

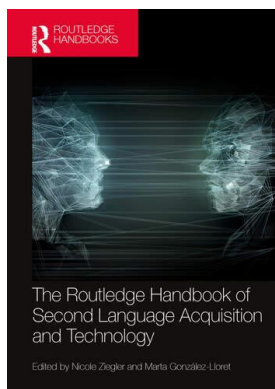
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Access details: *subscription number*

Publisher: *Routledge*

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The Routledge Handbook of Second Language Acquisition and Technology

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Technology-enhanced Approaches to Researching SLA Processes

Publication details

<https://www.routledgehandbooks.com/doi/10.4324/9781351117586-8>

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Published online on: 01 Feb 2022

How to cite :- Rémi Adam van Compernelle. 01 Feb 2022, *Technology-enhanced Approaches to Researching SLA Processes from: The Routledge Handbook of Second Language Acquisition and Technology* Routledge

Accessed on: 11 Dec 2023

<https://www.routledgehandbooks.com/doi/10.4324/9781351117586-8>

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6

TECHNOLOGY-ENHANCED APPROACHES TO RESEARCHING SLA PROCESSES

A Vygotskian Perspective

Rémi Adam van Compernelle

Introduction

As new computer, digital, and mobile technologies have become ubiquitous in educational contexts in most privileged societies they have also increasingly played central roles as research tools in the field of second language acquisition (SLA). In some cases, technology is at the forefront of investigations, while in many others, it is simply the right tool for the right job. In other words, for many of us, technological tools have become part of researchers' cultures of use (Thorne, 2003)—ways we have appropriated and developed various technologies to meet specific SLA research needs.

In this chapter, I examine the uptake of new technologies as tools for generating and analyzing data to investigate SLA processes from the perspective of Vygotskian sociocultural theory (SCT). The central tenet of SCT is that the human mind is mediated by cultural tools, such as language. Vygotsky (1978) argued that humans internalize cultural tools that reorganize the immediate, or direct, stimulus-response processes given to us by biology into mediated, or indirect, higher forms of psychological functioning. For instance, language gives us the ability to categorize objects into conceptual hierarchies (e.g., oaks and maples are part of the category “tree,” which is part of the category “plant” along with bushes and flowers), which allows us to transcend direct perception and relate to the world through abstract concepts. Vygotsky also referred to processes of assistance—intervening to direct a child's use of appropriate tools—as mediation (Wertsch, 2007). In the field of SLA, these two approaches to understanding mediation have generated a large body of research into the process of internalization of additional languages, language instruction, language testing, and the consequences of SLA on multilinguals' cognitive functioning (Lantolf & Poehner, 2014; Lantolf et al., 2018; Lantolf & Thorne, 2006). As we will see in this chapter, technology has played an important role in our investigations of mediation since the proliferation of networked communication technologies in the 1990s. Subsequently, researchers have expanded the use of such technologies as mobile applications, computerized tests, and video analysis software.

Historical Perspectives

As noted, the increased accessibility of networked communication technologies in the 1990s led SLA researchers to explore this new domain of language use in educational and noneducational contexts. While cognitivist researchers focused mostly on issues related to the qualities and contributions to

SLA of input, interaction (negotiation of meaning), and output in computer-mediated communication (CMC) (Ortega, 2009), sociocultural researchers examined the ways in which these new—mainly text-based—communication contexts could mediate language use and language learning opportunities through collaboration and text authorship (Warschauer, 1997).

The concept of mediation was taken up in two ways in this research. The first focused on how the technology itself mediated communicative practices. The second offered insights into the ways technology could help to create contexts for peers and more capable language users to provide assistance to learners. One finding of the first focus was that scrolling chat transcripts, which remain visible during quasisynchronous chat interactions, allowed students to reflect on utterances and produce responses in interaction (Kroonenberg, 1994). In addition, there seemed to be a democratizing effect on turn taking in CMC—students more frequently self-selected as next speaker and took a more diverse range of turn types than in the classroom (i.e., not just responses to teacher questions), which allowed them to engage in more diverse and student-centered discourse opportunities than are typically observed in teacher-fronted interactions (Kern, 1995; Warschauer, 1996). Both of these findings underscore the potential for CMC technologies to mediate communicative processes in ways that may be beneficial to student learning. Asynchronous CMC (e.g., email) offered students the opportunity to collaborate with each other outside of the confines of time and space in the classroom (González-Lloret, 1995). In addition, the potential for communication technologies to connect learners in extramural exchanges meant that language learners could have access to authentic, native speaker discourse as well as assisted performance (Kern, 1996; Kinginger, 1998).

