, gestures, and even physiological coupling, such as heart rate (Ayache et al., 2021).

For the purpose of this study, the term 'synchronization' will be used, conform to the classical definition of 'interpersonal synchronization'. This definition conceptualizes it as a social phenomenon involving the interaction of two or more individuals (Bernieri et al., 1988; Schmidt and Richardson, 2008), occurring specifically during simultaneous face-to-face interactions (Bernieri and Rosenthal,1991). Moreover, it is characterized by rapid and

spontaneous emergence (Davis, 2016), primarily comprised of unconscious actions. While previous findings on interpersonal synchronization provide valuable insights, the persistence of ambiguity regarding the various interpretations of 'synchronization', or 'coordination' can be attributed to several factors. One factor relates to the inclusion of a temporal dimension when assessing the extent of 'synchronization' in social interactions (Schoenherr et al., 2019). Firstly, synchronization is portrayed as perfectly simultaneous behavior and thus without a time lag. For instance, when during a conversation, both interaction partners (A and B) may synchronize their actions to the point where they simultaneously touch their elbows. Secondly, synchronized behavior may occur with a salient time lag. In this case, person B would, for example, touch their elbow 1 second later than person A. Thirdly, synchronization can also be understood as a process of convergence, where behavior gradually becomes more similar over time. Another factor involves the distinction between 'in-phase' and 'anti-phase' patterns (Haken et al., 1985), which describe the different manifestations of synchronization. In-phase refers to the simultaneous execution of similar movements, whereas anti-phase refers to alternating execution of similar movements (Ayache et al., 2021).

According to *dynamic system theories*, interpersonal synchronization emerges and relies on perceptual and contextual constraints between interacting individuals, explaining its occurrence (Ayache et al., 2021). This would imply that interpersonal synchronization occurs due to two biological systems. Conversely, *embodied cognition theories* stress that interpersonal synchronization is an expression of cognitive processes that arise from sensorimotor experiences (Ayache et al., 2021). These processes are the neuropsychological processes within a person, such as brain-body interactions like language or self-awareness. In line with the dynamic system theories, *enactive approaches* stress that actions are guided by perception which means that an individual or organism enacts on its sensorimotor capacities

to perceive the world (Corris, 2020). This suggests that each organism is coupled to its own environmental frame and has influence on it.

Interpersonal synchronization in the literature

In a study conducted by Bernieri and colleagues (1988) on mother-infant interactions, the occurrence of interpersonal synchronization was identified through the assessment of several factors. These included the degree of simultaneous movement between mother and child at specific time points, the similarity in the speed of their movements, and the 'smoothness' intertwining of their behavioral gestures. Independent judges were assigned the task of evaluating the level of synchronization observed in both genuine interactions and artificially constructed pseudo-interactions (video-clips). Moreover, de Graag et al. (2012) conducted a study to investigate the potential relationship between infants' sleeping patterns, which naturally increase in duration as a result of biological maturation, and the social dynamics between mothers and infants, specifically on mother-infant gaze synchronization. Gaze synchronization was defined as simultaneously looking at each other's head or looking away simultaneously (flexibility). The findings indicated that infants' sleep patterns (obtained from diaries of the infant's daily activities) played a role in predicting the temporal dynamics of gaze pattern shifts during mother-infant interactions (still-face procedure). As infants matured, the interaction exhibited increased flexibility, suggesting that infants' sleep patterns may serve as a predictive factor for the development of these interactions. Furthermore, it illustrates the occurrence of synchronization at an early stage in development (de Graag et al., 2012).

The overall occurrence of interpersonal synchronization has not only been detected in behavioral patterns between dyadic interactions, but also in brain activities. In fact, Cornejo et al. (2017) reviewed the main methods regarding interpersonal synchronization between individuals such as video analysis, motion tracking (e.g., markers attached to body parts),

psychophysiological (e.g., measuring synchronization in heart rate of dyads) and neurophysiological techniques (e.g. fMRI, EEG) and although there is a variety of methods at different levels of study, all cases showed the phenomenon of people synchronizing their movements and brain activities during face-to-face interactions. For example, Dumas et al. (2010) recorded dual-EEG activities in dyads during spontaneous nonverbal interactions involving simultaneous (no time lag), meaningless hand movements that indicated coordinated rhythm. The study provided evidence linking behavioral synchronization and turn-taking with the coupling of brain oscillations. Moreover, in another study by Kawasaki et al. (2013), similar brain activation regions, which are associated with working memory, were found in dyadic interactions during alternating and sequential pronunciation-speech tasks. As speech rhythms became synchronized, inter-brain synchronization was correspondingly enhanced which suggests that a working memory of the other person's speech rhythms may be a necessary factor for successful turn-taking between dyads (Kawasaki et al., 2013).

Furthermore, behavioral studies using motion-tracking and video analyses have provided evidence for a strong association between interpersonal synchronization and prosocial behaviors, including self-esteem, trust and empathy (Chartrand & Bargh, 1999; Wiltermuth & Heath, 2009) and other studies suggest that interpersonal synchronization may act as 'social glue' (Lakin et al., 2003), referring to the social connection or closeness people experience unconsciously when having an interaction. Moreover, the presence of a potential visuomotor pathway within the mirror neuron system was found by Hale et al. (2019) providing evidence that this pathway enables humans to mimic gestures and movements, typically exhibiting a time lag of approximately 350 milliseconds after the stimulus. Additionally, behavioral synchronization, particularly in terms of mimicry, may involve a longer time delay, ranging from two to ten seconds, suggesting the involvement of short-term memory in addition to the mirror neuron systems. This may be attributed to the necessity of

sufficient time to process and represent the observed behavior before it can be outwardly expressed (Hale et al., 2019; Kawasaki et al., 2013). Furthermore, a meta-analysis by Mogan et al. (2017) revealed that synchronization, which was defined as 'as the exact rhythmic matching of actions in time and in phase with another person', enhanced positive affect, however, not when behavioral movements and even vocalizations (e.g., singing/reading) were 'exact in phase'. This finding involves the idea of turn-taking rather than conceptualizing synchronization as exact matching in nonverbal and verbal interactions.

