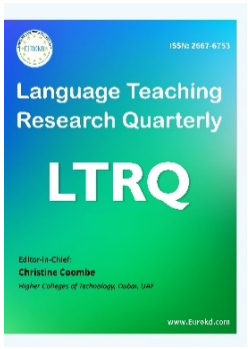

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Foreword

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[1]The breadth of topics covered in this volume gives some sense of the range of Brian MacWhinney's perspectives on and contributions to our understanding of language -- how it is learned, represented, and studied. My brief personal reflections will focus on this latter contribution – how language is studied, and how researchers can be supported in studying the acquisition and use of language, with appropriate attention to variation due to the language features themselves, the learner's stage of development, the linguistic context, the activity being engaged in, and the presence of clinical impairments.

Kempe, Brooks and Gillis in their chapter in this issue identify the launch of the CHILDES project (database and associated analytical tools) as the beginning of the 'big data' approach in child language. CHILDES had been in its turn inspired by the example of Roger Brown, who in the 1960s acted on the idea that any transcript of a child's utterances could be recurrently analyzed from multiple independent perspectives. Brown thus produced (with the help of his long-suffering secretary and an overworked mimeograph machine) multiple copies of the transcripts of Adam, Eve, and Sarah interacting with their parents and/or the Harvard graduate students recruited to lug enormous tape recorders to home visits. Those transcripts were analyzed in a regularly scheduled seminar that included Samuel Anderson, Ursula Bellugi, Courtney Cazden, Richard Cromer, Gordon Finley, Colin Fraser, Jean Berko Gleason, David

[1]This paper is part of a special issue (2024, 44) entitled: In Honour of Brian MacWhinney's Five-Decade Contributions to Language and Psychology Research (edited by Zhisheng (Edward) Wen and Hassan Mohebbi).

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McNeill, and Dan Slobin. (One set of those transcripts constituted an early entry into the CHILDES English database and lives on there still, even as the mimeographed pages have dimmed below legibility.)

In 1984 the MacArthur Foundation funded a research network focused on the transition from infancy to childhood. The Foundation provided funds for each of several local nodes of the network, and for yearly meetings of all the participants. I was part of the Harvard node, and Brian (because of his prior affiliation with the University of Denver) belonged to the San Diego node, led by Elizabeth Bates. Brian proposed a shared data bank for the language of children in the transitional developmental period that the network targeted – making the sensible argument that individual researchers' efforts to accumulate reasonable sample sizes were operating in very small increments. This was the period when n=3 was the default, and n=25 was gargantuan. We anticipated some difficulty in wresting our colleagues' data sets away from them but great joy at the prospect of being able to analyze a much-enriched database. In fact, datasets were donated with alacrity, as if we were all finally finding a home for the artifacts accumulating in our elderly parents' attics. Getting folks to actually use the data was, on the other hand, surprisingly slow; it required offering pedagogical supports for their own entry into the system and tools that would enable them to introduce the system into their teaching. Brian facilitated all these efforts by recruiting collaborators, contributing his own time and design skills, and disseminating knowledge of the affordances of the system. It should be acknowledged that the affordances of the system were at the beginning somewhat limited: automatization of the analytic procedures that we had been doing by hand (MLU, TTR, morphology analysis, frequency counts, word searches, etc.) But it developed quickly, thanks to Brian's willingness from the very beginning to design it as a field-wide collaboration. If some user suggested that new analysis or organizational feature would be useful, Brian acknowledged the need and oversaw its design and introduction. Thanks to Brian's generosity and responsiveness, CLAN was a product of distributed cognition, ultimately so widely used because it reflected the needs of the field.

Keeping the system going after the initial funding from MacArthur required regular and recurrent grant writing, efforts which Brian undertook with no apparent agita. He also had the vision, from the very beginning, of expanding the system beyond child language, to incorporate other data sets, including adult talk, classroom talk, talk produced by individuals with various cognitive or language disorders, as well of course as talk in as many different languages and crosslinguistic situations as possible. By now both the databases and the tools available for using the databases have expanded beyond anything we could have imagined in 1984. One of the most recently developed tools, collaborative commentary (see Fromm and Kowalsky chapter in this issue), in fact hearkens back to Roger Brown's mimeographed transcript pages, on which it is possible to see notes written in different colored pens by Melissa Bowerman, Rick Cromer, Ursula Bellugi and other participants in the collaborative analysis of the original transcripts.

Brian MacWhinney is, ultimately, a romantic. He dared to assume that researchers would operate in a spirit of generosity and collaboration, sharing their data and contributing their ideas about how to expand and improve a set of tools being offered to them. He launched CHILDES in an era when data exchange required mailing floppy discs and when teaching others how to use the system required holding IRL workshops. But making the system available created an

understanding of how, one day, big data about actual language use and large-group cross-site collaborations might help us answer a wide array of questions. Perhaps that day has come.

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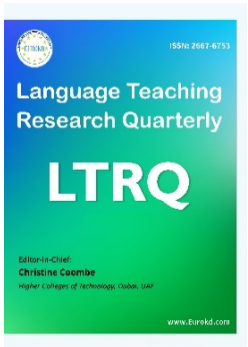

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Editorial: In Celebration of Brian MacWhinney's Five-Decade Contributions to Psychology, Computational Linguistics, and Modern Languages

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[1]Introduction

It is with great pleasure that we announce this latest edition of this special issue of LTRQ to celebrate the landmark achievements of Professor Brian MacWhinney. Brian MacWhinney is Teresa Heinz Professor of Psychology, Computational Linguistics, and Modern Languages at Carnegie Mellon University. Over a distinguished academic career spanning more than 50 years, Brian has made significant contributions not just to the three areas listed under his professor title, but far beyond.

Along his long list of groundbreaking achievements that have had lasting impacts across the multiple fields, the CHILDES (Child Language Data Exchange System) Project he co-founded with Catherine E. Snow back in 1984 stands out as a pioneering and trailblazing initiative for the computational study of child language transcript data. Since its inception, this

[1] This paper is part of a special issue (2024, 44) entitled: In Honour of Brian MacWhinney's Five-Decade Contributions to Language and Psychology Research (edited by Zhisheng (Edward) Wen and Hassan Mohebbi).

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data exchange and sharing system has now extended to 13 additional research areas, including L2 learning and code-switching, featuring dozens of languages under the auspicious of the TalkBank Project. The CHILDES system has benefited scholars from diverse disciplines, including psychology, language and neuroscience, including those working in the areas of bilingualism and language disorders.

Following the establishment of the CHILDES system, we are gradually entering the digital and AI-driven era in recent years. Brian's recent work has subsequently expanded to empirical studies of online learning of second language vocabulary and grammar, neural network modeling of lexical development, fMRI studies of children with focal brain lesions, and ERP studies of between-language competition, culminating in his influential framework of the Unified Competition Model (MacWhinney, 2005). This encompassing framework has enabled scholars from both language and psychology fields to analyze first and second language learning as facets of a single, unified system. Meanwhile, Brian has also explored the role of grammatical constructions in the marking of perspective shifting and the construction of mental models in scientific reasoning. Some of his most influential edited books include *The Handbook of Language Emergence* (Wiley, 2015) and *Competing Motivations in Grammar and Usage* (Oxford, 2014).

As the guest editors of this Special Issue, we set out to celebrate the influential work of Brian MacWhinney and his immense contributions to cognitive psychology and language learning research. We extended invitations to all potential contributors who have either been former colleagues, collaborators, or postdoctoral fellows/students of Brian. We are pleased to report that our calls have received a very positive and encouraging response, allowing us to assemble an impressive lineup of scholars from around the world to contribute these theoretical and empirical papers. Their contributions aim to explore both theoretical issues and empirical investigations from multiple theoretical perspectives and research paradigms spanning the broad domains of language and psychology, including psycholinguistics and second language research. All of these papers have been directly or indirectly influenced by Brian's theoretical models and research insights. To better organize these papers, we have structured this Special Issue into three distinct parts based on the specific sub-themes they are addressing.

Organization and Summaries of the Papers

The Special Issue begins with the **Foreword** written by **Catherine E. Snow** who co-founded the CHILDES system with MacWhinney in 1984 and provides a historical account of it, thus reflecting the academic achievements and personal character of Brian. Then following this **Editorial** (**Wen & Mohebbi)**, the Special Issue continues with an interview with Brian conducted by the two guest editors (**MacWhinney, Wen, & Mohebbi)**. The interview aims to solicit answers from MacWhinney directly, based on a prepared list of questions regarding some significant milestones and landmarks of his distinguished 50-year career, tracing his journey from a research student, to a teaching and research faculty member, a prolific book author and editor, and up to his current projects and future plans (even after his 'retirement').

After these introductory papers, **Part I** of the Special Issue contains three papers that focus on the CHILDES system and its associated tools. The first paper by **Kempe, Brooks, and Gillis** provides a detailed account of the world's very first open science data exchange and sharing system, namely, the CHILDES system co-founded (with Catherine E. Snow) forty

years ago and maintained by Brian until now. This paper chronicles the history, developmental milestones, and key features of the CHILDES system. The second paper by **Nan Bernstein Ratner** moves on to discuss a subsidiary component of CHILDES, namely, the TalkBank feature, which allows researchers to assess and treat speech and language disorders, thus augmenting clinical insights with computing information. The last paper in this section by MacWhinney's two close collaborators, **Fromm and Kowalski,** highlights the new language analysis tool (aka Collaborative Commentary) recently added to the TalkBank system. This innovative tool capitalizes on the rich resources from the TalkBank databases to share commentaries addressing important research and teaching objectives. In doing so, the paper underscores the very spirit of 'collaboration' that has been epitomized throughout Brian's long-term career.

If Part I is intended to be more practical and clinical in nature, then, **Part II** can be considered as more theoretical and exploratory. This part contains five papers that focus on the instrumental theoretical framework of the 'Unified Competition Model' and its related insights postulated by Brian. Based on the two mechanisms within Brian's framework, namely, that of competition and transfer, the first paper by **Kroll and Dussias** makes a strong case to argue that language processing among bilingual speakers is shaped by competition. The second paper by **Tokowicz, Warren, and Tolentino** continues **to** provide a comprehensive account of Brian's 'Competition Model' as a conceptual framework for explaining cross-linguistic similarities and implications for L2 morpho-syntax learning. Turning to a slightly different perspective, the third paper by **Wang and Christiansen** outlines the mechanism of chunking that underpins language acquisition, processing and performance. Following these three papers describing general theoretical accounts, the fourth paper (by **Pléh**) and the fifth paper (by **Chen & Perfetti**) delve into more specific languages, namely, -- Hungarian and Chinese -- that Brian has either directly involved in investigations (Hungarian) or indirectly influenced (Chinese).

Part III contains two papers that wrap up the Special Issue. The first is a lengthy **Commentary** from **MacWhinney, Panahi, and Mohebbi** that presents detailed literature and bibliometric analyses of the sub-domains influenced by MacWhinney's theoretical frameworks and empirical insights. The commentary ends with Brian's very own response to these findings and his further thoughts on their implications for language learning and teaching. Then, the final paper of the Special Issue is written by MacWhinney's former mentee (**Ping Li**) and two generations of doctoral students (**Helen Zhao & Zhe Gao**). This paper shares with readers the personal impressions and contacts the authors have had with Brian at different stages of their careers. Overall, these historical accounts (bibliometric and personal) serve as strong testimony to Brian's enormous influences on generations of scholars who have now become, or will soon become, well-established scholars themselves. In this way, the 'Brian legend' lives on.

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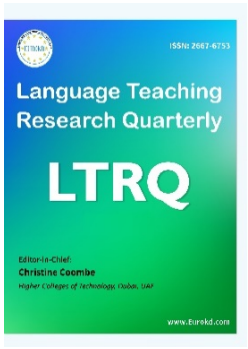

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An Interview with Brian MacWhinney on His Lifelong Commitment to Psychology and Language Learning Research

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[1]Dear Professor MacWhinney, many thanks for accepting our invitation for the interview.

1. **Edward and Hassan:** Let's begin with some background. Could you please share with us your journey into the field of psycholinguistics? In other words, what sparked your original interest in this area of research in the first place? For example, were there any specific persons, experiences, or events that influenced your decision to pursue psycholinguistics/psychology, and how has your background in cognitive psychology shaped your approach to studying language acquisition and processing?

Brian: I have always had an interest in languages. When I was 13, I visited Mexico City as an exchange student with the son of Luis Echeverría who later became President of Mexico. Throughout High School, I studied Latin and eventually presented my own translation of

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Cicero's First Oration against Cataline winning a prize at the national Oratory competition. However, what really hooked me on Psycholinguistics was a summer school at Berkeley organized by Dan Slobin, John Gumperz, Eve Clark, and Susan Ervin-Tripp with themes ranging from child language to Conversation Analysis. Then classes from Chafe, Fillmore, Searle, Macneilage and others got me finally hooked on trying to understand language structure and language learning.

2. **Edward and Hassan:** As we know, you and Professor Catherine Snow set up the CHILDES platform that has impacted the field of psychology, psycholinguistics and language acquisition. Could you share with us the story behind the establishment of CHILDES (although you've written about this somewhere else)? Specifically, for example, what motivated you to create this platform, did you encounter any difficulties in the process? How has the platform facilitated collaboration and data sharing among researchers worldwide? Additionally, could you highlight some notable research findings or breakthroughs that have emerged from the CHILDES database? Also, would you do things differently if you had the chance to do this again?

Brian: The idea of setting up a computer database for child language originated during a workshop that Dan Slobin organized at the Max Planck Institute in Nijmegen in 1981. We were all working with paper copies of transcripts loaded with handwritten comments in the margins that could scarcely be read, let alone tabulated and shared. Roger Brown had attempted some form of data-sharing by running photocopies of his transcripts from Adam, Eve, and Sarah. However, we reasoned, why not computerize this data and share it more broadly. Then, in 1983, at a summer meeting in the Rockies of the MacArthur network for child development research, I mentioned the idea to Catherine Snow who said that she had been thinking exactly the same thing. We proposed the project to the MacArthur board and they accepted right away, providing funding for an organizational event that met in the snowy Winter in Concord, Massachusetts. Twenty child language researchers participated and we agreed on the framework for the project which was then further supported by MacArthur and eventually by NIH and NSF.

The biggest difficulties we encountered were those involved in transferring typewritten and even hand-written transcripts to computer files. Since then, the technology underlying CHILDES and TalkBank has blossomed along with the stunning advances in computers, AI, and the Internet, and we have extended the project into 14 separate topic areas including second language, Conversation Analysis, bilingualism, aphasia, child phonology and several others. Our biggest current problem involves trying to deal with the mass of new governmental regulations making data-sharing much more difficult than it was back in 1984, despite the stated importance of "Open Science".

Given the fact that over 10,000 published articles have relied on the data and programs from CHILDES and TalkBank, it is difficult to summarize the results of all this work. For child language, we now know so much more about differences between languages and children, variation in the ways in which constructions are learned, and ways in which parents help their children to learn. In a fundamental sense, our current picture of child language learning is based primarily on facts derived from CHILDES. Other areas of TalkBank have not yet matured to

this level, although the tools are now available to make similar progress for second language learning, bilingualism, and various language disorders.

Looking back, I find it hard to imagine doing things differently. My only possible regret is that I didn't manage to keep up with my learning of Mathematics.

3. **Edward and Hassan:** Your competition model has been highly influential in the broader fields of psychology, linguistics and education. Could you provide its basic assumptions and explain the key principles of the model and its implications for understanding language processing and acquisition? Moreover, could you provide examples of how the competition model has been applied to specific language phenomena or developmental stages, and what insights have been gained from these applications?

Brian: I think it might be best for readers to just refer to a recent chapter on this topic (MacWhinney, 2021).

4. **Edward and Hassan:** We noticed you recently guest-edited a special issue on the topic of neuroemergentism in the journal *Frontiers in Psychology*. Could you please explain the difference between emergentism and neuroemergentism? What are the key principles of neuroemergentism, and how do they account for the relationship between neural processes and mental phenomena? Finally, what implications does the framework have for language evolution, acquisition, and processing?

Brian: Neuroemergentism is a specific application of emergentist analysis to neural functioning. Emergentism was first articulated by George Henry Lewes in 1875 using the emergent properties of water as an example. With roots in Darwin's theory of evolution, there are many emergentist accounts of population distributions, genetic drift, pandemics, protein structures, and other aspects of Biology. Application of these ideas to human social structures such as language and memetics uses similar reasoning about proliferation, competition, selection, levels, constraints, mechanisms and timescales. When we look at the brain, we find a series of proposals about the emergence of structure and processing based on induction during embryogenesis, migration from the germinal matrix, competition of cortical projections to areas, gene expression, synaptogenesis and synaptic pruning, and neuromodulators. These various internal forces interact with incoming experience and the shape of the body to lead to the formation of structures on the linguistic levels of audition, articulation, morphology, lexicon, constructions, syntax, mental models, narration, and conversational interaction. Thus, neuroemergentism can be viewed as a specific type of emergence.

5. **Edward and Hassan:** How have you seen the field of cognitive psychology and psycholinguistics evolve throughout your career from the 1980s to now, and what significant advancements or changes have you observed? For instance, have there been any paradigm shifts, methodological advancements, or interdisciplinary collaborations that have shaped the trajectories of the field? Additionally, how have these changes influenced your own research and theoretical perspectives?

Brian: Cognitive Psychology has gone through massive changes in the last five decades. The 1950s saw the shift from behaviorism to a system of symbolic AI led by MIT and CMU. In the 1980s, connectionist models challenged the prevailing symbolic models. In the 1990s, new experimental and imaging data supported an increasingly important role for embodied cognition in perception, action, and language. In the early 2000s fMRI studies initially support a rather modular view of language processing, but with the refinement of those methods, a much more interactive view emerged. We are now seeing a convergence of usage-based, crosslinguistic, and corpus Linguistics, AI modeling through large language models, situation sampling, data-sharing, and more dynamic use of imaging methods that are helping us understand how language structure emerges in the society and the learner.

6. **Edward and Hassan:** With the recent emergence and prominence of artificial intelligence (AI) and large language models (LLMs), what are your thoughts on their potential contributions to psycholinguistics and language acquisition research? In particular, given that one of your early developed CHILDES tools was also (incidentally) called 'CHAT', which in retrospect was very forward-looking as the current ChatGPT prevails, how do you see LLMs enhancing our understanding of language processing and acquisition, and what challenges or limitations do you foresee in incorporating these technologies into empirical psycholinguistic research?

Brian: I don't think that choosing CHAT as the name for our transcription format really foretold the advent of ChatGPT. But it is certainly true that we are now using trainable Transformer models to automatically transcribe, code, and analyze all types of data in TalkBank. Of course, these models don't learn the way humans do, but we can work with variations on these models, such as including more realistic multimodal input and conversational training to allow them to serve as better models of human learning.

7. **Edward and Hassan:** What is your stance on the difference between first and second language acquisition? Considering your extensive research on second language acquisition, what key insights or findings have you uncovered that could inform language teaching and learning practices? For example, are there any specific strategies or approaches that have been shown to be particularly effective in promoting second language acquisition, and how can educators and language learners benefit from these insights?

Brian: There are various differences between first and second language learning, but also many similarities, including the ambient language, human nature, the body, and the brain. The two biggest differences relate to the impact of the first language and the changing nature of the social pressures on the learner. Thinking of these differences in terms of some Critical Period is not very illuminating, although there certainly are changes involving some loss of plasticity with age. We have a complete account of this in a recent paper (Caldwell-Harris & MacWhinney, 2023).

8. **Edward and Hassan:** As a renowned expert in the scientific and interdisciplinary fields of psychology, linguistics, language education and computer science, what advice would you

give to young researchers who are interested in pursuing a career in psycholinguistics or language acquisition? Are there any specific areas of research or methodologies that you believe will hold great potential for future advancements in the field? If possible, what books/titles you would recommend for newcomers to read before they enter psycholinguistics?

Brian: One can pursue language studies either in an academic context or a commercial context. However, for both pathways, it is important to acquire two types of skills. One relates to specific methods such as neuroimaging, corpora, statistics, machine learning, clinical applications, or sociolinguistics. The other is learning and thinking about basic ideas supporting both the science and practical applications. It is easy now to focus on acquiring technical skills, because they have become so important and complex. However, understanding the general scope of language function, structure, and learning allows one to better understand the possible contributions from the various methods.

9. **Edward and Hassan:** Looking ahead, what do you see as the most pressing challenges or unanswered questions in the field, and where do you think future research efforts should be directed? Are there any emerging topics or interdisciplinary avenues that you believe deserve more attention, and how can researchers address these challenges to further our understanding of language and cognition?

Brian: For child language learning, we need complete working models of language learning based on data available in CHILDES and new data that will be available with new technology. For second language learning, we need to enroll learners in studies that use wearable devices to track the course of their language learning in terms of amount of exposure and specific interactions.

10. **Edward and Hassan:** After a remarkable career and numerous contributions to the field, what are your plans after retirement, and do you have any ongoing projects or plans that you would like to share? Are there any particular areas or questions that you hope to explore in your post-retirement endeavors, or any ways in which you aim to continue supporting the field and mentoring research students and junior colleagues?

Brian: For me, retirement means handing over the running of TalkBank to the new generation. It would be a shame to see it evaporate. Of course, I will be available for advice on how to make things work. Once I do that, I want to write up a complete view of what we know about the emergence of language.

11. **Edward and Hassan:** Lastly, based on your vast experience and knowledge, what do you envision as the future of psycholinguistics and its potential impact on our understanding of language and cognition? Are there any exciting advancements or emerging trends that you believe will shape the field in the coming years (say in 10 years), and how do you foresee these advancements influencing other disciplines or real-world applications of language research?

Brian: This seems like questions 6 and 9, to me. I think we are seeing advances on virtually all fronts. The trick is putting the pieces together and that is why emergentist theory is important.

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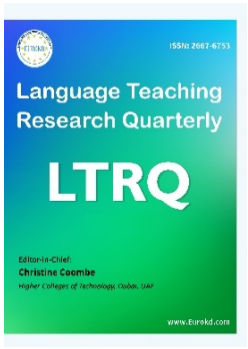

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Four Decades of Open Language Science: The CHILDES Project

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Abstract

The Child Language Data Exchange System (CHILDES), created by Brain MacWhinney and Catherine Snow in 1984, is one of the earliest Open Science and data sharing initiatives in child language development research, and probably in developmental psychology and the behavioral sciences more generally. It is the cornerstone of TalkBank—a repository of transcripts, audio, and video files of natural language samples. Here we highlight how the CHILDES Project served as a trailblazer for the language development research community by being the first initiative to introduce a Big Data approach, encouraging and facilitating crosslinguistic data collection and championing science collaboration through open access to data and analysis tools. We conclude with an outlook on the future of CHILDES and suggestions for where child language development researchers might turn their attention when collecting and donating observational data. Understanding the many paths to language will require expanding CHILDES to increase representation of culturally and neurally diverse populations, finding solutions to the challenge of promoting Open Science practices while safeguarding participant agency and privacy, and leveraging AI tools for automated transcription and data analysis.

Keywords: *Open Science, CHILDES, Big Data, Child Language, Data Sharing*

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[1]Introduction

Child language development research has a rich history of collecting observational data. Known efforts date back to the beginning of the 20th century and consist of detailed records

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ttps://doi.org/10.32038/ltrq.2024.44.04

by parents of their children's early language production (e.g. Stern & Stern, 1907, for German, Pavlovitch, 1920, for Serbian, Isaacs, 1930, for English, and Gvozdev, 1948, 1949, for Russian; see Slobin, 1968, for a review). Given the potential bias and selectivity of diary entries, once portable recording equipment became accessible and affordable, researchers and other interested adults began recording children's vocal productions and transcribing them for further analysis. Many of the early efforts to document child language development focused on longitudinal observations of a small number of children (e.g., Bloom, 1970; Brown, 1973). The initial emphasis on case studies greatly constrained generalizability of findings, prompting the need for efforts to pool data across laboratories and languages to further understanding of variability in language development trajectories.

The visionary contributions of Brian MacWhinney and Catherine Snow were to lay the groundwork for a data exchange system that would allow researchers to grow a database of authentic language samples collected from many children and to make the data freely accessible to researchers, students, and the interested public. The idea for the CHILDES project emerged in 1981 at a conference organized by Dan Slobin at the Max Planck Institute for Psycholinguistics in Nijmegen on the topic of crosslinguistic influences on language development (IASCL Child Language, 2023), and developed further in conversations with Susan Ervin-Tripp and Willem Levelt (MacWhinney & Snow, 1985). At the time, copying technologies like the mimeograph had made it possible to share paper transcripts of child language, albeit at a limited scale, to interested researchers. As an early example, Roger Brown's transcripts of Adam, Eve, and Sarah's early language development were circulated via paper copies, with just 12 copies available in total (IASCL Child Language, 2023). With the advent of the personal computer, the group meeting in Nijmegen came up with the idea of entering the data from the paper transcripts onto computers and making the digital files available to language development researchers around the world. The early efforts to share CHILDES transcripts and data analysis programs relied on floppy disks, CD-ROMs, and the postal service (IASCL Child Language, 2023). Thus, CHILDES preceded by several years the launch of the Internet in 1983 and the development of the World Wide Web—an invention that would make it possible for researchers (and the lay public) to use their personal computers to access and transfer data. A couple of years later, in 1984, the Child Language Data Exchange System (CHILDES) was born with funding provided by the MacArthur Foundation (MacWhinney & Snow, 1985).

CHILDES corpora are sets of transcripts and supporting media (when available) collected by researchers with varied research aims and donated to the repository. From the start, the CHILDES Project included data from a variety of languages in addition to English, such as Danish (Plunkett, 1986), Dutch (Elbers, 1985; Gillis, 1984), French (Suppes et al., 1973), German (Wagner, 1985), Hebrew (Berman, 1990), Hungarian (MacWhinney, 1974), Italian (Volterra, 1972), Polish (Weist et al., 1984), Spanish (Linaza et al., 1981), Tamil (Narasimhan, 1981), and Turkish (Slobin, 1982). Efforts to build the database of media often involved digitizing original audio files delivered via nine-track tapes or cassettes (e.g., Hall et al., 1984; Nelson, 1989). At the time of writing, 42.0% of the corpora had accompanying audio files and 11.7% had accompanying video. The difference in the availability of audio vs. video recordings in CHILDES has not changed markedly over the years, and likely reflects considerations related to protecting the privacy of participating children and their family members. Privacy

considerations may also require certain recordings to be embargoed; the description of CHILDES we provide below therefore refers only to its publicly accessible part.

