The Need for Dyadic Data Analysis as an Emerging Method to Explore Emotional Factors

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Abstract

Dyadic Data Analysis (DDA) has been suggested, in the existing literature, to be used to explore interpersonal variables which have long been conventionally investigated in isolation. DDA is effective in analyzing procedures that go on among dyads in studies of family relations, partnership, teacher-student affairs, and many other interpersonal relationships. Illustrative examples come from psychological, behavioral, and sociological studies that help develop the researcher's ability to investigate relationship processes, model and test for the effects of actors, partners, and relationships, and control for the statistical inter-dependence which can be conceived between partners. The present paper first reviews the distinctive features of DDA and the potential advantages it can have for language studies. Also, it shows how longitudinal DDA is strongly needed in the investigation of L2 affective variables in the Second Language Acquisition (SLA) domain to longitudinally explore the dynamic and developmental nature of language learners' affective factors. Finally, it goes on with making suggestions for a future line of inquiry using this innovative analytic procedure and ends with several conclusive remarks about this analytical framework which is compatible with the complexity of dynamic systems theory (CDST).

Keywords: **e**motional variables, interpersonal variables, complexity dynamic systems theory (CDST), dyadic data analysis (DDA), second language acquisition (SLA)

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1. Introduction

A foreign or second language (L2) classroom hosts the interactive development of many cognitive, affective, and behavioral variables. In every single session of L2 classes, the teacher and learners, as well as learners with peers, participate in a variety of interactive activities and tasks ranging from person-to-person interactions to more extended interactions, like those between the teacher and the entire class (Derakhshan, Karimpour, et al., 2023; Shakki, 2022). Given the nature of the dyadic teacher-student or student-student interactions within the environment of an L2 classroom, suitable innovative approaches to explore these dyadic interactions are needed more than before. Rooted in general psychology, dyadic data analysis (DDA) seeks to explore how related individuals (referred to as *dyad*s) are similar to each other or distinctive in terms of a certain cognitive, affective or behavioral trait (Planalp et al., 2017). The members of a dyad can be either exchangeable or non-exchangeable (Whittaker et al., 2014). The former refers to those who may not be identified by specific characteristics (e.g., student and student as peers) while the latter refers to those who can be recognized by specific characteristics (e.g., teacher and student) (Kenny et al., 2006). These are also referred to as distinguishable versus non-distinguishable dyads (Bolger & Laurenceau, 2013).

Analyzing dyadic data from distinguishable or non-distinguishable dyads involves different procedures of analysis (see Kashy et al., 2008; Olsen & Kenny, 2006). For a DDA, the data will be collected from dyads either cross-sectionally or longitudinally. More details will follow in the procedural section below. Collecting and analyzing data from dyads through time can be a challenge to applied researchers including applied linguists. Different modes of dyadic data analysis (e.g., MLM and SEM for cross-sectional DDA and dyadic curve of factors model for longitudinal DDA; Planalp et al., 2017) make it possible to analyze the data obtained from each type of dyad in an educational or non-educational setting (Whittaker et al., 2014).

The increasing interest in the dyadic line of inquiry is because it helps researchers make conclusions about how individuals behave and experience in social interactions by analyzing the data gathered from both members of a dyad simultaneously. Studies of dyadic affairs typically aim to assess the effect of the length of a relationship on the expected outcomes, for example, one's satisfaction with the relationship (e.g., Does the teacher-student satisfaction rise through the passage of time of a whole course?), or agreement between the self and the other

(the partner) (e.g., Does the teacher have a more accurate evaluation of the student when the time allows for more acquaintance?) (Brauer et al., 2022). The purpose of this review study is to highlight the significance of DDA as an emerging method in the field of applied linguistics for the exploration of emotional variables.

2. Literature Review

2.1. DDA Statistical Procedure

The most prevalent statistical procedures used for the analysis of dyadic data rely on path analysis (Boker & McArdle, 2005), multilevel modeling (Hox et al., 2010) or SEM (Bollen, 1989). In order to test the relationships among observed variables, the path analysis is preferred. The relationships might be modeled as regression paths, in which one variable anticipates another, or as covariances, in which covariance is assumed between both variables. Path analysis is extended to SEM to integrate latent variables. For instance, a latent variable that reflects a concealed ability construct can represent the common variance of several cognitive tests. SEMs are comprised of measurement and structural components, with the former referring to the latent variable modeling on the basis of the observed variables, and the latter referring to the between-construct relationships. In the case of clustered data, an extension of regression analysis is used, which is called multilevel modeling. For instance, these can include students clustered in classes or institutions or people clustered as regional groups. Individuals, in dyadic data, are clustered in dyads. As for the longitudinal dyadic data, the points of time are clustered within individuals, and individuals are clustered as dyads.