Taken together, these studies provide insight into the tendency individuals have to synchronize their behaviors, and what is intriguing is that these patterns can be observed not only through instrumental techniques but also by independent observers (Hale et al., 2019). Such observations provide valuable insights into interpersonal interactions, revealing the dynamic nature of interactions between individuals. Therefore, the more the occurrences and development of synchronized behaviors over time and the potential underlying mechanisms driving this synchronization are explored, the better we will understand whether existing theories on this subject can be verified or falsified.

Synchronization of Verbal and Nonverbal Language

The aspect of similarity in social interactions is important to consider, regarding the objective of this paper on Extraversion as a personality trait and the synchronization of speech. This is important, because similarities and differences in the way people talk or act towards each other can reflect the dynamics of social interaction. Indeed, Ireland et al. (2010) investigated the relatively new concept of *language matching style (LSM)* and its role in predicting outcomes for romantic relationships, including interest and long-term relationship stability. LSM refers to the extent to which individuals match each other's speaking or writing style during a conversation. The emphasis lies on function words such as pronouns and articles (e.g., he, on, an), and their use often happens quickly and unconsciously (Ireland et

al., 2010). Remarkably, they found a link between shared LSM in dyadic interactions and higher levels of verbal synchronization which may have facilitated the initiation and maintenance of the social relationships. Similar findings have been demonstrated by Doorn and colleagues (2020), but in the context of client-therapist relationships. Their findings revealed that clients tend to adapt their language style to the therapist, suggesting a possible influence of the therapist throughout the conversation. Consequently, LSM may contribute to the understanding of how interactions occur and develop, especially in therapeutic settings. LSM can converge during speech interactions which can foster mutual understanding and a deeper connection with others (Ireland et al., 2010). Further understanding of LSM may in time lead to the development of interventions in these contexts to optimize treatment and counseling.

Additionally, in another study by Reuzel et al. (2013) on synchronization and attunement of staff-client interactions, they found that speech rhythms in these relationships are coordinated. Staff and clients (who had an intellectual disability) had approximately 15-minute conversations that were videotaped. Synchrony was measured in percentage in terms of both simultaneous speech as well as turn-taking. For example, during a conversation, it was possible that 30% of the time, the staff and client were talking simultaneously or that there was a total silence 40% of the time. Their findings indicated that during the conversations, there was turn-taking, which refers to less talking across each other. They also found that clients experienced the conversations differently (e.g., how staff speaks to them) than staff members (e.g., giving the client time to speak) when independent clients and staff were asked to observe and rate the video interactions. Turn-taking in conversations may say something about the way a conversation takes its formation, referring to leader-follower relationships.

Another study by Reuzel et al. (2014), has been conducted to explore the possible association between dominance as a personality trait (e.g., the person who initiates and directs

the other person's actions) and synchronization in terms of turn-taking patterns in these staff-client interactions. Results showed that there was a link between synchronization in terms of turn-taking and verbal interaction patterns of dominance. These results are relevant because they give new perspectives on how staff-client interactions occur and develop and the role of synchronization in speech rhythms. These perspectives may give rise to innovations regarding collaborations and enhancement between staff and clients so that mutual understanding can be improved. This is necessary for providing proper and professional support.

Synchronization and Personality Traits

Since the trait of dominance has to do with the type of personality a person has, it motivates to investigate the potential impact of personality traits on speech synchronization during dyadic interactions. Additionally, an interesting review of how another person's personality can shape an event, provides valuable insights into the dynamics and characteristics of personality as an 'environment' (Asendorpf, 2017). This view highlights that both environment and personality are stable yet subject to change over time. From this perspective, interactions can be viewed as *transactions* involving unidirectional or bi-directional influences between two variables over time. If personality is considered as an environment, it implies that individuals often find themselves in environments where others possess similar traits and engage in similar behaviors (Asendorpf, 2017). For example, in a work setting, an employee's environment may consist of co-workers who share similar abilities and skills, and perspectives on work-related attitudes, values, and goals. This shared environment can play a role in shaping the dynamics of their interactions.

Applying this perspective to the context of speech synchronization in dyadic interactions suggests that dyads with similar personality traits who are performing within the same environment, may experience higher or lower levels of speech synchronization (in the broadest sense). This is because of the dynamic influence each person's personality exerts,

unconsciously, on the other throughout their interaction. A previous study by Cuperman and Ickes (2009) on personality and dyadic interactions demonstrated that Extraversion and Agreeableness shape interpersonal interactions more directly compared to the other Big Five personality traits such as Neuroticism, Conscientiousness, and Openness. Notably, their study revealed that similar dyads, characterized by shared traits such as Extraversion, exhibited a relatively good interaction compared to dissimilar dyads that can be characterized as one individual being extraverted and the other introverted.

The present study

The primary objective of this paper is to explore the effects of individual differences in personality traits, particularly Extraversion, on the interpersonal synchronization of speech within dyadic interactions during conversational settings. Personality involves the dynamics 'within' an individual and can be seen as intertwined with the person while synchronization of speech involves the dynamics 'between' individuals. Therefore, exploring the interactions between personality and speech synchronization opens up intriguing questions and possibilities for the understanding of the complex dynamics of human communication and mutual understanding.