To facilitate analysis of the written transcripts, MacWhinney and Snow (1990) developed standardized conventions for transcribing utterances (CHAT: Codes for the Human Analysis of Transcripts) and dedicated software for data analysis (CLAN: Computerized Language Analysis). CLAN encompasses dozens of different commands. As examples, *freq* generates frequency counts of words, parts of speech, and other coded information, *kwal* (key word and line) searches for specific words or coding categories, and *combo* searches for specific combinations of elements (words, codes, etc.). Other commands calculate summary statistics, e.g., *MLU* for mean length of utterance and *VOCD* for vocabulary diversity. These and other CLAN commands have been developed and refined over the years, with up-to-date manuals and programs available on the CHILDES website (https://childes.talkbank.org/). Additionally, with Yvan Rose and others, MacWhinney developed Phon, a software tool for examining phonological development (Rose et al.., 2006) and PhonBank (Rose & MacWhinney, 2013), a repository of child phonology data that is now part of the TalkBank system (MacWhinney, 2019). Phon automates coding of segments, syllables, and other phonetic and phonological features of children's speech production and supports direct comparison of adult-produced (i.e., target) and child-produced forms. CHAT transcripts and associated media files interface with a number of other programs including Praat for phonetic analysis (Boersma & Weenink, 1995-2023) and ELAN for annotation of audio and video files (Auer et al., 2010), and with scripting languages like Python to allow users to pipe data from one tool to another. Together, these tools allow diverse corpora, organized in a large and coherent database, to be analyzed using similar procedures.

Example (1) is an excerpt from a transcript within the MacWhinney (1991) corpus illustrating how CHAT is used to format the transcript. In CHAT, metadata containing information about participants, available media, date, situation, and other comments are listed on lines that start with the symbol @. The *main tiers* of the transcript start with the symbol * followed by a three-letter abbreviation of the participant's role (*FAT, *CHI). These lines contain a standardized orthographic transcription of the recorded speech, with specific conventions for marking overlapping speech, interruptions, pauses, repetitions, special words (e.g., onomatopoeia), unintelligible speech, and the like.

(1) Excerpt from MacWhinney (1991) transcript 020718c, available for download at: https://childes.talkbank.org/access/Eng-NA/MacWhinney.html

```
@Begin
@Languages: eng
@Participants: CHI Ross Target_Child , FAT Brian Father
@ID: eng|MacWhinney|CHI|2;07.18|male|TD||Target_Child|||
@ID: eng|MacWhinney|FAT||male|||Father|||
@Media: 020718c, audio
@Date: 19-AUG-1980
@Types: long, toyplay, TD
@New Episode
```

@Tape Location: tape22 , side b , 260
@Situation: Mark's making a pie of his breakfast
*__FAT:__ look Marky is making a mess !
*__CHI:__ yeah .
*__FAT:__ isn't that nice Mark .
*__CHI:__ that's nice .
*__FAT:__ that's real nice .
*__FAT:__ he's making a beautiful mess .
*__FAT:__ what's he doing .
*__CHI:__ he's making a mess .
*__CHI:__ not nice (.) Mark .
@End

Utterances may be coded in CHAT by inserting one or more *dependent tiers* under the main tier, with each dependent tier starting with the symbol %. Depending on the aims of the researcher, dependent tiers may contain phonetic or phonemic transcriptions, morphosyntactic coding, coding of grammatical relations in accordance with the universal dependencies (UD) framework (de Marneffe et al., 2021), or extralinguistic information (e.g., gestures, actions). Example (2) shows dependent tiers with morphosyntactic (%mor) and grammatical relations (%gra) coding of one of the child's utterances in transcript 020718c (MacWhinney, 1991); note that these coding tiers were auto generated using CLAN tools (MacWhinney & Fromm, 2022). Researchers may create their own dependent tiers to code features of child language that are of relevance to their interests.

(2) Example line from MacWhinney (1991) transcript 020718c showing dependent tiers
*__CHI:__ he's making a mess .
%mor: pro:sub|he~aux|be&3S part|make-PRESP det:art|a n|mess .
%gra: 1|3|SUBJ 2|3|AUX 3|0|ROOT 4|5|DET 5|3|OBJ 6|3|PUNCT

CHILDES as a Big Data Initiative

With the launch of Dataverse Network in 2006 (King, 2007), the Open Science Framework in 2012 (Spies, 2013), the Center for Open Science in 2013 (Foster & Deardorff, 2017), and Databrary in 2014 (Adolph, 2016; Gilmore et al., 2016), sharing of scientific data has become increasingly commonplace. In this context, it is easy to overlook the foresight of MacWhinney, Snow, and their collaborators who anticipated a Big Data approach to language development research over 40 years ago. Not only did the creators of CHILDES provide manuals with technical information (MacWhinney, 1991), but they also produced an edited volume demonstrating how to use CHAT coding and CLAN programs in specific, well-defined research projects on a variety of topics (Sokolov & Snow, 1994). Topics covered in this initial volume included parental use of diminutives (e.g., *froggy*, *doggy*), child and parental use of superordinates, children's acquisition of Spanish determiners, and the availability of direct and indirect forms of negative evidence pertaining to the grammaticality of children's utterances. In this section, we take stock of how CHILDES has evolved over this period and mention future directions that data-sharing efforts have taken within the broader TalkBank project.

The summary statistics presented in this section give an indication of how the CHILDES project transformed over a period of 40 years from a small repository that fit onto a CD-ROM into a rich database with sibling projects now known as TalkBank. At the time of writing, CHILDES comprised 436 accessible corpora containing a total of 73,958,859 words embedded in 19,908,190 utterances produced by 16,382 children and their caregivers living in diverse societies around the world. Please note that corpora are being added continuously, some of which remain embargoed for a variety of reasons. Table 1 provides various measures of the current database. Columns are organized by corpus type, determined by developmental status (typical vs. non-typical), language context (monolingual vs. bilingual/multilingual), and elicitation method (observational vs. narrative). Within the latter categorization, observational data include recordings of conversations (dialogue) collected at home or in the lab, in free-play contexts or during specific activities like mealtime or book reading. The corpora include both longitudinal and cross-sectional designs, with the majority recording interactions involving young children (< 5 years of age) with their family members. Narrative corpora are elicited monologues, with adults providing support but generally taking on a secondary role. In more than 30 of the narrative corpora, children were asked to tell a story about a frog, using a wordless picture book as a prompt (Mayer, 1969). Analyses of children's frog stories representing various language contexts and age groups were published as an edited volume (Berman & Slobin, 1994).

Table 1

Parameters Indicating the Amount of Data Contained within the Various CHILDES Corpora Grouped by Developmental Status (Typical vs. Non-Typical), Language Context (Monolingual vs. Bi-/Multilingual), and Elicitation Method (Observational vs. Narrative)

	Corpus Type				
	non-typical, monolingual, observational	typical, monolingual, observational	typical, monolingual, narrative	typical, bi-/ multilingual, observational	typical, bi-/ multilingual, narrative
# of languages	9	47	14	16	7
# of children	2,346	9,385	3,499	374	776
# of corpora	51	304	32	7	41
transcript only	30 (58.8%)	129 (42.4%)	19 (59.4%)	5 (71.4%)	16 (39.0%)
audio available	16 (31.4%)	134 (44.1%)	13 (40.6%)	2 (28.6%)	18 (43.9%)
video available	5 (9.8%)	39 (12.8%)	0 (0%)	0 (0%)	7 (17.1%)
# of words	4,978,779	60,929,540	1,393,252	6,154,120	492,791
children	1,378,320 (27.7%)	18,847,945 (30.9%)	994,650 (71.4%)	1,793,347 (41.1%)	418,875 (85.0%)
caregivers	3,600,459 (72.3%)	42,081,595 (69.1%)	398,602 (28.6%)	4,360,773 (58.9%)	73,916 (15.0%)
# utterances	1,499,551	16,334,646	252,214	1,712,189	107,096
children	538,411 (35.9%)	6,242,607 (38.2%)	165,702 (65.7%)	599,661 (35.0%)	79,990 (74.7%)
caregivers	961,140 (64.1%)	10,092,039 (61.8%)	86,512 (34.3%)	1,112,528 (65.0%)	27,106 (25.3%)

Note: *The single twin corpus combining data from typical and non-typical children is omitted from this table. Information about data type was unclear for two typical, monolingual, observational corpora, which are not included in the breakdown by media type.*

CHILDES also expanded to include language samples of children experiencing non-typical developmental trajectories due to autism (e.g., Bang & Nadig, 2015; Rollins, 1999), Down's

syndrome (e.g., Hooshyar, 1985; Rondal, 1978), Williams syndrome (Diez-Itza et al., 1998), epilepsy (e.g., Berl et al., 2005; Steinberg et al., 2013), delayed language development ("late talkers"; Moyle et al., 2007; Rescorla, 2011), developmental language disorder (formerly known as specific language impairment; e.g., Conti-Ramsden & Dykins, 1991; Paradis et al., 2013), prenatal exposure to cocaine, alcohol, and other substances (Malakoff et al., 1999), brain injury (Keefe et al., 1989), and hearing loss with/without cochlear implants (e.g., Ambrose, 2016; Szagun & Schramm, 2016). These clinical datasets represent various languages besides English, though relatively few include children growing up in bilingual or multilingual environments; see Tribushinina et al. (2017) for an exception (not included in Table 1). In the case of autism, datasets involving children acquiring Dutch, English, French, Greek, Mandarin, and Spanish are organized within a new ASDBank repository in TalkBank. In addition, TalkBank now includes FluencyBank—a repository of data from children and adults with fluency disorders (stuttering). Other repositories within TalkBank include datasets from adults with traumatic brain injury (TBIBank), right hemisphere damage to the brain (RHDBank), dementia (DementiaBank), and aphasia (AphasiaBank). Another repository is ClassBank, which contains transcripts of filmed interactions in a variety of classroom settings including, for example, basic geometry lessons with third graders (Lehrer & Curtis, 2000) and problem-based learning sessions with medical students (Loschmann & LeBaron, 2022). The entire TalkBank system uses CHAT format for transcription and CLAN programs for analysis, allowing child and adult corpora to be analyzed under a uniform framework and procedures.

CHILDES as a Crosslinguistic Repository

Despite growing appreciation of cross-cultural differences in childhood experiences, child-rearing practices, and child-directed speech, research efforts are still dominated by studies of children learning English (Kidd & Garcia, 2022). From its inception, CHILDES has been a major driving force behind the crosslinguistic expansion of language development research. To date, the monolingual and bilingual/multilingual CHILDES corpora encompass transcripts and recordings from 48 languages (for simplicity, we count Mandarin, Cantonese, and Taiwanese Hokkien as distinct languages). Figure 1 illustrates the rank-ordered frequency of languages by number of corpora, and Figure 2 shows the rank-ordered frequency of languages by number of children. While both indicators confirm an Anglocentric bias in existing research, they also show the success of collective efforts to diversify language development research, with progress most evident for Mandarin, Spanish, Dutch, French, German and Russian.

Figure 1

Rank-Ordered Distribution of Languages by Number of Corpora in CHILDES

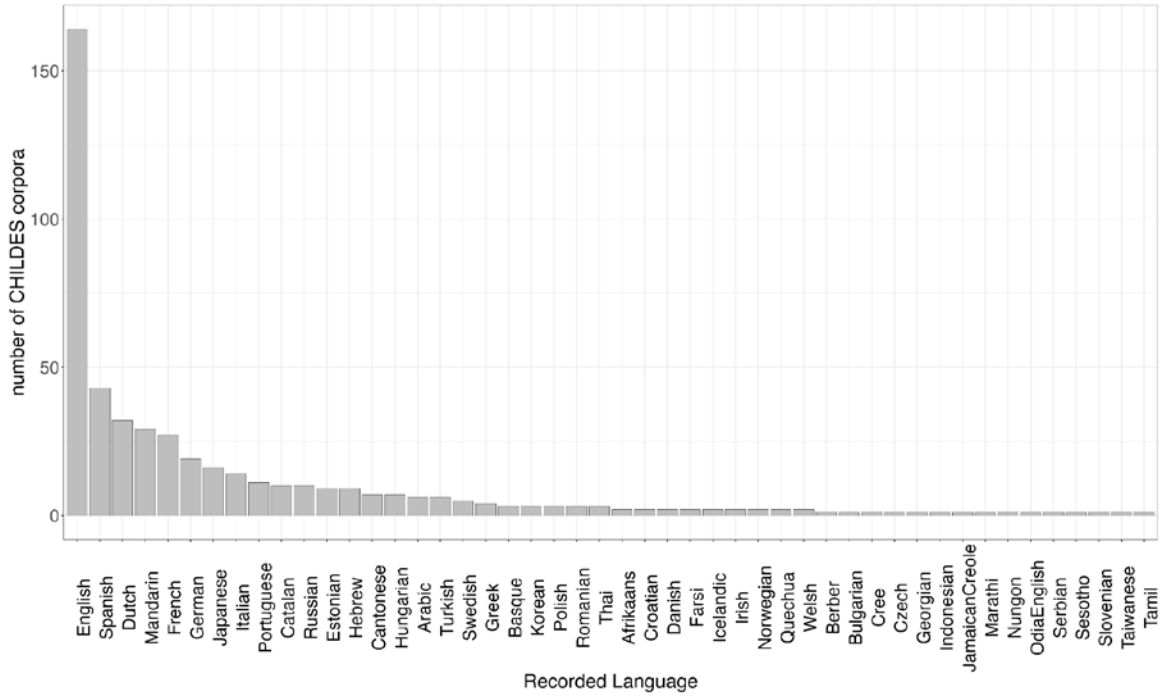


Figure 2

Rank-Ordered Distribution of Languages by Number of Children in CHILDES

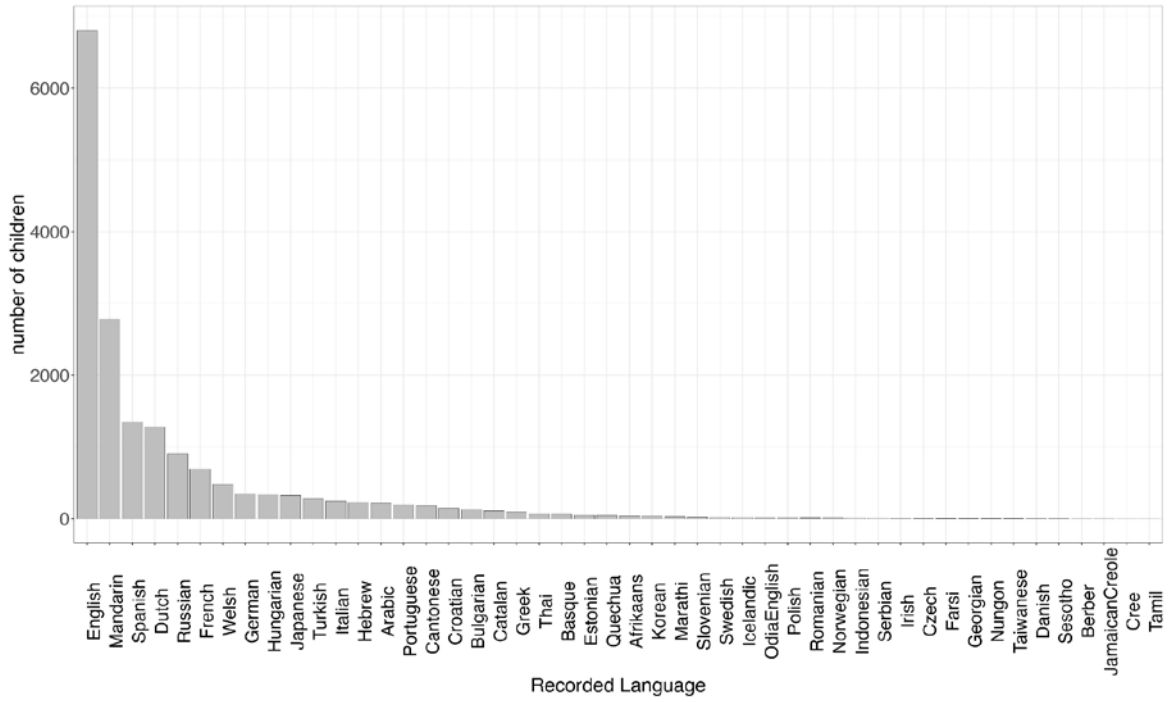
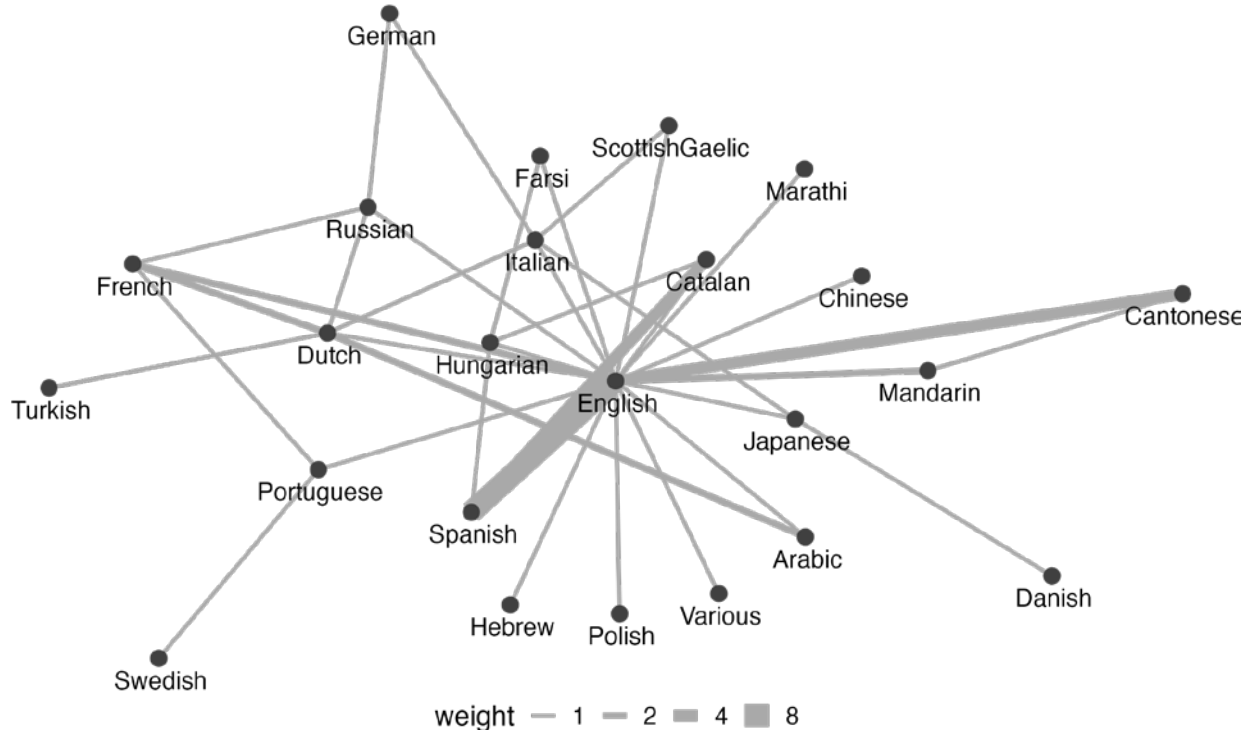


Figure 3 presents a network graph showing the frequency of the different language combinations (37 in total) represented in the bilingual and multilingual corpora. This visualization includes datasets involving sequential bilinguals, as in Guthrie's (1983) study of 14 Cantonese-speaking children learning English in school, as well as simultaneous bilinguals, as in Bailleul's (2017) case-study of a child learning Russian and French in accordance with

the one parent, one language approach (Grammont, 1902). Note that the language combinations refer to the child's language competence, as described in the documentation provided with each corpus, rather than the language of observation. As an example, the edge that connects "Various" to "English" refers to the Paradis (2005) corpus, which recorded productions of bilingual children speaking English as a second language. The dataset did not include recordings of children using their first languages: Arabic, Cantonese, Dari, Farsi, Japanese, Korean, Mandarin, Cantonese, Romanian, Spanish and Ukrainian. The network graph also disregards information about language dominance and includes datasets involving heritage speakers whose language dominance often shifts at school entry (e.g., Mai & Yip, 2017). As a summary of extant CHILDES corpora, the network graph indicates that most bilingual and multilingual language combinations include English, confirming its dominance in language development research. At the same time, it illustrates the growth of efforts to expand crosslinguistic studies of bilingual language development, as indicated by numerous language pairings that do not include English. Supplementing the CHILDES bilingual/multilingual corpora are BilingBank and SLABank within the TalkBank project, which provide mostly adult corpora for research on multilingualism and second language acquisition, respectively.

Figure 3

Language Combinations in the Bilingual and Multilingual Corpora



Note. Number of corpora is indicated by edge thickness.

CHILDES as a Data and Tool Sharing Platform

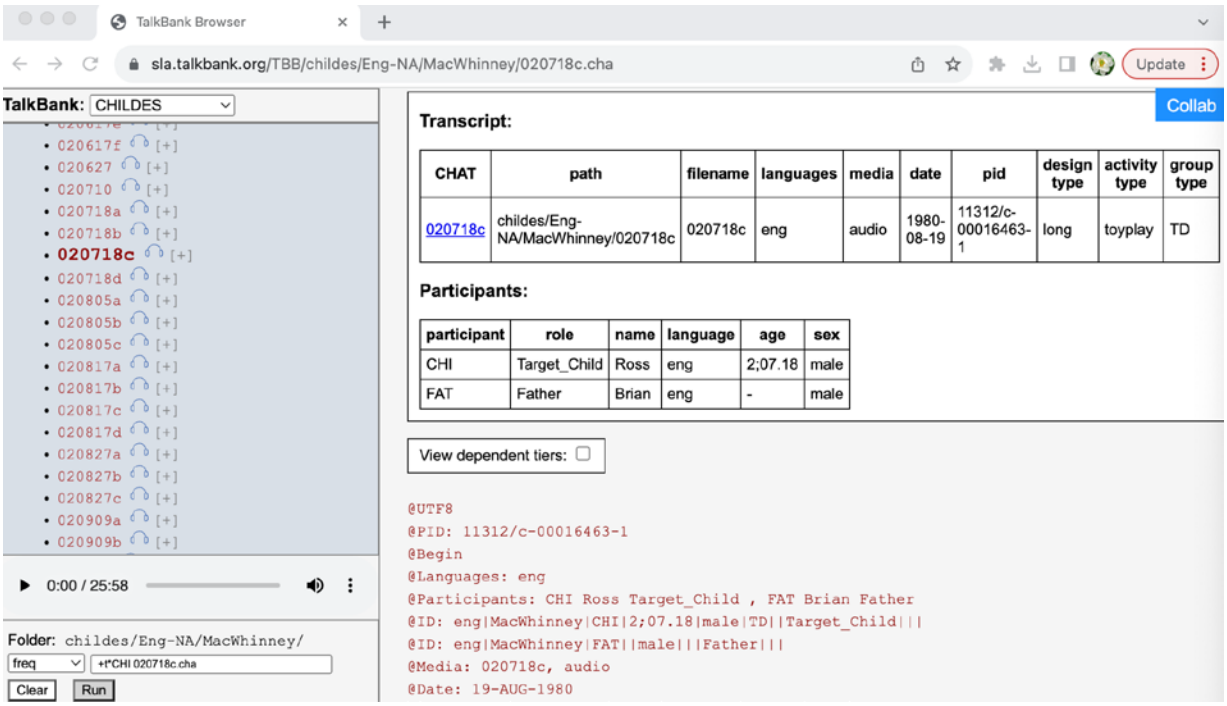
Judging from the more than 9000 published papers in which CHILDES corpora and/or CLAN programs were used (Liu et al., 2023), the CHILDES project has proven to be an invaluable database and tool-sharing resource. CHILDES corpora have been used to trace developmental trajectories of children's speech production (e.g., Marcus et al. 1992, Xu et al., 2023), to

describe features of the language input provided by caregivers (e.g., Cameron-Faulkner et al., 2003; Chouinard & Clark, 2003), to link these features to various language learning outcomes (e.g., Che et al., 2018; Ninio, 2014; Saxton, 2000), and as input to computational models testing theoretical assumptions about learning mechanisms (e.g., Macaulay & Christiansen, 2019; Monaghan & Christiansen, 2010). While this list of study aims is undoubtedly incomplete, it serves to illustrate how this rich data source has been used to advance understanding of child language development.

In this section, we will describe ways that researchers, instructors, students, and the interested public can interact with the CHILDES database and CLAN programs. CHILDES has a flexible interface allowing users to engage with corpora online via a standard internet browser or, alternatively, download corpora and CLAN programs to work offline. The browsable database is ideal for previewing datasets and for introducing students to CLAN because it does not require software installation; see Brooks et al. (2020) for sample lessons for using CHILDES in the classroom. Figure 4 is a screenshot of transcript 020718c from MacWhinney (1991) in the browsable database: https://sla.talkbank.org/TBB/childes/Eng-NA/MacWhinney/020718c.cha.