Although these benefits for technology-mediated interaction were encouraging, it should be noted that limitations were also identified. Kinginger (1998) drew on Vygotsky's (1978) notion of the Zone of Proximal Development (ZPD) to hypothesize that videoconferencing interaction with native speakers of French would give US learners access to expert assistance and, as a result, the learners would be able to perform beyond their current individual abilities. However, the interaction actually resulted in a novel form of “language classroom anxiety induced by the stress of public speaking in a networked or linked environment” (p. 510). In addition, the discourse of the French native speakers was too advanced and quickly spoken to be understood by the US learners. In other words, participating in the interaction was beyond their ZPD—it was beyond what they could do even when assistance from a more competent participant was available to them. It was only after a transcript was made and a follow up lesson focused on analyzing the native speaker discourse in collaboration with the teacher that the students were able to benefit linguistically from the interaction. In other words, since the videoconference had been recorded, Kinginger was able to transcribe the speech as text, which was used as a pedagogical tool with which to work within the learners' ZPDs. Thus, while the synchronous interaction alone may not have benefited students, the technology did produce an artifact (i.e., a recording) of this novel interactional opportunity that was later used to scaffold learners' comprehension of it and to foster additional learning opportunities with assistance from the teacher.

Such work continued into the 2000s, with a focus on technology-mediated intercultural exchanges. Belz and Kinginger's (2002) well known study of the development of pragmatic competent in French and German is an example. US learners were partnered with native speakers in France and Germany to collaborate on a project. The French learners used email to communicate with their partners while the German students used synchronous text-based chat. Belz and Kinginger were able to use transcripts from the email and chat exchanges in order to conduct a microgenetic analysis of the US learners' appropriate use of second-person pronouns (*du/Sie* in German; *tu/vous* in French). Methodologically, the technology-based study not only enabled the exchanges to occur, but they also generated real-time data (i.e., transcripts) that captured the moment-to-moment use of pronouns, metapragmatic commentary from the native speakers (i.e., corrections and explanations that they preferred *du/tu* and not *Sie/vous*, which the US learners were

using), and the learners' uptake of appropriate pronouns over time. This was a significant methodological advantage in comparison to pretest-posttest methods for documenting change over time and a reliance on retrospective accounts of exchanges with native speakers (e.g., diaries, interviews) used in study abroad research (see, e.g., Kinginger & Belz, 2005).

Belz and Vyatkina (2008) extended this line of inquiry and capitalized on the immediate availability of textual transcripts from CMC intercultural exchanges for engaging in data-driven learning (Johns, 2002). In their study, Belz and Vyatkina focused on German modal particles. US learners rarely use them, but Germans use them frequently in informal speech as part of building solidarity with their interlocutors. As in the Belz and Kinginger (2002) study, one methodological advantage of chat technologies was that learners in the US could be connected to German speakers abroad. But the real advantage that Belz and Vyatkina proposed was that chat transcripts are automatically produced and can be saved as part of a learner corpus for use in subsequent teacher-guided analyses of learner and native speaker language use without the need for time-intensive transcriptions of audio recordings (e.g., speech from face-to-face or videoconferencing data). In this way, the teacher was able to print out sample transcripts for her students to analyze immediately after each chat and email interaction and then to direct and guide their attention to the relevant features of discourse as part of an explicit pedagogical intervention. Therefore, technology served three methodological purposes: 1) it afforded the intercultural exchanges; 2) it generated real-time data for analysis through traditional and corpus-tool enhanced discourse analysis; and 3) the real-time data were able to be used as the pedagogical materials for the intervention.

The early work summarized above laid the groundwork for designing SCT-informed research studies on L2 development in technology-enhanced environments. The main focus was on connecting learners through communication technologies in order to enhance text authorship, classroom discourse, and intercultural learning. As work in the area has continued, researchers have explored the notions of collaboration and mediation using emerging technologies to create novel contexts of collaborative activity. In addition, researchers have begun to turn their attention to ways in which new and more affordable technologies can be used to collect relevant data in a wide range of online and offline contexts.

