

How Output Outweighs Input and Interlocutors Matter for Study-Abroad SLA: Computational Social Network Analysis of Learner Interactions

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This data-driven study framed in the interactionist approach investigates the influence of social graph topology and peer interaction dynamics among foreign exchange students enrolled in an intensive German language course on second language acquisition (SLA) outcomes. Applying the algorithms and metrics of computational social network analysis (SNA), we find that (a) the best predictor of target language (TL) performance is reciprocal interactions in the language being acquired, (b) the proportion of output in the TL is a stronger predictor than input (Principle of Proportional Output), (c) there is a negative relationship between performance and interactions with same-first-language speakers, (d) a significantly underperforming English native-speaker dominated cluster is present, and (e) there are more intense interactions taking place between students of different proficiency levels. Unlike previous study abroad social network research concentrating on the microlevel of individual learners' egocentric networks and presenting an emic view only, this study constitutes the first application of computational SNA to a complete learner network (sociogram). It provides new insights into the link between social relations and SLA with an etic perspective, showing how social network configuration and peer learner interaction are stronger predictors of TL performance than individual factors such as attitude or motivation, and offering a rigorous methodology for investigating the phenomenon.

Keywords: study abroad; computational social network analysis; social graph; peer learner network; interactionist approach; community/cluster detection

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ALTHOUGH EXISTING STUDY ABROAD (SA) research has analyzed the connections between language acquisition and use (both in and out of class), still relatively little consensus exists concerning the extent of the contribution of out-of-class language use to second language (L2) development (Badstübner & Ecke, 2009; Dewey et al., 2012; Isabelli-Garcia, 2010; Kinginger, 2009; Pinar, 2016). A relatively recent approach to SA research has emphasized that the key to improving L2 proficiency while studying abroad may be the development of social networks

(Baker–Smemoe et al., 2014; Dewey et al., 2012; Isabelli–García, 2006; McManus, 2019; McManus et al., 2014; Trentman, 2013). This study makes a case for the strong influence of social variables on second language acquisition (SLA) and constitutes the first application of the rigorous computational methodology of social network analysis (SNA) to a complete learner network, investigating naturally occurring, unregulated face-to-face conversational interaction among the members vis-à-vis their subjectively perceived and objectively measured L2 progress.

SOCIAL NETWORKS

A growing body of 21st-century research has sought to integrate methods and techniques from separate fields of science in order to further our understanding of the world and the governing principles therein. An established method that has been increasingly applied in addressing these cross-disciplinary questions is SNA (Borgatti et al., 2009). Resting on the tenets that humans are social beings (Kurata, 2010) and that individual behaviors and outcomes are influenced by relationships among the actors (Warner & Lunt, 1941), an SNA perspective focuses on the connections and relational ties established by individuals of interest, their integration into a group, and their role within it (Lanza & Svendsen, 2007; Milroy, 1987a, 1987b; Scott, 2017; Zappa–Hollman & Duff, 2015). In line with social capital theory (Putnam, 2001), belonging to different social networks is understood to afford access to less and more tangible resources and benefits, from material goods through (rich) information (Koka & Prescott, 2002), ideas, opportunities, influence, and social support (Moreno, 1934). In study abroad contexts, the number one resource (social capital) that can be leveraged for language learning is access to speakers of and opportunities to use the target language (TL). Additionally, integration into a dense social network confers rapid access to support (Castañeda & Zirger, 2011).

Conceptually, the social network was introduced in the 19th century by Durkheim (1893), who compared the structure and functioning of societies to biological systems consisting of interconnected components. Durkheim concluded that social phenomena are an effect not so much of the actions of particular individuals, but of the interactions between them. In a similar vein, Malinowski (e.g., 1922) skillfully combined anthropological study with knowledge from the frontiers of psychology, mathematics,¹ and economics in an attempt to gain a better grasp of the workings of

the world. However, several more decades had to pass for SNA to become the focus of researchers' attention (Wasserman & Faust, 1994) and an inspiration for numerous projects and publications spanning formerly disconnected disciplines. Testimony to the exponentially growing interest in—and importance of—multilayered and multifaceted interactions in the current world can be found in the works of Borgatti et al. (2009), Easley and Kleinberg (2010), and other researchers.

SOCIAL NETWORKS AND LANGUAGE: SETTING THE SCENE

Sociolinguistics

Initial investigations of language practices utilizing a social network theoretical approach had been carried out in the field of sociolinguistics (Chambers, 2009; Eckert, 2000; Kurata, 2010), for instance, to understand language variation and change (Bortoni–Ricardo, 1985; Edwards, 1992; Labov, 1963; Lippi–Green, 1989; Milroy, 1987a, 1987b; Milroy & Milroy, 1978). Labov (1963) conducted a study on young African Americans from poor educational backgrounds who were associated with two Harlem street gangs. He found a stronger linguistic and social affinity between gang members hailing from different neighborhoods, activities, and creeds than between the mob and unassociated “lames” living on the same block. Labov ascribed the results to the shared set of values among the former. (Intraspeaker) stylistic variation has long been recognized as indexing individuals' identity via affiliation with certain groups on the one hand (Schilling–Estes, 2002) and distinguishing themselves from groups with which they do not want to be identified on the other (Hansen Edwards, 2008; Mendoza–Denton, 2002; Ohara, 2001). A study by Milroy & Milroy (1978) in working-class Belfast neighborhoods characterized by low social and geographic mobility demonstrated how stronger territorial ties and memberships went hand-in-hand with the maintenance of “indexical” phonological features of the local variants. SNA has also been considered a useful tool for investigating language maintenance and shift in expatriate and immigrant communities, providing a means for comparing differences in relationships resulting from social pressures. For instance, Velázquez (2012) discovered that immigrant children coming from households with a high frequency of parental interaction exhibited increased instances of socialization. Trudgill (2011) likewise postulated that language is a product of various social networks and

structures, rather than a random occurrence. Recently, Lindberg & Trofimovich (2020) showed how L2 French learners' social network density involving speakers of the target variety was one of the strongest predictors of their attitudes toward it.

Social Interactions and SLA in Study Abroad Contexts

The last two decades of research on foreign language learning have seen the emergence of numerous, diverse models and theories making explicit allowance for the indissoluble link between the process of language acquisition and social interactions. This took place in line with the broader "growing recognition of the need to expand the theoretical scope and the database of SLA research (. . .) to move beyond a narrowly cognitive orientation to include the impact of social factors on cognition" (Tarone, 2009, p. 41). Particularly pertinent here is the interactionist approach, one of whose basic tenets is a focus on how learners use their linguistic environment to build their knowledge of the L2, taking into account input, that is, exposure to primary linguistic data that feeds into the language acquisition device (Lightbown & Spada, 2013); output, that is, production, which is argued to develop fluency (de Bot, 1996) and raise metalinguistic reflection and awareness (Swain, 1985, 1993, 1995); and direct and indirect feedback on the latter (Swain, 1985, 1993, 1995) via negotiation for meaning (Long's, [1996] Interaction Hypothesis) and the "communicative pressure" of interaction (Gass, 2003, p. 224; Gass, 2010, p. 2; Mackey, 1999), which may facilitate noticing of crucial features in the input. Interaction research "takes as its starting point the assumption that language learning is stimulated by communicative pressure and examines the relationship between communication and acquisition and the mechanisms (e.g., noticing, attention) that mediate between them" (Gass, 2003, p. 224). Taking into consideration the role of extralinguistic factors, such research can also be seen as a step toward a complex systems perspective (Paradowski & Jonak, 2012).

Residence and SA are commonly believed to be an ideal environment for linguistic and cultural development due to the unique chance of authentic extensive L2 contact through input, output, and interaction (Issa et al., 2020; Mitchell et al., 2020; Segalowitz & Freed, 2004). Opportunity for interactions outside the homestay and traditional classroom settings has been proven beneficial for the language learning process (Dewey, Belnap, et al., 2013; Whitworth, 2006).

It has consequently been argued and shown that, compared with at-home scenarios, such contexts can lead to significant gains in students' cultural understanding (Allen, 2010; Clarke et al., 2009), acculturation, personal development, motivation to learn the foreign language (Huebner, 1995; Schmidt-Rinehart & Knight, 2004), and linguistic proficiency (Coleman, 1998; Huebner, 1998; Ingraham & Peterson, 2004; Lafford, 2004; Lapkin et al., 1995; Meara, 1994; Oppen et al., 1990; Watson et al., 2013). Fraser (2002) found that SA learners in Germany participating in various community interactions (activities such as playing in an orchestra or on a soccer team) demonstrated more linguistic development of reading and writing proficiency than learners who only attended conventional in-class courses. In a similar vein, Whitworth's (2006) research conducted in France proved that engaging in various social events contributed to linguistic gains in French. Dewey, Ring, et al. (2013), too, pointed out the important role played by the surrounding population, finding significant differences in the progress of Arabic learners in Egypt—where accessing the local population for informal conversations proved frustratingly difficult, especially for female students—versus those in Jordan, where the documented encounters were much more open and relaxed. Zembrzusi et al. (2020) showed that in Polish–English bilinguals, more opportunities to use L2 English both in and outside the home environment led to lower phonological cross-linguistic influence from heritage Polish.

Yet, considerable variation has been evidenced in the amount of contact students have with members of the local community and peers, their experiences, and linguistic outcomes (Atsuzawa-Windley & Noguchi, 1995; Barron, 2002; Dewey et al., 2014; Kinginger & Belz, 2005; Kinginger & Blattner, 2008; Marriot, 1995; Pérez-Vidal, 2014; Regan, 1995), challenging the "osmosis myth" (Davidson, 2010) that spending time in a TL environment will automatically lead to an improvement in language proficiency (DuFon & Churchill, 2006; Freed, 1998; Gass, 1997) or to superior improvement in comparison with at-home learners (Collentine, 2004; Díaz-Campos, 2004; Freed, 1995; Herschensohn, 2003; Howard, 2005). Where out-of-class L2 contact in SA does result in linguistic gains, these do not hold across all measured aspects of fluency and proficiency (DeKeyser, 1991, 2010; Faretta-Stutenberg & Morgan-Short, 2018; Hernández, 2016; Juan-Garau, 2014; Llanes & Muñoz, 2009; O'Brien et al., 2007; see also Tullock & Ortega, 2017, for a scoping review).