Figure 4

Screenshot of a Portion of MacWhinney (1991) Transcript 020718c as Viewed via the Browsable Database

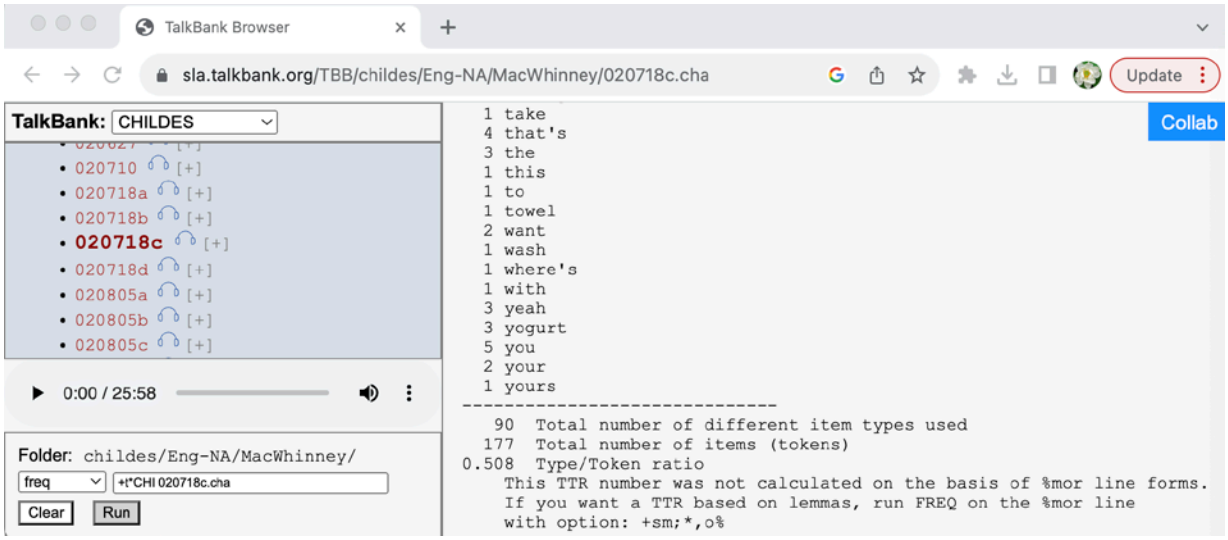


The left column lists the files contained within the MacWhinney (1991) directory with the selected file (020718c) in bold. Below the file list on the left is a control panel for playing the audio file linked to the transcript, and a control panel for running CLAN commands. The right column provides documentation including the participants (Target_Child Ross at age 2 years, 7 months, 18 days; Father Brian). At the top of the transcript is an option to view the dependent tiers. The screenshot cuts off the transcript so that only the metadata are visible (i.e., the lines

at the top with the symbol @). Users can scroll through the entire transcript using the mouse or trackpad. In addition to browsing the transcript, users can annotate the transcript using the Collab button (top right corner). This button opens the Collaborative Commentary feature of TalkBank, allowing researchers and instructors to create groups of users who work together to code transcripts for recurring features, such as children's two-word combinations or specific features of child-directed speech like diminutives or explicit correction.

Figure 5

Screenshot of a Portion of MacWhinney (1991) Transcript 020718c with CLAN Output of the "Freq" Command



Taking a closer look at the CLAN control panel, as shown in Figure 5 (bottom left), one sees the *freq* command for running an analysis on the Target_Child's utterances. In creating this example, we selected *freq* from a menu of available commands. Note that +t*CHI instructs CLAN to select only the child's utterances and 020718c.cha designates the file to use. Clicking on the *Run* button executes the *freq* command in CLAN, generating a list of all the words Ross produced, the number of times he produced them, and summary statistics for word types, word tokens, and type-token ratio. Figure 5 (right column) provides a screenshot of the summary table at the bottom of the *freq* output, indicating that Ross produced 90 different words (types) and 177 words in total (tokens).

While the browsable database may be perfect for teaching purposes and initial scanning of datasets, it is less suitable for research because the interface does not save any CLAN output. Consequently, researchers interested in using the CHILDES corpora and CLAN programs should install CLAN on their computer. Once the software is installed, the CLAN editor may be used to prepare new transcripts in CHAT format with direct links to the original audio or video files. This functionality allows researchers to run CLAN analyses on datasets that are not yet part of CHILDES. As an example, Harvey and Brooks (2022) used CLAN to analyze digital text messages produced by American children enrolled in a Chinese language immersion program as an indicator of their second language (Mandarin) proficiency. Researchers can add dependent tiers to CHAT formatted datafiles, then run CLAN on the dependent tier (rather than on the main tier) to analyze the codes. For instance, Aldrich et al. (2011) coded children's use

of psychological state terms (e.g., *thinking*, *heard*, *looked*, *scared*) and explanations of psychological states in their narratives of another frog story (Mayer & Mayer, 1975), then used the *freq* command to tally the codes for analysis. To streamline data processing, the researcher can use wildcards to instruct CLAN to analyze all transcripts in a given directory as a batch and save the output to files. The output can be assembled into spreadsheets or via Python script. To further improve this process, Sanchez and colleagues (2019) developed childes-db—a mirror of the original CHILDES database that restructures datafiles for statistical analysis in the R programming environment (R Core Team, 2021), a dedicated Python library for accessing the database, and a *childesr* package to replicate some of the functionality of CLAN.

It has no doubt been a massive undertaking to maintain the compatibility of the CHILDES data interface and CLAN programs across a wide range of computer operating systems (e.g., Windows, MacOS, Unix) and an evolving range of personal computing devices (e.g., tablets, smartphones) over the past four decades. While dealing with a myriad of technological challenges, MacWhinney and his team made continuous improvements to expand software functionality and integration with other applications (e.g., Praat, ELAN). MacWhinney has also been the driving force in community-building efforts. He created (and moderates) the *infochildes* listserv, which unites the community of language development researchers around information exchange, and the *chibolts* listserv, which provides tips and advice for data transcription, coding, and analysis. Using *chibolts* also gives users rapid access to technical support from CLAN software developer Leonid Spektor and Brian MacWhinney himself. Users can subscribe to these and other Google Groups through TalkBank (https://www.talkbank.org/share/email.html).

Conclusion

In organizing the CHILDES and TalkBank projects, MacWhinney created a high standard for open access to datasets and analytic tools that was well ahead of its time. It is important to underscore that the corpora were donated by researchers from around the world and were not collected as part of a coordinated endeavor. Yet, through MacWhinney's efforts, all the datasets are now accessible in a unified format just a few clicks away on an Internet browser. Further, given its XML compatibility, CHILDES datafiles can be read easily by many different programs, allowing its integration with new tools for corpus analysis as they become available. As an example, ALIGN is an open-source Python package for measuring linguistic alignment (i.e., semantic, syntactic, or lexical overlap) across conversational turns, which can run on CHILDES corpora (Duran et al., 2019).

Future efforts to expand the CHILDES database as a fully open-access resource face formidable challenge. This includes finding ways of reconciling the different international standards in regulating the privacy and self-determination rights of participants (especially non-consenting children) with the data-sharing ethos of the Open Science movement. Already, as the database grows, corpora are being password protected to safeguard privacy, as was evident with the creation of HomeBank, a repository for daylong (longform) recordings of home language environments (VanDam et al., 2016), and other TalkBank projects. Another challenge involves reducing the effort required for accurate transcription of audio files—a notoriously labor-intensive, expensive, and time-consuming process (Gillis, 2014). For purposes of automatic speech recognition (ASR), MacWhinney and his colleagues have developed an

automated pipeline called Batchalign that converts raw audio into CHAT files (Liu et al., 2023). Batchalign has shown promising results in recognizing and transcribing adult speech with a level of accuracy (> 95%) sufficient for a first-pass transcription, but the tool needs refinement to process speech from young children. A key challenge in the continued development of these tools involves accurately transcribing interactions characterized by significant crosstalk and conversational overlap across speakers.

From the start, CHILDES was conceived in an effort to increase crosslinguistic research on language development. Such efforts need to be given priority in light of the endangered status of many of the world's languages (Moseley, 2010). The call to diversify research is urgent as the ongoing loss of human languages places irrevocable limits on our understanding of the many paths to language acquisition. Finally, given evidence that language use for most individuals involves multiple varieties, encompassing accents, dialects, and languages (Evans, 2017), increasing representation of multilingualism and multidialectism within the database, especially of children with typical and non-typical developmental trajectories, will help to improve understanding of the breadth of human language development with theoretical, but also clinical and educational, implications.

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Competing Interests

No, there are no conflicting interests.

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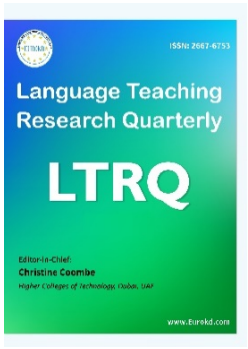

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Augmenting Clinical Insights with Computing: How TalkBank has Impacted Assessment and Treatment of Speech and Language Disorders

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Abstract

Our purpose is to highlight the contributions of TalkBank initiatives to improved understanding of clinical impairments in adult and child speakers and examine remaining challenges and proposed solutions.We review the origins and development of TalkBank initiatives that have targeted a wide array of typical and atypical child and adult populations. In particular, we discuss how such sets of data have given rise to evaluation and validation of traditional measures used to appraise spoken language performance. The durable contributions of AphasiaBank and CHILDES archives are already evident in a body of published research that has re-evaluated, refined and reconceptualized how we evaluate and set therapeutic goals for speakers with expressive speech and language impairments. More recent archival initiatives, such as PhonBank and FluencyBank, are also making impacts. Beyond improvements in basic and applied science in communication development and disorders, archival data are also being used to test and improve accessibility for communicatively impaired speakers. TalkBank has transformed how research in communication disorders is conducted. It no longer relies on small, unshared research ventures that enable limited clinical impact or follow-up research inquiries. Rather, it has enabled large-scale, more generalizable research more likely to spur further research and enable more rapid translation to clinical practice.

Keywords: *TalkBank, Language Disorders, Aphasia, Fluency, Dementia*

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[1]Introduction

Imagine a set of Jeopardy questions of the following sort: *When was the Internet invented, and by whom? Who invented the first set of data analytics for personal computers and when*? And finally, *who invented the world's first public library*?[2]

Now we can phrase the questions a little differently. What was the first large scale system for sharing language research data across sites around the world and when was it started? Who guided the development of the first freely available language analysis software? And who established the first "public library" for the preservation and sharing of language data for basic research and clinical use?

The answers to these questions will all involve the work of Brian MacWhinney, and the scope of his efforts (now collected under the umbrella of the TalkBank initiative) across these diverse but related areas have indelibly changed the ways in which we approach collection and analysis of language data. In turn, these changes contributed to improved understanding not only of typical communication development in children learning a wide array of languages, but also of individuals with numerous profiles of communication disorders, including language loss due to stroke and traumatic brain injury (AphasiaBank and TBIBank), speakers with phonological disorders (PhonBank), and those with fluency disorders (FluencyBank).

We provide a short history to ground these accomplishments. In 1984, only a year following the "birth" of the World Wide Web, Brian MacWhinney and Catherine Snow anticipated the need for data preservation, sharing and standardization to advance knowledge in the study of child language development. Funded by the John D. and Catherine T. MacArthur Foundation, the founding project that would evolve into today's TalkBank initiative (TalkBank.org) was launched. In its early days, users needed to use pre-Internet protocols such as Telnet or physically mailed disks to utilize its resources. However, the Child Language Date Exchange System (or CHILDES) quickly revolutionized a field of study that had been limited by the resource-intensive nature of language transcription and analysis. From an initial set of 14 corpora, mostly from English language learners (MacWhinney & Snow, 1985; MacWhinney & Snow, 1990; MacWhinney, 1996; MacWhinney, 2014), CHILDES and the ensuing specialty focus "banks" discussed later in this article have grown to much more than 1.4TB of transcript data, with more than 5TB of accompanying media data (Bernstein Ratner & MacWhinney, 2020). Analysis of the collected data was facilitated by the development of the open-access, free software program Computerized Language Analysis (CLAN; MacWhinney, 2000) and subsequent improvements to automatically tag morphosyntax and grammar in English and additional languages (Sagae et al., 2010; MacWhinney et al., 2020),

[1]This paper is part of a special issue (2024, 44) entitled: In Honour of Brian MacWhinney's Five-Decade Contributions to Language and Psychology Research (edited by Zhisheng (Edward) Wen and Hassan Mohebbi).

[2]According to Wikipedia and other sources: January 1, 1983 is considered the official birthday of the Internet, when Bob Kahn and Vint Cerf developed the Transfer Control Protocol/Internetwork Protocol (TCP/IP) that enabled computer-to-computer communication. The first version of Microsoft office suite was distributed in October 1983 and is credited to former Xerox programmers, Charles Simonyi and Richard Brodie, who were hired in 1981 by Microsoft founders Bill Gates and Paul Allen. The world's oldest known library was founded sometime in the 7th century B.C. for the "royal contemplation" of the Assyrian ruler Ashurbanipal. The first public library was established by Asinius Pollio in Rome some time before 4 AD.

link media to transcripts (MacWhinney & Fromm, 2022), and enable automatic generation of transcripts using automatic speech recognition (ASR; Liu, et al., 2023).

The CHILDES initiative was followed by the creation of AphasiaBank (Forbes, et al., 2012; MacWhinney, et al., 2010; MacWhinney, et al., 2011; MacWhinney & Fromm, 2016). This in turn was followed by the establishment of PhonBank (Rose, et al., 2013; Rose & Stoel-Gammon, 2015), and means to create compatibility between Phon-annotated corpora and CHILDES data (Rose, et al., 2006). The success of focused repositories and accompanying software tailored for discipline-specific analysis spurred the construction of ASDBank for autism spectrum disorder (MacWhinney, 2019), FluencyBank (Bernstein Ratner & MacWhinney, 2018) for typical fluency development, stuttering and cluttering, TBIBank for traumatic brain injury (Elbourn, et al., 2023; Power, et al., 2020; Togher, et al., 2023), RHDBank for right hemisphere disorder (Minga, et al., 2021, 2022), and DementiaBank (Lanzi, et al., 2023). Today, all of these combine under the umbrella of TalkBank.org.

CHILDES: From Typical Development to Clinical Implementation

First, it should be noted that CHILDES has become the *de facto* repository for language acquisition data from children learning over 40 different languages (not counting numerous distinct varieties of English and children learning numerous combinations of more than one language). These children vary from typically-developing monolingual and bilingual children to those with varying developmental disorders, such as autism spectrum disorder (ASD), hearing loss, Down Syndrome, focal brain injury and developmental language disorder of unknown etiology (MacWhinney, 1994). These repositories have, in turn, enabled identification of developmentally appropriate growth in child speakers across a wide range of communities. They have also informed the understanding of functional deficits that arise when this process goes awry or is slowed by inequalities in the experiences of children growing up in socioeconomically disadvantaged environments. It is beyond the scope of this article to list all of the seminal work that has been achieved across these areas, but as of the time that this manuscript was written in late 2023, the number of citations to CHILDES resources used in published research reports (as tallied by Google Scholar, using the term “Child Language Data Exchange System”) was roughly 5,500 articles, books and chapters.

CHILDES data have also been used to validate and refine measures for clinical assessment of children’s language for both diagnostic and goal setting purposes. The obvious utility of CLAN software for generating clinically-relevant indices of performance and progress has led to the incorporation of historical appraisal algorithms for child language development such as Developmental Sentence Scoring and the Index of Productive Syntax within “bundled” analyses [e.g., KidEval] for speech-language pathologists’ (SLPs’) use (Bernstein Ratner & MacWhinney, 2016, 2020, 2023; Garbarino, et al., 2020; Yang, et al., 2022). It has also been used to develop metrics for child language assessment that reduce the bias against speakers of non-mainstream versions of North American English inherent in older measures that are traditionally relied on by practicing SLPs (Overton, et al., 2021).

AphasiaBank: Closing a Loop between Assessment, Progress Monitoring and Best Practices

Historically, the transition to clinically relevant corpora, protocols and computer-assisted analyses was made with the founding of AphasiaBank in 2007 (MacWhinney et al., 2011).

Designed from the start to collect a large body of language data from typical and language-impaired adults based on a standard discourse protocol, AphasiaBank rapidly gained both research and clinical prominence. The initiative established the utility of tasks such as telling the Cinderella story (MacWhinney, et al., 2010) and the Famous Faces Protocol (Holland, et al., 2019) for assessment (Fromm, et al., 2020; Fromm, MacWhinney & Thompson, 2020; Stark, et al., 2021), aphasia subtyping (Fromm, et al., 2022) and progress monitoring of clinical participants (Holland, et al., 2017). The establishment of online tutorials (Grand Rounds) for education of SLPs in training, automated discourse analysis tools such as EVAL (Forbes et al., 2012) and C-QPA (Fromm, et al., 2021), and creation of the Collaborative Commentary tool (MacWhinney & Fromm, 2023, see Fromm & Kowalski, this issue) have made the use of TalkBank resources in the evaluation, treatment monitoring and practitioner education a standard component of research, clinical practice and education activities involving adults with acquired language loss. Most recently, the AphasiaBank initiative has led to working group activities that have engaged in protocol development for tracking the outcomes of aphasia rehabilitation treatments (Brady, et al., 2020; Stark, et al., 2021; Kristinsson, et al., 2023).

Old Data Repurposed to Answer New Questions

Even from the beginning, the premise that old data could inform new questions was robustly confirmed. Beyond mere replication and extensions of results, entirely new research initiatives made use of existing corpora that had been gathered with entirely different research goals in mind. As a personally relevant case study, the Bernstein corpus had originally been compiled as part of a descriptive study to examine acoustic features of infant-addressed speech (IDS; Bernstein Ratner, 1984), and was one of the earlier donations to CHILDES. A decade later, the data were utilized, by Brent and Cartwright (1996), to demonstrate that infants could plausibly segment spoken language input to identify word boundaries in running speech, using phonotactic distributional regularities. The corpus has now become “the de-facto standard for evaluating segmentation models” (Goriely, et al., 2023) that seek to understand how infants manage to identify words in the earliest stages on language learning. The corpus has been further used to test models of unsupervised induction of grammar in machine language learning (Glushchenko, et al., 2019), a prospect not remotely envisioned during the original study, when data were collected on reel-to-reel analog tapes, and acoustically analyzed using a dedicated mainframe computer that had to be booted with punched paper tape.

Some of Dementia Bank’s roots reflect a different, but equally serendipitous history (Fromm, personal communication), and involve the Pitt corpus. Its cassette tapes from the 1980s had been stored in mushroom mines. The TalkBank initiative oversaw having the materials excavated, digitized, and transcribed around 2010, and they have since become a major source of work by researchers all over the world on automatic detection of mild cognitive impairment and dementia in adults, with almost 500 articles, conference presentations, and theses to date.

FluencyBank: Basic Research and Clinical Education in Stuttering and Cluttering

In 2018, the National Institutes of Health and National Science Foundation contributed to the establishment of FluencyBank, specifically developed to preserve annotated, media-linked data on typical and atypical speech fluency profiles in adults and children (Bernstein Ratner &

MacWhinney, 2018). In addition to preservation of historically invaluable longitudinal data from ground-breaking studies of the onset and outcomes of childhood onset stuttering, the initiative created cross-linguistically applicable codes for marking fluency within transcripts across language communities, and developed a research and clinical tool (FluCalc) that could generate fluency profiles for clinical and research participants in seconds. Its Voices of Adults/Children who Stutter/Clutter are being used in the preparation of clinicians to work with this historically underserved community. Both its Voices and research corpora are being used to update and revise traditional descriptions of how stuttering is distributed within speakers' conversational efforts (Warner, et al., 2023). Critical to decades of advisement to parents of young children who stutter, its holdings are now being used to re-evaluate the evidence base and effectiveness of such therapeutic guidance, some of it apparently well-founded (e.g., LaSalle & Wolk, 2023), while others appear to do little to alter children's short- or long-term fluency profiles (e.g., Burns & Bernstein Ratner, 2022; Garbarino & Bernstein Ratner, 2022; Godsey & Bernstein Ratner, 2022). FluencyBank holdings have also been deployed, as we describe further in this article, to foster automated assessment of fluency profiles, as well as remove barriers to use of voice assistants by people who stutter.

Corpora Deployment to Perform Automatic Clinical Appraisal

While considered the Gold Standard for clinical appraisal, language sample analysis (LSA) faces significant obstacles to routine use in most speech-language pathology settings (MacWhinney & Fromm, 2022). TalkBank efforts have been focused on the facilitation of in-depth, software augmented analyses for clinical work with both children and adults with communicative impairments, particularly those that can guide informed intervention goal-setting (see Garbarino, et al., 2020; Guo, et al., 2018).

In the process of doing this work, we have discovered that some traditional measures are quite sensitive to detection of language delays or differences, such as Mean Length of Utterance (MLU), while others, such as Type-Token Ratios (TTR) are not (Yang, et al., 2022; Bernstein Ratner, et al., 2024). Further, we have distinguished diagnostically sensitive measures from those that are superior in informing goal setting, a much more challenging prospect for therapists and teachers (Overton, et al., 2021). One of these is the Index of Productive Syntax (IPSyn; Yang, et al., 2022). We were able to refine this traditionally time-consuming measure to use shorter samples (saving time in the assessment process), and delineate which subscales have the highest value in diagnosis and therapy planning in the clinical process.

For adults with a range of clinical impairments, large databases gathered using standardized discourse protocols that include control subjects allow for the development of discourse measurement tools for main concept analysis and core lexicons. Such protocols enable more precise evaluation of both linguistic and conceptual impairments that may follow brain damage producing aphasia or other expressive communication limitations that accompany brain injury (Dalton & Richardson, 2015; 2019; Richardson & Dalton, 2020).

In the same vein, once archived and standardized in format, large corpora from TalkBank are now increasingly deployed to test and validate automated algorithms for early detection of communication disorders. These uses were not originally anticipated. For example, it now appears to be possible to recognize signs of mild cognitive impairment and dementia in spontaneous speech samples archived at DementiaBank ((e.g., Haider, et al., 2019; Luz, et al.,

2021; Liang, et al., 2022; Ye, et al., 2021). This advance could enable remote screening of subtle emerging symptomology, as well as further inform how components of communicative competence decline with the onset of dementia and related disorders.

Corpora as a Mechanism to Remove Barriers to Communication

From the outset, TalkBank was committed to free and open access to data and computing resources in the service of knowledge building (MacWhinney, et al., 2018; MacWhinney & Bernstein Ratner, 2022). Beyond this mission, however, TalkBank corpora have recently been used to test algorithms for automatic speech recognition (ASR) by speakers who often find themselves disenfranchised from the use of digital assistants because of speech disorders that impede accurate mapping of their intended messages. A major case in point has been the frustration of People who Stutter in their efforts to use speech assistant technology, such as Alexa (Robinson, 2022). Independent of the motivations for seeking NIH support to establish FluencyBank, tracking of citations to its use shows an overwhelming focus on software refinement to improve accurate tracking of stuttered speech by ASR algorithms (e.g., Al-Banna, et al., 2022; Mohapatra, et al., 2022). Tang et al. (2023) used AphasiaBank and DementiaBank corpora to both identify and reduce word error recognition rates for speakers with these significant handicapping conditions. We see this work progressing to other speaker communities, such as dysarthria and apraxia. In a similar vein, the notorious difficulty of transcribing typically-developing and articulation impaired child speech, which stands as an impediment to conducting analysis of many pediatric populations, may eventually be rectified by use of CHILDES and PhonBank repositories as grist for algorithm development and testing.

TalkBank as a Paradigm Shift with Enduring Impacts

As MacWhinney and Snow noted in 1985, it was once perfectly natural for researchers to follow small numbers of children, expend enormous amounts of resources analyzing their language behaviors. As a case in point, Brown (1973), broadly credited with one of the first efforts to create a metric for typical preschool language development, Mean Length of Utterance [MLU]) followed only three children, although his findings have been surprisingly durable across decades of further study, many of which have used CHILDES data (e.g., Yang, et al., 2022).

Single subject design in aphasia research was very common (Thompson, 2006). It was also perfectly natural for the data gathered in such investigations to sit in researchers' file cabinets until they retired, with little obvious place to archive or use such data further. We can contrast such early reports and the many similar bodies of data that have been lost to future generations with publications making use of TalkBank resources just since 2020: Yang, et al. (2022) revised and re-normed a clinical measure of preschool language development by using records from well over 1,000 children. Stark and Fukuyama (2021) were able to contrast typical adult microstructure during discourse from those seen in a variety of aphasic profiles using data from more than 500 speakers. Suarez-Rivera, et al. (2022) were able to identify age of acquisition of early core vocabulary, and conditions facilitating their learning in over 5,500 children whose data reside in CHILDES. Benway, et al. (2023) provide a PhonBank training corpus just for production and perception of [r] that contains over 100, 000 utterances.

Simply put, the world of language study can be easily demarcated, just as we do historically, by noting what we knew and how we learned it, BC (Before CHILDES) and AC (After CHILDES). An enduring debt is due to Brian MacWhinney, whose efforts have taken us this far; it's likely that our collective, collegial benefits from data sharing in language studies have only just begun to accrue.

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Ethics Declarations

Competing Interests

No conflicting interests are declared; Nan Bernstein Ratner currently serves as Chair of the TalkBank Advisory Board.

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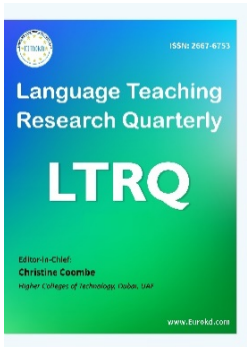

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Collaborative Commentary: A New and Innovative Tool for Language Commentary and Analysis

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Abstract

The goal of this article is to introduce the Collaborative Commentary (CC) tool and explain how it can be used in conjunction with the many TalkBank shared databases to enhance research and teaching in many areas of language study. The CC tool and its features are described in a detailed example of an assignment for an introductory course on language development. Students are able to join a CC group set up by their instructor, open specific transcripts in the CHILDES database, watch an interaction on video, follow the interaction in the transcript, and insert comments or codes directly into the transcript which are only available to members of that CC group. Additional examples of teaching, research, and clinical applications are given for using CC with other TalkBank shared databases such as AphasiaBank, TBIBank, DementiaBank, FluencyBank, and ClassBank. CC is an innovative tool that opens the rich resources of the TalkBank shared databases for a variety of purposes. Instructors can use CC to give students the opportunity to apply what they are learning by identifying behaviors such as those associated with typical dysfluencies versus stuttering or typical language development versus late talking that they are learning about in academic classes. Clinical instructors can have students practice scoring various tests or describe the techniques used in a particular treatment program. Researchers can use CC to debate theories on language, refine definitions of commonly used terms, establish coding reliability, and code behaviors of interests such as gestures, errors, coherence, macrostructure, and pragmatics. The CC tool can open up many exciting new ways to investigate language in many disciplines.

Keywords: *TalkBank, Language Analysis, CLAN, Shared Database*

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[1]Introduction

It feels like a metalinguistic exercise to use language to honor Brian MacWhinney's impact on the study of language. Yet, words – even superlatives – feel inadequate to describe the breadth and depth of his unique and groundbreaking influence. His work has always been on the cutting edge of linguistic theory, science, and technology. Undoubtedly, one of his most important and impactful achievements is the TalkBank project (https://talkbank.org/), a set of shared databases of spoken language which is free and openly available to students, educators, researchers, and clinicians from all disciplines around the world. It has continued to grow and expand since its beginnings in 2002, and thousands of published articles have made use of the TalkBank shared databases and language analysis tools for a wide range of research purposes. This article will highlight a new and valuable language analysis tool recently added to the TalkBank system called Collaborative Commentary (MacWhinney & Fromm, 2023). This tool makes use of the rich resources from the TalkBank databases for purposes of shared commentary to address important research and teaching objectives.