Critical Issues and Topics

Since the mid-2000s, SCT research has deployed a range of technologies for data generation and data analysis. Here, I will focus on the potential contribution of technology-enhanced research methods to four critical areas: 1) using technology to examine collaborative activity; 2) using technology to collect data; 3) designing computer and mobile applications that can mediate learner activity; and 4) using technology to document and analyze inner and private speech behavior. My comments here will be brief. Extended discussion of specific research studies is reserved for the following section on current contributions and research, where the critical areas often intersect.

Examining Collaborative Activity

Since the 1990s, the role of collaboration in learning and development has been one of the central research interests in SCT-SLA work (Gánem-Gutiérrez, 2018; Lantolf & Poehner, 2014). Advances in technological affordances in terms of contexts of collaboration (e.g., digital environments, CMC) and data generation and analysis tools (e.g., digital video recording and analysis software) have expanded the methods by which SCT researchers can investigate the ways in which experts and peers can mediate development through collaborative interaction. For instance, CMC, as well as text authorship platforms such as wikis, generate historical data of language use as well as metacommunicative discourse via commenting and text editing that provide a window

into developmental processes (Gánem-Gutiérrez, 2018). In addition, dramatic advances in affordable audio-video recording and computer-based video analysis have allowed researchers to capture and analyze in great detail the nature of multimodal (i.e., language, gesture, environment) face-to-face collaborative interaction (van Compernelle, 2015). For example, several low-cost software packages allow researchers to synchronize multiple audio and video tracks, thereby enhancing their ability to document the precise coordination of collaborative work from multiple camera angles and with relatively high-quality audio.

Technology as Data Collector

In addition to its role in generating data on collaborative activity, SCT researchers have turned to the use of Internet-based technologies to collect a wide range of data. These include surveys and questionnaires, performance tasks (e.g., discourse completion), metalinguistic tasks, and diaries/journals about learning experiences. Time-and-place independence is a major advantage of technology-mediated research methods (van Compernelle, 2017). Internet technologies have an international reach, so researchers are not necessarily limited to local convenience samples. In addition, where researchers work in intact classrooms, online data collection can assist in moving some research activities outside of regular class meetings in order to minimize the invasiveness of data collection or time away from regular instruction. These technologies have therefore expanded the accessibility of research participation for learners and the scope of convenient data collection for researchers.

Technology as the Mediator

A major focus of SCT research in the past decade has been on using technology to mediate development through computerized or online lessons and learning activities. Computerized dynamic assessment (Poehner & Lantolf, 2013) as well as intelligent computer-assisted language learning (iCALL) contexts (Ai & Lu, 2018) have been used as methods for provoking development and simultaneously tracking its trajectory, at least over short periods of time (i.e., microgenesis). In addition, computerized tutorials and mobile applications have been developed as means of researching conceptual development outside of a classroom context (van Compernelle, 2018, 2019). For example, preprogrammed and sometimes adaptive prompts (e.g., hints, corrective feedback) can be included in iCALL contexts and mobile applications as a means of scaffolding task completion and, potentially, mediating L2 development as a consequence.

Documenting Inner and Private Speech

Vygotsky (1986) argued that language functioned internally to mediate cognition. Consequently, the ability to capture and analyze inner speech (subvocal speech for the self) and private speech (verbalized speech for the self) has been an ongoing interest in SCT circles. Indeed, the earliest work in SCT-SLA focused on the functions of private speech (Frawley & Lantolf, 1985), with reference to what was then unobservable inner speech functions. As with advances in recording face-to-face interaction, researchers interested in inner and private speech have benefited from advances in low-cost and powerful recording equipment and video analysis software. This has been particularly useful for gesture researchers, who have argued that co-speech gestures provide insights into inner speech (McNeill, 2005; for L2, see Stam, 2018). For example, by analyzing the synchronization of L2 speech and gesture using video-editing software that allows slow playback while preserving audio, researchers have uncovered evidence that even if L2 speech appears fluent, the L1 continues to influence the underlying thinking processes involved in production (i.e., inner speech) through gesture.

Current Contributions and Research

Collaboration in Technology-Enhanced Contexts

Gánem-Gutiérrez (2018) identifies three principal contexts of collaborative activity in digital spaces that SCT researchers have investigated: 1) wikis, 2) multiuser virtual environments (MUVES); and 3) massively multiplayer online role-playing games (MMORPGs). These contexts of collaboration offer a number of possible advantages in terms of fostering learning and development as well as challenges (for discussion, see Gánem-Gutiérrez, 2018). Here, I will focus on the methodological merits of this research.