The term 'synchronization' will be employed to conceptualize speech as a behavioral action characterized by 'turn-taking'. This perspective encompasses a temporal dimension (Schoenherr et al., 2019) and incorporates the 'anti-phase' patterns (Haken et al., 1985) wherein individuals alternate their behavior, with one speaking while the other one remains silent, or vice versa. Through the examination of temporal patterns in turn-taking behavior, occurrences of synchronization can be detected as the presence of repeated turn-taking patterns within specific timeframes.

Overall, the concept of synchronization goes beyond simultaneous behaviors and rather occurs in certain windows of time (Tschacher et al., 2018) which refers to the time-lag

as noted earlier. Researchers on nonverbal synchronization differ in defining maximum appropriate time-lags in which the levels vary from 2.5 seconds to 7 seconds (Scheidt et al., 2021). This paper builds on previous work of Arellano-Véliz et al. (2023) in which their aim was to find relationships between interpersonal synchronization and personality traits, specifically Agreeableness and Extraversion, the strength of synchronization, post-interaction outcomes, and dynamic organization in dyadic interactions. They employed a windowed and lagged cross-correlation (WLCC) approach to assess nonverbal synchronization over time in which they used a lag-value of 5 seconds and windows of 30 seconds. This method involves exploring short time-lags of two time-series (for each dyad one) to capture the dynamic interplay between these time-series. However, most of the measurements mentioned above are primarily based on the nonverbal aspects of synchronization, particularly movements. An important consideration lies in defining an appropriate time-lag, as it heavily depends on the specific type of synchronization dynamics being measured, is whether they pertain to physiological, cognitive, social, or perceptual processes (Scheidt et al., 2021). The temporal dynamics of synchronization can vary across these processes, making it difficult to assess and adapt the time-lag to suit each scenario accordingly (Scheidt et al., 2021). Gaining more insight into the temporal dynamics of interpersonal synchronization between dyads will not only advance our comprehension of developmental psychology but may also offer valuable insights applicable to clinical settings.

Hypotheses

The expectation is that dyads with both partners scoring high on Extraversion compared to dyads with both partners scoring low on Extraversion (more introverted), will engage more in synchronizing their speech (H1). Additionally, the aim is to investigate the role of personality similarities or dissimilarities in dyadic interactions and their potential influence on speech synchronization (H2). A study by Koppensteiner (2013) demonstrated

that similarity in personality traits was associated with movement synchronization of individuals. This observation raises the possibility that, from the viewpoint of personality as an environment (Asendorpf, 2017), similarities in personality between dyads may likewise indicate a likelihood of speech synchronization. Therefore, it is hypothesized that similarity in personality will indeed influence speech synchronization. Dyads with both individuals scoring high on Extraversion compared to dyads with a mix of individuals scoring high and low on Extraversion (henceforth, 'mixed dyads') are expected to exhibit more speech synchronization (H2a). Dyads with both individuals scoring low on Extraversion compared to mixed dyads are also expected to exhibit more speech synchronization (H2b). This effect could be attributed to the overall experience and perception one might have of the other person; unconsciously perceiving a sense of familiarity or similarity. Furthermore, the relationship between speech synchronization and post-interactions outcomes will be examined, such as the perception of the interactions (e.g., enjoyment of the interaction) and Affect valence (e.g. positive and negative affect). Based on previous findings, extraverted individuals, who generally enjoy social gatherings and interactions, are more likely to enjoy such activities, even in competitive settings (Urbig et al., 2021). Consequently, speech synchronization and post-interaction outcomes, specifically, perceived enjoyment and affect are expected to correlate positively (H3).

Method

Participants

124 undergraduate students or 62 same-gender dyads (aged 18– 33, mean = 20.54, *SD*= 2.74; 72 females, 28 males) had a 15-minute conversation. However, the complete and usable data resulted in 100 individuals (50 dyads), constituting the final sample. For 6 participants (3 dyads), there was missing data for the questionnaires on Affect valence and Perception of Enjoyment, and were only excluded from the data when testing for the third

hypothesis. In principle, the dyads were conformed by individuals who scored 0.5 SD below or above the sample mean in Extraversion and Agreeableness. Nevertheless, for this study, the focus was only on the trait Extraversion, and the trait scores were approached continuously without thresholds in order to perform the analyses (see section Data Analysis).

Approximately ten days before the dyadic interactions, participants first filled in online self-reports on personality traits (International Personality Inventory Pool, IPIP-NEO-120, Johnson, 2014) on the Qualtrics platform. This study was approved by the Ethical Committee for research with human participants of the Faculty of Behavioural and Social Sciences, University of Groningen, code PSY-1920-S-0525 (Arellano-Véliz et al., 2023).

Equipment

For the conversations, a digital camera, two microphones for speech recording, two Wii balance boards, and two Polar heart rate belts were used. For the present study, only the audio stream was analyzed.

Self-report Questionnaires and Protocols

Personality Traits

Personality traits were measured approximately ten days before the laboratory study was conducted. These traits were measured online using the International Personality Inventory Pool - 120 (IPIP-NEO-120; Johnson, 2014). This questionnaire consists of 120 personality items that measure the Big Five personality traits, namely: Extraversion, Neuroticism, Agreeableness, Conscientiousness, and Openness to Experience. The scales of the IPIP-NEO-120 were highly correlated (Extraversion 0.85; Neuroticism 0.87; Agreeableness 0.76; Conscientiousness 0.80; and Openness to Experience 0.84 (all $p < .01$); $N = 501$ (Johnson, 2014) with the NEO-PI-R scales (Costa & McCrae, 2008), referring to the consistency of the psychometric properties. The IPIP-NEO-120 showed a good internal

consistency (Cronbach's alpha of 0.84, 0.88, 0.81, 0.84 and 0.85, respectively), indicating reliable and valid scales.