Throughout the procedure of a standard dyadic research design, the data are provided by each individual within the dyad. Moreover, the dyads have the characteristic of interdependence; thus, the observations are non-independent (Kenny et al., 2006). Accordingly, the error variances and test scores of the members of the dyad are correlated with each other. Also, a wide range of different variables can diverge within or between dyads as well as their members (Kenny et al., 2006; Brauer & Proyer, 2020). The first point to note is that the variables within a dyad capture the distinctions between dyad members. Yet, for all dyads they are, on average, the same. The second point is that, for dyad members, the between-dyad variables are stable. Yet, they differ from one dyad to another. For instance, every dyad can have a certain extent of similarity that is reflected in a

profile correlation coefficient and applies to any dyad, yet diverges across dyads. The third point is that the variation within and between dyads is described by the mixed variables. For instance, within a dyad, the personality questionnaire scores can differ.

If researchers show interest in assessing questions of change, stability, or the effects of the length of the relationship, the design of the study and the approach to data analysis should be taken into account. Initially, the design of the study can be generally differentiated as either longitudinal or cross-sectional. The analytic approach depends on the design of the study and the available data. There are reasons for preferring longitudinal data for the exploration of learner-related variables. Cross-sectional data solely involves a comparison between dyads, whereas longitudinal data provide comparisons of both inside and between dyads (i.e., utilizing the data from the same individuals across time). Longitudinal data enable for testing influences at a mixed-variable level and represent variability in individuals' scores throughout time within and between dyads. The further advantage of using longitudinal data is that they allow testing the effects of time on the within-individual scale. Thus, the points of data that were gathered at least two times are correlated. It helps estimate variance at the within-individual level through the passage of time. There is a need for data collected on several occasions to answer research questions about the trajectories of different learner-related variables (cognitive, affective, behavioral, etc.) through time. Assessing the within-person correlation of the same individual in the same factor makes it possible to infer the growth of the learner-related variable of interest throughout the study over time.

It is noteworthy that SLA studies usually explore significantly more complicated research questions about the length of teacher-student or student-student relationships; for instance, how dyadic indices like self-other agreement or partner similarity relate to the length of the relationship. Moreover, mind that temporal variation may not just be within- or between individuals. Rather, they can also differ across dyads, which is indicative of the distinct change and stability trajectories (Curran & Bauer, 2011; Lee et al., 2021). Longitudinal designs help evaluate the variance components required for modeling the target effects between and within the dyad members as well as between and within the dyads through time (e.g., Gistelinck & Loeys, 2019; Heck & Thomas, 2009).

2.2. The Need for Longitudinal Analyses of L2 Affective Variables

Previous SLA research, shaped mostly by the theory of complex dynamic systems (CDST), has highlighted the need of mapping the dynamic nature of many emotive variables such as anxiety, boredom, and enjoyment that can be incorporated into the L2 learning process (Dewaele, et al, 2022; Dewaele & MacIntyre, 2019; Elahi Shirvan et al., 2020, 2021; Kruk et al., 2021, 2022). More longitudinal research is needed to trace the intricate dynamic relationships of these constructs in a dynamic approach to these affective variables. According to Dewaele et al (2019), the field of SLA has passed general and domain-specific phases and reached its third phase of an investigation which is the dynamic phase.

The dynamic shift is characterized by the interest in both positive emotional factors (e.g., foreign language enjoyment, self-confidence, motivation, and grit) (Derakhshan, 2022a; Derakhshan, Dewaele, et al., 2022; Derakhshan & Fathi, 2023; Derakhshan, Solhi, et al., 2023; Derakhshan, Wang, et al., 2023; Elahi Shirvan & Talebzadeh, 2020; Solhi et al., 2023; Wang et al., 2021) and negative conceptions (e.g., boredom demotivation, and anxiety) (Wang, 2023; Wang & Guan, 2020). This new trend in SLA research needs the introduction of innovative study designs that are consistent with the CDST in identifying and defining and constructing different language learners' affective variables. A variety of qualitative and quantitative research methodologies for exploring various behavioral, affective, and cognitive aspects affecting language learning processes have been proposed (see e.g., Hiver & Al-Hoorie, 2019). One of the novel CDST-consistent research approaches is DDA, a quantitative method involving complex statistical calculations (Wang et al., 2023; Wang, Pan & Wang, 2023). Despite the fact that DDA involves complex statistical procedures, this research approach is capable of tracing the fluctuation of different factors encountered by both members of dyads (especially teacher and learner) in the context of language learning that different factors interact in a dynamic way.