Two studies using Engeström's (2008) activity theory¹ have investigated collaborative writing and offer interesting methodological insights into examining writing processes and motives (i.e., how participants orient to the goal of task at hand). Lund (2008) audio- and video-recorded his participants as they constructed their wikis, focusing on the collaborative nature of the interactions around language use and wiki design (e.g., inserting links, text formatting). The wiki itself also made available the students' thinking and writing in more or less real time, so Lund was able to capture the writing and editing process by screenshotting the relevant pages over the duration of the task. Blin and Appel (2011) used asynchronous messages posted to students' wiki forums as a means of understanding how students interpreted the objective of their writing task, for example, how they understood the teacher's instructions as well as orienting to reflecting on language use and formal accuracy. In other words, the forums served the dual functions of fostering collaborative learner-learner communication as well as a producing a record of their writing and revising process that was available for third-party analysts.

MUVES and MMORPGs present potential opportunities for language learning and intercultural exchanges in non-pedagogical contexts for two reasons. First, most such environments include some form of language-mediated communication (e.g., text-based chat) that allows players to interact with one another. Second, MUVES and MMORPGs often involve participants from all over the world, meaning that players from diverse cultural and linguistic background may have the opportunity to interact, negotiate a lingua franca or multilingual practices, and provide language assistance to each other as needed. For instance, Thorne (2008) was able to capture a serendipitous exchange between an American and a Ukrainian player of *World of Warcraft* via in-game text-based chat. In the interaction, the players established an interpersonal context through language-mediated collaborative activity. Although the exchange was predominately in English, the American player did produce several utterances in Russian (the language first used by the Ukrainian player) after consulting with a Russian-speaking colleague through another chat service. In the examples, both players are observed providing assistance to each other and mediating possible language learning opportunities in the chat. However, the methodological benefits of such environments (e.g., capturing authentic language use and spontaneous goal-directed communication) may be limited if transcripts of text-based chat are the only data collected. Of course, as video screen capture software has become much less expensive over the last decade, it may be possible to equip participants' devices for real-time audio and video recording to capture the kinds of collaborative exchanges that take place in text-based chat and audio chat, as well as the actual actions occurring on screen. To be sure, doing so raises ethical and practical questions about obtaining consent for audio and video recording of other players that the focal participants may interact with in game, so it may be more feasible to conduct such research within educational contexts where researchers have access to all participants outside of the game (Scholz & Schulze, 2017; Zheng et al., 2009).

Dynamic Assessment and iCALL

Dynamic assessment (DA) draws directly on Vygotsky's (1978) ZPD concept as an approach to evaluating learner abilities in a way that accounts for what becomes possible with support in

addition to what one is able to do alone. DA has been explored within SCT-SLA since the mid-2000s (Poehner, 2008) as a way of understanding learner responsiveness to mediation as well as learning potential (i.e., readiness to benefit from further instruction). While face-to-face interactions with individual students can be useful for tapping into their ZPDs, this is time consuming and labor-intensive. Computerized DA (C-DA) (Leontjev, 2016; Poehner & Lantolf, 2013; Poehner et al., 2015; Qin, 2018; Qin & van Compernelle, 2021) has recently gained attention as an approach to evaluating learning potential that is scalable to large numbers of test-takers. To date, C-DA instruments have taken several formats, each of which can be used to examine SLA processes.

Poehner and Lantolf (2013) and Poehner et al. (2015), for example, report on multiple-choice C-DAs of listening and reading comprehension in French, Chinese, and Russian. The instruments were designed to include preprogrammed standardized prompts for each item throughout the evaluation. This means that if a learner did not select the correct response on the first attempt, they were given additional attempts along with a prompt (e.g., ‘try again’, a metalinguistic cue, etc.). Point values for the item decreased with additional attempts. The prompts were organized from least to most explicit, which allowed researchers to track how much assistance was needed during the test as well as at what point a learner no longer required assistance. More difficult transfer items at the end of the test were also included in order to assess whether any learning that had occurred during the assessment was recontextualized. Because test administration and scoring were automated in these exams, they could be used rather efficiently by researchers drawing on three scores: 1) an actual score which includes points awarded for items answered correctly on the first chance only; 2) a mediated score, which adds additional points awarded on second, third, and fourth attempts; and 3) a learning potential score, which accounts for the difference between actual and mediated scores in relation to the maximum score.