Affect

Participants also filled in the International positive and negative affect schedule short form (I-PANAS-SF; Thompson, 2007) to measure their positive and negative affect before and after the interactions. The questionnaire consists of 10 emotion adjectives that are divided into positive (inspired, active, alert, attentive and determined) and negative (ashamed, upset, hostile, nervous and afraid) emotions on a scale ranging from 1 (very slightly) to 5 (extremely).

Perception of the interaction

Participants were asked to complete a modified questionnaire that was used by Cuperman and Ickes (2009), to examine the participants' perception of the interactions after the dyadic interactions took place. In this paper, only the degree of enjoyment participants experienced on a scale ranging from 1 ('not at all') to 5 ('very much') was used.

Interpersonal Closeness

The Self-Disclosure Paradigm (adaptation from Aaron et al., 1997) was used during the conversations. The main purpose of this paradigm is to create closeness in an experimental environment. The original protocol consists of three sets with each 12 questions which takes about 45 minutes. For this experiment, the protocol was modified into three sets of three questions which took about five minutes in which both participants of a dyad had to ask and answer the questions.

Procedure

Participants were invited to the laboratory, and all completed their informed consent. Before filling in their informed consent, participants received a heart rate transmitter belt. The participants were then asked to stand in a fixed position in front of each other on a balance

board with a distance of 1.5 m. The balance board was used to measure postural control. The participants were also instructed to fasten a microphone to their clothes and a camera was used to record the interactions at a distance of 4.5 m with a side-view of both participants. The main focus of this thesis is on the speech recordings (audio); therefore the results of the heart rate belt, camera and balance board are not a part of this thesis.

The semi-structured conversations consisted of three phases for which 5 minutes were given for each participant: 1) an introduction of oneself, 2) self-disclosure topics (for example: 'What would constitute a 'perfect' day for you?), and 3) an argument or debate. However, when the given 5 minutes had passed, participants were allowed to finish their conversation prior to starting a new phase. Example topics were given to the participants in case they needed guidance to initiate interactions. For the last phase, participants had to choose a topic in which they had to take on opposite sides of the arguments (pro or against). An example of a topic in this phase was: 'Are dating apps a good platform for meeting a romantic partner?'. After the interactions, participants filled in other self-reports: Affect (International Positive and Negative Affect Schedule Short Form I-PANAS-S, Thompson, 2007), Perception of the Interaction (adaptation from Cuperman & Ickes, 2009) and Interpersonal Closeness (Aaron et al., 1992). All the data streams were recorded by means of a Lab Streaming Layer software (Kothe et al., 2019). See procedure as reported in Arellano-Véliz et al. (2023).

Data Processing

To measure the synchronization of speech, speech and silence segments from speech signals (audio) of the conversations were extracted using Matlab, then the audio files were cleaned using Adobe Audition to remove excessive background noise, using first the noise print feature in which Adobe Audition automatically computed a proper 'noise print' for each audio file. After this, in the Effects option, the DeNoise feature was used in which Adobe

Audition automatically removed excessive background noise. Further, the software program Praat was used to label silence and speech segments for each participant creating a time series for both participants of each dyad in the form of: 1: speaking, 0: silence. The parameters employed were 0.3 seconds for the Long-term Window, 0.1 for the Short-term Window, 0.3 seconds for the Silence Interval, 0.0001 for the Speech Interval. These parameters, in principle, provided an accurate recognition of speech/silence occurrences. Furthermore, in order to perform the Windowed Lagged Cross-Correlations, a further step of the time series obtained, were conducted. Utterances (onset and offset of speech) were considered, for which the data was resampled by means of a silence threshold of 1 second, which was the minimum duration of a silence required between two consecutive speech segments to consider them as separate utterances. Likewise, utterances of 2 seconds of length were defined as a minimum, defined by a speech threshold. This procedure was conducted in order to prevent breaking the utterance segments as advised in other studies (Behrens et al., 2020). Due to microphone issues and differences in participants' voice volumes, the threshold was determined manually for each audio file resulting in an average of 34 decibels. In terms of synchronization, the amount of speech time and average duration of speech time for each participant was also measured.

Data Analysis

After, the Windowed Lagged Cross-Correlations (WLCC) was applied to the time series to explore the correlations of between the speech-and silence segments of each dyad during the conversations, obtaining a grand average, in order to operationalize nonverbal synchronization of speech by means of a single score per dyad. Subsequently, a linear mixed-effects model (LMM) was conducted to test the effects of Extraversion, as continuous variables, on speech synchronization, and three generalized linear models (GLM) were conducted (using the ‘stats’ R package, R Core Team, 2023) to test the effects of speech

synchronization * Extraversion on affect valence and perception of the interaction. To simplify the interpretation of the results, the scores on Extraversion were centered in order to have better convergence of predictors on scale-level.

Windowed Lagged Cross-correlation (WLCC)

Windowed lagged cross-correlation (WLCC) analysis provides insights into the dynamic changes in synchronization (Behrens et al., 2020). Classical cross-correlation estimates the association between events occurring in two time series (Boker et al., 2002). The WLCC adds to this classical estimation in two ways, namely the windows and lags that can be seen as an elaboration on the classical method. Signals of a time series are broken down into smaller 'windows' for which correlation coefficients are calculated for each of these windows. For example, for every 40 seconds over a 15-minute conversation, a correlation coefficient is calculated between two time series. Along with a chosen window, lag-values can be chosen which demonstrate the difference in pace of an individual's reaction to another individual. For example, individual 1 speaks while individual 2 remains silent and after a few seconds individual 1 becomes silent, individual 2 may have a delay before initiating speech. From these correlations, a grand average occurs which is the maximum correlation across different lags for different windows. This grand average correlation coefficient can be considered as the operationalization of synchronization. Based on this method, it is possible for a pattern to occur for a specific window value and a specific lag-value, referring to a temporal aspect in dyadic interactions and the synchronization between them.