Most of the existing research comes from studies of U.S. university students (see Llanes, 2011, for an overview of the imbalance). Baker–Smemoe et al. (2014) examined 102 native English speakers who participated in SA in Mexico, Spain, France, Egypt, Russia, and China. From among predictors such as personality, amount of L2 use, gender, age, intercultural sensitivity, and global social network metrics (size, dispersion, and density), the strongest predictor of L2 gains turned out to be the latter variable. Isabelli–García (2006) demonstrated that interaction in social networks during SA serves as “a conduit between motivation and language acquisition” (p. 255). Baker–Smemoe et al. (2014) found only two contextual variables to predict language gains of SA learners: the formation of deeper and closer relationships with other speakers and the interlocutors’ proficiency in the students’ first language (L1), that is, English. Dewey, Belnap, et al. (2013) concluded that despite the obvious significance of meaningful social interactions, “there is not yet a definitive answer regarding what factors influence social interaction most, how best to prepare learners for these interactions, or how to foster interaction during residence abroad” (p. 87) and emphasized the need for additional research in this area—a call more recently reiterated by Borràs and Llanes (2019), Isabelli–García et al. (2018), Issa et al. (2020), and Marijuan and Sanz (2018).

Second and Foreign Language Learning and Measures of Social Influence

Despite the interest among scholars, virtually no rigorous quantitative data-driven analyses have been carried out to systematically investigate the impact of social graph structure and peer interaction dynamics on SLA outcomes in the ecology of naturally occurring face-to-face conversational interaction.²

Where some studies did look into language learners’ interactions outside the classroom, they mainly relied on language-contact-profile-type surveys examining the summative amount of time learners spent in the L2 (Day, 1985; Freed, Dewey, et al., 2004; Segalowitz & Freed, 2004), mainly focusing on interactions with native speakers—and none has attempted to systematically quantitatively cross-match students’ linguistic gains with their (leisure-time) communication patterns with other L2 classmates. All this despite the early identification of peer interactions as an important component of SA experiences (Kington & Farrell, 2004; Ransbury & Harris, 1994) and sub-

sequent scholarship suggesting that interaction with fluent *normative* peers may be more beneficial to observable L2 development than mere interaction with native speakers (Conroy, 2018; Martinsen et al., 2010; although the literature also reports findings in the opposite direction: see, e.g., Magnan & Back, 2007, who observed a negative relationship between proficiency gains and reported time spent speaking in French with U.S. classmates).

Moreover, the studies provided somewhat inconclusive results, with some revealing a positive correlation between the amount of L2 contact and TL development, and others failing to show a relationship (Magnan & Back, 2007; Segalowitz & Freed, 2004; see Taguchi, 2008, for an overview). Much of the research also relied on post-SA questionnaires, with the delay in self-reports likely lowering their reliability (Issa et al., 2020). Most of the studies also focused on static structural measures (such as network size or density) while largely ignoring interactional metrics such as frequency and intensity or direction of interaction. The sample sizes tended to be small, often in single-digit numbers and rarely exceeding 20 participants. Further, the extant studies have only looked at individual learners’ egocentric networks, without attempting to reconstruct full learner graphs and compute their influence on L2 gains. This contribution addresses these lacunae and aims to refine the current level of understanding of the role of peer learner networks in SLA during SA.

THE STUDY

Research Questions

The fundamental aim of the current study has been to investigate the influence of students’ peer interaction—that is, their making use of the affordances of immediately available social capital (Thiele et al., 2018)—on success in L2 and third language (L3) acquisition. Via trailing the influence of graph structure and interaction dynamics on the learning outcomes, this study combines analyses of SLA with the technique of computational SNA. So far, no such quantitative study had been carried out on a complete learner cohort *in natura*. The main research questions are as follows:

- RQ1. Is the learners’ L2 progress influenced by their position in the peer interaction network (center vs. periphery) and community membership?

- RQ2. Which types of interaction revealed in the social graph structure are the most robust predictors of L2 progress: unidirectional or reciprocal, overall (irrespective of the language[s] used) or in the TL, incoming or outgoing?

Accomplishment of this goal serves to verify Swain's (1985) output hypothesis and its later iterations concerning the role of language production in SLA (Gass, 2003, 2010; Long, 1996; Swain, 1993).

- RQ3. If progress depends on LX³ use, is what matters the absolute number of immersion hours in the language (e.g., in terms of spoken production, total talking time), or the proportion of of TL use to total communication (the Principle of Proportional Output)?

- RQ4. Is there a relationship between participants' language progress and the intensity of their contacts with same-L1 users (investigation of homophily effects; Lazarsfeld & Merton, 1954; McPherson et al., 2001)?

- RQ5. Do the students prefer to congregate around peers demonstrating a similar or different level of L2 proficiency (another take on homophily effects)?

- RQ6. Is TL progress conditioned by network-external factors such as motivation or competence in other (background) languages?

Site Selection, Population, and Timeline

The observed population was a complete cohort of 39 exchange students (21 females and 18 males) taking part in a 5-week intensive German language course at a university in Baden-Württemberg, comprising 15 nationalities from five continents: 13 from the United States; 5 from Brazil; 4 from Italy; 3 from South Korea; 2 each from Japan, Poland, and Spain; and 1 each from Colombia, Ecuador, Mexico, Greece, Slovenia, Israel, Taiwan, and Australia.⁴ The students were residing in the university town throughout the academic year, only leaving for major holidays. Their L1s were English (13 students from the United States, 1 from Australia, and 1 bilingual from Brazil), Spanish (5 students from Mexico, Colombia, Ecuador, and Spain), Portuguese (5 from Brazil), Italian (4), Korean (3), Japanese (2), Polish (2), Greek (1), Hebrew (1), Chinese (1), and Slovene (1). In most cases, German was not their second, but third foreign language (see Appendix A). The students' rationale behind

choosing Germany as their destination country varied; however, some recurrent themes could be observed, including globally recognized study programs and well-developed international co-operation agreements, the possibility to not only study but also take part in internships paving the way for future careers, and perceived prestige. In this last regard, while Asian students most often underlined the social prestige connected with living and working in Germany, Latin Americans pointed to the high standard of living in the country.

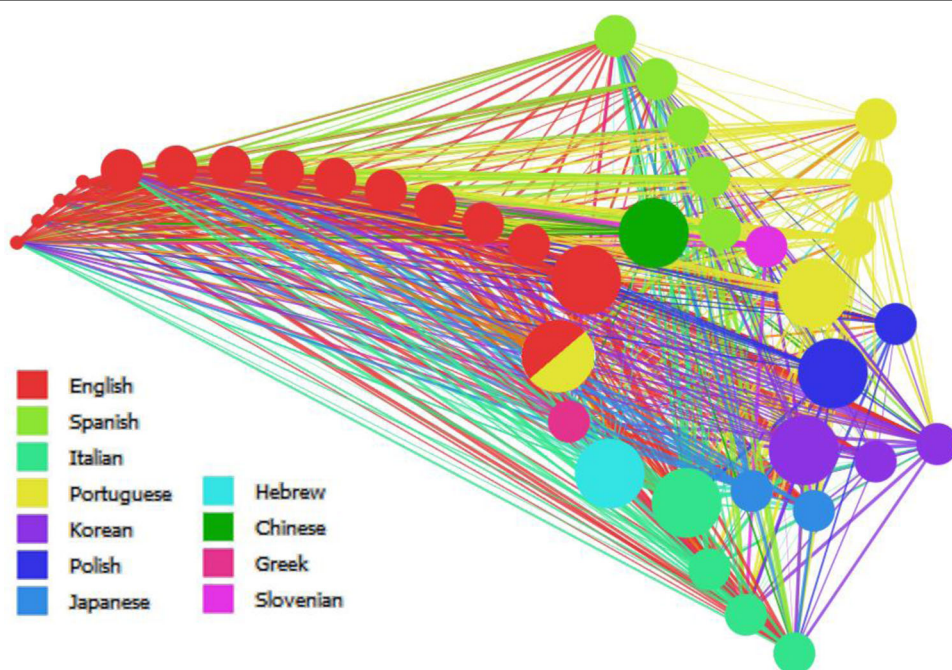
Research investigating SA contexts where English is used as a *lingua franca* has been the focal point of scholarly attentions for years, yet much still remains to be explored (Köylü, 2021). The selection of a non-Anglophone university was motivated by the fact that an investigation of the acquisition process of a language other than English would be more informative. The majority of university exchange students are most familiar with English and tend to use this language to communicate when abroad. Second, in investigations of the development of linguistic competence, one must consider factors normally difficult to tease apart—the influence of the (traditional and digital) media, as well as out-of-group contacts; other things being equal, in most of these cases one cannot rule out the presence of English. As a result, it would have been difficult to separate other external factors that could also influence the language acquisition process. Third, in an age where English fulfils the role of a *lingua franca*, a vast proportion of the users treat the language in a utilitarian manner and make do with functionally communicative competence (Paradowski, 2013). For all these reasons, a choice of language other than English was more suitable for the purpose of our study.

The selection of this particular “vintage” of students was spurred by the fact that during the academic year concerned, several German-language instructors at the university independently observed that—unlike in most of the previous years—the arriving cohort of exchange students became a visibly cohesive group. This had a measurable impact on the improvement of their linguistic competence over the course of the sojourn.⁵

The research spanned the 5-week period of the intensive language course (beginning in March; over 180 contact hours) plus the following 4 months of the summer semester (until the end of July), thus 5 months in total. Following a placement test administered on Day 1, the course participants had been divided into three smaller groups. The requirement for partaking in the

FIGURE 1

German Total Interactions Unfiltered [Color figure can be viewed at wileyonlinelibrary.com]



Note. Unfiltered = with all interaction strengths retained. Edge (link) thickness indicates relative link weight (representing the frequency or intensity of interactions). Each branch of the graph corresponds to one native language (color) and is sorted by participants' self-reported improvement in German (node size). The two-colored node represents a participant who had been raised bilingually.

Deutsch-Kompakt-Kurs (DKK) was having undergone at least 200 hours of German tuition, since there was no beginning-level course offered. The students were taught by qualified and experienced teachers using proprietary materials published by the university (3.5 hours/day) as well as trained German students–tutors (1.5 hours/day). At the end of each course week, the students took a written test.

The quotidian routine also included optional activities. During the lunch breaks, the students would usually go to the canteen together. In the evenings, they were offered one welcome dinner party, several film screenings, joint evenings in German pubs, and a barbecue on the riverbank. The program offered numerous excursions. The students enjoyed one another's company so much that they organized additional trips on their own at the weekends. They also met up for joint international cooking evenings.