Qin and van Compernelle (2021; Qin, 2018) have expanded this work into the domain of pragmatics, focusing on implicature comprehension among US learners of Chinese. Qin and van Compernelle’s C-DA used the same methodology as Poehner and Lantolf (2013) and Poehner et al. (2015), although their instrument was more balanced in terms of transfer items: the first half of the test targeted indirect refusals while the second half focused on indirect opinions, which are more difficult because they are less formulaic. Qin’s (2018) doctoral work innovated and took advantage of the computerized format to make the C-DA adaptive. Test-takers first completed an independent performance assessment (i.e., no assistance) of indirect refusal comprehension. A second mediation phase was then presented to test-takers that was tailored to their performance in the independent performance assessment: they were given additional opportunities to respond to items that they answered incorrectly along with assistance. In a third phase, the learners were given another independent performance assessment with new items to evaluate transfer of learning. The three phases were again repeated in a second half of the assessment focusing on the more difficult speech act of indirect opinions. This methodology allowed Qin to generate truly independent scores (i.e., assessment tasks with no access to assistance), individualized learning needs, and individualized diagnoses of responsiveness to mediation.

Qin’s (2018) work links with recent calls to envision intelligent computer-assisted language learning (iCALL) applications within SCT-SLA principles (Ai, 2017; Ai & Lu, 2018). While iCALL has drawn mostly on computational linguistics, Ai (2017) has argued for expanding the concept of “intelligence” to include not only artificial intelligence and natural language processing (NLP) but “computer systems that are designed to be sensitive to the extent and type of mediation learners need ... regardless of whether or not the system used NLP software” (Ai & Lu, 2018, p. 411). In other words, as already noted in relation to C-DA, iCALL systems have the potential to adapt to learner needs in real time and, at the same time, to track language learners’ performances and development on the basis of their interactions with the system. This creates a powerful method for researching microgenetic development as well as the potential differential effect of mediation strategies on individual learners’ developmental trajectories.

Concept-Based Language Instruction

Research into concept-based language instruction (CBLI) has integrated technologies for delivering instruction, collecting data, and tracking development in a number of ways. While CBLI is interested in communicative performance and use of relevant forms, it also places a heavy emphasis on the development of metacommunicative knowledge that can mediate language use. This knowledge is based on scientific, or academic, concepts rather than everyday knowledge or rules of thumb (Lantolf & Poehner, 2014).

Building on van Compernelle's (2014) work on pragmatics instruction, van Compernelle and Henery (2014) integrated two forms of technology into their methods to suit their research context (i.e., an intact French classroom). The first was a relative basic approach to using the web course management system, Blackboard, to assign various concept-based learning tasks focused on the concepts of self-presentation, social distance, and power in relation to the French address pronouns *tu* and *vous*. This methodological choice was motivated by the institutional context in which class time had to be reserved for teaching in the target language (the concept-based materials were in English) and the instructor had to cover a large amount of textbook material. Thus, while the conceptual materials were integrated into the syllabus, it made practical sense to introduce them outside of class via technology in order to reserve class time to building on the concepts in short discussions and other activities.

The second methodological decision was to conduct communicative tasks via synchronous text-based Google Chat. Time pressure was one motive: there simply was not enough time in class for all students to engage in extended communicative tasks. By assigning such tasks as homework for students to complete outside of class with a partner, van Compernelle and Henery were able to collect far more communication data than would otherwise have been possible. An additional motive for the use of text-based chat connects back to earlier CMC research: since a scrolling transcript is available to learners, some of the real-time communicative pressure is relieved so they have more time to reflect on utterances and generate responses. This benefit was seen as particularly advantageous in the context of researching elementary-level French learners (second semester in a US university) who were capable of engaging in interaction to some extent, but very limited—especially at the beginning of the study—in sustaining a prolonged face-to-face spoken interaction. Students were able to copy and paste the transcript for their teacher, and these transcripts were subsequently used for data analysis.