After obtaining the speech and silence fragments of the 15-minute conversation between dyads, a time series for both individuals was created. WLCC was applied for the time series with a window value of 30 seconds and a lag-value of 5 seconds. This suggests that over every 30 seconds of the conversation, correlations between both time series were

calculated, with lags of 5 seconds referring to the time delay between the speech segments of both individuals.

Linear Mixed-Effects Model (LMM)

A maximum likelihood LMM (using the lme4 R package; Bates et al., 2015) could demonstrate a potential relationship between independent variables and a response variable. The models have two levels, where the observations per task (Level-1) are nested within the dyadic structure (Level-2). Within LMM, fixed factors and random factors are used, where fixed factors are independent variables with multiple levels that are used in the model and typically do not change, for example 'gender' which has two fixed values: male and female (Magezi, 2015). However, random factors only include a sample of all levels referring to variables that can change in the population, for example high school math class, which is a sample of one or a few schools but that has no fixed values and for which students will change each year (Starkweather, 2010). Speech Synchronization (grand average WLCC) was the response variable and the model included fixed effects of Extraversion (Extraversion A * Extraversion B) and the type of interaction, respectively, Introduction, Self-disclosure, and Argumentative for which the Introduction was used as a baseline. The model included a random intercept at dyadic level.

Results

The mean score of the participants (N = 100) on Extraversion was approximately 77 (M = 77.45, SD = 16.08). The total duration of speech during the conversations was approximately 8 minutes on average ($M_{seconds}$ = 499.67, SD = 129.87, N = 100) and the total duration of time for which participants were silent during the conversations was approximately 10 minutes on average ($M_{seconds}$ = 583.66, SD = 135.34, N = 100).

A Linear Mixed-Effects Model (LMM) was conducted to estimate the association between the personality trait Extraversion and speech synchronization. The model's fixed

effects accounted for approximately 12% of the variance (marginal $R^2 = 0.116$), which is relatively a medium effect of explained variance (Cohen, 1988). However, the fixed and random effects accounted for 69% of the variance (conditional $R^2 = 0.690$). This suggests a relatively high effect of explained variance by the model (Cohen, 1988). At the dyadic level, there was a random intercept ($SD = 0.112$). Furthermore, at the baseline interaction type, Introduction, the model showed a significant (Table 1), mean score (intercept) for speech synchronization ($\beta = - 0.121$, $SE = 0.012$, $p = < .001$). This indicates the presence of speech synchronization. Furthermore, a main effect was found for interaction type 3, Argumentative and speech synchronization ($\beta = - 0.033$, $SE = 0.017$, $p = < .048$) which demonstrates that this type of interaction likely promotes speech synchronization. First, it was expected that dyads with both individuals scoring high on Extraversion, compared to dyads that scored low on Extraversion, would engage more in synchronizing their speech (H1). Significant interaction effects were found between the Extraversion score of both participants individually and speech synchronization, specifically during the Argumentative task ($\beta_A = - 0.040$, $SE_A = 0.017$, $p_A = < .021$; $\beta_B = - 0.039$, $SE_B = 0.018$, $p_B = < .030$) and between the Extraversion score of both participants together and speech synchronization during the Argumentative task ($\beta = - 0.039$, $SE = 0.018$, $p = < .036$). These results suggest that during the Argumentative task, dyads with higher scores on Extraversion engaged more in speech synchronization, compared to dyads with lower scores on Extraversion. The higher the score on Extraversion for both participants, the stronger speech synchronization was between dyads in terms of the magnitude of value (β).

The results exhibit a negative value for speech synchronization which refers to turn-taking behavior. For example, when Participant A was speaking, Participant B remained silent, but when Participant A stopped speaking, after a delay of 5 seconds, participant B started to speak.

Table 1

Linear mixed model (LMM) with Extraversion and Type of Interaction as fixed effects and Speech synchrony as the dependent variable

Predictors	*Estimate* (β)	*SE*	CI (95%)	*p*
Intercept	-0.121	0.020	-0.16 – -0.08	< 0.001*
E_A	-0.014	0.021	-0.05 – 0.03	0.502
E_B	0.024	0.021	-0.02 – 0.07	0.252
Type 2	0.006	0.017	-0.03 – 0.04	0.737
Type 3	-0.033	0.017	-0.07 – -0.00	0.048*
E_A x E_B	0.011	0.022	-0.03 – 0.05	0.624
E_A x Type 2	-0.014	0.017	-0.05 – 0.02	0.438
E_A x Type 3	-0.040	0.017	-0.07 – -0.01	0.021*
E_B x Type 2	-0.010	0.018	-0.04 – 0.03	0.578
E_B x Type 3	-0.039	0.018	-0.07 – -0.00	0.030*
E_A x E_B x Type 2	0.011	0.018	-0.03 – 0.05	0.557
E_A * E_B * Type 3	-0.039	0.018	-0.07 – -0.00	0.036*

Note. $N = 100$; *SE* = Standard Error; CI = 95% confidence interval; *p* = correlation is significant at 0.05 level*; E_A = Extraversion score of participant A; E_B = Extraversion score of participant B; Type 2 = Self-disclosure as interaction type; Type 3= Argumentative as interaction type.