Toolkit and Data Collection

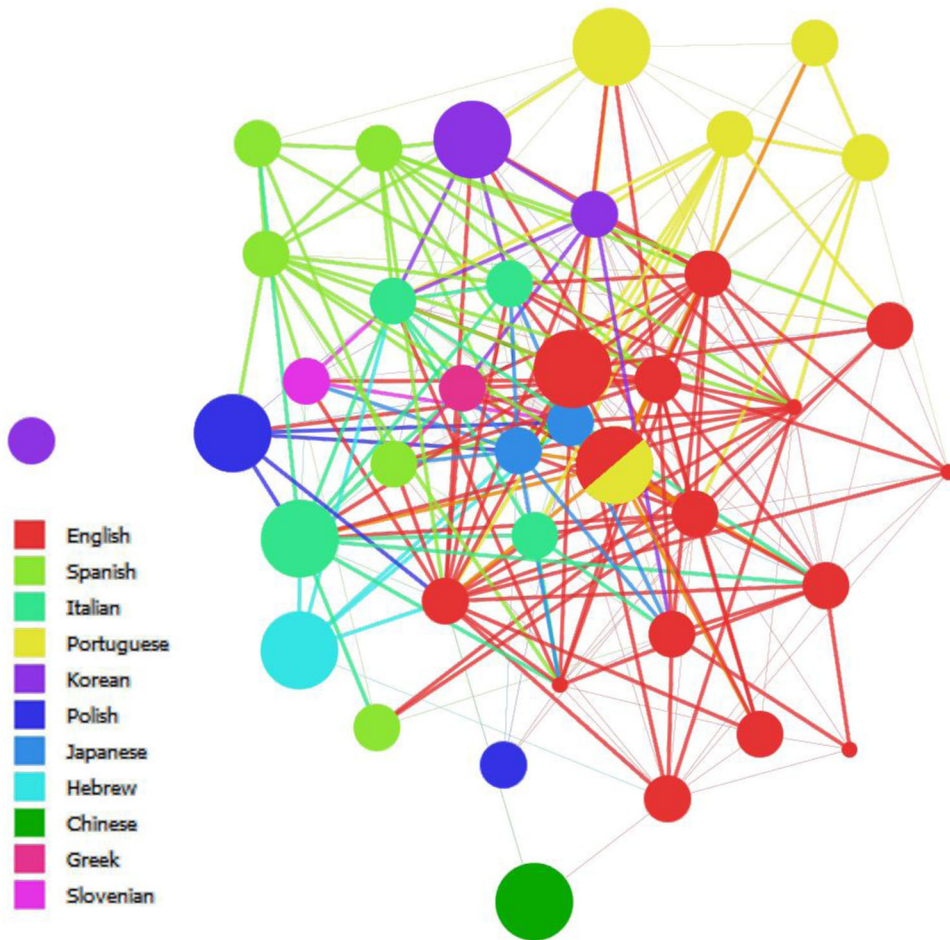
The investigation of the process of SLA taking into consideration social relations was accom-

plished through careful employment and triangulation of several complementary data sources, collection instruments, and established research methods.

All members of the group ($N = 39$) were approached with specially customized in-depth structured interviews, with the goal of grasping the impact of peer interaction dynamics and social network topology on motivation and learning outcomes. For a more objective corroborative measure of end-state proficiency, we received copies of the students' final certificates detailing both course level and grade received (using the German grading scale)—in the case of our participants, spanning from 3 (satisfactory) to 1 (very good) in .25 increments, thus a sufficient level of granularity to allow meaningful comparisons. In addition, we procured evaluations from the course instructor of the participants' integration and learning progress. The responses obtained were also corroborated post hoc by one of the co-investigators who had been present in the location throughout the study's duration, observing the participants' interactions and evolving language competence levels.

FIGURE 2

German Total Interactions With Only Links With Strongest Interaction Weights Shown [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/modl.12811)]



Note. Node size corresponds to participants' self-reported improvement in German. Different node positions are a result of treating links as attractive forces, which causes the formation of visible natural interaction clusters: English, Portuguese, and Spanish.

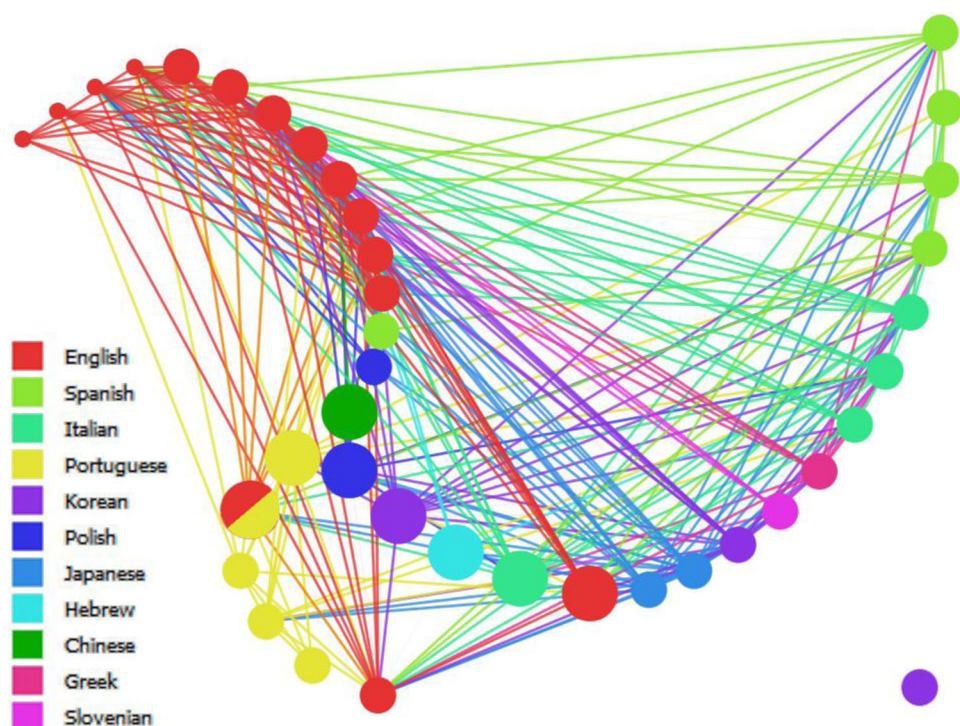
The comprehensive interview and questionnaire⁶ investigated the impact of individual and social factors on learning progress. It comprised four parts covering factual, attitudinal, and behavioral closed- and open-ended questions. These inquired into participants' mother tongues, other languages spoken and the level of fluency therein, TL level at the commencement of the language course (assessed with a placement test; the course had begun 7 weeks before the spring semester) and 4 months after the course (self-assessed by the participants, gauged in keeping with the *Common European Framework of Reference for Languages* proficiency scales; Council of Europe, 2001, 2018—and

corroborated via the *Zertifikate* described in the previous paragraph as well as observation by one of the investigators in the project), self-perceived language learning aptitude, extroversion, motivation, and attitude toward the TL, the language course, and the host country.

The respondents were additionally asked about their overall assessment of the language course and its components. The concluding and key part of the questionnaire aimed at investigating the social relations established within the groups of students. Every participant assessed the intensity of their interactions with each other classmate (a) overall, and (b) in the TL. Interaction frequency

FIGURE 3

Bidirectional Interactions in German, Strongest Interactions Only [Color figure can be viewed at wileyonlinelibrary.com]



Note. Node size corresponds to participants' self-reported improvement in German. The three branches of the hive plot represent the groups detected by a network clustering algorithm. Notably, the upper (English-speaker-dominated) branch displays significantly smaller German language improvement than the other two. One node is isolated because it does not have any reciprocated interactions of strength >2 .

was rated on a 5-point Likert scale, where the maximum score was given to participants with whom the individual felt they interacted most frequently. The participants filled out the paper-and-pencil questionnaire at the end of the semester (in late July), 4 months after the end of the intensive language course. Each student was subsequently interviewed in person.

The study protocol received institutional review board clearance from the University of Warsaw's Human Research Ethics Committee; all the students were provided with information about the study and participated voluntarily.

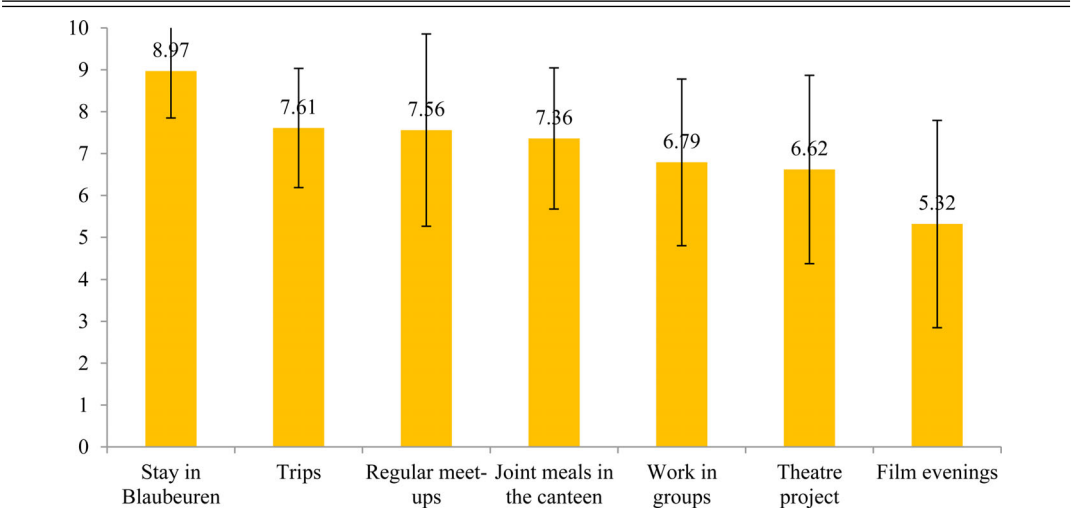
Capturing Social Network Effects: Methods and Measures

In order to measure the impact of social networks on language attainment, allow for predictive modeling, and corroborate or falsify social theories concerning SLA, we employed SNA combined with other complexity science

techniques. In particular, we considered the relationship between strengths of interactions among the students and their performance. The validity of the framework's predictive strength is bolstered by the multilingual make-up of the learner community under investigation (Lanza & Svendsen, 2007).