Brian originally conceived of having a research community involved in some kind of interpretive annotation of electrical records over 20 years ago (MacWhinney, 2007). In fact, he and a group of colleagues attempted an early version of this with a large database of materials on classroom discourse (Sfard & McClain 2002). It involved a CD-ROM that accompanied articles in a special journal issue and pdf files with links to replay relevant video clips for each of the articles. With support from an NSF grant and many important advances in technical infrastructure this can now be a much more accessible, live, streaming, and interactive activity.

After a brief summary of the TalkBank shared databases, this article provides a detailed "how-to" description of Collaborative Commentary (CC) using a classroom teaching example, followed by more examples of research and teaching applications that TalkBank members have begun to use. Given the very recent development of this tool, no published literature on its use is available yet, though one article has been submitted for publication. Because of our areas of expertise, the examples provided here may be a bit outside the typical language areas covered by this journal. However, we believe it will be easy for readers to swap out the content to make the approach relevant to their work in second language or foreign language teaching and related areas.

The TalkBank System

By way of a brief summary, the TalkBank system provides online multimedia data for 14 types of spoken language data. Most of the data is in English, but all databases include corpora in a variety of languages (e.g., Cantonese, Danish, Dutch, English, French, German, Hebrew, Italian, Japanese, Mandarin, and Spanish). The databases range from conversation banks (CABank, SamtaleBank, ClassBank) to child language banks (CHILDES, PhonBank, HomeBank), multilingualism banks (Second Language Tutors, BilingBank, SLABank) and clinical banks (AphasiaBank, ASDBank, DementiaBank, FluencyBank, PsychosisBank, RHDBank, TBIBank). The media files in these databases have been transcribed in CHAT format using the CLAN program (https://dali.talkbank.org/clan/), which allows for the

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transcripts to be automatically analyzed for parts of speech and grammatical relations. These CHAT transcripts are also temporally aligned to the media file at both the utterance and the word level. All of this information can be seen in the example below, which is one utterance from the transcript of a 58-year-old control participant from the Pitt corpus in DementiaBank (Becker et al., 1994) describing the Cookie Theft picture from the Boston Diagnostic Aphasia Exam (Goodglass et al., 2001).

- The *PAR tier indicates exactly what was said. The numbers at the end, surrounded by circles (bullets), show the time stamp in milliseconds corresponding to the media file. The *PAR tier has traditionally been entered by human transcribers but can now be generated automatically using a batchalign pipeline developed by Liu et al. (2023). The resulting ASR-generated CHAT transcript requires human review but can be completed with high accuracy and much less time and effort than creating the transcript from scratch.
- The %wor tier shows the time stamp for each word in the utterance. This is generated automatically by a batchalign program (Liu et al., 2023).
- The %mor tier shows the parts of speech and morphological parsing for each word in the utterance. This is generated automatically by the MOR command in the CLAN program (MacWhinney & Fromm, 2022).
- The %gra tier shows the pairwise grammatical relations between words and is also generated automatically by the MOR command.

CHAT Transcript Example

*PAR: the mother seems to have nothing in the house to eat except cookies
in the cookie jar . •40360_44310•

%wor: the •40360_40760• mother •40760_40960• seems •40960_41280• to •41280_41350• have •41350_41470• nothing •41470_41710• in •41750_41810• the •41810_42000• house •42000_42150• to •42150_42250• eat •42250_42520• except •42520_42760• cookies •42860_43260• in •43260_43320• the •43320_43540• cookie •43540_43810• jar •43810_44310• .

%mor: det:art|the n|mother cop|seem-3S inf|to v|have pro:indef|nothing
prep|in det:art|the n|house inf|to v|eat prep|except n|cookie-PL
prep|in det:art|the n|cookie n|jar .

%gra: 1|2|DET 2|3|SUBJ 3|0|ROOT 4|5|INF 5|3|COMP 6|5|OBJ 7|6|NJCT 8|9|DET 9|7|POBJ 10|11|INF 11|6|XJCT 12|11|JCT 13|12|POBJ 14|13|NJCT 15|17|DET 16|17|MOD 17|14|POBJ 18|3|PUNCT

In the CHAT transcript example, the participant produced the utterance in a fluent, grammatically intact, error-free manner. Of course, that is not always the case, especially with young children and speakers who have a variety of communication impairments. The CHAT transcription system includes consistent ways to mark such things as revisions, repetitions, fillers, sound fragments, dysfluencies, non-verbal behaviors (e.g., laughing, sighing, gesturing), unintelligible segments, target replacement words for errors, and error coding. The use of these consistent markings allows for automatic tabulations and searches of these features. Some of these markings will be seen in the examples described in the upcoming

section. All are described in the CHAT manual (https://talkbank.org/manuals/CHAT.pdf) and the SLP manual (https://talkbank.org/manuals/Clin-CLAN.pdf).

The information from all of these tiers (*PAR, %wor, %mor, %gra) is used for many of the automatic discourse analyses that can be done with CLAN. While those analyses are not the focus of this article, interested readers can learn more about TalkBank tools for language sample analysis from other articles (e.g., Fromm et al., 2020; Gabarino et al., 2020; MacWhinney et al., 2020; MacWhinney & Fromm, 2022; Ratner & MacWhinney, 2020). In addition, the main TalkBank webpage includes manuals and tutorial screencasts that explain and demonstrate many of these functions. The remainder of this article focuses on how these CHAT transcripts can be accessed and used by individual groups (e.g., classes, research personnel, clinical trainees) for a variety of educational and research purposes using a new and innovative tool.

Collaborative Commentary (CC)

Collaborative Commentary is a tool that allows groups to collaboratively code and comment on transcripts in the TalkBank databases. This tool facilitates a new and highly transparent, interactive way of understanding communication and finding evidence to support or refute theories about communication. Using CC, researchers, clinicians, and students can access video and audio recordings of spoken language interactions in the TalkBank Browsable Database (https://sla.talkbank.org/TBB), watch the video (or listen to the audio), follow along with the linked transcript, and enter codes or comments that directly attach to the utterances in the transcript. These codes or comments are then visible to everyone in the commentary group, which may be a class, a research group, or clinical trainees.

Eight short tutorial screencasts (https://talkbank.org/screencasts/) demonstrate the steps involved in using CC, such as registering as a new user, joining a CC group, inserting tags and comments, searching, creating tag sets, and managing group permissions. Also, the CC manual (https://sla.talkbank.org/CCmanual/) has simple, straightforward instructions with screenshots.

To start up Collaborative Commentary, you can click on “The CC Project” link at the main TalkBank webpage or click on any of the “Browsable Database” links from the home page of any of the 14 language banks. In the TalkBank Browser, you then click on the blue “Collab” button in the top right corner (Figure 1a), which brings up a login screen for already registered or new users (Figure 1b). Next, a detailed example is provided for using CC as a teaching tool. The example is presented in a step-by-step fashion with screenshots to illustrate the process for both instructors and students. Following that, more examples of the tool’s application for teaching and other purposes are described, but in less detail.

Figure 1a

Screenshot of "Collab" Button in TalkBank Browser

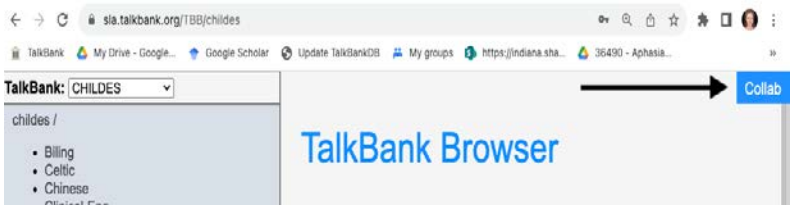
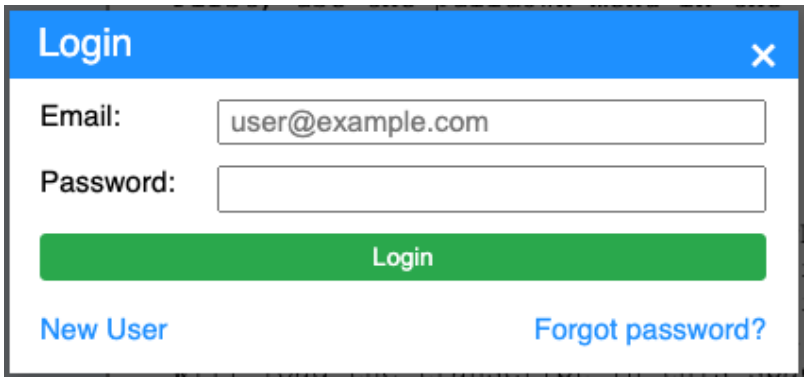


Figure 1b

Screenshot of CC Login Screen



Teaching Example

If an instructor wants her students to find speech and language behaviors in 2-year-old speakers that indicate typical development versus late talking, she could create a group within CC and give it a name (e.g., C-2). Then she would tell her students to register as CC users and request to join the C-2 group. She would need to give her students her email address (the one associated with her CC registration) so they could look up her groups and request to join the relevant one.

The instructor could set up the task in two ways. She could either create a set of codes within the C-2 group for the students to use to identify specific features in the child's utterances in the transcript (Figure 2), or she could have the students enter open comments into the transcript identifying features of typical language development or late talking. As part of the assignment, she should make a list of specific files from the CHILDES database to use. By going to the CHILDES webpage (https://childes.talkbank.org/) and clicking on *Index to Corpora*, and then *Clinical-Eng* (if the instructor is interested in English speaking children with and without language disorders), the instructor could see all the possible corpora along with information on ages and media. Figure 3 shows the first third of the list of possible corpora from that page. The Ellis-Weismer corpus would provide good material for this assignment: the ages are right, there are typically developing children and late talking children, and there are audio files. Clicking on the *Ellis-Weismer* link brings up the corpus page which has a description of the corpus as well as a link to the *Browsable Database* where the files can be accessed. Clicking on that link brings up the Browsable database (Figure 4), where you see the groups of LT (late talkers) and TD (typically developing talkers) listed on the upper left. If you click on *TD*, you see another list of the participants grouped by age (in months) and examiner-child (ec) or parent-child (pc) interactions (Figure 5). Clicking on *TD* brings up the full list of participants (Figure 6). Clicking on any of those filenames brings up that child's transcript,

which can then be heard and read in the transcript by pressing the arrow to the right of the speaker line.

Figure 2

Screenshot of Example 1 Assignment Codes

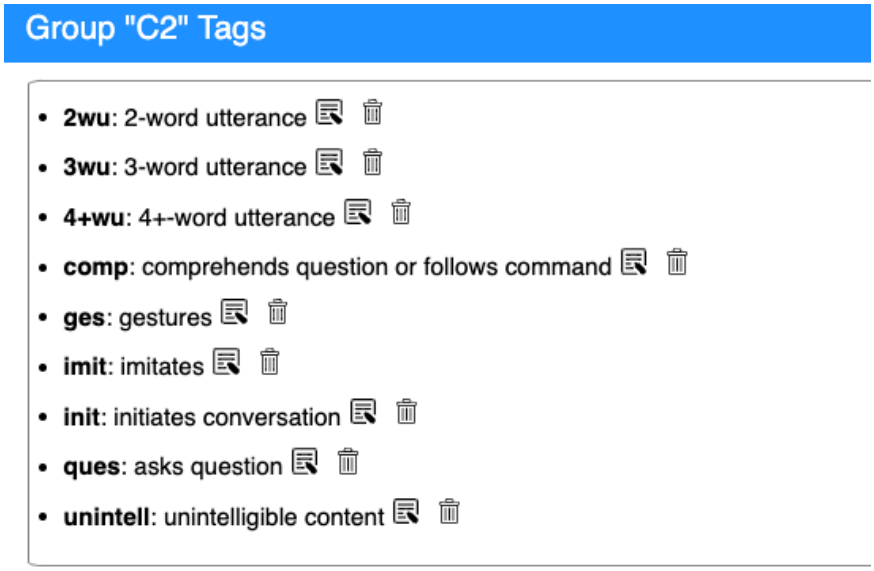


Figure 3

Screenshot of Clinical-Eng Corpora in CHILDES Database

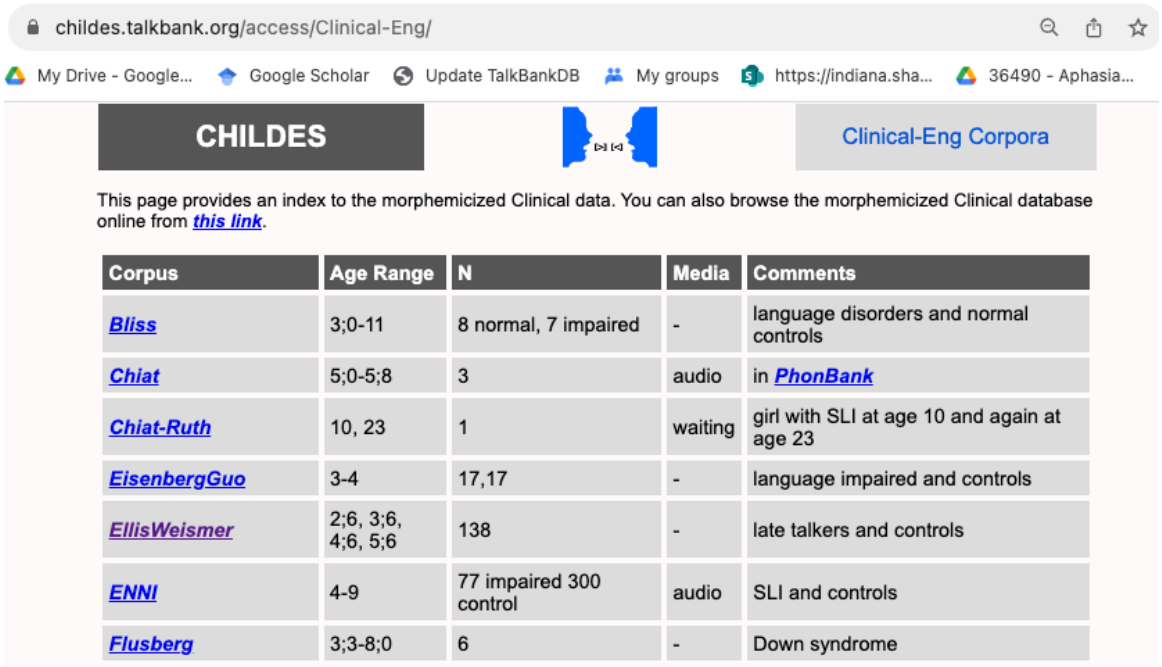


Figure 4

Screenshot of Ellis-Weismer Corpus at Browsable Database

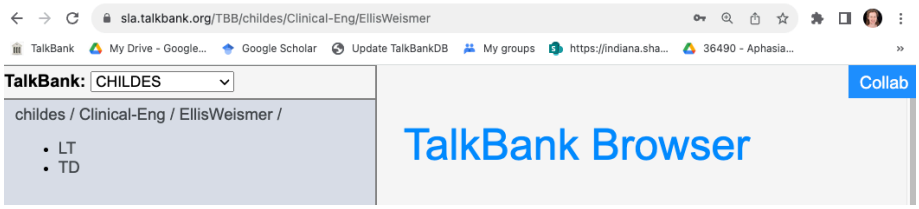


Figure 5

Screenshot of Expanded TD Files

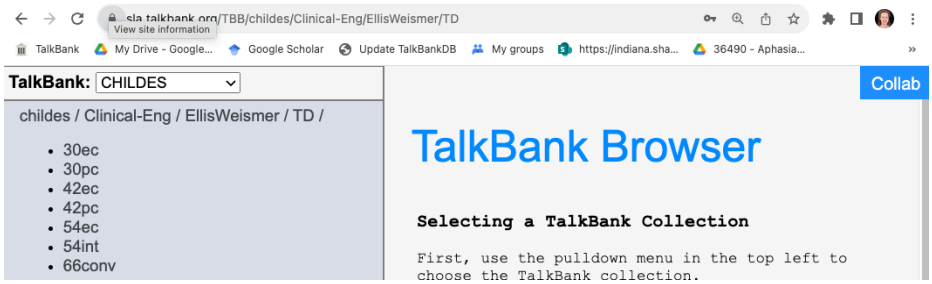
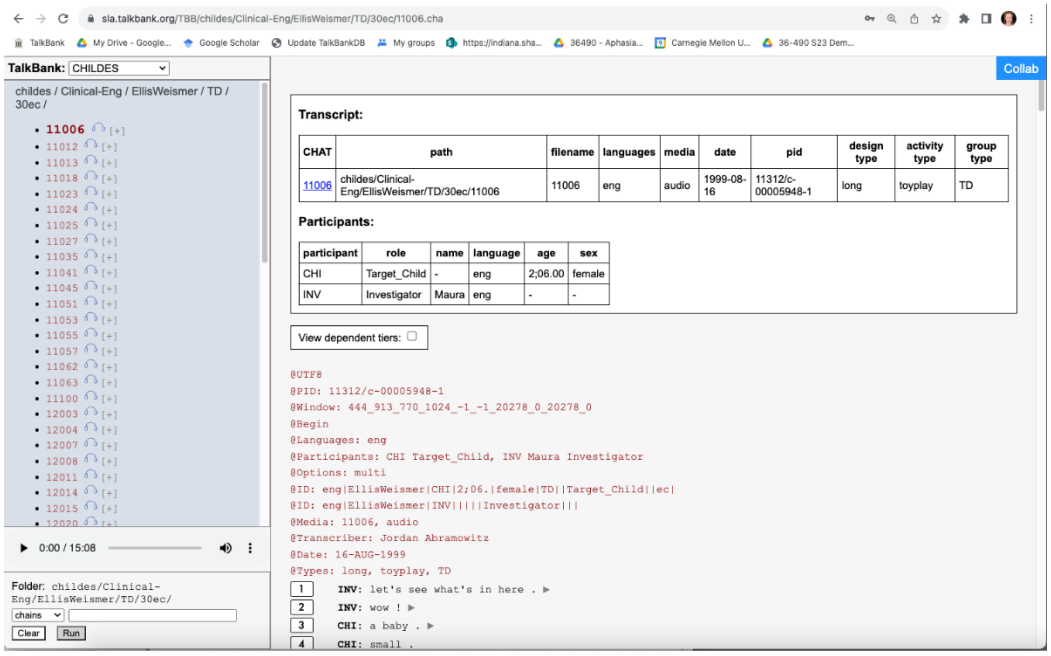


Figure 6

Screenshot of Files in the TD 30ec Folder



Finally, the instructor needs to decide what type of permission to give to the group members: “Read only”, “Write only”, or “Read and Write”. “Write only” means that the students could enter their codes/comments without being able to see other students’ entries; “Read and Write” means that students could enter their input AND see what other students have entered. The instructor would use the “Manage Permissions” option in the CC menu to set these preferences and could change them (e.g., from “Write only” to “Read and Write” or “Read only”) for class review after the assignment is completed.

After registering as a new user, and requesting to join the C-2 group, students would use the directory at the upper left of the TalkBank Browser to navigate to one of the assigned files (let's say file 11025, for example) and click on it to see the transcript. They could then listen to the language sample by clicking on the gray arrow to the right of the utterance (Figure 7) starting at line 1 with "little table". (Note: In the browser, the default mode is to show transcripts with only the main speaker tiers. To see the other tiers described above, such as %mor, check the box next to "View dependent tiers" just above the start of the transcript.") To enter a code and/or comment for the first utterance, the student just clicks twice on the utterance number "1". The student can then enter a comment in the box that appears and can select a tag from the drop-down menu of codes the instructor prepared (Figure 8). (A full list of the tags with descriptions can be seen by clicking on the tag icon next to the blue "Collab" button, as seen in Figure 9.) After selecting a tag, the student clicks the "Tag" button. After selecting as many tags as needed and entering a comment if desired, the student clicks on "Submit". A circled "C" then appears on that line, indicating that it contains comments or codes (Figure 9). Clicking on the circled "C" opens up the comments or codes, as seen in Figure 10 where the utterance on line 7 was coded as a 3-word utterance and the student commented that the child gave a command, "wash your hands". When multiple people enter comments or codes for a given line, they will all be listed when the circled "C" is opened (unless the "Write only" option is in place). Also, one can enter a comment or code that applies to a series of utterances rather than just one utterance by first clicking on the first utterance number and then clicking on the last utterance number, instead of clicking twice on the same number.

Figure 7

Screenshot of 11025 Transcript for Coding

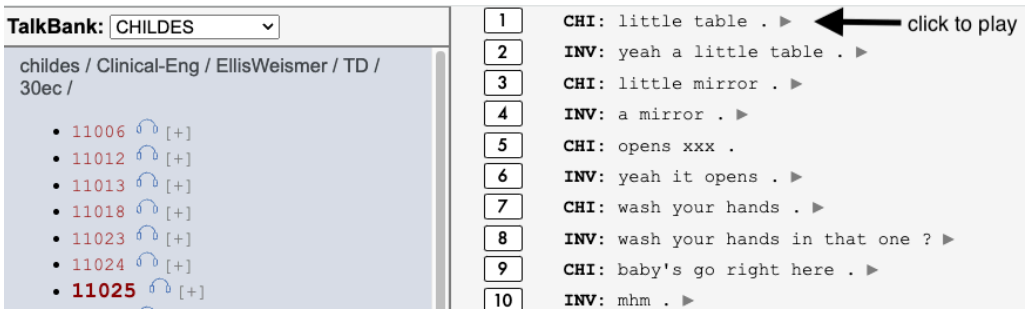


Figure 8

Screenshot of Prompts for Comments and Codes

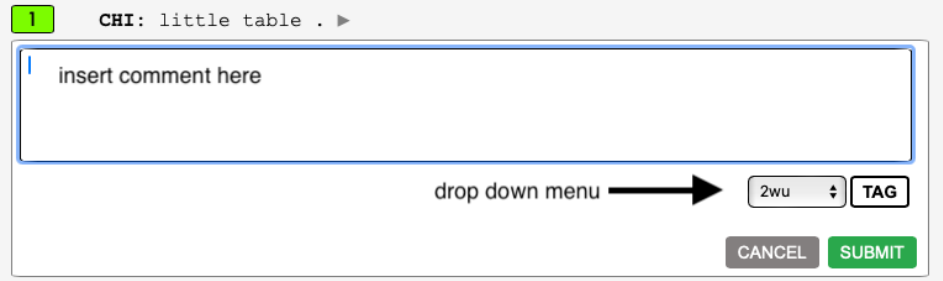
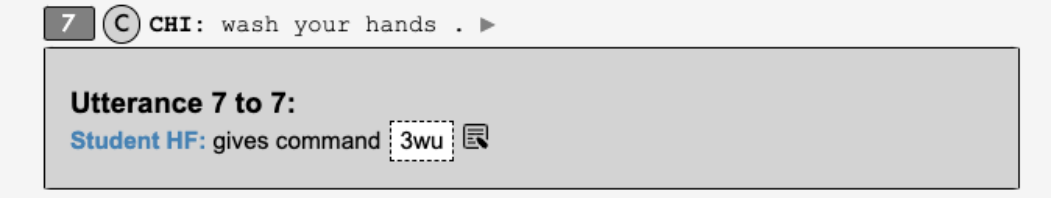


Figure 9

Screenshot Indicating Comment(s) or Code(s)

Figure 10

Screenshot of Comment and Code Entered for Utterance 7



After students complete the assignment, the instructor can proceed in many different ways. She could engage the students in whole class or small group discussions on the evidence they found demonstrating typical language development versus late talking in the various transcripts. Alternatively, students could write summaries or give presentations using examples from their observations to prove why the language characteristics of particular children suggest typical development versus late talking. The instructor could instead choose to provide feedback to each student individually about codes they used correctly and incorrectly, comments they made that were on or off target, and perhaps important features they missed. She could also mark up the transcripts in the CC group with her own codes and comments for the students to review afterwards in class or independently.

In summary, the CC tool is unique in a number of important ways: it provides open web access to transcribed and spoken language interactions that are linked to media; the transcripts are in a common format (CHAT) with additional tiers of useful morphosyntactic information; the format allows for group comments to be stored separate from the main transcript database so that other users still see the unmarked transcripts; and the format also allows for a variety of coding, commenting, reading and/or writing only options. Importantly, the CC tool is part of the TalkBank system which complies with international standards for database and language technology (MacWhinney & Fromm, 2022). The novel and fundamental impact of this tool in this context is how it enhances traditional teaching about language and communication, utilizing the rich resources in the TalkBank databases.

Additional CC Features

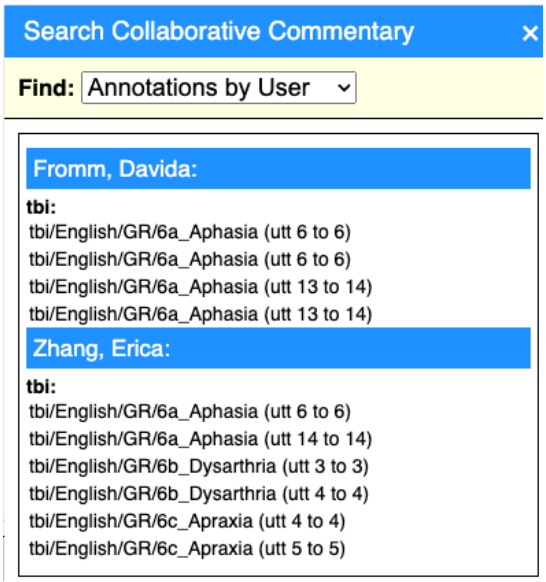
Searching

Next to the blue “Collab” button and the tag icon is a search icon (magnifying glass, see Figure 9). Users can search within a group in three ways: by user, by documents, and by tags. If you click on the search icon you get a drop-down menu with all three of those options. If you select “user” you get a list of the users that have inserted codes or comments in that group along with a list of the files and utterances where their input is located (Figure 11). Clicking on any of those lines takes you to the relevant location. Searching for documents with comments

produces a list of the files with comments for whichever group you are currently working in. (Note: the black semicircle that can be seen in Figure 9 shows that the user is working in group C2. To change to a different group, simply click the "Collab" button and select a different group from the "My groups" or "Joined groups" drop-down lists and click the "Participate" button.) Likewise, searching by tags produces a list (filename and utterance line) of where each tag was used. Again, clicking on any of those will take you directly to the appropriate utterance.