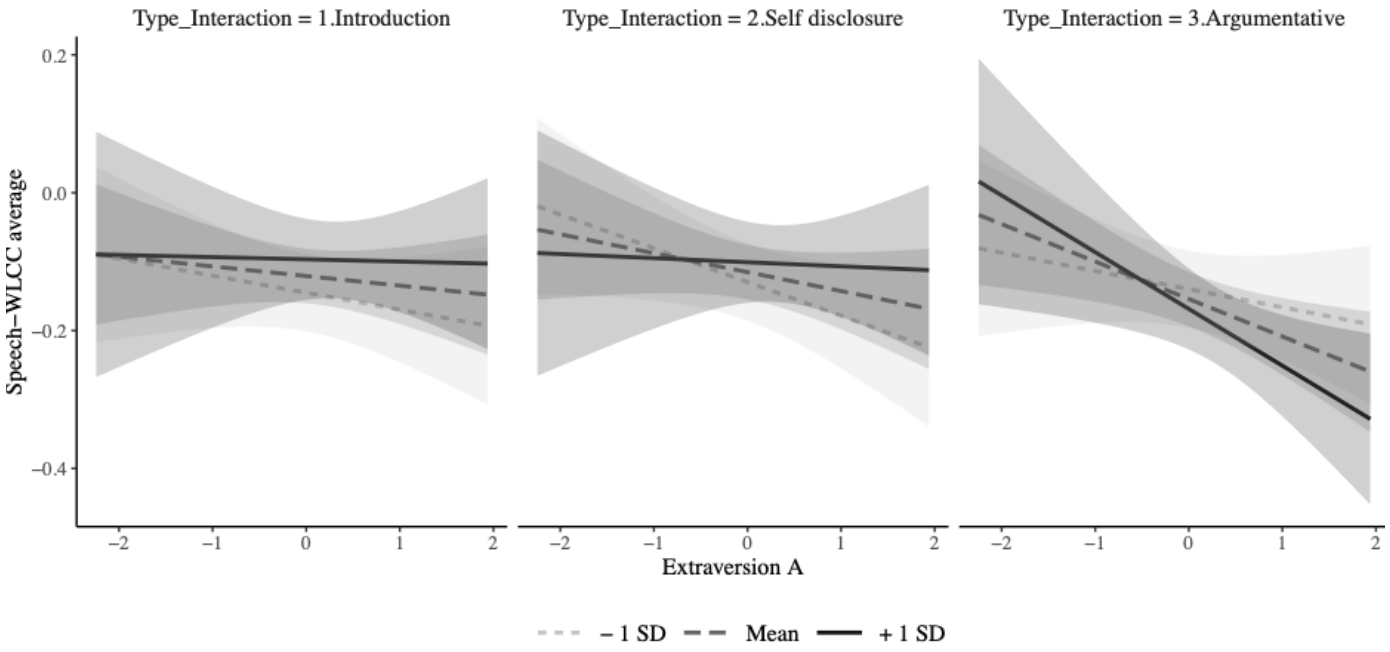
This scenario indicates turn-taking behavior and when this pattern repeats itself within windows of 30 seconds over the whole conversation and with delays of 5 seconds, it is referred to as synchronized patterns, since the individuals are taking turns in conversation within specific timeframes. On the other hand, a positive synchronization value would refer to simultaneous speech (crosstalk) or simultaneous silences for both participants. For example:

participant A starts speaking and participant B remains silent, and then participant A stops speaking, allowing for a delay of 5 seconds, consecutively, participant B remains silent. This indicates both participants being silent simultaneously within specific timeframes. In this case, simultaneous behavior would rather occur than turn-taking behavior.

Second, the expectation was that similarity in personality will indeed influence speech synchronization, namely, greater speech synchronization for dyads scoring high on Extraversion, compared to the mixed dyads (H2a) and for dyads scoring low on Extraversion compared to mixed dyads (H2b). The results demonstrated lower synchronization strength for the mixed dyads that were composed of individuals scoring high and low on Extraversion, compared to both individuals scoring high on Extraversion during the Argumentative task (Figure 1).

Figure 1

Effects of Extraversion on Speech-WLCC by Task



Note. The interaction lines represent the Extraversion score of participant B.

However, the results did not demonstrate lower synchronization strength (a more positive value) for the mixed dyads compared to both individuals scoring low on Extraversion (Figure 1).

Lower synchronization strength refers to a less negative speech synchronization value that indicates less turn-taking behavior. This does not necessarily imply that simultaneous behavior occurred, since the speech synchronization values remained negative. Based on these results, less speech synchronization, and therefore less turn-taking was found for mixed dyads. There was a slight difference in results between the mixed dyads exhibiting somewhat more turn-taking behavior compared to dyads scoring high on Extraversion.

Third, it was hypothesized whether perceived enjoyment and affect valence are linked to speech synchronization in post-interactions between dyads. A paired samples T-test was performed (Table 2) to see whether there was a significant difference in affect states before and after the conversations. The results indicated that there was a significant average difference between the positive affect pre-scores ($M = 14.62$, $SD = 3.96$, $N = 94$) and the positive affect post-scores ($M = 15.83$, $SD = 3.99$, $N = 94$); $t(93) = 4.84$, $p = < .001$, and between the negative affect pre-scores ($M = 8.23$, $SD = 3.29$, $N = 94$) and the negative affect post-scores ($M = 6.39$, $SD = 2.53$, $N = 94$); $t(93) = -8.07$, $p = < .001$.

These results imply that there was a significant increase ($M_{difference} = 1.21$, [0.72, 1.71], SD = 2.43) in the positive affect scores which suggests that participants may have experienced a higher level of positive emotions after the conversations took place. Moreover, there was also a significant decrease ($M_{difference} = -1.84$, [- 2.29, -1.39], $SD = 2.21$) in the negative affect scores which suggests that, overall, participants may have experienced fewer negative emotions after the conversations compared to their emotional states prior to the conversations. The effect size was d = 0.50 (Cohen, 1988), a medium effect size, for the

average difference between the positive affect scores and the effect size was d = - 0.83, which is considered as a large effect (Cohen, 1988) between the negative effect scores.