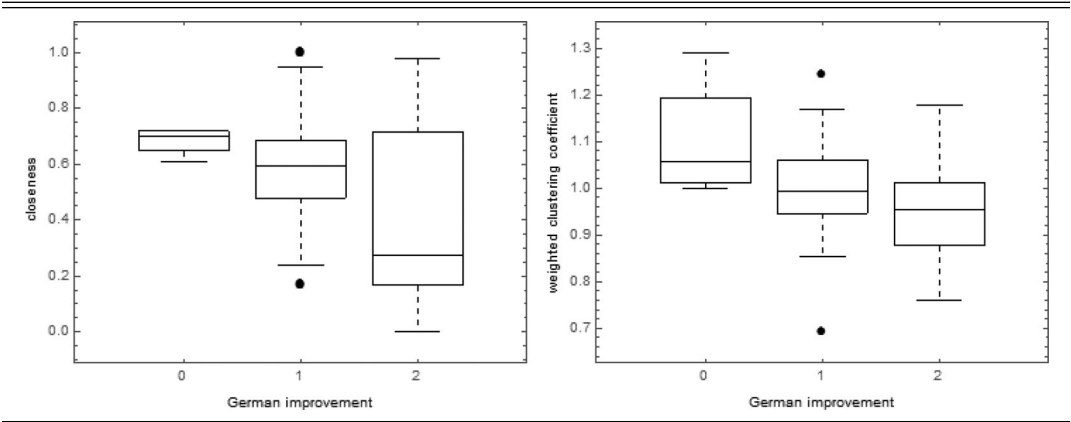
The selected tools of SNA and complexity science permitted a multifaceted exploration of the complementary research foci (RQs 1–6). The central dependent variable (performance) was measured in terms of improvement, taking the difference between the participant's initial proficiency in German and their level at the end of the semester. Due to the relatively low number of participants ($N = 39$) and the fact that the majority improved by one level,⁷ we had to ensure that any apparent similarities between strongly linked individuals (characterized by high frequencies of interactions) were not simply due to homogeneity. To address this, we compared the predictions that would be made by the

FIGURE 4
“To What Extent Have These Activities Contributed to Your Acquisition of German?” [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1111/modl.12811)]



Note. 0 = no contribution; 10 = maximum contribution. Error bars indicate one standard deviation.⁹

FIGURE 5
Closeness Centrality in the General Directed Network (Left) and Weighted Clustering Coefficient in the General Undirected Network (Right) Versus Performance



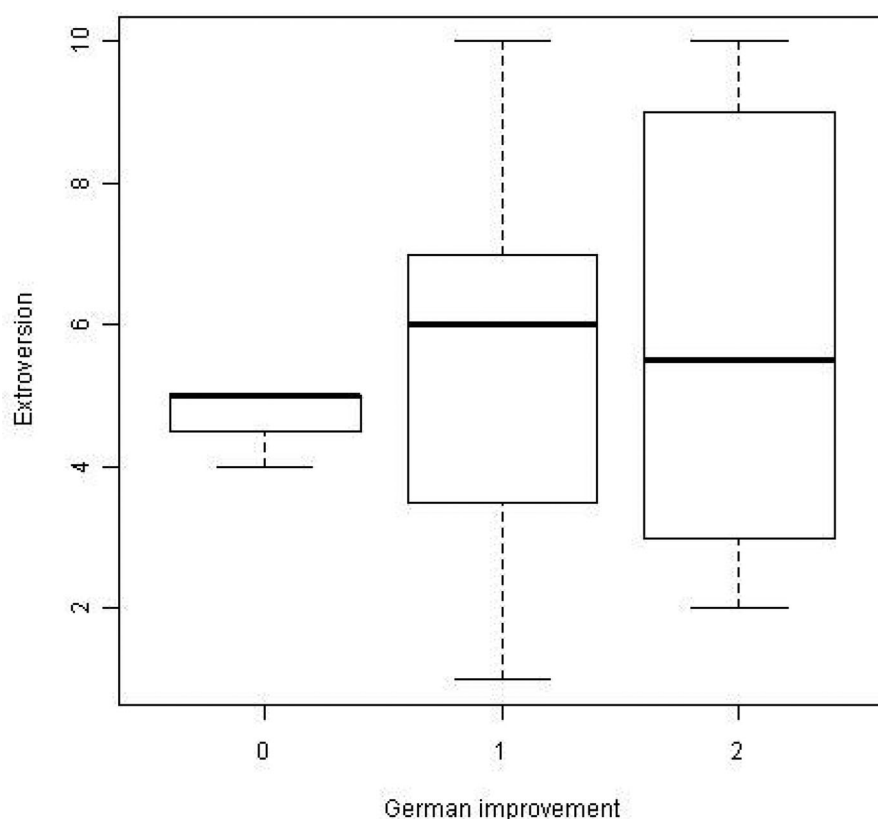
actual network with those that would be made by the network randomly rewired.

Another, more objective measure of performance used was grades from the final certificates. Since there were three groups differing in the level of proficiency and the grades in each group ranged from 1 to 3 in increments of .25, we mapped the grades linearly $G = l \times 3 + g$ onto the range 1–9 (highest and lowest score, respectively, reflecting the directionality of German), where g is the grade, l is the group’s level (A2/B1 = 2, B1/B2 = 1, B2/C1 = 0), and G is the resulting score. While this can measure only exit linguistic competence and not its change, we did check

it for consistency with the initial and final self-reported measures.

The data analysis enabled tracing interactions within the graphs, that is, revealing (a) relations demonstrating frequent communication overall, and (b) interactions taking place specifically in the TL. In our case, the graphs⁸ consist of students as agents or nodes and communication between them as directed links or edges. The analyses considered six different variables and weighted interaction networks—namely, those of (a) general directed interactions, where individual i has an in-link from individual j if j has reported talking to i (irrespective of whether or not i has also

FIGURE 6
General Extroversion and Improvement in German



reported such interaction), (b) sum of overall interactions (which renders the network undirected), (c) only bidirectional (i.e., reciprocated) interactions, (d) directed interactions in German, (e) the sum of total German interactions, and (f) bidirectional interactions in German (a snapshot of graph [e] is visible in Figure 1). In so doing, we go beyond coarser, global structural network measures—such as network size, intimacy, inclusiveness, dispersion, and density (Baker–Smemo et al., 2014; Doucerain et al., 2015)—that have characterized most of the earlier quantitative L2 social network studies in the field.

Reported pairwise interactions between the study participants ranged between 0 and 4. We formalized them as directed weighted networks (a) and (d) in the previous paragraph, and their undirected—and consequently less informative—counterparts (b) and (e). We also scrutinized their versions with weights standardized with respect to participants' total outgoing or incoming interactions so as to account for individual differences in sociability and popularity (thus, e.g.,

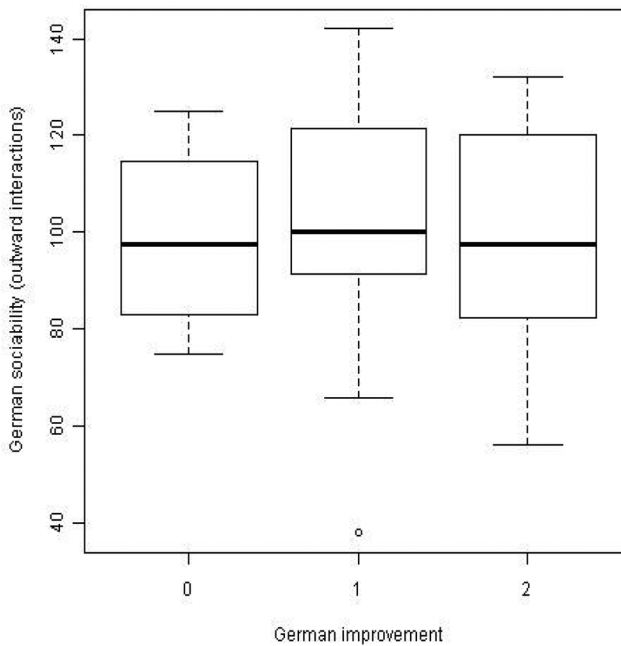
if a participant had a high level of interaction, a score of 4 will be treated the same as a score of 2 for a participant who did not interact very much).

For each of those cases, we also consider networks with the weakest interactions removed and only the strongest retained (see Figure 2). These networks are then more transparent, with both hubs and isolated nodes clearly perceptible. Such filtering of interaction strength is essential for bidirectional networks (see Figure 3), that is, when the condition of mutuality is fulfilled, since all but two reported interactions were reciprocated. These various network models permitted different research angles in determining the relationship between each participant's performance and their position in the network.

To comprehensively characterize the latter (and subsequently the structure of the entire network), established metrics were used such as node degree, closeness, betweenness, and other centrality measures (Ochab, 2012; Paradowski, Jarynowski, Czopek, & Jelińska, 2021; Paradowski,

FIGURE 7

Sociability (Outgoing Interactions) in German and Improvement in German



Jarynowski, Jelińska, & Czopek, 2021), as well as local clustering coefficients (Saramäki et al., 2007), using generalizations of these metrics to weighted graphs (Opsahl et al., 2010), which allows for both the number and strength of interactions to contribute to the metrics. Additionally, we tested three community detection algorithms: Infomap (Rosvall & Bergstrom, 2008), Louvain method of modularity maximization (Blondel et al., 2008), and order statistics local optimization method (OSLOM; Lancichinetti et al., 2011) enhanced with the consensus algorithm by Lancichinetti & Fortunato (2012). These are established unsupervised clustering methods that reveal relatively densely connected subgroups of nodes based on the structure of the network (see Figure 3).

As a complementary measure, we ran Moran's I spatial autocorrelation test, which reveals whether the distribution of a given quantity in space is random, localized, or alternating. Although an interaction network does not represent physical Euclidean space, the strength of interactions can be used as an inverse distance between two people. The test was repeated for all quantities collected in the questionnaire on all the network types (a)–(f).

Rather than use traditional network analysis methods that depend on large numbers of nodes

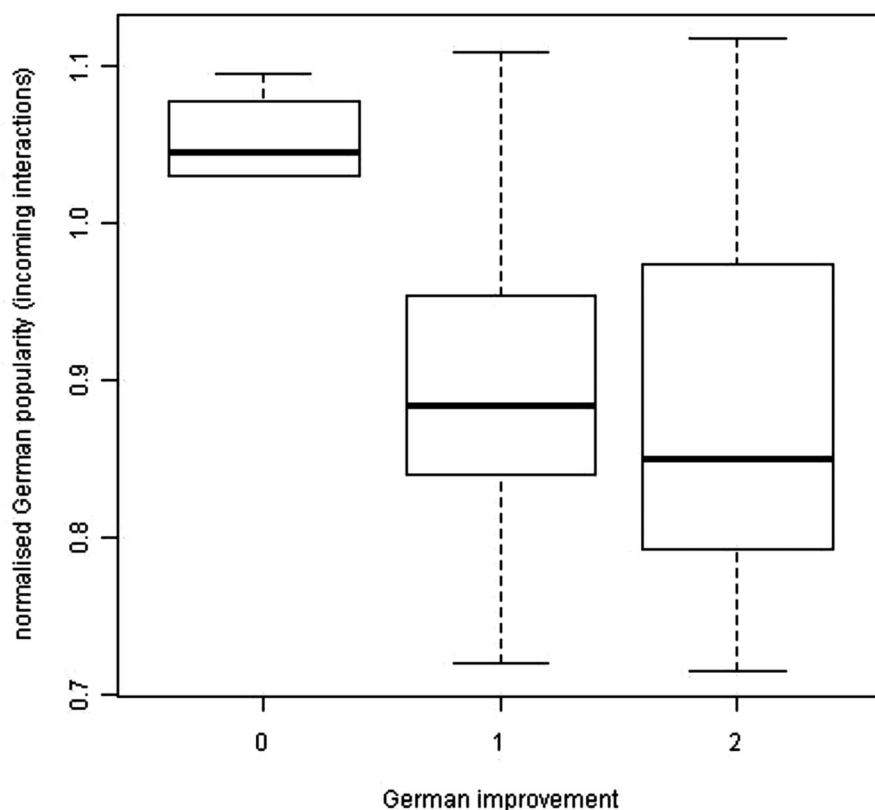
and links, we tested hypotheses by evaluating alternative models that overlay or weight graphs. For example, to gain further insight into the interplay between social factors, language factors, and homophily (Lazarsfeld & Merton, 1954; McPherson et al., 2001), we compare models where social interactions are weighted by homophily with those that treat them as orthogonal to each other.