Figure 11

Screenshot of "Search by User"



Direct Email Link

As can be seen in Figure 10, the student's name is actually a hyperlink that opens a direct email message to that student with that specific utterance and comment in the message body for reference. In this way, it is easy for the instructor to send quick and targeted feedback on a comment or code that was insightful or perhaps inaccurate. For example, it could be used to clarify the difference between certain types of phonological processing errors in children, different types of paraphasias in a person with aphasia, different interpretations of a gesture, and more.

Other Features

When you create a new group and click on the "Tag" icon to create tags, you have the option to "Import Tags" from another user if you have read or heard about a set of tags that were used that you would like to use as well. This button opens a screen that requests the email address of the group owner you want to import from. That person's groups are then listed in a drop-down menu. If you know you want Brian's CA-1 tags, for example, you select that group and then click the "Import" button for all of the CA-1 tags you want to use in your set. Depending on the permissions the other person has set for their group, you may first need to email that person to request permission to import their tags. It is worth mentioning that users will find transparent icons and prompts that allow for editing or deleting comments or codes that have

been entered. Finally, a feature that allows for downloading the results of searches and downloading the results of a group's entries to a spreadsheet is currently being completed.

Additional Examples of CC Teaching Applications

Illustrations of classroom assignments using CC are given at the CC webpage: https://talkbank.org/CC/ . In some of those cases and the examples that follow, readers should be aware that some of the materials mentioned are open access (e.g., CHILDES) and others (e.g., AphasiaBank, DementiaBank, TBIBank, RHDBank) are password protected. Faculty, licensed clinicians, and researchers can request membership; students can request access through their faculty advisor.

Using CC, students in introductory courses in communication sciences and disorders could view specific transcripts and videos to comment on characteristics of right hemisphere disorder, language changes in dementia, different types and severities of aphasia, and behaviors that distinguish typical disfluencies versus stuttering in children. Students could compare and contrast language behaviors across disorders such as right hemisphere versus left hemisphere strokes. In a course on aphasia, students could identify specific behaviors such as paraphasias, circumlocutions, and agrammatism. Students in a child language development class could comment on pragmatic skills of children at specific ages, for example, 18–24-month-old children who should be doing things like initiating pretend play, acknowledging or answering, requesting objects or actions, expressing feelings, protesting or rejecting, labeling and noticing, etc.

Brian has been using CC in his undergraduate classes now for several semesters. One of the sets of tags he created was for conversation analysis coding using specific files from CABank. The set includes tags for: alignment, dispreferred response, hedge, laughter, misalignment, overlap, adjacency pair, pause, pitch change, presupposition, preference management, turn projection, recipient design, repair, tempo, trouble, and volume change.

Three TalkBank databases have guided tutorials that include curated examples from people with various types and severities of aphasia, traumatic brain injury (TBI), and right hemisphere disorder (RHD). These can be found at the "Grand Rounds" links at the respective websites (AphasiaBank, TBIBank, and RHDBank). Students can view the videos directly from the Grand Rounds, but if they access the Grand Rounds videos and transcripts through the TalkBank Browser they can respond to the questions posed in the Grand Rounds material. For example, a question in the TBIBank Grand Rounds asks, "What cognitive difficulties did you observe and how did these impact Liam's communication?" (Elbourn et al., 2020). Using CC, students could view that 2-minute video in the TalkBank Browser and enter relevant comments.

Sample Clinical Applications

Clinical instructors could select videos and transcripts for students to learn specific clinical skills. For example, a general approach that could apply to any age group and any type of impairment is to have students comment on strategies that a speaker with a communication impairment uses successfully or unsuccessfully and suggest ideas for how/when to intervene when speakers demonstrate difficulties. What does a child do when he is experiencing moments of stuttering? What, if anything, seems to make the problem better or worse? What does a child

with intelligibility issues do when she says something that the parent could not understand? What does the parent do that is helpful in those situations?

CC could be used to have student clinicians learn how to score assessment instruments. The AphasiaBank database includes videos of administrations of the Boston Naming Test (BNT, Kaplan et al., 2001), the Verb Naming Test (Cho-Reyes & Thompson, 2012), the picture description task from the Western Aphasia Battery (Kertesz, 2007), and the Quick Aphasia Battery (Wilson et al., 2018). It is simple to create a set of tags for scoring any of those tests based on the test manual. For instance, responses to the BNT are scored as 0 or 1 (incorrect or correct) and then coded for each of the nine possible errors (circumlocution, multi-word paraphasic error, perceptual misnaming, etc.). A clinical instructor could create a set of those BNT scoring tags, have student clinicians score a number of pre-selected files, and use the results of the students' scoring to clarify any concepts that were not scored accurately. AphasiaBank also contains videos of some legendary, expert clinicians such as Audrey Holland and Nancy Helm-Estabrooks. In the Holland2 corpus, a video of "Jean" provides a master class in Audrey's clinical expertise with a woman whose expressive output contained a lot of jargon. Students could identify the specific clinical strategies Audrey employs such as providing cues, using closed questions, and suggesting and modeling strategies. They could also comment on other relevant aspects of her conversational and clinical style in the interaction, such as giving time, slowing the pace, using humor, and commenting on improvement.

The Lanzi corpus in the DementiaBank database includes two small group sessions of external memory aid treatment for individuals with mild cognitive impairment (Lanzi et al., 2019). Students could identify specific aspects of the clinical intervention, noticing how and when the clinician asks questions, requests elaboration, provides explanations, gives feedback, introduces new information, and so on.

CC Research Applications

For research teams, CC can be helpful in establishing reliability for coding a wide variety of behaviors. The possible uses here seem infinite: gestures, global coherence, local coherence, agrammatism versus paragrammatism, fluency, apraxia of speech features, correct information units, conversation analysis, and more. Disagreements about how something was coded could be resolved with the research team looking at the videos and the transcripts together and discussing reasons for having scored or coded something a certain way. As a result, the coding scheme may need to be refined to improve reliability, the training materials may need to be improved, or the coder may need further mentoring by a more experienced coder.

Among specialists within a particular field, for example aphasiologists, a group could collectively evaluate behaviors such as hesitations, repairs, false starts, silent pauses, filled pauses, repetitions, and agrammatism that are lumped into terms like "fluent", "dysfluent", or "nonfluent". It could function like a collaborative forensic examination of fluency behaviors in aphasia. This approach could be applied to behaviors used to diagnose apraxia of speech, anomia, or agrammatism as well as any number of possibly fuzzy terms used in other fields. In the TBIBank database, researchers have used CC to analyze the macrostructure and organization of discourse samples in a longitudinal study of recovery from traumatic brain injury. In the APT (Academically Productive Talk) corpus of the ClassBank database, researchers developed coding systems using CC to measure academically productive talk in

teachers and students (Al-Adeimi & O'Connor, 2021). That system could provide a model for research in bilingual classrooms.

Theoretical debates could take place in a CC group, where supporters of a particular theory could identify evidence that supports their theory and refutes competing theories. Again, the potential applications here using the many shared databases and wide range of available corpora seem almost endless. The rich collections in the SLABank and BilingBank databases were not even tapped for examples of the myriad ways the Collaborative Commentary tool could be used for teaching, clinical, and research applications in those areas.

Summary

This has been an introduction to one new tool from a vast array of tools available through TalkBank and an equally vast amount of linguistic wisdom Brian MacWhinney has shared over the years through his teaching, invited lectures, workshops, presentations, articles, chapters, and books. In addition to this being a new tool, it is also a tool that allows for something that has been very important to Brian throughout his career: collaboration. He has created the world's largest open access integrated repository for spoken language data and an international community of people interested in language with the simple, fundamental goal of advancing the science of understanding language. Brian's collaborators span not only a huge range of disciplines, but also a broad range of specialties within those disciplines. If we can learn from each other through collaborative, evidence-based, transparent enterprise – whether we are students or experienced researchers – we can make more meaningful progress and be more effective in our respective fields. We hope that readers will be inclined to experiment with this tool and add to the literature and knowledge base in their respective areas of study.

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Ethics Declarations

Competing Interests

No, there are no conflicting interests.

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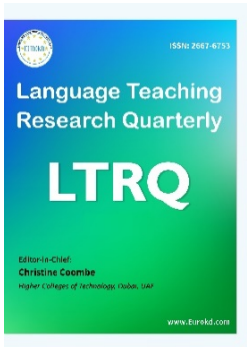

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Beyond Transfer: Language Processing in Bilinguals is Shaped by Competition and Regulation

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Abstract

In the history of psycholinguistics, there are traditional accounts that have been told about language learning and processing. These accounts revolve around the constraints imposed by the age of language learning and by universal principles that are assumed to be natively given. The contribution of Brian MacWhinney and his collaborators has been to challenge the fundamental principles on which these traditional accounts rest. By taking an emergentist approach that assumes that variation in learning will better inform foundational mechanisms than fixed constraints, they shifted the focus from language development in monolingual speakers to a broader consideration of cross-linguistic and cross-language contexts. We have been beneficiaries of this shift. In this paper, we describe research on bilingualism that examines two key mechanisms within the MacWhinney framework: Competition and transfer. We argue that what we have learned about bilingual language processing supports the central role of competition and its broad consequences. We claim that one of these consequences has been to reframe questions of transfer to consider the requirement that bilingual speakers regulate their two languages. The dynamic nature of cross-language interactions across languages and across varied language environments reflects the deep plasticity associated with language and its cognitive and neural bases.

Keywords: *Bilingualism, Cross-Language Dynamics, Language Regulation, Language Processing*

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[1]Introduction

In the last 30 years, there has been a radical shift of focus in studies of language learning and language processing to recognize that most speakers in the world use two or more languages. The resulting scholarship is flourishing, exploiting a broad range of tools that include experimentation, computational modeling, and neuroscience and bridging linguistics across the allied cognitive sciences. Brian MacWhinney's research program has been central to the development of this effort. By embracing an emergentist perspective that enables domain-general cognition to act in the service of language rather than as an intruder and by recognizing the plasticity of language systems and the variation in language users, his work has enabled lines of inquiry that require that traditional accounts of language learning and language use be revised.

In this paper, we bring together two research programs on bilingualism that have been supported by this approach. One of us is trained as a cognitive psychologist and the other as a linguist. In research that we have conducted independently and collaboratively, we have come to see the importance of the competition that reflects the dynamics of a dual language user's two languages. But the course and consequence of cross-language competition varies across individual experience and across the opportunities and obstacles that emerge within environments for language learning and language use. In what follows, we briefly review the research on language processing in bilinguals that reveals the dynamics of competition and the resulting openness of the language system itself. That openness reflects the engagement of cognitive resources during language processing but also the ways that the bilingual speaker's two languages change with respect to one another. While the research that we review provides strong support for the principles of competition, it also suggests that the notion of cross-language transfer as it was initially conceptualized, requires modification. Not only does the native or first language, L1, transfer to the second or less dominant language, L2, but both languages come to influence each other from the start of learning and from the first moments of language processing in proficient speakers. As a result, there is a reorganization that affects both languages, their relationship, and the ways that domain-generation cognitive resources are engaged.

How do the bilingual's two languages come to have this bidirectional influence? One of the most profound observations about bilingualism is that both languages are continually active, even when only one language is required and regardless of modality and form similarity across the two languages (e.g., Dijkstra et al., 1998; Marian & Spivey, 2003; Morford et al., 2011; Thierry & Wu, 2007). The parallel activation of the two languages may seem counterintuitive because bilinguals are rarely aware of the language not in use and indeed make few errors of speaking the unintended language (e.g., Gollan et al., 2011). Despite this phenomenology, there is overwhelming evidence that when bilinguals read, listen, or speak one language alone, the other language is active.[2] The implication is that to become a dual

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[2] The evidence for nonselective access to both of the bilingual's languages has been reviewed extensively (e.g., Bultena & Dijkstra, in press; Dijkstra & Van Heuven, 2018; Kroll et al., 2014; Kroll et al., 2015; Kroll, 2017; Kroll et al., 2022; Kroll, 2024)

language speaker, there is a continual requirement to navigate the joint activation of the two languages, a process that also requires that individuals acquire the ability to regulate or control the use of each language (e.g., Declerck & Koch, 2023; Green, 1998). We return to this process in the review that follows to consider how this might happen and how the contexts in which bilingual speakers use each language may determine how easily each of the two languages can be used. The point that is critical in thinking about transfer processes is to recognize that this cross-language exchange is dynamic, occurring continuously as each language is used and when bilingual speakers switch between the two languages. The observation of ongoing bidirectional influence potentially changes the notion of transfer as a developmental process that emerges over time as learners acquire new information about the L2 and its relation to the L1, to one that imposes the need for adjustment or regulation in real time. A key feature of the Competition Model (Bates & MacWhinney, 1989; MacWhinney, 1987, 2022) is sensitivity to predictive cues that differentiate the grammatical features associated with each language. We later discuss how we might think about cues more generally because the evidence on the parallel activity of bilingual language processing suggests that not all cues are necessarily functional in providing a means to identify the language in use and to reduce the activation of the nontarget language. The research that we review on lexical and syntactic processing illustrates the consequences of this dynamic interchange across the bilingual's two languages. Crucially, the "in the moment" processes that appear to characterize bilingual language processing and that come to create continual modulation of the two languages, are not the only time-sensitive factors that influence language outcomes. While debates around the importance of age of acquisition persist (e.g., Caldwell & MacWhinney, 2023), there has also been interest in understanding how other features of early life language experience may continue to influence language learning and to shape language use across the lifespan. These features include, among others, the language in which individuals first acquire literacy skills (e.g., Bice & Kroll, 2021), whether they were language brokers as children (e.g., López, 2020), and whether they overheard of a language in childhood that they never learned to speak (e.g., Au et al., 2002). Although studies on the consequences of early life language experience that may endure are only beginning to emerge, the evidence suggests that adult language processing reflects a complex mix of immediate demands placed by language and by the environmental contexts in which language processes occur (e.g., Green & Abutalebi, 2013) and by language experience.

In what follows, we briefly overview what we have learned about lexical and syntactic processing in bilingual speakers and then consider some of the broader implications that we think owe a debt of inspiration from Brian MacWhinney's research program. Our effort will inevitably be far from comprehensive or complete but will hopefully point to directions of promise for future research.

The Dynamics of Lexical Processing in Bilinguals

In this section, we consider the evidence that reveals the competitive nature of bilingual lexical access and the mechanisms that have been proposed to resolve competition to enable proficient language use. We have reviewed this work in detail in other publications (e.g., Kroll, 2017; Kroll et al., 2022; Kroll, 2024; Kroll, in press) so we focus here on the primary discoveries and their relation to issues of competition and transfer. Initial models of bilingual lexical access assumed that there was transfer from the native or dominant L1 to the L2. Transfer was

operationalized in two different ways. The Revised Hierarchical Model (Kroll & Stewart, 1994) proposed that the asymmetry in the dominance of the bilingual's two languages for adult L2 learners was responsible for a pattern in which the less dominant L2 relied upon the more dominant L1. According to the model, the L1 is privileged with respect to its ability to access meaning relative to L2. That privilege then becomes a source of mediation for the weaker L2. Kroll and Stewart tested this claim by having bilinguals translate from their L1 to L2, in the forward direction of translation, or from their L2 to L1, in the backward direction of translation. They found that there was indeed an asymmetry, with translation in the forward direction taking significantly longer than translation in the backward direction. Critically, only forward translation was sensitive to the semantics of the information being translated, suggesting that translation in the backward direction, from L2 to L1, relied on direct access to the L1. Subsequent research has supported the hypothesis that the L1 translation may play an important role when adults learners acquire a second language although it appears to remain available, at least implicitly, when proficient speakers process words in the L2 (e.g., Guo et al., 2012; Ferré et al., 2006; Morford et al., 2011; Sunderman & Kroll, 2006; Talamas et al., 1999; Thierry & Wu, 2007). [3]

A second form of transfer can be seen in the continual cross-language interactions between the two languages. As noted earlier, the persistent activation of the language not in use has been documented in over hundreds of studies reported in the last 30 years. When bilinguals read or listen to words in one language only, the influence of the other language is evident. The initial demonstrations of transfer at the level of lexical form (e.g., Dijkstra et al., 1998; Marian & Spivey, 2003) exploited the presence of ambiguity across shared lexical features (e.g., orthography or phonology) in different languages. That ambiguity was shown to produce facilitation in word recognition tasks when form and meaning converge, in the case of cognates, translations that share the same or similar form (e.g., the word "hotel" in Dutch and English) or interference when words conflict, in the case of interlingual homographs or false friends (e.g., the word "room" that means cream in Dutch). Critically, the consequences of lexical-level ambiguity have been shown to persist even when those words appear in sentence context (e.g., Libben & Titone, 2009; Schwartz & Kroll, 2006), suggesting that these well-documented cross-language interactions are not the result of presenting words in an artificial laboratory task. They can also be seen for translation equivalents that share meaning but not lexical form (e.g., Morford et al., 2011; Thierry & Wu, 2007) and they are evident even when bilinguals are planning speech in one language alone (e.g., Costa et al., 2000; Kroll et al., 2006; Strijkers et al., 2010).

If transfer at the lexical level were only a matter of applying experience with the native or more dominant L1 to the weaker or less dominant L2, then one might expect to see robust cross-language lexical interactions from L1 to L2 but not the reverse. Contrary to this prediction, we see effects of the L2 on the L1 even when adult learners are at the earliest stages of acquiring an L2 (e.g., Bice & Kroll, 2015) as well as for highly proficient speakers (e.g., Schwartz et al., 2007; Van Hell & Dijkstra, 2002). The entire language system appears to adapt to the presence of the L2 in a manner that creates multiple sources of cross-language transfer.

[3] For additional discussion and debate on the role of the translation equivalent see Brysbaert and Duyck (2010) and Kroll et al. (2010).

The competitive dynamics of these interactions has been shown to create change even in the native or more dominant L1 (and see Chang, 2012, for evidence on the effects of L2 on L1 at the phonetic level). These changes have also been documented in studies that have adopted neuroscience methods (e.g., Midgley et al., 2011; Van Heuven et al., 2008; and see Schwieter & Festman, 2023 for a recent review of evidence on bilingualism and the brain).

The research on cross-language interactions at the lexical level reveals pervasive competition that characterizes bilingual language experience. But how is this competition resolved to enable fluent use of each language? We argue here that bilinguals acquire the regulatory skills to rapidly adjust the state of play across the two languages and across the contexts in which they find themselves using one language alone or both. A model of inhibitory control by Green (1998) and a seminal study by Meuter and Allport (1999) on language switching gave rise to a body of research that has continued to examine the mechanisms that bilinguals use to effectively resolve cross-language competition. Meuter and Allport examined the processing costs following the switch of language in a simple cued lexical production experiment. They found that proficient bilingual speakers were slower to produce words in each language following a switch from the other language. But there was an asymmetry. The switch costs were differential for the two languages, with larger switch costs in L1 following L2 than in L2 following L1. At first that may appear counterintuitive if we assume that L1 is the more dominant and active language. But by the logic of Green's inhibitory control model, the more dominant language is hypothesized to be inhibited to enable speech planning and production in the less dominant language. If the two languages are always active, then the regulation of the more dominant L1 may be required to enable the L2 to be spoken at all.

In the time since the initial work on inhibitory control appeared, there has been an extensive body of research that asks how bilinguals acquire the ability to regulate the two languages and how that process draws on domain-general cognitive resources. Bilingual speakers are not only slower to speak L1 following L2 in lexical switching tasks that require trial-to-trial adjustments, but they are also slower to speak L1 following L2 when they speak the L2 for an extended period and then speak L1 for an extended period of time (e.g., Casado et al., 2022; Van Assche et al., 2013). The same costs to L1 can be seen in brain activity (e.g., Guo et al., 2011; Misra et al., 2012). And in a phenomenon that may seem most counterintuitive of all, highly L1 dominant bilinguals reveal a "dominance reversal" when they perform lexical production tasks in a mixed context in which there is uncertainty about language of naming from one spoken utterance to the next (e.g., Declerck et al., 2020). An early conjecture was that these control mechanisms might be more important at early stages of acquiring L2 proficiency (e.g., Costa & Santesteban, 2004) but we now know that this is not a matter of acquiring control early in L2 learning; the most proficient bilinguals rely on these skills to adapt dynamically to the regulatory needs of specific communicative contexts.

How does language regulation differ from domain-general cognitive control? We and others have argued that the regulation of the two languages engages a network of cognitive control but not in a manner that necessarily maps identically to the ways that executive control tasks reflect that network (e.g., Guo & Ma, 2023; Kroll et al., 2022). In both cases, there may be resolution of competition and conflict, but there is not a one-to-one relationship. Moreover, the process of resolving cross-language competition may depend on the demands of the environmental context and individual differences in bilingual language experience. Green and

Abutalebi (2013) argued for the adaptive control hypothesis such that the recruitment of domain general cognitive resources depends on the way that the two languages are used in any given context. Some bilinguals code switch, a topic we consider in detail in the next section of this paper, and others do not. Some bilinguals live in an environment in which most people with whom they interact are similarly bilingual but others live in contexts in which they may encounter few others who speak one of their two languages. Some bilinguals are immersed in their L1 or native language context, but others are immersed in the L2, with potentially fewer opportunities to use the L1. Which of these features matters? We are at a moment in the research program of just beginning to identify the relative contribution of each of these scenarios.

An important insight in the recent studies of bilingual lexical processing, following the logic of adaptive control proposed by Green and Abutalebi (2013), is that all speakers are immersed. We typically assume that immersion means L2 immersion but given the variation in the contexts in which bilinguals use the two languages, a richer characterization is required to acknowledge the distinctive features across environments and the impact they have on bilingual experience (e.g., Beatty-Martínez & Titone, 2021). In an early study of the consequences of L2 immersion for lexical processing, Linck et al. (2009) found that there was inhibition of the L1 when learners were immersed in the L2 context. But immersion is more than simple suppression. Beatty-Martínez, Navarro-Torres, Dussias, Bajo, et al. (2020) compared three groups of highly proficient Spanish-English bilinguals who lived in different locations that created distinct interactional contexts for the use of the two languages. One group used the languages separately, another used the languages interchangeably, and a third group was immersed in an L2 English setting in which few others spoke the L1. Beatty-Martínez et al. asked how cognitive control, using the AX-Continuous Performance Task (e.g., Braver, 2012), might differentially be engaged during performance on a lexical picture naming across these three contexts. The striking result was for the Spanish-English bilinguals living in a predominantly L2 English environment. Those speakers appeared to use proactive control mechanisms to maintain their use of Spanish in an environment that afforded few opportunities to speak Spanish with others. A subsequent study by Zhang et al. (2021), using the AX-CPT and a language switching paradigm, compared Mandarin-English speakers in China and in the US. Like Beatty-Martínez et al., they found that immersion in the L2 was associated with higher proactive cognitive control processes and that proactive control was coupled with increased inhibition of the L1 in the switching task. The implication is that even similarly proficient L2 speakers vary in how they recruit cognitive control and how they regulate each of their two languages as a function of the opportunities to speak each language. Other studies have shown that diversity of the social networks in which bilinguals live and work have a profound influence on language performance and on the recruitment of cognitive control (e.g., Gullifer & Titone, 2020; Gullifer et al., 2018).

In this brief review of research on bilingual lexical processing we have attempted to show that there is a high level of competition across the bilingual's two languages that is bidirectional, with each language coming to influence the other and with the modulation of that processes open to the influence of the environments in which bilinguals find themselves. While transfer from the native or dominant language is certainly present during initial L2 learning, it does not diminish as individuals become proficient speakers of the L2. To the contrary, it gives

rise to a language system in which there is adaptation to the presence of the two languages via a mechanism of regulation, drawing on domain-general cognitive resources and shaping both languages as a result. Some bilinguals may habituate to a situation that is relatively consistent over time whereas others may find themselves in a continually changing context that requires regulatory adjustment. In the next section, we consider how these cross-language interactions are manifest at the level of syntactic processing and how language regulation may be crucial in understanding the ability of bilingual speakers to code switch with one another.

Cross-Linguistic Interactions during Syntactic Processing in Bilinguals

In this next section, we review recent contributions to the study of bilingual sentence processing that will serve to illustrate how exposure to an L2, even for a brief period, can influence syntactic processing in the native language. The influence of the native language system on the acquisition and processing of a second language has long been noted (Bates & MacWhinney, 1982; Corder, 1981; Gass & Selinker, 1994), but the reverse has not been recognized until relatively recently. Although more research has examined bilingual language interactions for words than for sentence, the available evidence converges on the finding that the bilingual's two languages are open to one another at every level of representation. These results challenge the interpretation of a critical period for syntactic learning and demonstrate that the native language adapts flexibly to the linguistic environments and the cultural contexts in which bilinguals use their two languages (Liu et al., 2021; Pot et al., 2019). The evidence now shows that variations in language dominance and language use prompt system alterations—some subtle, some significant, even when individuals have acquired high proficiency in the second language (e.g., Gollan et al., 2011; Ivanova & Costa, 2008; Kasparian & Steinhauer, 2017; Runnqvist et al., 2013). Importantly, we view the evidence on the weakening of the native language constraints (Kroll & Finger, 2023) not as indicative of signs of first language loss, but rather as evidence of the inherent flexibility of the linguistic system (Kroll et al., 2015).

Monolingual speakers also demonstrate linguistic adaptability, adjusting to and incorporating unfamiliar structures from different language varieties into their own language (e.g., Fraundorf & Jaeger, 2016), and exhibiting reduced sensitivity when exposed to ungrammatical structures for a brief period (Hopp, 2016). To take just one example, Wells et al. (2009) systematically manipulated input-driven experience in a self-paced reading task involving subject and object relative clauses. The constructions were selected based on the well-established finding that object relative clauses are typically more challenging to process than subject relative clauses. Participants were divided in two training groups. The 'non-exposed' group participated in three training sessions over the course of several weeks, during which they were exposed to various syntactic structures, none which included subject and object relatives. The 'exposed group' also completed three training sessions, but crucially they saw an equal number of subject and object relative clauses. At testing time, the exposed group took significantly less time to read object relative clauses compared to the non-exposed group, indicating a reduction in processing difficulty brought about by exposure to the less frequent structure.