2.3. DDA in the Investigation of Affective Variables

Here is a summary of exemplary existing research on dyadic analyses of affective variables in psychology and education. One of the earlier works of research was conducted by Silberg et al. (1994). They used SEM to test the effect of contextual and genetic variables on twin children's emotional development. Their findings drew attention to the significance of shared, genetic, and particular contextual

variables in explaining fluctuations in the participants' emotions. They reported the effect of internalizing and externalizing behaviors both, and also found dramatic divergences in the underlying reasons for these fluctuations in externalizing behaviors of young males and females. These researchers pinpointed the benefits of using longitudinal dyadic analysis for the exploration of changing emotional and behavioral development and the psychopathological implications it can have.

In another study, Kashy et al. (2008) used growth models for analyzing dyads. They considered dyadic growth models for the cases marked by no associated variables which could empirically tell apart the dyad members (formerly referred to as non-exchangeable dyads). These researchers elaborated on the detailed procedure of using growth models as longitudinal DDA for non-exchangeable dyads taking advantage of multilevel modeling and SEM both. Kashy et al. (2008) contended that both statistical procedures could be used to measure the same latent models. They focused on the functional commonalities and divergences between the two statistical procedures. Their study had implications for parent-child interactions during young teenage.

In a more recent work of research, Planalp et al. (2017) raised the issue that though in dyadic analysis, researchers increasingly agree that simultaneous data collection from the dyad members is more useful than the separate data collection, still in practice, the latter prevails. These researchers speculated that this tendency can be because of the underestimation of the additional information obtained from simultaneous modeling procedures. Planalp et al. (2017) compared the multiple growth curve modeling framework for longitudinal DDA in both multilevel modeling and SEM procedures. The models that separately traced variation through time for members of exchangeable dyads were contrasted with simultaneous models matched with longitudinal DDA from the two members of the dyad. Moreover, these researchers contrasted the simultaneous default vs. dependent approaches, and found that the estimated variance and covariance elements resulted in contrary findings. Planalp et al. (2017) finally suggested the use of simultaneous dependent method to infer divergent variation within a dyad through the passage of time.

As for emotions involved in learning, Frenzel et al. (2018) investigated enjoyment. These researchers, first, introduced enjoyment as one of the most prevalent discrete emotions experienced by students and teachers in classroom contexts. Then, they relied on the emotion transmission theories between interactive partners and put forth a bidirectional and dynamic effects model that linked students'

and teachers' enjoyment in class. Their model illustrated positive bidirectional associations between students' and teachers' enjoyment and that these associations were indirectly influenced by students' and teachers' observations of each other's behavior in class. They tested their model using longitudinal data gathered over six months during a school academic year from female teachers and their students.

Their mediation hypotheses were confirmed by a multilevel structural equation model. Their results showed that, teacher enjoyment was positively correlated with student perceptions of teachers' enthusiasm while teaching four weeks afterward, which was positively correlated with student enjoyment when the class reached the midterm's time. These researchers also found that student enjoyment at the starting stages of the school year was positively correlated with teacher perceptions of the students' class activity in class, four weeks after the school year began, which was positively correlated with teacher enjoyment at the time of the mid-term. Frenzel et al.'s (2018) study was pioneering in providing longitudinal evidence for the reciprocal transmission of emotion between students and teachers, and had implications for teacher training courses.

In the same year, Hareli et al. (2018) adopted a dynamic approach to the investigation of emotion expression. They introduced emotion transmission as a key factor of a dynamic nature involved in social communication, and whose temporal dynamic features required longitudinal inquiry. As the majority of emotion perception literature was based on non-dyadic analytic procedures, Hareli et al. (2018) aimed to unravel the dynamic quality of emotion transmission by indicating how the exchange of a dyadic emotional interaction influences how it is perceived by observers who are not involved in the interactions. Thus, they did three works of research to explore how observer's interpretation of social power was affected by the emotions transmitted between the members of a dyad. In a very recent study, Wang et al. (2023) examined the dynamic interplay between EFL teachers' Trait Emotional Intelligence (TEI) and that of their learners over time. Having explored this interplay over four measurement occasions, they found a positive reciprocal association between learners' TEI and teachers' TEI.

In all their studies and various levels of dynamic stimuli, these researchers found that always fear reactions increased the perceived power. The perceived power was mostly affected by neutrality, contempt and happiness. This impact was mediated by the degree to which the member thought that the other interaction partner's reaction

indicated that the s/he accepted the different power relations of the two members. These experiments put together suggest significant changes in the social signal value of emotion expressions as influenced by the expressions' target emotional response. Therefore, the social signal load of emotions is not to be considered on its own. Rather, it needs to be interpreted in a more inclusive interaction network.