The second stage sought to identify the strength and structure of interactions by using factors to parameterize network nodes. This permitted an exploration of the modulatory and mediatory effects of individual differences such as motivation. The topological data were overlaid over the independently collected sociobiographical data and learning outcomes in order to carry out a multifaceted analysis of the mutual influence of individual (gender, introversion–extroversion, motivation, etc.) on social factors and vice versa. The goal was to then determine how—if at all—these were associated with performance.

Last, we considered interactions in subcommunities of students speaking the same native or preferred language to determine whether increased communication within these groups can have a detrimental effect on SLA processes.

FIGURE 8

Normalized Popularity in German (Incoming Interactions) and Improvement by Level



SOCIAL INTERACTION AND PERFORMANCE: RESULTS

Before presenting an analysis of the relationships between student interactions and their L2 performance, we point to the fact that the self-reported (thus potentially biased) fluency levels were highly consistent with the final certificate grades obtained by the students. The linear correlation coefficients between the initial and final self-reported measures and the placement and final grades are, respectively, $r = .814 \pm .094$, $R^2 = .66$, $p < .001$; and $r = .77 \pm .10$, $R^2 = .59$, $p < .001$, thus lending strong validity to the high reliability of the self-reported progress indicators.

Before being asked about their interactions, the participants were requested to assess the degree to which the social activities they had been involved in—both in and especially out of class—contributed to their progress in the German language. The results are presented in Figure 4.

The highly interactive activities that brought the participants together for longer periods of time (e.g., excursions) were at once deemed the most beneficial (the two topmost responses were also characterized by the lowest standard deviations—1.14 and 1.44, respectively), while (dubbed) film screenings, which by definition do not afford many conversation opportunities, scored lowest on the list.

RQ1: Is the Learners' L2 Progress Influenced by Their Position in the Peer Interaction Network (Center vs. Periphery) and Community Membership?

Network analyses reveal the emergence of three natural communities formed around English-, Portuguese-, and Spanish-speaking participants, as seen in Figure 2. This graph also shows both high- and low-performing students appearing on network peripheries, which suggests that a central position in the undirected network of strong Ger-

FIGURE 9
Normalized Sociability in German (Outward Interactions) and Improvement by Level

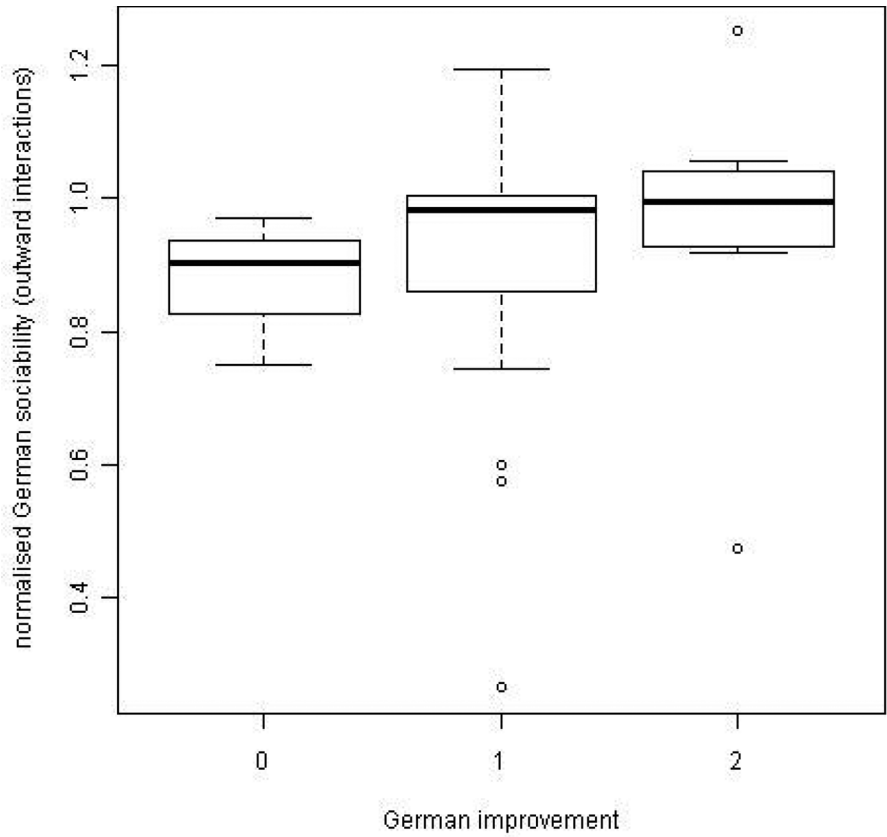
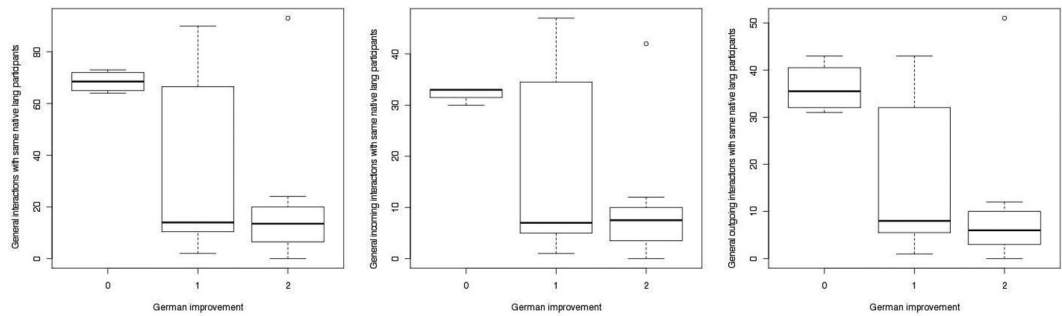


FIGURE 10
General Interactions with Same-L1 Participants

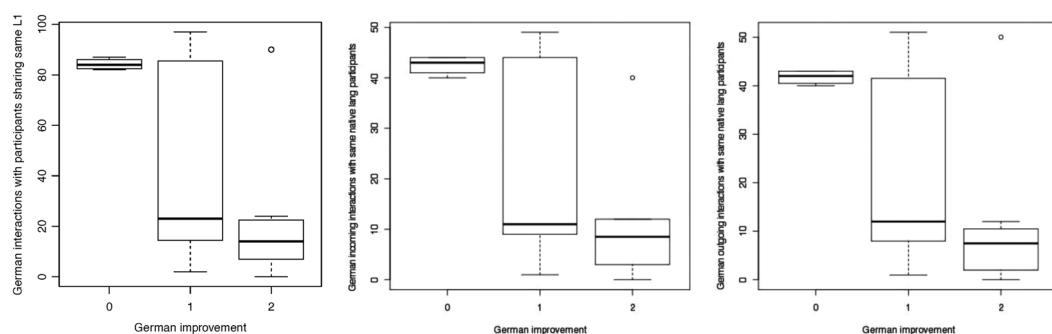


Note. Left: both incoming and outgoing interactions; center: incoming; right: outgoing.

man interactions does not necessarily contribute to improvement in language performance. This mirrors findings by Bernstein (2018) from a study of English language learners in a U.S. prekindergarten, where a more central place in classroom interaction did not lead to greater

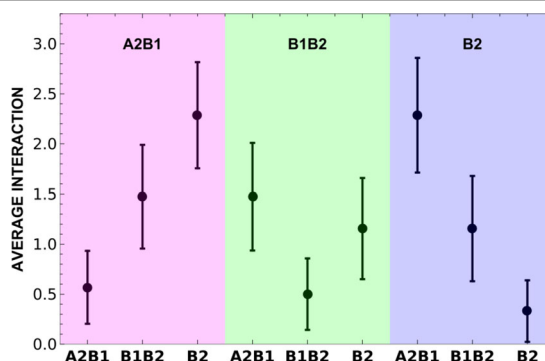
growth in vocabulary and syntactic complexity. One could ask if the resultant graph suggests that students consciously position themselves within the group, as for instance in the case of the two Japanese participants in the very center of the network.

FIGURE 11
German Interactions with Same-L1 Participants



Note. Left: both incoming and outgoing interactions; center: incoming; right: outgoing.

FIGURE 12
Average General Strongest Directed Interactions Between Different Language Proficiency Groups [Color figure can be viewed at wileyonlinelibrary.com]



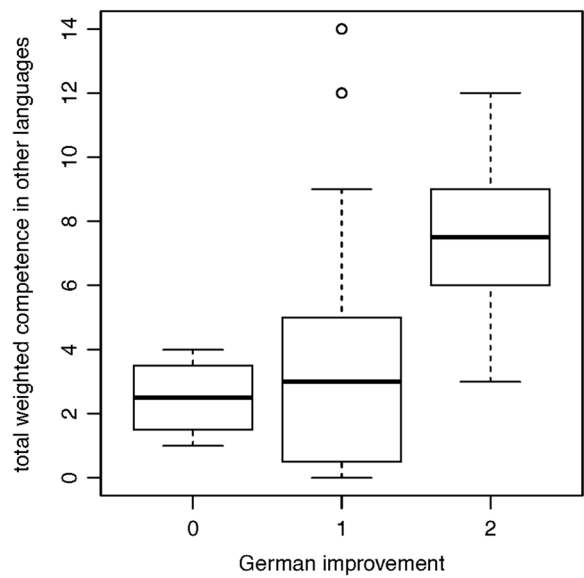
Note. The data points are grouped by interaction source (upper group labels) and sorted by interaction target (lower labels). The same pattern also holds for interactions in German. Error bars indicate one standard deviation.