Studies have also shown that monolingual language users are able to adapt rapidly to novel distributional patterns in the input within a single experimental session. Hopp (2016) tested whether grammatical gender assignment that deviated from native speaker expectations would

lead to erroneous gender-based prediction. German native-speaking participants saw four pictured objects on a computer screen. In the critical condition, three of the four objects were identical in color but were differentiated by their grammatical gender (i.e., feminine, masculine, and neuter). One of the objects served as the target and remaining two as competitors. The fourth object served as a distracter. Adult native German participants were assigned to one of two experimental groups. In one group, participants heard target sentences that followed German grammatical gender agreement rules. The second group was additionally exposed to a small number of filler trials in the final quartile of the experiment that contained gender agreement violations, effectively creating a context in which the distributional properties of the input were not helpful to generate predictions. The findings showed that the presence of this relatively small number of erroneous tokens in the experimental session attenuated participants' sensitivity to grammatical gender as a cue to predictive processing. In other words, the native listeners in the Hopp study showed evidence of strategic shifting by adapting their expectations away from the a priori more frequent morphosyntactic agreement patterns in German towards the more recent statistics and used these local statistics to guide their decisions about language comprehension in real time (see Fine et al., 2013 for related discussions). There is also evidence that when L1 has been reconfigured (as would be the case in individuals who use their two languages in their daily lives or individuals regarded as L1 attriters) even brief re-immersion in the first language can realign processing strategies towards monolingual-like preferences (Chamorro et al., 2016; Dussias et al., submitted).

The results with monolingual speakers suggest that their linguistic experiences affect processing, underscoring the key role of input and experience. While speakers of the same linguistic variety often converge on the information employed during sentence processing, there nonetheless exists great heterogeneity and variation in the way monolingual speakers approach sentence processing in their native language (Farmer et al., 2012). In what follows, we exemplify experience-based interactions while bilinguals process sentences in their two languages by reviewing two illustrative cases of native language reconfiguration, which we argue are natural extensions of a dynamic linguistic system.

In one of the earlier studies demonstrating the influence of the second language on the native language, Dussias and Sagarra (2007) examined whether extensive immersion in English would impact how Spanish-English bilinguals resolved syntactically ambiguous sentences in Spanish (their first language). English and Spanish differ in the interpretation of syntactically ambiguous relative clauses preceded by a complex noun phrase, exemplified in "Alguien disparó al hijo de la actriz que estaba en el balcón" ('Someone shot the son of the actress who was on the balcony'). When asked "¿Quién estaba en el balcón?" ('Who was on the balcony?'), Spanish speakers typically respond "el hijo" ('the son'), while English speakers respond "la actríz" ('the actress'). Dussias and Sagarra found that bilinguals immersed in an English-speaking environment favored the interpretation associated with English when reading in Spanish. This differed from a non-immersed, proficiency-matched bilingual group, who favored the expected Spanish-associated interpretation.

Additional evidence of changes to the L1 has been observed in bilinguals who regularly codeswitch between their two languages. In numerous bilingual communities, speakers frequently alternate between languages, sometimes within a single utterance. Far from being random and haphazard, codeswitching is systematic and requires highly skilled bilingual

ability, not only because bilinguals must be proficient in both languages to identify potential switch sites, but because they must be practiced at combining the languages to adapt strategies from each (Beatty-Martínez, Navarro-Torres, Dussias, 2020; Torres Cacoullos & Travis, 2015) . Using Spanish and English as an illustrative example, a large body of corpus studies has shown an asymmetric use of Spanish determiners in mixed noun phrases. When determiners and nouns mix within a single noun phrase, Spanish-English bilinguals' preference is not only for combinations of Spanish determiners followed by English nouns ("el fork"/the$_{MASC}$ fork) rather than, for example, English determiners followed Spanish nouns ("the tenerdor$_{MASC}$"/the fork) but, in particular, for Spanish determiners with *masculine* grammatical gender followed by English nouns regardless of the grammatical gender of the noun's Spanish translation equivalent. Both "el fork" ('fork' = 'tenedor$_{MASC}$') and "el table" ('table' = 'mesa$_{FEM}$') are found in Spanish-English bilingual corpus. Mixed noun phrases involving Spanish feminine determiners followed by English nouns are infrequent and restricted to contexts in which the noun's gender would be feminine if it were translated into Spanish. Hence, "la blender" ('blender' = 'licuadora$_{FEM}$') has been documented but "la shoe" ('shoe' = 'zapato$_{MASC}$') has not (see Jake et al. 2002; Otheguy & Lapidus, 2003; Trawick & Bero 2022; Valdés Kroff, 2016;).

Correspondingly, psycholinguistic studies have asked whether the asymmetry described above, which is amply attested in Spanish-English codeswitched naturalistic productions (e.g., Parafita Couto & Gullberg, 2017) modulates bilingual language comprehension such that feminine determiners would signal the upcoming presence of a feminine gender noun either in Spanish or in the English translation equivalent of the corresponding Spanish word, but masculine determiners would not. This was the central question of a lab-based study by Valdés Kroff et al. (2017). Specifically, the authors examined whether experience with determiner-noun asymmetric codeswitching patterns affected comprehension in such a way that masculine gender determiners would no longer exclusively signal the presence of masculine gender nouns either when bilinguals were in a codeswitching mode or in a Spanish mode.

To address this question, Spanish-English codeswitching bilinguals were shown visual scenes with two picturable objects while they listened to auditory instructions to click on one of the two objects. When the instructions were delivered in a code-switching mode, the bilinguals predictively processed English targets soon after hearing a feminine article, but when they heard a masculine article, they delayed processing until they heard the target noun onset. Strikingly, these were also the findings when the bilinguals heard Spanish-only instructions. These results suggest that the bilingual comprehension system adapted to the speakers' codeswitching experience, modulating sensitivity to grammatical gender as an anticipatory cue even when they were processing Spanish-only noun phrases. Despite potential limitations on cross-language interactions, these influences reflect a dynamic native language system responsive to bilingual language contact and usage patterns. This and other findings advocate for a research approach that thoroughly characterizes bilingual experience to better understand the influence of bilingualism on language and cognition (Kroll & Finger, 2023).

Although the results discussed above indicate that the bilinguals' two languages do not functionally behave like either native language of monolinguals (Grosjean, 1989), there may be limitations on the types of cross-language interactions in bilinguals. Ahn et al. (in press) compared the sentence processing and production of a group of Korean-immersed speakers in

Korea (with little English exposure) with Korean-immersed speakers in the US. The critical conditions included Korean sentences in two possible word orders: one that did not overlap with English (SOV – the canonical word order in Korean) and one that overlapped with English (SVO –a less preferred word order in Korean but the canonical word order in English). The key question was whether there would be an effect of English immersion on Korean manifested as a preference for the English SVO word order while processing Korean sentences. The results showed changes in the US Korean-immersed speakers but not as an L2 straightforward influence on L1 sentence processing and production, suggesting that perhaps the greater typological difference between Korean and English might modulate the influence of L2 on L1.

The studies examined in this section illustrate the influence of the second language on the first, collectively underscoring the permeability of the L1 linguistic systems, sometimes involving processing costs that initially slow down the native language or that make bilingual speakers less sensitive to features of the native language. These and many other studies (Fine & Jaeger, 2016; Kleinschmidt & Jaeger, 2015) demonstrate how linguistic experience modulates native language processing. These modulations may be short-term and adaptive in nature and may be driven by changes in an individual's expectations or predictions about upcoming input, which in turn affect how participants react to deviations from norms in the moment (Hopp, 2016). Modulations may also be the result of long-term, community-based norms (Valdés Kroff et al., 2017) that reflect at least some shift in the underlying representations, such that the new or unfamiliar structures become entrenched in the individual's linguistic system. Whatever the case, variability in language processing should be considered the norm, rather than the exception. The evidence presented here advocates for an approach that connects L2 language processing with language experience and basic cognitive principles that is more compatible with our current knowledge of the architectural underpinnings of the systems responsible for language acquisition and language processing, and that provides a more fruitful approach in future studies of bilingual syntactic processing.

In summary, in this section, we have examined recent advancements concerning the permeability of the native language system, primarily emphasizing sentence comprehension. Our goal has been to elucidate the perspective that changes to the native language signify the openness of the networks underpinning language knowledge and usage and are an inherent feature of the linguistic system's architecture. While the adaptability of the native system is observable in both monolingual and bilingual individuals, bilingual speakers serve as a "natural experiment." Changes to the native language, prompted by the exposure and contextual usage of a second language, occur organically when individuals engage with and utilize multiple languages. Moreover, recent methodological advances have furnished unique insights into the emerging inquiries briefly reviewed in this section. Stepping away from the specific experiments discussed, our review's overarching theme underscores the remarkable openness between the bilingual's two languages, characterized by persistent cross-language interactions spanning from word to sentence processing, and modifications to the native language that offer a framework to test assertions regarding the plasticity of cognitive and neural representations.

Conclusion

We have reviewed research on bilingual language processing that has transformed our understanding of how the bilingual’s two languages come to live together in the same mind

and brain. The continual activation of the two languages creates a situation that is highly competitive. In the spirit of Brian MacWhinney's research program, there is competition everywhere we look. There is competition in selecting which language is in use and there is competition across the alternative linguistic structures that may be associated uniquely with one of the two languages or shared by both. This work shows that it is not only that the L1 is used as a source of transfer but that the native and/or more dominant language is remarkably open to transformations that enable the dynamic and plastic changes that occur over the course of bilinguals' lives (and see Pliatsikas, 2020, for a model of how brain plasticity changes over the lifespan). The adaptive nature of these changes and the regulatory skill that is acquired to navigate the variation across speakers and environments enable bilingual speakers to speak proficiently in each language and to code switch with one another with far fewer, if any, costs than might be anticipated.

The results we have reviewed also have several other important consequences. We have already described the significance for how we conceptualize the native or dominant language. Not only is the L1 changed by virtue of its role in bilingual language dynamics, but it renders that language different in some critical respects relative to monolingual speakers of the same language and relative to other bilingual speakers who may use the two languages in distinct contexts. We have learned that not only bilinguals but also monolinguals vary in how pressures on speakers across alternative contexts and as a reflection of their language experiences may come to influence language processing (e.g., Bice & Kroll, 2019; Pakulak & Neville, 2010). While there may be some enduring consequences associated with early acquisition of the L1 (e.g., Kousaie et al., 2017), the evidence on bilingualism suggests that there is less stability associated with the L1 than traditional accounts have assumed and that liberating the narrative from its fixation on the native speaker may enable richer and more complete accounts of the language variation that results (e.g., Caldwell-Harris & MacWhinney, 2023; Rothman et al., 2022). This is an exciting enterprise and one that has been inspired by Brian MacWhinney and his collaborators.

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Ethics Declarations

Competing Interests

No, there are no conflicting interests.

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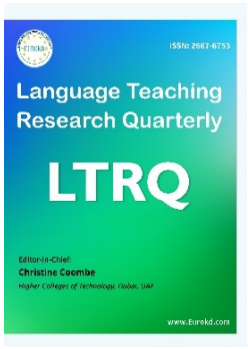

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The Competition Model and Adult Second Language Learning: Cross-Language Similarity and L2 Morphosyntax Learning

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Abstract

Adult second language learners arrive at the language learning situation with an already formed first language grammar system in place. The study of cross-language similarity across the first and second languages explores how the similarities and differences in the two languages make learning more or less difficult, particularly for adult learners. From a Competition Model (MacWhinney, 1997) framework, the authors and their colleagues have conducted research examining the relationship between cross-language similarity and adult second language learning and processing with actual learners and in training paradigms with naïve learners; converging methodological approaches have been used (eye tracking, event related brain potentials, self- paced reading, and grammaticality judgments). We review these studies and describe the predictions derived from the Competition Model framework as a function of whether grammatical constructions are formed similarly or differently in the two languages or are unique to the second language. We conclude with a description of Brian MacWhinney's influence on this body of research.

Keywords: *Competition Model, Cross-Language Similarity, Grammaticality, L2 Morphosyntax Learning*

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[1]Introduction

How does an adult's first language (L1) impact the learning of a second language (L2)? We ask this question in relation to learning L2 morphosyntax. In a series of studies, we and our colleagues have used the predictions of the Unified Competition Model (MacWhinney, 2005) as a basis for exploring the consequences of cross-language similarity for learning L2 morphosyntax. These studies have involved testing actual language learners as well as training then testing naïve learners. These studies use a variety of methodologies (self-paced reading, event- related brain potentials, eye tracking, and behavioral grammaticality judgments) to gain traction on the relationship between cross-language similarity and L2 morphosyntax learning. In all of these studies, we have used morphosyntactic constructions that are similar, different, and unique across languages. We use a violation paradigm to assess sensitivity to grammatical violations using the tasks listed above.

The initial investigation in this line of work was conducted by Tokowicz and MacWhinney (2005). They defined similar constructions as those that would be formed in a similar manner in both languages in terms of which grammatical features had to agree or be explicitly marked. Different constructions were those in which the two languages both marked a grammatical feature, but the languages differed in terms of whether those features had to agree or be explicitly marked in a particular construction or with particular words. Finally, unique constructions were those in which the relevant grammatical feature did not exist in L1 and was unique to L2. Thus, similar constructions should encourage transfer across languages, different constructions should lead to competition across languages, and constructions that are unique to the L2 should encourage neither transfer nor competition.

A construction such as demonstrative determiner number agreement would be considered similar in English and Spanish because both languages have number agreement and expect agreement between a demonstrative determiner and its noun, as in (1).

(1) Ese/*Esos gato duerme. [That/*Those cat sleeps.]

In this example[2], the point at which the violation of agreement could be detected is the noun, *gato*, and this word is underlined for illustration. By contrast, definite determiner number agreement would be considered different between English and Spanish because although both languages use definite determiners and number agreement in some instances, in English the definite determiner doesn't have to agree with the noun in number, whereas it does in Spanish, as in (2).

(2) El (*Los) gato duerme. [TheSING/*ThePL cat sleeps.]

Lastly, a construction such as definite determiner gender agreement would be considered unique to Spanish because English does not use a grammatical gender system.

(3) El/*La gato duerme. [TheMASC/*TheFEM cat sleeps.]

[1] This paper is part of a special issue (2024, 44) entitled: In Honour of Brian MacWhinney's Five-Decade Contributions to Language and Psychology Research (edited by Zhisheng (Edward) Wen and Hassan Mohebbi).
[2] Note that this sentence is for example purposes only; actual stimuli were typically longer.

Based on the predictions of the Unified Competition Model, we would anticipate that similar constructions as in (1) would engender transfer and it would therefore be easiest for learners to detect violations in these constructions. Different constructions should be difficult because of competition. Constructions that are unique to L2 should not benefit from transfer but also should not suffer from competition; processing of these constructions should therefore rely on input-driven learning (e.g., MacWhinney, 1997). In particular, according to the Competition Model, processing will be facilitated the stronger and more valid the cues are in the input. In the case of grammatical gender in Spanish, it is a fairly regular (valid) system (Alfonso, Domínguez, Álvarez, & Morales, 2014) and is typically taught early and often in classrooms in the sense that nouns are rarely taught separate from their determiners, which carry gender information. And because of the requirement for gender agreement throughout the language system, even naturalistic input should have regular opportunities for learning.

In the first investigation in this line of work, Tokowicz and MacWhinney (2005) tested native English speakers who were learning University Spanish. Participants read similar, different, and unique constructions with and without violations embedded in sentences while their brain responses were recorded. Tokowicz and MacWhinney anticipated stronger sensitivity (both behaviorally and as measured by brain responses) for similar and unique constructions than for the different construction. Event-related brain potentials (ERPs) were derived from the continuous electroencephalogram to permit comparisons between conditions. In line with predictions, participants were sensitive to the distinction between grammatical and ungrammatical sentences for the similar and unique conditions, but not the different condition. Behaviorally, however, participants had higher accuracy for the similar and different constructions than for the unique constructions, which were near chance. From the perspective of the Competition Model, it is not surprising that the similar condition showed sensitivity in both the ERP and the behavioral grammaticality judgments, whereas sentences in the other two conditions did not. However, it was surprising to find a dissociation between the online (ERP) data and the offline grammaticality judgment data in the different and unique conditions, in which we would have expected similar sensitivity in both measures (see also Chen, Shu, Liu, Zhao, & Li, 2007; McLaughlin, Osterhout, & Kim, 2004). This pattern underlines the fact that these two types of tasks access different types of processing. Further investigation of the behavioral data in this study (McClain & Tokowicz, 2006) demonstrated that grammaticality judgments are related to the number of words that agree with the critical word of the sentence in gender and/or number prior to the grammaticality judgment. For example, in a sentence such as (4), the verb is the only piece of agreeing information (in number) with the critical noun (camión). In contrast, in (5), there are two pieces of agreeing information: the verb (está) and the adjective full (llena), which are both singular.

(4) El/*Los camión está en el garaje. [The$_{SING}$/*The$_{PL}$ truck is in the garage.]

(5) La/*Las caja está llena de libros. [The$_{SING}$/*The$_{PL}$ box is full of books.]

The correlation McClain and Tokowicz reported between pieces of agreeing information and judgment accuracy suggests that end-of-sentence judgments may reflect an accumulation of evidence across an entire sentence, pointing to a possible source of dissociation between

online measures, which are taken at the point of the violating (or not) word, and offline measures that are taken at the end of the sentence.[3] Given this information, it is less surprising to find a dissociation between these measures, particularly because McClain and Tokowicz found that the unique construction happened to have the fewest agreeing words. Focusing on the ERP results that measure processing at the critical word, we can take the findings to suggest that learners are more sensitive to violations in the similar and unique conditions, consistent with the idea that competition led to a decrease in sensitivity in the different condition.

The final section of Tokowicz and MacWhinney (2005) was entitled "Creating improvements in performance". There, they discussed an ongoing pilot study that was aimed at improving participants' behavioral performance to better match their performance as measured by ERP. This was motivated particularly by participants' performance in the unique condition in which behavioral performance was near chance and yet ERP sensitivity was most pronounced. That initial pilot study was followed up by a more thorough one by Tolentino (2008) in which participants were tested in four between-subjects conditions. Participants in all conditions completed an initial block in which sentences were shown and acceptability judgments were made, similar to the Tokowicz and MacWhinney study. This was followed by a block in which participants were shown one of the following (grammaticality judgments were made in all conditions): (a) word pairs with/without a violation; (b) word pairs with/without a violation and judgments that were followed by feedback; (c) sentences with/without a violation; or (d) sentences with/without a violation and judgments that were followed by feedback. During the third block of trials, sentences were again shown without feedback. Judgments were most accurate in the condition in which word pairs had been presented and feedback was provided in the middle block (see the logic of feature focusing of the Knowledge-Learning-Instruction Framework of Koedinger, Corbett, & Perfetti, 2012). Given these findings, Tolentino (2008) used this word pairs plus feedback condition in a full ERP study. She examined the increase in performance during the interpolated block of trials in which the word pairs plus feedback were shown, as well as during the third block of trials in which sentences were shown without feedback. In the third block, a further manipulation was implemented such that some of the items in Block 3 had previously been seen in Block 2 (half as identical repetitions, half with a change in grammatical acceptability).

Sentence acceptability judgments were significantly more accurate in Block 2 than in Block 1 (as determined using d', a measure of sensitivity that takes response bias into account). Given that the pilot study had shown no similar improvement when sentences without feedback were continued for an equivalent number of trials, the switch to word pairs plus feedback was most likely responsible for the increase in accuracy. Moreover, judgments were also significantly more accurate in Block 3 (for both new and repeated items) than in Block 1. This sustained accuracy suggests that the intervention carried out during the interpolated block changed the way that the participants responded to the sentences. ERPs were recorded throughout Tolentino (2008). The findings showed that the increase in behavioral sensitivity observed in Block 3 was accompanied by an increase in online sensitivity as measured by the P600 ERP component. This finding is related to

[3] The correlation between pieces of agreeing information and grammaticality judgment accuracy was present only for ungrammatical sentences (which generally had lower accuracy). See Tokowicz and Warren (2010) for additional details.

the observation of increased ERP sensitivity with increased L2 proficiency (e.g., Rossi, Gugler, Friederici, & Hahne, 2006).

Two findings are notable from the Tolentino study. First, performance on the grammaticality judgment task improved when word pairs were removed from sentence context and feedback was provided. As a reminder, the pilot study indicated that performance was most improved when both word pairs and feedback were used. Taken together, the findings suggest that isolating the violations from the sentences somehow aided learners in being able to perform better not only during the interpolated block but also in the later block of sentences. This may be because reading sentences in L2 is challenging and it aids attention or noticing and therefore learning when the violations are isolated, so their positions and types are more salient. Furthermore, having feedback likely assists with the yes bias that learners tend to exhibit when performing grammaticality judgment tasks (e.g., Tokowicz & MacWhinney, 2005); getting feedback can assist learners in calibrating their responses. Notably, these improvements carried over to the third block of trials when sentences were again provided without feedback.

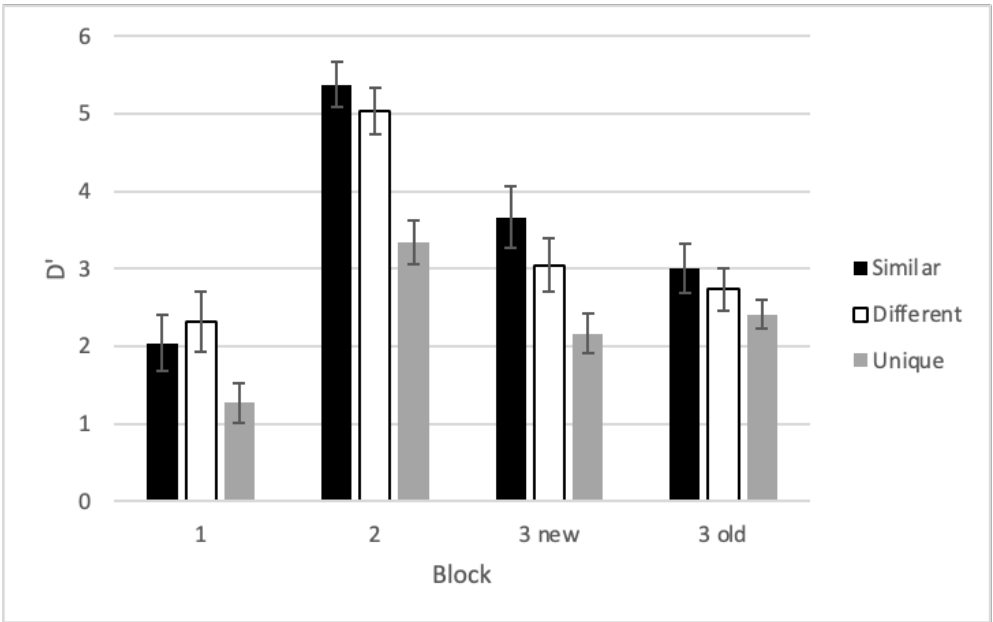
The second notable finding is that the improvement in behavioral performance was accompanied by an increase in online sensitivity to violations as measured at the P600 component. Given that there was no condition in this study in which only sentences were provided without feedback, it is not possible to definitively determine that the change in online performance is due to the change in judgment performance. But we can look for a correlation between changes in grammaticality judgment sensitivity across blocks and the change in online P600 sensitivity to ungrammaticality across blocks. Across the three cross-language similarity conditions, changes in d' correlated with the change in online P600 sensitivity significantly only for the unique condition, which had the worst performance across all conditions and showed improvement from Block 1 (see Figure 1). This correlation supports the possibility that the change in behavioral performance drove a change in ERP sensitivity. Given that the unique condition is the condition in which learning should be most relevant according to the Competition Model, because the construction is not already part of the L1 system, it is reasonable that this is the condition that should benefit most from this form of intervention.

Tokowicz and Warren (2010) directly followed up on Tokowicz and MacWhinney (2005). They also tested very early English L1 learners of Spanish and used the similar, different, and unique conditions from Tokowicz and MacWhinney. However, Tokowicz and Warren added an additional similar condition (similar2) and used self-paced reading rather than ERPs with a fixed presentation rate to permit participants to process at their preferred speed. The similar2 condition included a violation of demonstrative determiner- noun number agreement, i.e., Esa/*Esas clase empieza al mediodía. *This/*These class begins at noon.* The benefit of including this similar2 condition is that it is directly parallel to the different condition because they both involve violations of number agreement between determiners and nouns. This makes the comparison between the similar2 and different conditions better controlled such that any observed differences are more likely to be related to transfer. Tokowicz and Warren's participants showed longer reading times for ungrammatical than grammatical sentences in the two similar and different conditions, but not the unique condition, on the word at which the ungrammaticality became apparent. Sensitivity analyses (d') on the grammaticality judgments also confirmed higher sensitivity to ungrammaticality in the two similar and the different

conditions than in the unique condition. Transfer accounts, like the Competition Model, predict the participants' sensitivity to ungrammaticality in the two similar conditions, but would predict that participants should have more difficulty detecting ungrammaticality in the different condition, given that the different condition requires participants to make a distinction (between singular and plural definite and possessive determiners) that they don't have to make in their L1. The fact that participants did not detect the ungrammaticality in the unique condition suggests that they had not yet learned grammatical gender in Spanish well.

Figure 1

D' by Cross-Language Similarity and Block (Adapted from Tolentino, 2008)



Tolentino and Tokowicz (2014) followed up these studies by conducting a training study in which native English speakers were taught a miniature version of Swedish (vocabulary and grammar), including a similar, different, and unique construction (see Table 1). The grammatical constructions were taught to participants in one of three between-subjects instructional manipulations: contrast plus color highlighting of the relevant location of the violation (Salience Group), contrast plus highlighting with grammatical explanations (Rule & Salience Group), or neither (Control Group; see Table 2). Participants were tested in a pretest and three posttests across two weeks.

Table 1

Sample Stimuli from Tolentino and Tokowicz (2014)

Similar (Demonstrative determiner- noun number agreement)	**Different** (Singular noun phrase definiteness marking)	**Unique** (Indefinite singular article-adjective gender agreement)
Den där pojken leker.	Pojken leker.	En ung pojke leker.
De där pojkarna leker.	En pojke leker.	Ett ungt djur leker.

Table 2

Instructional Conditions from Tolentino and Tokowicz (2014) (Example from the Different Condition)

Control	Salience	Rule & Salience
Pojken leker. Filckan springer.	Pojk**en** leker. **En pojke** leker.	Pojk**en** leker. **En pojke** leker.
		Notice that definiteness is marked by attaching "(e)n" or "(e)t" to the end of a noun without the preceding articles "en/ett".