3. Conclusion

Dyadic data analysis (DDA) is a distinctive line of research, born out of the psychology domain, to make great contributions to psychological, sociological, psychopathological and educational disciplines. It aims to see how related individuals are similar to each other or differ in terms of a certain cognitive, affective or behavioral trait. To explore these potential similarities or differences, the data should be collected from dyads comprised of two individuals interacting with each other in a certain context. The data collected from this pair are known as dyadic data. As pinpointed in this paper and raised by scholars in the field, in order to account for the interdependence of responses obtained from the two members of dyads, longitudinal DDA run in sophisticated statistical packages such as SEM is preferred. To closely examine the developmental nature of affective factors in dyads, longitudinal DDA is preferred too, especially in the light of the CDST guides line of inquiry. Longitudinal DDA is a quantitative research methodology compatible with the CDST and suitable to trace the trajectory of changes in different affective variables that can emerge out of the interactions among dyad members.

As just reviewed, DDA analytical studies of affective variables have been within the fields of psychology and education mostly. Yet, there has been a significant dearth of research into the longitudinal DDA of L2 affective variables in SLA studies. Though, as previously acknowledged, the SLA research has recently entered the dynamic phase, the dyadic analysis of the dynamics of emotions involved in the language learning process is still under-researched. Considering the high probability of emotion transmission among interacting partners, how this actually happens in an L2 class is still unexplored. The highly interactive nature of language classes, which hosts the dynamic emergence and reciprocal effect of emotions in student-student and student-teacher dyads, summons up a new dyadic line of research.

The works of research on affective variables in psychology and education

showed a wide gap in similar investigations in the SLA domain. In other words, though not expected, dyadic analysis of data has been scarcely done to capture the dynamic and developmental nature of L2 affective variables. As previously noted, the recent dynamic shift in the SLA research has hosted a new line of longitudinal studies. Yet, there seems to be a huge gap in the longitudinal DDA of the affective factors that influenced the processes of language learning. Almost all studies that have been conducted so far in the SLA domain have investigated dyadic interactions, dyadic communicative tasks in L2 classes (e.g., Hellerman & Cole, 2008; Jang & Cheung, 2020; Storch, 2002). They have not conducted a longitudinal DDA of the data obtained from the dyads in the language classroom. Neither have they investigated the development of L2 affective variables.

The current research that employed DDA to explore affective variables in psychology and education (outside the SLA domain) has been limited in number, yet has produced interesting findings, as reviewed in the previous section. Thus, adopting a DDA approach to exploring the affective factors involved in a language class can be hoped to produce promising findings too. An example has been the exploration of enjoyment involved in learning done and reported by Frenzel et al. (2018). These researchers modeled this affective variable by delineating the reciprocal effects that linked students' and teachers' (as the dyad) enjoyment in class. They used longitudinal data to test their model and ran SEM analysis, which led to the confirmation of their mediation hypotheses through a multilevel structural equation model. Their results showed that, teacher enjoyment was positively correlated with student perceptions of teachers' enthusiasm. Frenzel et al. (2018) also found that student enjoyment at the starting stages of the school was positively correlated with teacher perceptions of the students' class activity in class later on during the academic semester. This valuable study can be replicated in the SLA domain to explore the dynamic growth of foreign language enjoyment in different time points of the semester.

The importance of L2-related affective elements and how they can emerge from the interactive context of classroom learning is not a novel topic for SLA researchers. So far, the corpus of research in SLA has highlighted the importance of numerous affective variables that can be engaged in L2 learning. L2 learners' self-confidence (Lee & Lee, 2019; de Saint Léger & Storch, 2009; Peng & Woodrow, 2010), L2 anxiety (Lee, 2019; Lee & Lee, 2019; MacIntyre & Legatto, 2011), and various types of language learning motivation (Khajavy et al., 2016; Lee,

2019; Lee & Lee, 2019; MacIntyre et al., 2002; Yu, 2011; Wang & Guan, 2020). Though SLA scholars have long been interested in these emotive characteristics, studies illuminated by the dynamic theory are still restricted. That is why analytical frameworks like the DDA are critical for taking a longitudinal and dynamic approach to investigating L2 teacher and learner emotions.

The other point to consider is that, in the interactive context of language learning, the affective variables emerge out of interactions. Frenzel et al. (2018) already drew attention to the concept of emotion transmission within the interactions of teacher and students in classroom learning. Thus, the co-development of such emotions as foreign language enjoyment (FLE), boredom, and anxiety in teacher-student interactions is what actually occurs in the reality of classroom learning, and needs longitudinal investigation (Derakhshan, 2022b; Derakhshan et al., 2023; Xie & Derakhshan, 2021; Wang & Derakhshan, 2023). The line of DDA research in L2 affective factors does not have to be limited to the exploration of emotions emerging out of teacher-student interactions only. The other topic for dyadic analytic research with this respect can focus on how certain emotions develop dynamically in student-student pair-works, especially when two students of a different proficiency level are put together in a dyad (i.e., a more competent student working together with a less competent student to provide for scaffolding). It is hoped that these gaps will be soon filled in the SLA line of research in light of the CDST guidelines.

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