In terms of community detection, Figure 3 presents the results for the bidirectional network with the weakest links filtered out, found by the OSLOM clustering algorithm, which contains a module calculating the statistical significance of the detected communities.¹⁰ The clustering result was compared with randomly rewired networks in order to rule out false positives. As can be observed, three communities were found: a lower-performing branch comprising mostly the English-speaking students, a mainly Portuguese-speaking group, and the rest. While there was no significant similarity between these communities and the different proficiency groups, community membership was associated with linguistic improvement: There was a significant difference in improvement between the three groups in a Kruskal–Wallis test, $p = .025$, and in

a post hoc Dunn's test resulting in differences between the English- and Portuguese-speaking groups, $p = .049$, Cohen's $d = .93$, 95% CI $[-.06, 1.92]$; and English and the rest, $p = .016$, $d = .92$, 95% CI $[-.20, 1.64]$; with no significant difference between Portuguese and the rest, $p = .82$, $d = .84$, 95% CI $[-.18, 1.50]$.

An additional clue that clustering algorithms can provide is the nodes whose assignment to a community is uncertain or who are members of more than one community. There were seven such nodes in the general interaction networks and two in the German interaction networks. Such double memberships can be interpreted as individuals who keep either uniformly strong or uniformly weak social ties with most alters; it is interesting to observe that, as a group, these nine participants are characterized by statistically lower

FIGURE 13
Total Competence in Other Languages Spoken vis-à-vis Performance



extroversion, $p = .0019$, Cohen's $d = -1.27$, 95% CI $[-2.13, -.41]$ (one missing value of extroversion omitted) than the rest.

Next, we used standard linear correlation tests to examine socially distributed learning. The only significant correlates with (self-reported) improvement are closeness centrality (negative) and weighted clustering coefficient (negative; see the next paragraph), total competence in other foreign languages (positive; also correlated with final grades; see the answer to RQ6), the ratio of incoming interactions in German to general interactions (negative; see the answer to RQ2), and the number of interactions with participants with the same native language (negative; see the answer to RQ4). The details are elaborated as follows.

Out of all the network measures, only closeness centrality in the general directed interaction network and weighted clustering coefficient in the general undirected network (Barrat's variant, as given in Saramäki et al., 2007) had a statistically significant (negative) linear correlation with improvement in the German language (see Figure 5 and Table 1). This is related to the answers to RQ2, since closeness is defined as the reciprocal of a node's total distance to all other nodes, and the distances can be interpreted as the reciprocals of link weights.

Among other network measures, in-degree (in the German network with the standardized

outgoing interactions) was a candidate slightly below the significance margin (weak negative correlation). The result can be interpreted as follows: The lower the average general interaction with others, the better the improvement. Given the characteristics of the clustering coefficient, the intuition could be that it is better to have strong social ties with a few selected people and weak ones with others than to spread oneself thin by building medium or shallow ties with everyone around—the pattern of successful SA language learners gradually narrowing down their initially larger TL-speaker contacts to spend more time with fewer people has been evidenced in the literature (Baker–Smemoe et al., 2014). The in-degree correlation is mainly the result of eight participants—seemingly popular and significantly introverted in comparison with the rest—in the A2/B1 group, who lower the grade adjusted for group membership.

RQ2: Which Types of Interaction Revealed in the Social Graph Structure Are the Most Robust Predictors of L2 Progress?

No significant direct associations were found between extroversion and performance (see Figure 6) or between outgoing interactions (neither general nor in German) and performance (see Figure 7).

TABLE 1
Summary of Main Findings

Variable	Association with Performance (Linear Correlation)	95% CI	<i>p</i> Value
Closeness centrality in the general directed network*	−.34	[−.65, −.031]	.032
Weighted clustering coefficient in the general undirected network*	−.32	[−.63, −.01]	.046
In-degree in German, standardized	−.28	[−.60, .03]	.075
Extroversion	.12	[−.21, .45]	.460
Outgoing interactions (overall)	−.17	[−.49, .15]	.290
Outgoing interactions among same-L1 participants*	−.31	[−.63, .00]	.048
Outgoing interactions in German (overall)	−.03	[−.35, .30]	.870
Outgoing interactions in German among same-L1 participants	−.31	[−.62, .01]	.055
Outgoing interactions in German normalized by general (overall)	.11	[−.21, .44]	.490
Incoming interactions (overall)	.10	[−.23, .43]	.540
Incoming interactions among same-L1 participants	−.30	[−.61, .02]	.064
Incoming interactions in German (overall)	−.26	[−.57, .06]	.110
Incoming interactions in German normalized by general (overall)*	−.34	[−.65, −.04]	.029
Incoming interactions in German among same-L1 participants*	−.38	[−.68, −.08]	.015
Competence in other languages (without German)*	.49	[.21, .78]	.001

**p* < .05.

Participants who failed to show improvement had fewer general incoming interactions, but significantly more German incoming interactions. The latter effect becomes even more prominent when framed in the context of the former. This finding may at first glance seem counterintuitive (suggesting that more incoming TL interactions are associated with poorer performance). However, if one remembers that for each participant, incoming interaction scores are dependent on the reports of others, it follows that those receiving more incoming interactions are at the same time enabling others to engage in more outgoing interactions (in other words, the “receivers” are being “used” by others for speaking—output—practice; see Figure 8).

Neither incoming nor outgoing German interactions alone are strongly associated with homophily in performance. However, when both are considered, the frequency of interaction between participants is strongly associated with similarity in their performance.

There appeared to be no relationship between general interactions and performance.

RQ3: If progress depends on LX^2 use, is what matters the absolute numbers of immersion hours in the language (e.g., in terms of spoken production, total talking time), or the proportion of TL use to total communication (the Principle of Proportional Output)?

A positive trend can be observed between outgoing German interactions and performance when these outgoing German interactions are framed in the context of the general outward interactions (i.e., using $\frac{i_{\text{German}}}{i_{\text{general}}}$,¹¹ indicating the degree to which the participants interacted in German less or more when compared with their general interactions; see Figure 9).

RQ4: Is There a Relationship Between Participants' Language Progress and the Intensity of Their Contacts With Same-L1 Users?

There was a clear negative relationship between improvement and the volume of interactions with peers sharing the same native language, such that participants who showed no improvement in level

interacted more with those sharing their L1 than did the participants who improved by two levels (in the case of outgoing interactions, the association was statistically significant). This effect was observed both for the general and the German interactions (see Figures 10 and 11).

RQ5: Do the Students Prefer to Congregate Around Peers Demonstrating a Similar or Different Level of L2 Proficiency?

Communication between the participants at the most coarse-grained level—that is, at the level of the three groups differing in German proficiency—is anticorrelated. Specifically, the average interaction (outgoing and incoming, general and German alike) is stronger across the groups than within them—Cohen's $d = .58$, 95%CI [.45, .71], $p < .001$ with Mann–Whitney U test for general interactions; Cohen's $d = .55$, 95%CI [.42, .67], $p < .001$ with Mann–Whitney U test for German interactions—and increases with the proficiency gap (see Figure 12). The heterophily effect is most apparent in networks with the weak individual interactions filtered out.

This observation is confirmed by the spatial autocorrelation test based on Moran's I , which indicates random distribution for most of the quantities collected in the questionnaire. The only exceptions are significantly negative¹² Moran's I values corroborating alternating spatial distributions of five measures: assignment to a subgroup (depending on the placement test; z -score = -10.4), initial and final competence in German (z -scores = -7.3 and -6.8 , respectively), final certificate grade (z -score = -3.1), and total competence in foreign languages (z -score = -5.6). Whereas the idea of space built out of interaction networks may not be straightforwardly interpretable, these results point to the relative intensity of interactions between the subgroups and a preference for interactions between students of markedly differing language competences. Logically, this is reflected in the answer to RQ3, albeit formulated in a slightly different framework.

RQ6: Is Target Language Progress Conditioned by Network-External Factors such as Motivation or Competence in Other (Background) Languages?

No direct relationship was found between motivation and performance,¹³ nor between motivation and outgoing interactions in German. Participants' competence in other languages in turn was positively associated with improvement in German ($r \approx .49$; $R^2 = .24$; $p = .0012$; see

Figure 13) and the final grade ($p = .0041$), where competence in other languages was the weighted sum of the participant's competences in all the languages they speak excluding their L1 and German (see Paradowski & Jelińska, 2021, for discussion). In contrast, no association was found with merely the number of other languages spoken.

The main findings are summarized in Table 1.

DISCUSSION

Once it had become clear through empirical L2 development studies that there is a positive relationship between interaction and learning, research moved toward an explanation of the mechanisms behind this relationship (Gass, 2010). Our study contributes to the field by applying a novel perspective, methodology, and metrics to a complete network of SA sojourners learning a second or further language, with a focus on their mutual out-of-class communication.

The importance of the proportion of outgoing to incoming TL interactions is in line with Swain's (1985) output hypothesis and its later iterations suggesting that producing language can lead to deeper processing and consequently trigger interlanguage restructuring. In the words of Tarone and Liu (1995):

It is in those interactional contexts where the learner needs to produce output which the current interlanguage system cannot handle that the learner pushes the limits of that interlanguage system to *make* [emphasis in original] it handle that output, thus keeping the system 'permeable' (Adjemian, 1976) and open to change. In such contexts, the learner functions in much the same way as the learner in Schmidt & Frota (1986): struggling to produce output, becoming aware of a gap or need for a structure, and *then* [emphasis in original] noticing that structure in the input. (p. 120)

Bohman et al. (2010) showed that while in Spanish–English bilinguals semantic–lexical knowledge seems to be driven more by input, morphosyntactic development depends on both input and output. This is in line with the findings by Conroy (2018), which also resonate with those of Rivers (1998) and Magnan & Back (2007), that those SA learners who were most frequent television watchers were not among the high achievers, presumably because this activity happened at the expense of more productive and engaging communication required to trigger interlanguage restructuring. Kurata (2010), in a case study of a Japanese learner's interactions with two Japanese speakers in Australia, found that the overall learning opportunities were

increased with exposure to the TL as *both* speaker and listener. Fathman (1976), in a study of 331 elementary- and high-school L2 learners in the Washington, DC area, found a more marked improvement in groups who were in settings encouraging greater usage of English for communication. Importantly, while Swain's early work was informed by cognitive theory, her later writings were influenced by sociocultural theory and thus remain central to interaction-based research (notably in terms of the notion that learners can help each other notice and acquire new language features; Spada & Lightbown, 2009; Swain & Lapkin, 2002).