Overall, the results demonstrated better performance on similar and unique constructions than on different constructions and better performance on the final posttest than on earlier tests (e.g., Sabourin & Stowe, 2008; Sabourin et al., 2006). There was little difference between instructional conditions for the similar condition, which is perhaps to be expected given that transfer from L1 is possible. For different constructions, both the Salience and Rule & Salience (at posttest 3) conditions yielded better performance than the Control condition. For unique constructions, the Rule & Salience (at posttest1) and Salience conditions outperformed the Control condition. These results suggest that although the three training conditions didn't differ with respect to the similar construction, salience was particularly helpful in training different constructions, likely because the visual enhancement drew attention to the critical areas in the sentences where agreement was necessary (see Han, Park, & Combs, 2008, for a review), which aided the learner in overcoming competition from L1. Unique constructions benefited most (in terms of effect sizes) from the Rule & Salience condition. The presentation of a grammatical rule or explanation for a construction that does not exist in L1 was likely useful because it provided necessary background (e.g., "Notice that you add a "t" to adjectives that follow the "ett" article but not the "en" article."). The salience aspect of this condition helped to draw attention to the words where agreement was necessary, which, combined with the rule, may have been a powerful training mechanism. The overall pattern of performance as well as the pattern of interaction with instructional condition is consistent with the predictions of the Competition Model.

Tuninetti, Warren, and Tokowicz (2015) continued to look for evidence of transfer effects in L2 learning based on similarity, difference, and uniqueness in the ways that language processing cues would map from L1 to L2. However, this study had a few important differences from most previous work in this line of research. First, instead of manipulating morphosyntactic agreement, Tuninetti et al. focused entirely on syntax and manipulated word order in English. Second, instead of testing a single group of L2 learners, for whom each violation condition mapped to a single kind of transfer (i.e. similar, different, unique), Tuninetti et al. tested two learner groups: L2 learners with L1s of Mandarin Chinese or Arabic. Differences across Mandarin Chinese and Arabic meant that the same English word-order violation could be similar for learners from one L1 but different for learners from the other L2.

This is important because when there is only a single mapping between violations and kinds of transfer, it is difficult to rule out the possibility that some confounding factor could independently make some violations harder to detect than others for L2 learners. Having a single violation map to multiple kinds of transfer eliminates the potential for this kind of confound. Third, this study was conducted with eye tracking. Fourth, the L2 learners in this study were considerably more advanced than the L2 learners in previous studies.

Tuninetti et al. (2015) had L1 English, L1 Mandarin Chinese, and L1 Arabic readers read English sentences while their eyes were being tracked and judged their grammaticality. The sentences were either grammatical, e.g., *She pulled the short skirt up over her leggings,* or were ungrammatical because the object noun was moved to before the article and adjective of its noun phrase (noun-article condition), e.g., *She pulled skirt the short up over her leggings,* or ungrammatical because the order of the object adjective and noun were switched (noun-adjective condition), e.g., *She pulled the skirt short up over her leggings.* Nouns and articles have similar orders and properties in Arabic and English, but Mandarin does not have articles in the same way English does, so the noun-article condition was classified as similar for Arabic L1 learners of English, and unique for Mandarin L1 learners of English. This means there should be positive transfer for Arabic L1 learners, i.e., they should detect noun-article violations quickly and often, and no transfer for Mandarin L1 learners, i.e., they might detect violations of this type less quickly or often. Nouns come after adjectives in Mandarin and English, but before adjectives in Arabic, so the noun-adjective condition was classified as similar for Mandarin L1 learners of English and different for Arabic L1 learners of English. This means that there should be positive transfer for Mandarin L1 learners, i.e., they should detect noun-adjective violations quickly and often, and negative transfer for Arabic L1 learners, i.e., they should have difficulty detecting noun-adjective violations. Tuninetti et al. found that all groups of participants' grammaticality judgments were most accurate for the noun-article violation sentences and participants also showed the earliest eye movement disruption in this condition. Both L2 English groups were less accurate at detecting noun-adjective violations and showed some evidence of longer-lasting eye movement disruption in this condition, but there were no clear differences between the two groups reflecting different kinds of transfer.

The results of Tuninetti et al. (2015) do not fit with the results of the other experiments in this line of work in that there was little to no evidence of transfer effects. All violations were detected similarly quickly. One potential reason for this is that the L2 learners in Tuninetti et al. were more proficient than the learners in the other studies. Tuninetti et al.'s learners were students taking college classes in their L2 rather than learners in the first few semesters of their L2. This is important because transfer effects are likely to be clearer and more evident nearer the beginning of learning, when new routines have not yet been established for the new language. With increased proficiency comes more efficient language processing; Efficiency is likely to be improved via sensitivity to the new language's properties rather than by porting over processing routines optimized for a different language. Another factor that may have played into the lack of transfer effects is that Tuninetti et al. tested word-order violations rather than violations of morphosyntactic particles or endings. Word order is relatively rigid in English and is reinforced by almost every sentence that a learner encounters. This is different from features tested in previous studies, like word-specific gender marking, demonstrative determiner agreement, or verbal aspect markers, in that features like these are less frequently

encountered and therefore not likely to be learned as well. And indeed, of the two violations of word order in Tuninetti et al., results showed better detection of the one that violated patterns present in almost every sentence than the one that violated patterns encountered less frequently.

Since Tuninetti et al. (2015) was published, a new literature has sprung up investigating the conditions under which L1 speakers fail to notice word transpositions while reading their L1 (e.g., Liu, Li, Cutter, Paterson, & Wang, 2022; Mirault, Snell, & Grainger, 2018). This work has aimed to address the following questions: when do readers incorporate visuospatial information about word location into the mental representations they build during sentence comprehension, are words are accessed and processed serially or in parallel during reading, and can top-down expectations for a particular order of words override bottom-up evidence for a different order? These are quite different from the questions about transfer in language learning that were addressed in Tuninetti et al., but it is worth considering whether Tuninetti et al. can inform these questions and whether the fact that L1 speakers sometimes fail to notice word transpositions might change the way we think about Tuninetti et al. and its results. In Tuninetti et al.'s adjective-noun condition, two adjacent words were swapped, like in the rest of this word transposition literature. However, in their noun-article condition, the noun moved to a position two words before where it belonged. In Tuninetti et al., L1 English speakers were 99% accurate at identifying noun-article violations and 95% accurate at detecting either no violation or noun-adjective violations. The fact that readers were better at detecting the noun-article violations is consistent with multiple accounts of why readers fail to detect transposed words. Accounts that explain readers' lack of detection of word transpositions as being the result of two words being accessed or processed close enough in time that their positions in a visuospatial representation are assigned concurrently (Engbert, Nuthmann, Richter, & Kliegl, 2005; Snell, van Leipsig, Grainger, & Meeter, 2018) would likely predict lower detection rates for word swaps that are adjacent and higher detection rates for swaps that involve three words. But accounts that predict that words are processed and integrated into a sentence one by one (e.g. Reichle, Warren, & McConnell, 2009) also would predict higher detection rates for the noun-article condition, because there are more cues to ungrammaticality in this condition (see Tuninetti et al., 2015, for discussion). The 95-99% overall accuracy that Tuninetti et al. observed is considerably higher than many of the accuracies reported in the word transposition literature (see Huang & Staub, 2021, for a review) and suggests that their participants almost always noticed word transpositions. This very high accuracy may be because most studies in this literature have used speeded grammaticality judgments, whereas Tuninetti et al. did not put time pressure on their participants. These high accuracy rates limit the amount that Tuninetti et al. can contribute to the literature on word-transposition detection and vice versa. The questions that Tuninetti et al. (2015) address with respect to cue strength, transfer effects in language learning, and violation detection intersect in important and interesting ways with another relatively recent literature on noisy channel comprehension (e.g., Gibson, Bergen & Piantadosi, 2013). One goal of this noisy channel literature has been to characterize changes in how heavily a comprehender relies on particular cues depending on properties of the context. For example, when reading in a context with many typos, a comprehender may rely more heavily on top-down expectations about what a sentence should mean than on the exact letters of the bottom-up input they are processing, and therefore overwrite (or possibly not process) violations in the input (Gibson et al., 2013). The fact that reliance on cues in L1 can shift adds

to the complexity of considering the transfer of cue-weightings from L1 to L2 during language learning and is an interesting issue to consider within the Competition Model framework.

Ongoing Research

In addition to the research described above, we have several ongoing studies that interface with these. In the first, we further investigate violations like those explored by Tokowicz and Warren (2010). Getty, Adams, Tokowicz, & Warren (2024) tested native Mandarin speakers on violations of English morphosyntax following the similar, different, and unique scheme. Two of the conditions (one of the similar conditions and the different condition) focus on number agreement because there has been disagreement about whether number is able to be learned by native Mandarin speakers (e.g., Jiang, 2003, 2007; Rusk et al., 2020).

Also, Tkacikova, Warren, and Tokowicz (2023) followed up on Tolentino and Tokowicz (2014) by teaching native English speakers a miniature version of Slovak (vocabulary and grammar) using Tolentino and Tokowicz's Salient condition. Testing involved the self-paced reading task as used by Tokowicz and Warren (2010). Tkacikova et al. further examined the role of musical training and musical ability to assess whether individuals with more musical training and higher musical ability would be more sensitive to violations of grammar in a newly-learned L2, particularly in the different condition, which is expected to generate the greatest amount of competition across languages.

These ongoing studies add to the already-existing body of research in this area and help us to answer additional questions about the role of cross-language similarity in adult L2 learning. Taken together, the findings from these studies suggest that constructions that are similar in L1 and L2 benefit from positive transfer, whereas those that are different in L1 and L2 do not and are susceptible to competition, although the gravity of that competition for processing depends on a number of factors (e.g., proficiency in L2, processing speed required for the task).

Constructions that are unique to L2 vary the most in what is observed across studies, and seem the most changeable based on additional pieces of information, training in the form of an interpolated block (with focusing and feedback), etc. These findings are broadly supportive of the Competition Model and have provided a useful framework for examining the way that adults learn a new language. We thank Brian MacWhinney for his many contributions to the field and to our work in particular. We'd like to share some of the ways that Brian has impacted us in particular.

Brian's Influence

Tessa's exposure to Brian's ideas began when she started collaborating with Natasha on the line of work discussed in this chapter. Having been trained from a Chomskian viewpoint, at first Tessa saw the Competition Model and its components of cue-weightings and transfer as being primarily relevant to L2 learning. But over the years she has come to think of these mechanisms as core principles of cognition and all language processing. Thinking in this way has changed the direction of her major research program, e.g., how and why different language

users bring different sources of knowledge to bear during language use (e.g. Dresang, Warren, Hula, & Dickey, 2021; Warren & Dickey, 2021) and she is grateful.

When Natasha began working with Brian as a postdoctoral fellow her previous work had focused on vocabulary learning. She was excited to do work with him on grammar learning but discovered that he was interested in working with her on vocabulary learning. They decided to meet in the middle, and they applied lessons learned from her work on translation ambiguity (see, e.g., Tokowicz, Rice, & Ekves, 2023), which occurs when a word in one language has more than one translation in the other language, to new work on morphosyntax learning. This was quite fitting because this had been the motivation for her application to work with Brian after reading his chapter on L2 acquisition and the Competition Model (MacWhinney, 1997). The work that she completed with Brian has formed the basis for a major line of her ongoing research and for her current grant funding. She is honored to have been able to work with Brian on these issues, to have learned from him, have had his support, and to continue to engage with him intellectually.

Leida was Natasha's PhD student and was therefore exposed to Brian's work through Natasha. Her research in this area was some of her foundational work and formed the basis for her master's thesis, comprehensive exam (Tolentino & Tokowicz, 2011), and dissertation (Tolentino & Tokowicz, 2014).

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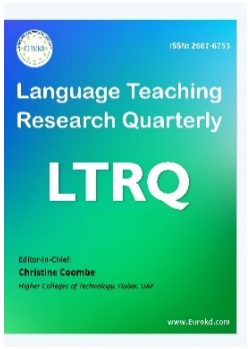

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Chunking in the Second Language: Implications for Language Learning and Teaching

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Abstract

Among the various challenges that adult and other late language learners face on their journey to achieving nativelike proficiency, chunking has been identified as one of the most difficult tasks to master. Language users are able to derive and utilize chunks during language processing—both in the first (L1) and the second language (L2)—yet the extent to which the L2 learners utilize and benefit from chunking is not on a par with L1 speakers. L2 learners are generally less sensitive to the statistical regularities in the linguistic input and possess a smaller repertoire of multiword expressions, leaving them susceptible to slower real-time language processing, hampered comprehension during conversation, and distinct production errors. Drawing on insights from Brian MacWhinney's Unified Competition Model of L1 and L2 acquisition, this review examines these unique challenges in L2 chunking as a function of differences between L1 and L2 learning. According to the Unified Competition Model, the existence of deeply entrenched L1 linguistic representations may hinder effective L2 chunking by encouraging over-segmentation in favor of L1 transference at the lexical level and diverting the necessary attention away from the grammatical elements in prefabricated multiword units. Based on these observations, we offer practical suggestions for educators to facilitate chunking in L2 learners and bring them closer to nativelike fluency.

Keywords: *L2 Learning, L1 Learning, Chunking, Multiword Sequences, Real-Time L2 Processing, L2 Instruction*

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[1]Introduction

Brian MacWhinney has had an outsized impact on the study of language over the past five decades. In addition to establishing one of the foundational resources for computational language learning research—the CHILDES database (MacWhinney & Snow, 1985)—he also introduced groundbreaking theoretical frameworks, such as the Competition Model for understanding language learning and processing (Bates & MacWhinney, 1982). In this article, we draw on MacWhinney's Unified Competition Model (e.g., MacWhinney, 2002, 2005, 2008, 2012, 2015b, 2017), which aims to provide an integrated account of both first (L1) and second language (L2) learning, in a discussion of recent work on the role of chunking in L2 learning.

Chunking, defined by Gobet et al. (2001) as the process by which the cognitive system groups multiple elements in the input together into a single unit, has emerged as a key mechanism in learning, perception, and cognition. The utilization of chunks enables more efficient processing of information, enhancing the ability to gather relevant knowledge from the environment in the face of inherent cognitive limitations (Gobet et al., 2001). The construct of chunking has also attracted growing attention in the field of psycholinguistics (e.g., Christiansen & Arnon, 2017; Christiansen & Chater, 2016; de la Cruz-Pavía et al., 2020; MacWhinney, 2005; Mauranen, 2009; McCauley et al., 2017). This pattern-based memory skill facilitates the compression of incoming input by drawing on prior experiences with co-occurring elements such as syllables, words, phrases, and syntactic patterns. In usage-based approaches, chunking is seen as a crucial mechanism through which language learners and users develop more abstract linguistic structures from statistical regularities (e.g., Christiansen & Arnon, 2017; Christiansen & Chater, 2016; de la Cruz-Pavía et al., 2020; Ellis, 2003; MacWhinney, 2005; Mauranen, 2009; McCauley & Christiansen, 2019b).

Learners of a second language rarely reach native-like fluency (e.g., Arnon & Christiansen, 2017; Clahsen & Felser, 2006; Ellis et al., 2008). While some researchers attribute such learning outcomes to a biologically determined critical period (e.g., DeKeyser, 2000; Lenneberg, 1967; Long, 2005), MacWhinney (e.g., 2008, 2015b, 2017) proposes in his Unified Competition Model that it is L1 entrenchment and transference that prevents learners from learning and processing the L2 in a nativelike way. L2 learners tend to over-analyze utterances, both grammatically and semantically, and break them down into smaller segments in favor of item-based patterns for L1 transference. Indeed, limitations in the ability to properly and efficiently form and use chunks have been extensively observed and noted as posing one of the most prominent challenges in L2 learning (e.g., Arnon & Christiansen, 2017; Conklin & Schmitt, 2012; De Cock, 1998; Ellis et al., 2008; Wray, 2000).

This review surveys research on chunking in the second language, noting both opportunities and challenges, and proposing some future directions for more effective L2 learning and teaching practices. The next section discusses the necessity of Chunk-and-Pass processing when faced with the Now-and-Never bottleneck in real-time interactions and the facilitating role of chunking in language processing in general. The subsequent section focuses on chunking in the second language, drawing on current empirical evidence regarding L2 learners' chunking abilities and exploring the theoretical implications through the lens of MacWhinney's

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(2002, 2005, 2008, 2012, 2015b, 2017) Unified Competition Model. The final section provides recommendations for L2 pedagogy, incorporating a chunk-based approach that embodies explicit chunking instructions with an emphasis on high-quality input and appropriate feedback.

To Chunk or Not to Chunk

The Now-and-Never Bottleneck and Chunk-and-Pass Processing

Language happens in the here and now. In real-life language production, the average speech rate is approximately 10-15 phonemes or 5-6 syllables per second, corresponding to 150 words produced every minute (Studdert-Kennedy, 1986). Yet the human auditory resolution for non-speech sounds maxes out at 10 sounds per second, beyond which the input is interpreted as a continuous buzz rather than discrete auditory events (Miller & Taylor, 1948). The working memory for auditory sequences is limited too, as it can hold and process only a small amount of information, ranging from 4±1 (Cowan, 2001) to 7±2 (Miller, 1956) units at a time. In the presence of such a "Now-or-Never Bottleneck" (Christiansen & Chater, 2016), the cognitive system must quickly chunk lower level linguistic units into higher level ones, from syllables to words or multiword combinations to phrases and beyond. For example, the acoustic input might initially be compressed into syllables, but once there are multiple syllables, they may interfere with one another (Brown et al., 2007); so the process is repeated, chunking multiple syllables into words and multiword sequences. This process of repeatedly recoding language input into increasingly more abstract levels of linguistic representation for semantic interpretation, called "Chunk-and-Pass" processing, allows linguistic information to be maintained across ever-longer temporal windows (Christiansen & Chater, 2016). Such Chunk-and-Pass processing allows language users to make sense of the fleeting input in the face of the Now-or-Never bottleneck.

Chunking Facilitates Language Processing

Chunking is contingent on the statistical properties of the language input. Language processing is sensitive to these properties at all levels, from phonemes to syllables, words, and multiword units in both comprehension and fluency of speech production (Ellis, 2012). Language then is strikingly, yet unsurprisingly, repetitive. For example, highly predictable, semi-preconstructed multiword units are abundant in natural language (e.g., Christiansen & Arnon, 2017; Ellis et al., 2008; Sinclair, 1991, 2004; Wray, 2002). Multiword units refer to bundles of words, typically three or more, that co-occur repeatedly at a frequency higher than expected by chance and function as coherent structural or semantic units (e.g., Biber et al., 1999; Ellis & Ogden, 2017). Erman and Warren (2000) estimate that about half of spoken and written language consists of such prefabricated multiword units. Corpus analyses have revealed that multiword units may appear as frequently as single words (Jackendoff, 1997)—up to 50% of language produced by native speakers is composed of frequently co-occurring multiword units (De Cock, 1998). A direct comparison of spoken and written corpora suggests that multiword units are even more prevalent in spoken language than in written text (Leech, 2000) because speech involves more real-time processing which imposes higher cognitive demands, and retrieving chunks from long-term memory rather than putting words together in real-time alleviates the taxing cognitive load (Ellis, 2012).

Indeed, multiword chunks are associated with both faster processing speed (Conklin & Schmitt, 2008; Jiang et al., 2020) and better memory accuracy (Isbilen et al., 2022; McCauley et al., 2017) compared to individual words and non-chunkable sentence fragments matched on word lengths and frequencies (Tremblay, 2011), pointing to a processing advantage in the face of the general cognitive constraints. In addition, Ellis et al. (2009) discovered through a series of lexical decision tasks that native speakers recognized frequent verb-argument and booster/maximizer-adjective pairs with more ease compared to less frequent ones. An eye-tracking study by McDonald and Shillcock (2003) revealed that the reading times of individual words varied as a function of transitional probabilities of the lexical components—high transitional probability sequences (e.g., *avoid confusion*) were read faster than low transitional probability sequences (e.g., *avoid discovery*) in the same sentence context. In speech production, words with high contextualized probability tend to be shortened according to analyses of articulation time for successive two-word sequences (Jurafsky et al. 2001). By focusing on verb–argument constructions, Ellis and Ogden (2017) concluded that co-occurring statistical patterns drive first language learning, facilitate online processing, and are implicated in spreading activation and prototypicality effects in semantic reference, as language users are sensitive to distributional properties and the strength of association between form and meaning. These findings substantiate the view that single words and larger sequences, such as multiword units and constructions, are stored and processed similarly by the same cognitive mechanisms, blurring the boundaries between vocabulary and grammar (e.g., Arnon & Christiansen, 2017; Bybee, 2010; Christiansen & Chater, 2016; Elman, 2009; Jolsvai et al., 2020; see Contreras Kallens & Christiansen, 2022, for discussion).

On the big picture level, the abundance of statistical regularities in language makes chunking possible and useful; on the individual differences level, the ability to chunk information together is associated with efficiency in online language processing. McCauley and Christiansen (2015) examined whether chunking ability might explain individual differences in the processing of subject (SRCs) and object relative clauses (ORCs). Through a letter chunking task and a self-paced reading task, they found that chunking sensitivity was a significant predictor of reading times for both SRCs and ORCs, as individuals with higher chunking sensitivity read both types of sentences faster than those with lower chunking sensitivity. In addition, chunking sensitivity was also found to interact with sentence types in predicting reading times, indicating that individuals with higher chunking sensitivity experienced less difficulty reading the hard-to-process ORCs than those with lower chunking sensitivity.

Taken together, these studies suggest that chunking can potentially alleviate the cognitive and computational load associated with language processing (McCauley & Christiansen, 2015). These findings are consistent with previous computational modeling work suggesting that chunking might explain important aspects of children's phonological knowledge and word learning abilities (Jones et al., 2014), as well as language learning during real-time processing (McCauley & Christiansen, 2011, 2014, 2019a). In sum, the Now-and-Never Bottleneck necessitates that language processing occurs incrementally and in real-time, emphasizing the crucial role of chunking (Christiansen & Chater, 2016).

Chunking in the Second Language

L2 Learners Also Chunk

Like L1 speakers, L2 learners also chunk. MacWhinney (2008) points out that L1 and L2 learners are faced with the same overall goals and specific tasks in language acquisition: both groups need to figure out the patterns and regularities that govern the combination of words in syntactic structures and connect their expanding vocabulary with the syntactic knowledge to achieve fluency. Indeed, as Ellis (1996; 2012) contended, language learning is in essence sequence learning, and chunking is a general process underlying both L1 and L2 acquisition. Ultimately, obtaining fluency in comprehension and production in both L1 and L2 requires acquiring memorized sequences of language: learning vocabulary entails the sequencing of the sound properties; learning discourse entails the sequencing of the lexical units (phrases and collocations); and learning grammar entails extracting and abstracting regularities from the repertoire of previously stored lexical sequencing (Ellis, 1996).

Through a series of online grammaticality judgment tasks, Jiang and Nekrasova (2007) demonstrated that both L1 speakers and L2 learners reacted more quickly and accurately to formulaic sequences than to non-formulaic sequences matched for word length and frequency (e.g., *to tell the truth* vs. *to tell the price*). Similarly, Conklin and Schmitt (2008) confirmed that both L1 and L2 speakers processed formulaic sequences faster than non-formulaic phrases generated creatively during passage reading. Nekrasova (2009) employed two controlled production tasks targeted at multiword units in both L1 and L2 speakers of English and again confirmed that multiword units are processed as coherent chunks by both groups. In the first task, participants were prompted to complete the omitted components of the target multiword units embedded in sentences. The underlying assumption is that the knowledge of multiword units as holistic entities will enable language users to recognize and reproduce the missing parts based on the surrounding context. Results showed no significant differences between L1 and advanced L2 speakers in their performance on successful phrase completion, although intermediate-level L2 speakers completed fewer multiword units than the other two groups. The second task involved elicited imitation, where participants listened to and immediately recalled a textbook passage two sentences at a time, and the target multiword units were embedded in some of the to-be-recalled sentences. Unsurprisingly, the L1 speakers were not the only ones who recalled the multiword units; both highly proficient and less proficient L2 speakers were able to recall the target multiword units as well. Moreover, the highly proficient L2 speakers even outperformed the L1 speakers on this measure. These results suggest that L2 learners, like L1 speakers, are also capable of acquiring and storing linguistic units larger than words as coherent chunks.

Despite differences between the native/highly proficient speakers and the less proficient L2 learners as shown in the Nekrasova (2009) study, the capacity to utilize chunks is not limited to only advanced level L2 speakers. Learners with lower proficiency levels also benefit from chunks during L2 acquisition (Myles et al., 1998, 1999; Skiba & Dittmar, 1992; Weinert, 1995). In an extensive analysis of longitudinal and cross-sectional corpora involving speech production by beginner (Mitchell & Dickson, 1997) and intermediate (Myles, 2002) L2 French learners in England, Myles (2004) revealed that multimorphemic sequences with rather complex syntactic features are frequently used even when the individual components have not been mastered. For example, L2 learners may produce finite verbs, case-marked pronouns, and

clitics within but not outside of formulaic chunks. Ellis (2012) highlights that such unanalyzed chunks coexist with very simple utterances, often without verbs or tenses, in early L2 production for a prolonged period of time. Moreover, Myles (2004) examined how individual learners acquire and use chunks over time, revealing a clear association between the usage of chunks and linguistic development (Ellis, 2012): rather than abandoning the chunks, L2 learners were observed to actively engage with them over the course of data collection. These chunks form part of an inventory of advanced structures that L2 learners can use before their grammatical knowledge catches up to allow them to easily produce complete novel sentences.

Gries and Wulff (2005) expanded the investigation of L2 chunking to construction-level priming. They observed significant priming effects between constructions in a sentence-fragment completion task administered to L1 German speakers learning L2 English. Participants were instructed to complete sentence fragments, some of which were primes and some were targets, and make them grammatically correct full sentences. Each prime contained a post-verbal noun phrase that represented either a recipient, which likely prompts a ditransitive (e.g., *The racing driver showed [the helpful mechanic]*...), or a patient, which likely signals a prepositional dative (e.g., *The racing driver showed [the torn overall]*...). Participants' responses to the targets, where the post-verbal noun phrases were omitted from sentence fragments, showed a clear tendency to continue using the same syntactic structure as they just produced in the prime. Gries and Wulff (2005) further established that such priming effects were strongly associated with the verb-construction preferences in corpora for native English speech and, more importantly, not with verb-construction preferences from German translation equivalents. Finally, they confirmed the constructional nature of the priming effects by a sentence sorting task, where participants exhibited strong preferences for construction-based sorting when categorizing sentences based on semantic similarity, and such tendencies were consistent with those of native speakers (Bencini & Goldberg, 2000). Based on Bock's (1986) conclusion from a series of experiments that the priming effect is attributed to cognitive processes that involve phrase structure construction or representation, the authors deduced that despite having less exposure to the input, L2 learners similarly draw on constructional knowledge, as they develop grammatical abstractions by forming and storing chunks.