Additional pragmatics research (van Compernelle, 2018, 2019) has designed technology-enhanced instruments to provide online/mobile CBLI that reaches beyond traditional classroom contexts. Van Compernelle (2018) used an online platform to test the effectiveness of concept-based instruction of pragmatics versus a rule-based approach. Conducting the study using an online system provided several methodological benefits: 1) reaching a relatively large participant pool ($n=103$); 2) generating a randomized sorting of participants into concept-based and rule-based groups; and 3) automatic collection and scoring of the data. Thus, in addition to addressing the SLA question of the effectiveness of the two approaches to instruction, the study also demonstrated the feasibility of remote concept-based pragmatics instruction in a technology-enhanced environment. In an ongoing companion study, van Compernelle (2019) has been developing a mobile application that integrates C-DA/iCALL principles of adaptive instruction (Ai & Lu, 2018) by providing individually tailored concept-based feedback on learner responses to a game-like learning activity. The app appears to be particularly beneficial for research because it automatically tracks learner interaction with the system, which research can use to trace learning behavior in real time.

Technology-enhanced CBLI research has thus far integrated technology as a means of expanding the scope and accessibility of study-related tasks beyond the classroom and as means for collecting data relevant to learning processes and products. In addition, technology-enhanced tools may also provide opportunities to mediate development as learners interact with technology-based tasks and feedback.

Video Analysis

Here, I want to turn to work outside of the digital world but in which technology still plays a central role. As noted earlier, some of the first research from SCT-SLA scholars focused on the analysis of inner, private, and social-collaborative speech, mostly based on audio recordings. The availability of low-cost but high-quality audio-video recording equipment, as well as video analysis software, in the last decade or so has greatly expanded researchers' abilities to conduct fine-grained analyses of talk-in-interaction from a multimodal perspective. Such research focuses on the content of speech, its delivery, and its nonverbal gestural, embodied, and environmental co-occurring actions in relation to SLA processes.

Gesture research in particular has utilized video analysis technologies, such as the software ELAN, to conduct studies on speech-gesture synchrony (Stam, 2018). Drawing on McNeill's (2005) extension of Vygotsky's (1986) notion of inner speech, gesture research investigates the ways in which co-speech gestures (i.e., gestures that synchronize with speech) provide a window into internal thinking processes during communication. These technologies have helped to provide insights into language learners' cognition that goes beyond what is analyzable through audio recordings only (Frawley & Lantolf, 1985). For instance, one finding is that even very advanced speakers of a second language who master the linguistic system in communicative speech continue to gesture using patterns from their first language or as a hybrid L1-L2 system (Stam, 2018), meaning that language learners' inner speech remain L1-based or at least heavily influenced by the L1 across the lifespan. In a similar vein, classroom discourse research (e.g., van Compernelle, 2015, 2016) has used video analysis technology (e.g., CLAN, V-Note) to examine the intersection between interpersonal and intrapersonal communication in pedagogical interactions. As with gesture research, this work relies on detailed analyses of speech, gesture, and other nonverbal dimensions of the communicative situation (e.g., eye gaze, objects in the environment) in order to document such processes as mediation, private vs. social speech, and internalization. The major advantage of new video analysis technologies is its ability to synchronize videos and transcriptions of speech along with codes for nonverbal behaviors. These data can in turn be collected as corpora and exported in various formats for both quantitative and qualitative analysis.

An offshoot of classroom discourse research has drawn on video analysis scholarship and the concept of data-driven learning (Johns, 2002), discussed above in relation to telecollaboration. Dolce (2019) and Adams (2020) both used video analysis software to conduct their research on teacher development in classroom discourse management but also as a means of generating data (i.e., coded video clips and transcripts) for the teachers they worked with to engage in data-driven learning. In other words, like Belz and Vyatkina (2008), the data produced for their studies were also used as pedagogical materials to help guide teachers in the analysis of classroom discourse patterns (e.g., turn taking, topic management) with an eye toward democratizing interactive practices in the classroom.

Recommendations for Practice

New technologies offer researchers in SCT-SLA numerous advantages for generating the kinds of data needed to examine interesting questions about L2 development. In addition, technological tools for analyzing new forms of data (e.g., online/digital environments) as well as data from more traditional settings (e.g., classrooms) are enhancing researchers' abilities to document L2 processes. Here, I will offer two main recommendations for research practice derived from the review presented above.