Recognition of the importance of the *proportion* of TL use to total talking time (the Principle of Proportional Output) over the absolute amount of time spent speaking the target language contributes to earlier research underscoring the value of immersion, which seldom drew attention to this crucial distinction. The finding is consistent with that of a small-scale investigation by Sabawi and Yıldız (2016), which suggested that the steepest rates of progress are associated with students surrounding themselves with highly dense multiplex relationships using the TL. Alternatively, the lack of a correlation between attainment and mere gross amount of time speaking the second language may hint at the possibility that extended social time spent with friends might take place at the expense of formal language study.

The confirmation that frequent interactions with persons who share the speaker's mother tongue are detrimental to L2 progress—even if those interactions (are claimed to) take place in the foreign language—is probably not surprising. The issue of international students choosing to group together with others who share the same language (Alreshoud & Koeske, 1997) and using their L1 to communicate (Amuzie & Winke, 2009) is well recognized in the SA literature. While upon arrival in a new location, co-national “linguacultural nets” (Smit, 2010, p. 124) may help with initial adjustment, provide solidarity, support, and exchange of information, lingering in this comfort zone (Campbell, 2011) may reduce the motivation to adjust to the host culture, act as a “stumbling block” constraining the development of friendships with other nationals (Campbell, 2011, p. 59; Pearson-Evans, 2006),¹⁴ and consequently hinder long-term language development (Ayano, 2006; Campbell, 2011). Geeraert et al. (2014) concurred that while in the beginning close proximity to co-nationals has a stress-reducing effect, in the long run it can

be deleterious to adjustment and understanding of the target culture. In Magnan & Back's (2007) study of American learners of French in a SA program in France, the only factor having a significant—and negative—impact on learners' language development was interaction in the TL with other speakers of their L1 (while living arrangements and increased interaction with native French speakers did not matter). Sabawi and Yıldız (2016), in their look at 11 boarding-school students, also implied a clear, “almost toxic” (p. 16) negative impact of (nonschool) friend relations coming from the same L1 background—and the student who reported the lowest level of progress had been surrounding herself with co-nationals. The negative influence had also been reported of homestays where the family spoke the learners' L1s (Conroy, 2018; Hashimoto, 1993). Similar findings had been reported in immigrant scenarios; for instance, in a study of the social networks of immigrant adolescents in Sweden, Wiklund (2002) reported lower TL performance among those students who had strong relationships with members of their own ethnic group.

This self-evident result merits comment as well, as there exist several (not mutually exclusive) conceivable explanations:

1. The respondents may be underestimating the proportion of time when they actually switch (back) into their L1s, whether unbeknownst to them or in order to provide the desired answer and project a positive image of themselves.¹⁵
2. Seeing faces associated with a particular culture has been known to prime processing in the congruent language—in other words, facial features suggestive of the mother tongue may be hampering foreign language processing (Hartsuiker, 2015; Woumans et al., 2015) in a similar way as cultural icons do (Zhang et al., 2013).
3. Opportunities to fall back on the shared common denominator mean that calques and translanguaging (Paradowski, 2021) will be easier and less time-consuming ways out of communication breakdown (Pawlas & Paradowski, 2020) than attempts at repair in the TL. This means fewer chances of encountering situations that would push the language users beyond their zone of achieved development (Vygotsky, 1934) into conscious effort at finding out what caused the communication failure; this has the potential of consequently leading to a restructuring of the speaker's

interlanguage (as this happens not only when input is comprehended, à la Krashen, but also—if not primarily—when it is not).

4. Same language background may lead to interference errors being unnoticed, perpetuated, spread, and stabilized.
5. Increased amounts of time spent with same-L1 speakers naturally diminish exposure to interlocutors hailing from other linguistic backgrounds, who may be providing more varied and hence more enriching input. Over time, a close-knit group typically leads to its members becoming more alike (linguistically and otherwise). Conroy (2018) found that SA learners' language development can particularly benefit from residential environments with fellow TL speakers from a mixture of linguistic backgrounds.

Earlier research showed that students do not always use the TL to the anticipated extent and that they often fall back on social relationships with native speakers of their own language (DeKeyser, 2007; Dewey, 2008; Dewey, Belnap, et al., 2013; Freed, Segalowitz, & Dewey, 2004; Wilkinson, 1998a, 1998b). This is, however, a nontrivial relationship, as Baker–Smemoe et al. (2014) found that the language gains of U.S. learners of foreign languages in a SA context were positively associated with the *English* proficiency of their interlocutors—in line with Al Masaeed's (2016, 2018) and Trentman's (2019, 2021) observation that the ability to insert a word from another language in an otherwise TL utterance upon encountering difficulty in expression often actually enables the learner to continue using the TL instead of either giving up or regressing to the other tongue entirely. At first glance, people whose native tongue is English may seem to be privileged given the status of this language as the global *lingua franca* (Paradowski, 2013). But this may have a detrimental effect on the acquisition of other languages. First, because of the principle of least effort. Second, because students may be lured into speaking English by others—in Germany, most foreigners are more fluent in English than in German (Scheller, 2011). This holds especially for native speakers of English, with a well-documented tendency for Americans abroad to use English as much as or more than the TL (Dewey, Belnap, et al., 2013; Freed, 1990, 1995; Freed, Segalowitz, & Dewey, 2004; see also the comment by the DKK coordinator in Appendix B). Observations in the present project showed that three Americans and

one Australian became close friends, which was deleterious to their German acquisition. The data analysis confirms that this clique of friends indeed performed badly: Two did not improve at all, while the remaining two only improved by one level. Thus, once again, the right kind of social network can be pivotal to language acquisition (Dewey, Ring, et al., 2013).

All the students in the cohort spoke English (15 as their L1, 19 as an L2, 3 as an L3, and 1 each as an L4 and L5). Interestingly, this factor did not yield any statistically significant tendencies.

Isabelli's (2001) SA research in Argentina revealed that students declaring the highest levels of motivation were more likely to form strong social networks and, consequently, to develop stronger linguistic skills. Whitworth (2006) likewise emphasized the fundamental importance for learners of generating motivation, and thereby of pushing beyond their comfort zones to develop friendships or acquaintances. Our failure to find an impact of motivation on L2 progress may suggest that if there is such an influence, its nature may be indirect—with motivation shaping social network formation, and only the latter moderating attainment. A correlation between academic motivation and social network centrality had been reported by Li and Stone (2018), among others. Alternatively, the way the construct was operationalized may have been too coarse grained to reveal meaningful relationships.

The benefits of speaking other foreign languages for SA proficiency gains had been observed before (e.g., by Brecht et al., 1995, in a college program in Russia). The strong positive correlation between participants' improvement and their competence in non-L1 languages when taking into account the levels of proficiency—but lack thereof when merely counting the number of other languages spoken—is potentially consistent with the participants differing in their ability or aptitude to learn languages. It is also consistent with our recent findings (Paradowski & Jelińska, 2021) on the superiority of a weighted measure of multilingualism in the setting of teachers' and learners' adaptation to emergency remote instruction during the COVID-19 pandemic.

LIMITATIONS AND FUTURE DIRECTIONS

One obvious risk in administering questionnaires is the prevalence of self-report bias¹⁶ (DeKeyser, 2007). As a means of validating the responses, our study incorporated grades from the final certificates (see the results section), as well

as feedback on the questionnaires by one of the investigators who was a participant in the course herself and had good insight into her peers' social profiles and language development, given her daily interactions within the group. The consistency of the self-reported interactions with her feedback provided a strong indication that the students had answered the questions accurately. In future studies, reports in the form of journal or mobile entries taken at more frequent, regular intervals might provide more accurate data.

Since peer learners are far from the sole source of interactions and exposure to language, in order to capture the bigger picture, our new project (Paradowski, Jarynowski, Czopek, & Jelińska, 2021; Paradowski, Jarynowski, Jelińska, & Czopek, 2021) contains additional questions probing the amount of students' TL conversations outside the group of their classmates. Still, while the results of a small-scale project carried out by Sabawi and Yildiz (2016) indicated that the strongest negative impact on students' progress in the foreign language ("expanding circle") context of a boarding school was that of an increased frequency of *nonschool* friends in the social graph, at the same time they found that family, boarding house, and day school relations had a very low impact on the rate of progress—perhaps due to a lack of opportunity for significant interaction and socialization afforded by these relations, preventing them from adding value to or subtracting from the language learning experience. In the current study, we trust that the findings transpiring from the observation of classmates alone in a context where—at least for the duration of the intensive language course—fellow Erasmus+ exchange students tended to account for the majority of the participants' social interactions are already revealing and valuable.

There is also a need for more longitudinal data. In order to facilitate systematic dynamic time-series analyses and growth curve modeling, future projects may take multiple measurements after successive intervals. This can enable tracing reorganization of the social network structures over time and the resultant changes in study results.

Granted, the process of language acquisition—or any learning, for that matter—is conditioned by numerous variables: motivation, age, aptitude, nonverbal intelligence, working memory capacity, prior knowledge, grit, self-confidence, exposure, opportunities for practice, and so forth. Case studies notwithstanding, it is impracticable for large-scale quantitative research to cover all conceivably relevant variables. Our

intention was to focus on one aspect influencing the SLA process—interactions within the peer learner network—but to do so in a rigorous, comprehensive, and well-thought-out procedure.

As pointed out by Ring et al. (2013), "much is yet to be understood regarding the processes by which SA students form social networks" (p. 95). Subsequent research should thus also take a step back and investigate the mechanisms of network formation.

CONCLUSIONS AND PEDAGOGICAL IMPLICATIONS

From the perspective of an emergent complex adaptive system (Ellis & Larsen-Freeman, 2009; Tabor & Tanenhaus, 2001; The Five Graces Group, 2009; Van Geert, 2009, 2011; Winters et al., 2010), the adaptive properties of a (second) language are shaped by interactions. SNA helps capture the behavior of individuals and establish the degree to which they meet their educational goals. The rigorous methodology employed here allowed plotting the students' individual and social network characteristics against their language progress, returning a number of statistically valid observations. Researchers working in the complexity theory paradigm postulate that in order to capture the complex and dynamic nature of (second) language development, there is the need to merge structural and nonstructural factors and contributions. The current study has aimed at achieving this by looking at issues that had hitherto remained virtually unexplored and applying an ecological approach and a methodological apparatus in a combination never before carried out in natura.

The DKK participants exemplify a well-integrated social network structure, whose members for the most part successfully achieved their L2 acquisition goals. Although the group was formally organized by the university, from the very beginning, one could not but notice a very positive attitude toward cooperation on various planes of their interactions. Despite representing distant countries, nationalities, histories, cultures, customs, mores, values, social conventions, and languages, the 39 individuals managed to build strong and supportive relationships with one another.