Table 2

Average Differences between the Positive and Negative Affect Pre- and Post- scores on the PANAS-questionnaire

			CI (95%)				
	M	*SD*	Lower	Upper	*t*	df	*p*
Positive Affect – Post Positive Affect – Pre	1.213	2.431	0.72	1.71	4.836	93	< 0.001*
Negative Affect – Post Negative Affect – Pre	-1.840	2.211	- 2.29	- 1.39	- 8.071	93	< 0.001*

Note. $N = 94$; M = mean difference in scores; SD = Standard Deviation; CI = 95% confidence interval; * indicates significance at $p < .05$.

Three Generalized Linear Models (GLM) were then applied to assess a possible link between the effects of speech synchronization combined with Extraversion, perceived enjoyment, Positive Affect and Negative Affect (Table 3). The mean score on Perceived Enjoyment was $M = 3.84$ ($SD = 0.69$), which indicates between the third and fourth level on a scale of 1 to 5 for the degree of perceived enjoyment after the interactions. This refers to responses: 3, ‘to some extent’ and 4, ‘rather much’. The fixed effects of the first model (Perceived Enjoyment) explained approximately 18% of variance ($R^2 = 0.178$), indicating a medium effect (Cohen, 1988). Furthermore, the model showed a significant intercept for Perceived Enjoyment ($\beta = 4.783$, $SE = 0.569$, $p = < .001$) and there was a main effect of Speech Synchronization on Perceived Enjoyment ($\beta = 10.839$, $SE = 2.949$, $p = < .001$) which

indicates that speech synchronization played a role in the way participants perceived enjoyment during the conversations. Additionally, no significant effect on Perceived Enjoyment was found for Extraversion. However, there was a significant interaction effect for Speech synchronization * Extraversion in Perceived Enjoyment (β = -0.124, SE = 0.040, p = < .001). Since the coefficients for speech synchronization were negative values, indicating turn-taking (exclusively in the Argumentative interaction-type), an increase in one unit of the predictor (Speech synchronization * Extraversion) may result in a more positive value of this predictor. This perspective suggests that the increase of the predictor unit leads to a decrease in Perceived Enjoyment. However, when considering the nature of the negative speech synchronization coefficients, these results can be interpreted as; the more speech synchronization took place within the conversations during the Argumentative interaction-type, the more 'enjoyable' the conversations were perceived by the participants.

The second model (Positive Affect-Post) revealed an explained variance of 18% for the fixed effects (R^2 = 0.180) which is a medium effect (Cohen, 1988). There was a significant intercept for Positive Affect (β = 13.868, SE = 3.281, p = < .001). Additionally, a main effect was found for Speech Synchronization on Positive Affect (β = 33.534, SE = 16.992, p = .048), revealing that an increase in the predictor unit of Speech Synchronization leads to an increase in Perceived Enjoyment. However, when Speech Synchronization was combined with Extraversion, no significant interaction effect was found predicting (an increase in) Positive Affect.

The third model's (Negative Affect - Post) fixed effects explained 6.7% of the explained variance (R^2 = 0.067) in the model which is considered a small effect (Cohen, 1988). A significant intercept was found (β =6.351, SE = 2.219, p = .004).

Table 3

Three Generalized Linear Models (GLM) with Perceived Enjoyment and Positive-and Negative Affect post-scores as dependent variables and Speech Synchronization and Extraversion as fixed effects

Predictors	1. Perceived Enjoyment				2. Positive Affect- Post				3. Negative Affect – Post			
	Estimates (β)	*SE*	CI (95%)	*p*	*Estimates* (β)	*SE*	CI (95%)	*p*	*Estimates* (β)	*SE*	CI (95%)	*p*
(Intercept)	4.783	0.569	3.67 – 5.90	<0.001*	13.868	3.281	7.44 – 20.30	<0.001*	6.351	2.219	2.00– 10.70	0.004*
Speech - WLCC	10.839	2.949	5.06 – 16.62	<0.001*	33.534	16.992	0.23 – 66.84	0.048*	- 16.562	11.492	- 39.09– 5.96	0.150
E_all	- 0.011	0.007	- 0.02 – 0.003	0.136	0.032	0.041	- 0.05 – 0.11	0.425	- 0.003	0.027	- 0.06 – 0.05	0.925
Speech - WLCC * E_all	- 0.124	0.04	- 0.19– -0.06	<0.001*	- 0.368	0.200	- 0.76 – 0.02	0.065	0.185	0.135	- 0.08 – 0.45	0.171

Note. $N = 94$; Speech – WLCC = Speech Synchronization; E_all = Extraversion scores of all individuals; *SE* = Standard Error; CI = 95% confidence interval.

However, Speech Synchronization exclusively, and Speech Synchronization * Extraversion, did not predict (a decrease in) negative Affect post-interactions, although the paired samples t-test showed a significant difference between the pre- and post-scores. Overall, these models partially showed a relationship between the post-interaction outcomes, specifically for Perceived Enjoyment and Speech Synchronization * Extraversion, but did not show a possible relationship in terms of predictability, between Speech Synchronization * Extraversion and Positive- or Negative Affect post-conversation scores (H3).

Discussion

The aim of this paper was to investigate the effects of the personality trait Extraversion on speech synchronization within dyadic conversations. The findings, firstly demonstrate the occurrence of speech synchronization during dyadic interactions at baseline level, which was when participants had to introduce themselves. Secondly, another key observation was that similarities and dissimilarities of Extraversion as a personality trait predicted the strength of speech synchronization. However, this was only found when participants had to debate about a chosen topic and use opposite arguments (Argumentative task) and was not found for the other interaction types. Dyads that scored higher on Extraversion, compared to dyads that scored relatively low, exhibited stronger synchronization in speech, in terms of turn-taking.