This first recommendation aligns with the historical perspectives as well as current research on collaborative activity in the digital world. CMC, Wikis, and virtual environments offer researchers interesting spaces in which to provoke developmental processes through educational design and to

observe and document these processes in educational as well as noneducational contexts. Consequently, researchers should think about the use of technology not simply in terms of its potential effectiveness for learning, but more important, to document what kinds of developmental patterns are generalizable or context dependent. Such technologies also provide researchers with access to participants beyond the traditional space of the classroom or classroom related activity. Indeed, developing online research tools can expand researchers' access to a wider range of language learners (i.e., not just those enrolled in university courses) from a variety of backgrounds. It should also be noted that digital spaces are common and high frequency communicative environments in their own right. This means that SLA processes observed in them may be substantially different from those observed in more traditional face-to-face or literacy-based learning environments. Research investigating these possible differences (i.e., generalizable vs. context-dependent SLA processes) would make a substantive contribution to the field.

A second recommendation stemming from the review above is to use technology to automatically track developmental processes, or at least to produce records of learner interactions with the technology and/or other learners/language users that can subsequently be subjected to human analysis. While this is frequently done in CMC contexts where the focus is on language-mediated interactions, we should be conscious of the role that tracking learner interaction with learning systems (e.g., C-DA, iCALL) can provide important insights into the moment-to-moment changes taking place. In other words, it is insufficient to collect only product data (e.g., pretest and posttest outcomes); process data are also needed, which can be easily collected via computer/mobile applications, in order to track microgenetic development. For instance, C-DA and iCALL applications can track learner responses and response times as a means of documenting changes in learner response behavior, including the possible reduction in the explicitness and/or frequency of mediation needed. In addition, although not explicitly noted earlier, video screen capture software can provide additional insights into human-computer interaction (e.g., eye gaze, private speech, cursor movements), especially when it captures both the user's screen and the user's voice and face via the computer's built-in camera (e.g., Qin, 2018). Finally, developmental processes related to inner, private, and social interactive speech (e.g., mediation and internalization) may be tracked via in-depth analyses of video recorded data using specialized software.

Future Directions

Although the use of technology in SCT-SLA research dates back over two decades, there has been relatively little critical discussion of its role in research methodology. Future research will do well to consider some of the following points with regard to research design.

More research is needed that engages with learners from underrepresented communities. Technology offers new opportunities to reach beyond convenience samples of (relatively) privileged students in universities who are the majority of the participants in the research reviewed above. In so doing, we would be able to potentially contribute to a social justice initiative in applied linguistics but also to make theoretical contributions about the role played by learner histories, identities, educational circumstances, socioeconomic status, and so on in SLA processes.

There is also a real need for research into adaptive computerized forms of mediation. Indeed, this is probably one of the greatest challenges for SCT research since for mediation to be effective it needs to be tailored to the learner's need at the moment. While teachers can do this in face-to-face interaction, training computerized systems (e.g., NLP systems) to do so is incredibly difficult (Ai & Lu, 2018). Intelligent systems such as C-DA and iCALL have great potential for conducting SCT-SLA research if they can mimic—at least to some extent—the strategies that teachers rely on in order to mediate learners and learning processes. An intermediate goal, of course, could be to follow Ai's (2017) suggestion that we focus on developing systems that can be sensitive to the extent to which learners need assistance and are designed to provide support and track learning/development, even in the absence of NLP technologies.

Note

- 1 Activity theory is derived from Vygotskian sociocultural theory and focuses on the analysis of activity systems of which human actors are a part.

Further Reading

Lantolf, J. P., & Poehner, M. E. (2014). *Sociocultural theory and the pedagogical imperative in L2 education: Vygotskian praxis and the research/practice divide*. Routledge.

This book focused the notion of praxis—the unity of theory and practice—in Vygotskian theory. Examples from concept-based language instruction and dynamic assessment are included, including some focus on technology.

Lantolf, J. P., & Poehner, M. E. (Eds.), with M. Swain. (2018). *The Routledge handbook of sociocultural theory and second language development*. Routledge.

This handbook focuses on Vygotskian theory and its extension to SLA research. A wide range of topics are covered, including three chapters specifically dedicated to technology.

Van Compernelle, R. A. (2015). *Interaction and second language development: A Vygotskian perspective*. John Benjamins.

This book presents an approach to understanding and researching SLA processes in interaction using detailed multimodal analysis of interaction, with specific focus on video analysis.

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