The results of the present study advance our understanding of the mechanisms and impact of social interaction on language development. Until now, the complexity of the processes of language acquisition and learning in general has hampered attempts at creating verifiable models

that would realistically take into account the multifarious role of external factors. That is why in-depth analyses of the role of social impact on the effectiveness of SLA are so desirable. The rigorous interdisciplinary research paradigm and its predictive power afford answers to both existing, but still unresolved, and original burning questions about the role of social factors in the learning process, especially in SA contexts, an opportunity seized by more and more students every year,¹⁷ but where instructors and researchers have been pointing to the insufficient linguistic preparation of many undergraduates and graduates. The proposed methodology enables a verification of previously empirically unexplored hypotheses, offering a valuable contribution to, promising insights into, and new perspectives on our understanding of the processes of L2 acquisition. It also adds to the growing body of literature supporting the idea that the quality and nature of linguistic experiences may matter more for L2 development than mere amount of exposure (Moyer, 2011).

From a pedagogical standpoint, by identifying social behaviors that can positively or negatively impact learners' language attainment, one can hope to accelerate students' progress by looking at ways to enhance and encourage beneficial practices while containing and discouraging deleterious ones. The results may aid SA directors in informed programmatic choices regarding the selection of living arrangements (where, for instance, dormitories have often been found to be unsupportive of L2 use due to offering ample contact with L1 speakers; Mendelson, 2004; Rivers, 1998), group placement, and an offer of extracurricular activities with the aim of helping students create and expand their relationships with peers of other nationalities. Teachers in turn could use the results to choose optimal forms of in- and out-of-class activities and assignments (Chi, 2009), such as group- or team-based projects, as well as identify students who might need intervention. Last, the findings may help students themselves raise their awareness of both more and less straightforward relations between their interactions within a group and the effects of learning, so that they can make better-informed choices—especially in the initial, network-building period of their stay. Recommendations that students be tutored in ways to build social networks have been put forward, for instance, by Isabelli-García (2006).

The reported findings highlight the need for a better understanding of the impact of learner networks on language development. It is hoped that

this study will pave the way for future interdisciplinary SLA research adopting a computational full-network SNA perspective in order to better comprehend currently underexplored linguistic phenomena.

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NOTES

¹ In the realm of linguistics, already half a century ago, Jakobson (1963) remarked on the striking coincidences and convergences between the latest stages of linguistic analysis and the approach to language in the mathematical theory of communication.

² Sabawi and Yıldız (2016) attempted a study along these lines; however, (a) the population investigated ($n = 11$) was too modest to allow statistically significant conclusions, and (b) despite the article title (i.e., “An analysis of the relationship between social networks and English attainment of boarding students in Dubai”), the authors only explored egocentric reports of each student's contacts, without reconstructing the graph of relations or applying computational network analysis. Trentman (2013) looked at students studying abroad in Egypt, but with a focus on their contact with members of the local community and relying more on the constructs of imagined communities and communities of practice.

³ Here and throughout, we use the notation of L2 and LX (Dewaele, 2018) interchangeably to refer to the use of any language other than L1.

⁴ In Bochner et al.'s (1977, 1985) taxonomy, the students' social graph and friendship patterns can thus be classified as a multicultural network (other national friendships).

⁵ See Appendix B for a comment by the teacher and organizer of the course, who had previously been modifying and ameliorating its structure for roughly 15 years.

⁶ Available at <https://osf.io/7xgpps/>

⁷ Women's mean improvement was by 1 level, while men's was by 1.1667. This might be due to men's slightly higher tendency to brag in comparison with women—an observation that finds corroboration in the professional experience of one of the authors during her work as a verifier of the linguistic competences of over 60 corporate employees, where men tended to overestimate their proficiency more than women (by .60, $SD = .70$ and .57, $SD = .77$ CEFR levels on average, respectively), but in neither that setting nor this study were the differences statistically significant or the effect sizes substantive.

⁸ Here and throughout, we use the term “graphs” interchangeably with “networks.”

⁹ Presented as the highlight of the *Deutsch-Kompakt-Kurs* was a 1-week stay in the second week of the course at a conference center owned by the university, when the group left the town and travelled to a retreat in the Swabian Jura.

¹⁰ Neither of the other methods provides such a statistical score. Moreover, the Infomap algorithm fails to detect clusters in complete weighted graphs, which is our case, while the Louvain method produces false positive results on randomized networks and suffers from the general problem of resolution (i.e., there is a preferred size of the detected clusters), whose shortcomings make their results uninformative or unreliable in the context of the current study. For the remaining network types, OSLOM too does not find any communities.

¹¹ Where i_{German} stands for total outward German interactions, and i_{general} for total outward general interactions irrespective of the language(s) used.

¹² p values were typically several orders of magnitude below the confidence level.

¹³ The participants' declared motivation to learn German and attitudes toward speakers of the TL and toward the intensive course were all quite high and ranged from 8.02 to 8.56 on a 10-point scale, with standard deviations from 1.19 to 1.59.

¹⁴ This is both because one may conceive the number of available “slots” to fill in a social network as finite (Tooby & Cosmides, 1996), and because staying in a group of co-nationals may reduce the likelihood of being approached by TL speakers.

¹⁵ While most participants orally reported that it was “totally awkward” to speak German among people from their own countries (see also Paradowski, Jarynowski, Czopek, & Jelińska, 2021, p. 110), they claimed that once they tried to do so from the very beginning, they pursued to use German exclusively throughout the rest of the course. This is congruent with Potowski's (2007) observation that the vast majority of social exchanges among English–Spanish dual immersion students in the United States take place in the language of the environment.

¹⁶ A similar idea to the Dunning–Kruger effect (the cognitive bias wherein inept individuals tend to overestimate their level of skills, while actual competence may weaken self-confidence; Ehrlinger & Dunning, 2003; Kruger & Dunning, 1999) had been expressed in the literature by William Butler Yeats: “The best lack all conviction, while the worst / Are full of passionate intensity” (1920, p. 466); Bertrand Russell: “The fundamental cause of the trouble is that in the modern world the stupid are cocksure while the intelligent are full of doubt” (1933, p. 204); and Charles Bukowski: “the problem is that bad writers tend to have the self-confidence, while the good ones tend to have self-doubt” (Mills, 1989).

¹⁷ In 2018, 5.6 million tertiary students worldwide had crossed a border to study, more than twice the number in 2005 (OECD 2020, p. 216).

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APPENDIX A

Participants' Language Competence (L1 and Other Languages Spoken)

Participant	Country	Languages (Proficiency)
1	Spain	Spanish (native), German (A1), English (A2)
2	Israel	Hebrew (native), Arabic (C2), German (B2), English (B1)
3	Brazil	Portuguese (native), English (native), Spanish (C2), German (B1)
4	Brazil	Portuguese (native), English (C2), German (B1)
5	United States, Louisiana	English (native), German (A2)
6	United States, Texas	English (native), German (B1), Spanish (A1)
7	Brazil	Portuguese (native), English (C2), German (B1)
8	Brazil	Portuguese (native), English (C2), Spanish (A2)
9	United States, Illinois	English (native), Spanish (C2), German (B1)
10	Colombia	Spanish (native), German (A2), English (B2)
11	United States, Texas	English (native), German (A2)
12	Taiwan	Chinese (native), English (C1), Japanese (A2), German (A1)
13	Poland	Polish (native), English (C2), German (C1), French (A2), Spanish (A1)
14	United States, Montana	English (native), German (A1)
15	United States, Ohio	English (native), German (B2), Russian (A1)
16	Brazil	Portuguese (native), English (B2), Spanish (B2), German (A1)
17	Italy	Italian (native), English (B2), German (A1), French (A2),
18	United States, South Carolina	English (native), German (A2)
19	Italy	Italian (native), English (B2), German (B1), Spanish (A1)
20	South Korea	Korean (native), English (C1), German (B1)
21	South Korea	Korean (native), English (B1), German (B1)
22	South Korea	Korean (native), Japanese (C1), English (B2), German (B1)
23	Japan	Japanese (native), English (A2), German (A2)
24	Slovenia	Slovenian (native), English (B1), German (B1), Serbian (A2)
25	United States, Pennsylvania	English (native), German (B2), French (A2)
26	Spain	Spanish (native), French (C1), German (B2), Catalan (B2), English (B1)
27	Italy	Italian (native), English (A2), German (A1)
28	Greece	Greek (native), English (C1), German (B1)
29	United States, North Carolina	English (native), German (A2)
30	Ecuador	Spanish (native), German (A2), English (C1)
31	Poland	Polish (native), German (B1), English (A2)
32	Mexico	Spanish (native), German (B1), English (C1), Italian (B2), Portuguese (A2), French (A2), Chinese (A1)
33	United States, Illinois	English (native), German (B2), Greek (A2), French (A2)
34	Japan	Japanese (native), German (A2), English (A2)

Participant	Country	Languages (Proficiency)
35	Italy	Italian (native), German (B1), English (B1)
36	United States, Texas	English (native), German (B1), Spanish (A2), Chinese (A1)
37	United States, Virginia	English (native), German (B1)
38	Australia	English (native), German (B2)
39	United States, Georgia	English (native), German (A2), Latin (B2), French (A1)

APPENDIX B

A Comment by the Organizer and Teacher of the Course

Note. The interview was conducted in German and translated by authors.

The group learning German during the Deutsch-Kompakt-Kurs (DKK) in spring 20XX made considerable progress. The key to the participants’ success was the fact that from the very first day of the course they spoke German with one another. They used German not only in the classes, but also during the breaks, social activities, and private meet-ups.

The principal aim of the DKK is that everybody should speak only German as much as possible. There are many components in the course that were deliberately designed, so that the group were made to speak German. We are deeply convinced that the more often the participants are stimulated to communicate in German (both during and after the classes), the faster and more efficiently they acquire German.

In the spring 20XX course everybody did their best to speak German from the very beginning. There were some communicative people who introduced much dynamics into students’ interactions. They subconsciously established the rule to communicate in German only. Others cooperated willingly. Almost all participants felt like communicating in German, they made friends with one another and the whole group was really sociable. One could observe the wonderful dynamics in the group. Nobody was excluded, everybody was integrated and accepted. The participants were interested in being in touch with the German tutors, as well as in spending their evenings together.

A counterexample to the aforementioned group was the DKK autumn 20X(X–1) group. The latter was dominated by three Americans who spoke only English and subconsciously established such a rule. The remaining students followed them. We the teachers were unable to prevent this phenomenon. Although we kept telling them to speak German, they used English only—both during the breaks and even during the joint meals in [university retreat].

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Supplementary Information