A possible explanation may be the characteristics such as the structure of the conversation. For example, one person starts with their statement and after that, they explain why they chose that statement. Another example is the clear role of the participants (pro or against) in this type of interaction which promotes turn-taking, because participants expect the other person to likewise make their statement and argue about it. This finding is relevant, since it adds to recent findings that have shown this predictive effect of Extraversion on nonverbal synchronization based on body motion, during the Self-disclosure task and the Argumentative task (Arellano-Véliz et al., 2023).

Moreover, the present study demonstrates that similarity in personality contributes to stronger synchronization of speech. This is also consistent with the findings which implied that similarity in personality traits promotes interpersonal, and nonverbal synchronization (Cuperman & Ickes, 2009; Asendorpf, 2017; Koppensteiner 2013). By analyzing speech and silences which refer to verbal communication, additional information is obtained about turn-taking patterns that involve nonverbal acts. These findings broaden our knowledge in the field

of the effects on personality traits in interpersonal synchronization and give new perspectives on interpersonal interactions.

Additionally, the findings first indicated a link between speech synchronization and perceived enjoyment, but since Speech Synchronization and Extraversion are in reality dependent factors because both are found 'within' individuals, it is difficult to conclude with certainty that merely speech synchronization can predict perceived enjoyment of individuals in conversational interactions. However, the present study also found this link between speech synchronization interacting with Extraversion as a personality trait, and perceived enjoyment. That is, when more turn-taking took place, the conversations were more perceived as enjoyable which is in line with previous research (Urbig et al., 2021) suggesting that extraverted individuals enjoy social gatherings and interactions and even in competitive settings. The latter may in this case refer to the Argumentative nature of the interaction-type which may have been seen as 'competitive' by individuals, since the task is to persuade one another that their opinion or view on a topic is correct. The involvement and role of speech synchronization combined with Extraversion adds value to these findings regarding enjoyment.

Although the paired samples t-test demonstrated differences between the pre-and post-Affect scores, that is, an increase in Positive Affect and a decrease in Negative Affect, no relationship was found between speech synchronization together with Extraversion and Affect. This is inconsistent with findings suggesting that synchronized behavior is linked to positive affect (Mogan et al., 2017) or that synchronized behaviors in terms of mimicry and imitation even promote positive affect (Tschacher et al., 2014). This inconsistency lies plausibly in the fact that the present study has implemented verbal features of communication (e.g., speech segments) to explore synchronization and affect, while previous studies have mostly focused on nonverbal aspects of synchronization (e.g., body movements) and affect.

Another possibility may be the differences in the conceptualization of ‘speech synchronization’ in terms of singing or reading compared to synchronization in spontaneous conversations.

Previous research has mainly focused on and found evidence about the nonverbal manifestation of synchronization. There is little research regarding the influence of personality traits in this conceptualization due to previous conceptual differences on the Big Five dimensions (Cuperman & Ickes, 2009). This paper, however, addresses not only the verbal manifestation of synchronization between dyads, but also addresses a personality trait. A question that is important to answer is: Why is it important to gain knowledge about synchronization? Synchronization involves people interacting with each other, which most people often do. Previous research provides multiple predictions and explanations for the underlying purpose of why people tend to synchronize behaviors, such as an increase in cooperation when motor activities are synchronized (Wiltermuth & Heath 2009) or that synchronization may show interest or a feeling of proximity to the other person (Ireland et al., 2010). Gaining knowledge about the relationship between personality and synchronization provides a relatively new framework in this research field, and personality is found within each human being and therefore nearly inevitable. This knowledge may, for example, lead to future possibilities for clinical applications, enabling, for instance, a therapist to make a better estimation and gains a better understanding of the client as ‘a person’ and consequently is able to provide better care.

Although this study provides new insights, there are limitations that should be considered. First, the audio stream in the present study exhibited much noise making it necessary to eliminate as accurately as possible to obtain ‘clean’ speech segments. However, the applied definition for synchronization was ‘turn-taking’ which might have been addressed better with Cross Recurrence Quantification Analysis (CRQA), because of its strength in

working with noisy signals and allows to analyze synchronization and speech rhythms from the temporal pattern in the timeseries (Reuzel et al., 2014). Additionally, CRQA is a 'nonlinear' method that allows a researcher to avoid assumptions linear statistics make, in this case also the Linear mixed effects model (LMM) and the generalized linear models (GLM) (Coco & Dale, 2014). Second, the results demonstrated only the emergence of synchronization in the Argumentative interaction task which can also be attributed to the structure of the interaction type that may have contributed as a moderator in the conversations. The question is whether the same results would be obtained when a similar structure (pro or against a statement) was incorporated for the Self-Disclosure task, for example. Third, the research was conducted in an experimental setting which may have influenced the interactions between dyads in terms of a less natural environment that may have prohibited (stronger) synchronization. Future research could experiment with different, more natural contexts for dyadic interactions to see the manifestation of synchronization. Fourth, the modest sample size may have given an overestimation of the results. Therefore, future research with larger samples is necessary for more accuracy. Additionally, the participants were all students between the ages of 18-33, and most participants were females, therefore the results may not generalize well to people of different ages or to males.

Conclusion

This study has focused on differences in the personality trait of Extraversion and speech synchronization in terms of turn-taking. Key observations were that extraverted dyads exhibited stronger speech synchronization in an argumentative conversation; similarity in personality was associated with stronger speech synchronization, and that extraverted individuals and speech synchronization predicted the perceived enjoyment of the dyadic interactions.

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