Like in L1, chunking sensitivity in L2 also predicts language learning and processing at the individual differences level. Ellis (2012) identifies sequencing ability in phonological short-term memory (STM) as an important mechanism for language acquisition that predicts success in learning vocabulary and grammar in both L1 and L2. Specifically, phonological STM is associated with lexical diversity and syntactic complexity in L2 production (Wen, 2012), development of knowledge in L2 vocabulary and morphosyntactic structures (French & O'Brien, 2008), and improvement in L2 oral fluency over time, including enhanced L2 narrative skills in learners with lower proficiency and gains in correct use of function words in learners with higher proficiency (O'Brien et al., 2006). Moreover, L2 learners' knowledge of multiword units correlated strongly with multiple aspects of L2 proficiency such as the cloze test tapping into global proficiency (Keshavarz & Salimi, 2007), narrative speaking (Hsu & Chiu, 2008) and retell tasks measuring oral proficiency (Boers et al., 2006; Stengers et al., 2011), and overall quality of writing (Dai & Ding, 2010).

Using an eye-tracking paradigm, Pulido (2021) examined the relationship between chunking sensitivity and the processing of multiword units embedded in L2 sentences. The

target multiword units embedded in the relative clauses were either congruent or incongruent with the L1 translation equivalents. Congruence entailed perfect L1-L2 mapping between the constituent words in the multiword units, whereas incongruence entailed a sensible translation only at the multiword level and not at the individual word level (e.g., *pedir hamburguesas*, the Spanish functional equivalence to 'order hamburgers,' literally translates to 'request hamburgers' in English). The eye-tracking results from natural reading of L2 sentences revealed a significant two-way interaction between L2 chunking sensitivity and congruence condition in predicting the fixation time at the verb region. These results indicate that the processing difficulty associated with L1-L2 incongruent multiword units documented in prior research (e.g., Carrol et al., 2016; Wolter & Gyllstad, 2013; Wolter & Yamashita, 2018) may be alleviated by better L2 chunking. It has been concluded that since sensitivity to prefabricated chunks in natural language taps into both language experiences and domain-general chunking ability, it extends beyond mere static familiarity with fixed chunks and predicts the ability to draw upon prior experience in connecting individual elements and forming associations in real-time.

Collectively, these findings support an emergentist view that language, L1 and L2, is processed and represented in a similar manner, where learners are sensitive to the frequencies and transitional probabilities at which different linguistic patterns occur, and they acquire these statistical patterns through exposure and usage (Ellis, 2012; MacWhinney, 2015a). For both L1 and L2 learners and speakers, forming chunks and committing them to long-term storage for future use in comprehension and production serve as the foundation for language learning and for ultimately achieving automaticity and fluency (Ellis, 1996).

Caveat: L2 Learners Chunk Differently (and Less Efficiently)

Even though L2 learners are able to utilize statistical information and chunk linguistic inputs for learning and more efficient processing, research has also shown that the extent to which L2 learners chunk and benefit from chunks is rather limited compared to L1 learners and speakers, rendering chunking one of the most telling differences between L1 and L2 speakers (e.g., Arnon & Christiansen, 2017; Conklin & Schmitt, 2008, 2012; De Cock, 1998; Ellis et al., 2008). Advanced L2 speakers are reported to have rather limited knowledge of multiword units compared to L1 speakers (Arnaud & Savignon, 1997; Moon, 1997), and their mastery of formulaic language is not comparable to their vocabulary knowledge in general (Steinel et al., 2007). Pulido et al. (2024) and Pulido (2021) administered two chunking sensitivity tasks to L1 English speakers learning L2 Spanish and found significant differences between L1 and L2 chunking. In contrast to L1 speakers, advanced L2 learners also tend to opt for singular verbs (e.g., *to mention*) rather than risking making word choice or grammatical errors by using multiword lexical verbs (e.g., *to bring up*) even when the latter is more appropriate for the context (Siyanova & Schmitt, 2007).

Craig (2008) highlights that function words, such as articles and prepositions, are often omitted or misused by L2 learners, constituting an identifiable and potentially stigmatizing characteristic of L2 production (Benson et al., 1992; Reid, 1988). For example, to a native ear, phrases like *taking advantage from* or *access for electricity* immediately signals that the speaker is an L2 learner due to the distinctively foreign and unusual use of prepositions, even though the combination of content words are correct and sufficient to convey the intended

message. In corpus analyses of academic prose, Reid (1988) unveils quantitative differences in the frequency of preposition use between L1 and L2 English writers. Catalán (1996) discovers that as many as 75% of Spanish students learning English made preposition substitution errors. Additionally, Flowerdew (2006) reports that up to 68% of all errors relating to nouns that connect ideas within and across clauses are attributed to the misuse of prepositions following them (e.g., *argument in* as opposed to *argument for*; *discrimination to* instead of *discrimination against*). MacWhinney (2008, 2015b, 2017) reasons that L2 learners are more likely to focus on the lexical level during language learning and processing, overanalyzing utterances into individual words in favor of L1 translation and transference, rather than treating the multiword verbs and noun-preposition clusters as chunks functioning as single lexical items (Biber et al., 1999; Craig, 2008).

In a similar vein, research has shown that L2 learners have difficulties with collocations and idiomatic expressions, failing to correctly interpret most L2 idiomatic expressions dissimilar to their L1 (Irujo, 1986). L2 learners also tend to derive the literal interpretations of idioms that are already known to them (Cieślicka, 2006) and produce jumbled collocations with incorrect selection and ordering of the component words (Wray, 2004). Martinez and Murphy (2011) reported that lower-intermediate L2 learners may misinterpret the meaning of idiomatic expressions based on individual words (e.g., *by and large* vs. *large, and, by*) without consciously knowing they made such an error, hence overestimating how much they understood from the target texts as a function of multiword expressions that are either unnoticed or misinterpreted. Even highly proficient L2 learners generally produce less formulaic language in both speech and writing compared to L1 speakers (Howarth, 1998; Paquot & Granger, 2012), overuse a restricted range of expressions while neglecting others when they do use formulaic language (De Cock, 1998; Durrant & Schmitt, 2009), and do not benefit as much from the processing advantage that multiword units often provide (Conklin & Schmitt, 2012), displaying a non-nativelike pattern of chunk usage (see Arnon & Christiansen, 2017, for a review).

Not only do L2 learners chunk less compared to L1 speakers, but they also seem to rely on somewhat different statistical information when they chunk in the second language. In a series of simulations, McCauley and Christiansen (2017) trained a chunk-based learning model on utterances generated by three different groups of speakers: L1 children, L1 adults, and L2 adults. Using backward transitional probabilities to determine whether words should be chunked together, the model learned to generalize to novel utterances produced by the same individuals. Production performance was higher for L1 learners/speakers compared to L2 learners, suggesting that L2 learners might rely less on multiword units derived via statistical learning than L1 learners/speakers. This was confirmed by a second simulation in which chunking was based on basic frequency information instead of conditional probabilities. In these simulations, generalization performance for the L2 learners improved relative to the first simulation, whereas the performance worsened for the L1 learner/speakers. These results indicate that L2 speakers learn differently from the linguistic input, employing different chunking strategies than those used in L1. McCauley and Christiansen (2017) then conclude that while both L1 and L2 learning involves utilizing multiword sequences, how they are acquired and the extent to which they are used vary across L1 and L2 learners.

These computational findings dovetail with results from human behavioral research. Using three different experimental paradigms, Ellis et al. (2008) illustrated that even highly proficient L2 speakers attend to and utilize different statistical information in language than L1 speakers. When presented with formulaic phrases and non-phrases for grammaticality judgements, L1 speakers' reaction times to the phrases were predicted by mutual information, which measures the extent to which the words within a phrase co-occur more frequently than expected by chance (Manning & Schuetze, 1999; Oakes, 1998). By contrast, the reaction times of the L2 speakers were predicted by raw frequencies, rather than mutual information. Similarly, L1 participants' voice onset time and duration of articulation in a read-aloud task correlated with mutual information, while those of the L2 participants were associated instead with raw frequencies. These results suggest that, unlike L1 speakers who recognize the distinctive functions of formulaic sequences when processed as coherent chunks, L2 learners' sensitivity to recurring multiword units was driven by the mere high frequencies of constituent words, even when they comprise grammatical fragments (e.g., *and at the* and *that to the*).

In summary, many of the major challenges L2 learners face in achieving native-like proficiency stem from difficulties with chunking in the second language, including problems with function words, lack of awareness and mastery of collocations and idioms, and reliance on statistical regularities that differ from those that govern L1 learning and processing. Arnon and Christiansen (2017) attribute such L1-L2 differences to the differential ways in which L1 and L2 are learned: due to the presence of prior linguistic and conceptual knowledge, L2 learners differ from L1 learners in the building blocks they use during acquisition, and such a difference leads to differences in learning strategies and outcomes (Arnon, 2010).

Differences in L1 and L2 Learning

L1 and L2 learners are equipped with different tools when it comes to language acquisition (MacWhinney, 2008). Infants have the advantage of relying on a highly plastic and adaptable brain that has not yet been dedicated to any specific functions (MacWhinney et al., 2000) when simultaneously learning language and engaging in the broader task of understanding the world in a robust system of social support provided by their caregivers (Snow, 1999). Yet the adult L2 learners are left with a brain that has already been molded to deal with various tasks of processing their L1 with a comprehensive understanding of the world and human society, and they are often deeply involved in social and professional obligations conducted in their primary language, which distract them from interactions in the new language (MacWhinney, 2008).

According to MacWhinney's (2008) Unified Competition Model of L1 and L2 acquisition, language is learned through self-organizing brain networks that restructure and update themselves by adapting to the statistical information in the input. During L1 learning in infancy and childhood, the brain networks are highly malleable due to a lack of prior experience and specialization. Having limited experience with both language and the conceptual world, infants do not inherently perceive word boundaries at the beginning of language learning. It has been proposed that they extract linguistic units according to statistical and prosodic information rather than lexical knowledge: based on sensitivity to conditional (co-occurrence probabilities) and distributional statistical information (frequency distributions) in the linguistic input (Erickson & Thiessen, 2015; Saffran, 2020), infants can discover both words and multiword units as possible building blocks for language (Arnon & Christiansen, 2017). Evidence from

early language production shows that children utter “frozen” chunks, or multiword sequences consisting of elements used unproductively, even during the single-word stage of language development (Arnon & Christiansen, 2017; Peters, 1983). Children’s reliance on multiword units is also reflected in the patterns of errors they make due to high-frequency co-occurrences in the input. For example, Kirjavainen et al. (2009) explain that the common *me*-for-*I* errors that children make, such as saying *me do it* instead of *I do it*, can be attributed to the high proportional use of *let me do it* in the input from their caregivers. Although L2 learners also have the capacity to employ formulaic chunks during early production (Mitchell & Dickson, 1997; Myles, 2002, 2004), the degree to which they can fully utilize such units as building blocks for language is not on a par with L1 learning children—the frozen chunks spoken by children represent up to 50% of their early multiword utterances (Lieven et al., 2003).

With more exposure to objects, actions, and concepts alike paired with verbal labels, words and multiword units encoded as form-meaning associations accumulate, comprising increasingly more elaborate and fine-tuned brain networks. The process of specialization and stabilization of these networks inevitably leads to rigidity and entrenchment with increasingly more limited potentials for future movements and less plasticity in language learning (MacWhinney, 2008). For the adult learners, years of exposure to the L1 input makes little room for change in the deeply entrenched brain networks, let alone expanding them to encompass a whole new system of L2 regularities. For them, a new L2 Korean form 사과 is simply treated as an alternative way of saying ‘apple.’ Moreover, the adult L2 learners, possessing rather developed brain networks and metalinguistic knowledge, are well-aware of the existence of discrete words and their role as basic-level building blocks of language. Bypassing the necessity to extract sequences with undefined boundaries based on mere statistical regularities in the input, the adult L2 learners are unlikely to acquire multiword units as a result of under-segmentation like L1 learning children do (Arnon & Christiansen, 2017; Kurvers & Uri, 2006). Therefore, rather than building a new system from scratch by associating chunked/segmented phonological sequences with newly acquired concepts like L1 learning infants, the adult L2 learners often try to transfer the entire L1 conceptual world directly to the L2 at the lexical level when they first start learning the new language (MacWhinney, 2008; Arnon & Christiansen, 2017).

As summarized in the revised hierarchical model of bilingual lexicon (Kroll & Stewart, 1994; Kroll & Tokowicz, 2005), L2 is often parasitic on the L1 during early stages of L2 learning, lacking its own independent representations because L2 learners seek to access meaning through their L1 vocabulary, rather than through a direct L2-conceptual link. The weaker L2-conceptual links are evidenced by slowed forward (L1 to L2) translation compared to backward (L2 to L1) translation (Kroll & Stewart, 1994), diminished Stroop interference in L2 compared to in L1 (Brauer, 1998; Tzelgov et al., 1990), and reduced automatic emotional reactivity to L2 stimuli compared to their L1 counterparts as measured by skin conductance (Harris et al., 2003).

Moreover, the existing L1 phonological representations and word-conceptual associations provide a convenient shortcut to L2 learning, as rapid initial progress can be achieved through L1 transference (MacWhinney 2008). For example, L2 phonological learning typically starts with massive L1 transference, embedding L1 articulatory patterns into the new L2 pronunciations (Flege & Davidian, 1984; Hancin-Bhatt, 1994; MacWhinney, 2008). This

transfer rapidly enables a reasonable level of communication early on, yet it can result in a strong L1 accent and may eventually become counterproductive as the L2 vocabulary expands. Similarly, L1 transference can lead to a 'syntactic accent' at the constructional and sentential levels (MacWhinney, 2008). For an L1 Chinese speaker, the phrase 打开电视 ('to turn on the TV') is composed of 打开 ('to open') and 电视 ('television'); it thus makes sense to them to ask if they can turn on the TV by saying *can I open the TV?* due to L1 transference when they attempt to communicate in L2 English. Indeed, MacWhinney (2008) argues that every L1 structure with an L2 counterpart will transfer, and because the transference of whole syntactic frames or sentences would not be feasible, individual predicate-argument constructions are transferred one by one, which likely leads to the over-analysis and over-segmentation of L2 sentences and constructions into smaller chunks than necessary, especially into individual words.

Having deeply entrenched L1 brain networks encourages L2 learners to rely on L1 transference at the lexical level while also reducing sensitivity to certain kinds of statistical information in the L2 input. Arnon and Christiansen (2017) point out that L2 speakers are more capable of directing their attention to content words, such as verbs and nouns that convey semantic meaning, rendering them less attentive to the grammatical elements such as how specific articles and prepositions are connected to the content words within the meaning-carrying units (Ellis, 2006). This explains not only the well-documented shallow processing and less detailed syntactic representations computed by L2 learners (e.g., Clahsen & Felser, 2006; Pulido, 2021) but also the phenomenon in which L2 learners generally have difficulties mastering function words (Benson et al., 1992; Craig, 2008; Reid, 1988), number classifiers (Hansen & Chen, 2001), and grammatical gender even after extensive exposure (Dewaele & Véronique, 2001; Scherag et al., 2004).

As an example, consider the learning of article-noun agreement in languages with grammatical gender. One way an L1 French infant can learn the article-noun pair *la pomme* ('the apple') is by initially mapping the unsegmented sequence of sounds "*la-pomme"* onto their experience with an apple. With more exposure to the language and more experience with the conceptual world, the infant likely encounters other article-noun associations featuring either the same noun (e.g., *une pomme* 'an apple') or the same article (e.g., *la fleur* 'the flower'). These subsequent encounters help with the formation of the article and the noun as separate representations, while the early three-way association among the article, the noun, and the concept is maintained into and through adulthood. Another possible way for the L1 French infant to learn this article-noun pair is through chunking, or repeated exposure to the co-occurrence of these two constituent sequences. Learning either to segment or to chunk the input while simultaneously acquiring the concept promotes the incorporation of adjacent function words into the developing concept (Sloutsky & Fisher, 2012), making the grammatical elements predictive, informative, and learnable (Arnon & Christiansen, 2017). For the adult English speaker learning L2 French, on the other hand, *la* and *pomme* are treated as two distinct representations that can be mapped onto existing concepts already learned through L1 English: *pomme* being the translation equivalent of 'apple' and *la* being the definitive article functioning as 'the.' Having learned the article-noun pair as composed of separate entities with already established form-meaning associations, the three-way article-noun-conceptual link that L1

French speakers possess is less likely to be established as easily by L2 learners. This process obscures the predictivity and informativity of the grammatical elements in the constructions and thereby directs the attention away from them (Arnon & Christiansen, 2017).

While some researchers attribute the non-nativelike usage of grammatical structures to the existence and operations of a biologically determined critical period (e.g., DeKeyser, 2000; Lenneberg, 1967; Long, 2005) where language learners lose access to universal grammar after a certain age, MacWhinney's (e.g., 2002, 2008, 2015b, 2017) Unified Competition Model offers new insight into such struggles from the perspective of L1 entrenchment and transference. Having highly developed L1 linguistic and metalinguistic knowledge, the adult L2 learners often try to transfer as much from their L1 as possible to their L2. This results in a tendency to over-segment the L2 inputs and use smaller units as building blocks for the L2, which ultimately contributes to an over-reliance on individual words (Clahsen & Felser, 2006; Silva & Clahsen, 2008) and an under-reliance on larger chunks such as multiword units (Arnon & Christiansen, 2017) as well as relevant L2-specific syntactic constructions (MacWhinney, 2008; Culicover & Jackendoff, 2005; Goldberg, 2006).

Implications and Recommendations for L2 Education

Language learning occurs incrementally as the learner processes the fleeting input in real-time, drawing on prior experiences and making new connections based on the statistical patterns through the process of chunking (McCauley & Christiansen, 2011, 2014, 2019a). The mismatch between the abundance of statistical regularities in language and L2 learners' limited inclinations to take full advantage of them while struggling to achieve native-like proficiency thus sheds light on the implications of chunking for L2 pedagogical and instructional practices. As substantiated in the previous sections, L2 learners indeed have the capacity to chunk as well as to benefit from utilizing chunks even at the early stages of L2 acquisition (e.g., Jiang & Nekrasova, 2007; Myles, 2004; Nekrasova, 2009), yet the crux of the matter lies in the limited scope and effectiveness of their chunking practices as a result of having deeply entrenched L1 brain networks. To foster efficient real-time language processing and scaffold exercises to encourage chunking, L2 pedagogy would benefit from incorporating explicit chunking instruction and providing ample opportunities for learners to practice chunking with appropriate input and feedback. By equipping L2 learners with enhanced chunking skills, language instructors can unlock the potential for improved fluency in comprehension and production, thereby facilitating successful L2 learning.

Learning to Process

Traditional L2 instruction and assessments typically separate comprehension and production into different domains of language skills, such as listening, reading, writing, and speaking. However, such artificial divisions may not be conducive to optimal learning outcomes. For example, it is not uncommon for an L2 learner to be able to read academic journals full of technical jargon and complex sentence structures yet struggle to write a simple essay free of mistakes or sustain a conversation about mundane topics with a native speaker. As suggested in the previous section, L1 entrenchment and transference naturally hinder the incorporation of grammatical elements into L2 conceptual representations. Adult L2 learners may thus benefit less from the mere input than L1 learning children, leading to a larger discrepancy between

comprehension and production performances. Fortunately, earlier iterations of McCauley and Christiansen's (2017) chunk-based learner model revealed that excellent learning outcomes for both comprehension and production can be achieved by targeting their shared underlying mechanisms—chunking and real-time processing (Chater et al., 2016; McCauley & Christiansen, 2011, 2014). Upon training with speech input from caregiver corpora, the model exhibited outstanding performance on both phrasal segmentation (comprehension) and reproduction of child utterances (production). Remarkably, the model achieved its high performance by using backward transitional probabilities to discover chunks in the input and building up an inventory of those chunks for future use in both comprehension and production. This suggest that if statistically-based chunking can be enhanced in L2 speakers then, perhaps, they may be able to improve their real-time L2 processing and overall proficiency.

Similarly, accurate L2 assessments should also reflect chunking and real-time processing skills that underlie both comprehension and production. Culbertson et al. (2020) developed an utterance recall task, simultaneously assessing both comprehension and production while tapping into chunking and real-time processing. They found that L2 chunking at the sentence level is a better predictor of real-time proficiency than some of the traditional measures such as self-report and standardized multiple-choice comprehension tests. The rationale behind such a measure is that when the lengths of the stimulus sentences exceed working memory limitations, rote memorization becomes impossible, forcing the recall to rely on semantic and structural reconstruction based on real-time comprehension paired with the retrieval of long-term L2 knowledge through top-down processing (Bowden, 2016; Hamayan et al., 1977; Jessop et al., 2007).

Ultimately, to achieve native-like fluency or to enhance L2 proficiency in general, the L2 learner needs to advance their real-time language processing skills for both comprehension and production. L2 instruction and assessments should therefore prioritize the shared underlying mechanism of chunking, helping L2 learners overcome their tendencies to fixate on individual words and instead attend to larger building blocks.

Using the Right Building Blocks

Language learning—both L1 and L2—shares the same developmental pattern, progressing from formulaic phrases to limited-scope, slot-and-frame constructions, and ultimately to fully productive schematic patterns (Ellis, 2012). Building blocks then can be an important determinant of learning outcomes—indeed, empirical evidence has corroborated that larger building blocks are associated with better learning outcomes (Arnon & Christiansen, 2017). In an artificial language learning paradigm, Arnon and Ramscar (2012) showed that grammatical gender, a linguistic feature that non-native speakers typically struggle with, is better learned if participants were first exposed to larger linguistic units (full sentences) rather than the smaller ones (the target articles and nouns as individual words). Participants who heard full sentences containing the target article-noun sequences prior to hearing the single nouns outperformed those who heard the same targets in the opposite order on both a forced-choice article selection task and a prompted production task. Similar results were replicated in a natural language learning study by Paul and Grüter (2016), where monolingual English speakers learned Chinese noun-classifier associations better when first being exposed to full sentences rather than to single vocabulary items.

Siegelman and Arnon (2015) established a more direct link between building blocks and language learning outcomes. The experimental design was similar to Arnon and Ramscar (2012), except that both conditions involved exposure to full sentences, where sentences in one condition were segmented into individual words and those in the other remained unsegmented. Participants who were first exposed to unsegmented sentences again exhibited better learning than those who were first exposed to the segmented sentences on article-noun pairings as shown in both the forced-choice article selection task and the prompted production task. Together, these results indicate that to foster the necessary skills required for real-time language processing, L2 instruction should strive to help L2 learners become better chunkers by introducing and emphasizing larger linguistic units as building blocks: multiword units, formulaic sequences, as well as collocations and idioms.

Incorporating Multiword Units in L2 Education

Given that the most pronounced challenges that L2 learners face stem from not using adequately large building blocks frequently enough for acquisition and processing, the solution is to incorporate and emphasize both the mechanism and the product of chunking in L2 learning and teaching practices. Indeed, MacWhinney (2008) proposes that to block the rather counterproductive transference from deeply entrenched L1 brain networks, construction-based patterns should be taught to the L2 learners early on. Ellis (2002, 2012) suggests that even though chunking based on the statistical learning of frequency information and transitional probabilities is an implicit process (Christiansen, 2019), it does not hurt to bring such a process to explicit attention and instruction.

To raise the awareness of chunks in context, Lewis (1997) recommended highlighting coherent and meaningful multiword units in authentic L2 text, followed by inter-learner comparisons and feedback from instructors. However, even though such a practice was indeed effective in making L2 learners notice the existence of chunks when encountering new text (Jones & Haywood, 2004), the rate of retention and usage in production yielded mixed and rather underwhelming results (e.g., Boers et al., 2006; Stengers et al., 2010). Boers and Lindstromberg (2012) reason that given the existing gap between receptive and productive knowledge of multiword units in L2 learners, the sparse encounter of each chunk across large amounts of text is unlikely to be sufficient for securing mastery.

Thus, besides fostering awareness of the existence of chunks in natural spoken and written language, it is also important to focus on a subset of items at a time to ensure these target building blocks are learned well enough for future usage. The first step then is to identify and compile corpus-based, pedagogically useful chunks suitable to serve as building blocks for L2 learning and teaching. Because L2 learners are typically more sensitive to raw frequencies than to mutual information (Ellis et al., 2008; McCauley et al., 2017), deliberately increasing the frequency of target expressions in the input will likely facilitate mastering multiword units with high mutual information. Fortunately, ample efforts have been devoted to composing academic formula lists for learners of various languages, including English (e.g., Ackermann & Chen, 2013; Martinez & Schmitt, 2012; Simpson-Vlach & Ellis, 2010), Spanish (Parra Escartín et al., 2018), Chinese (Wang, 2020), and Japanese (Taguchi, 2007). Other than using existing academic formula lists, linguists and language teachers alike can also employ corpus analysis to curate their own formula lists by identifying highly frequent and coherent multiword units

typically lacking in L2 production. Once the target chunks are identified, appropriate input for L2 learners need to be generated. By attending to concentrated repetitions of the target chunks across different contexts in full-form native inputs, L2 learners can both learn to treat frequent co-occurring sequences of words as coherent units and have a better grasp of their meaning and usage in real-life language situations. To further reduce the chance of over-segmentation from showing perceptually salient word boundaries in the visual modality, auditory presentation of such tuned inputs should be preferred and implemented as often as possible to promote real-time Chunk-and-Pass processing. When visual presentation is necessary, it would be helpful if coherent multiword units are displayed and emphasized in a typographically enhanced manner that promotes chunking.

In addition to encouraging practice with large amounts of carefully tuned native utterances containing selected multiword units on the learners' end, educators should also incorporate explicit instruction into chunk-based L2 pedagogy. Explicit instruction refers to a structured and systematic way of teaching, where the purpose and rationale for learning the target skill are stated directly, clear explanations and demonstrations for the instructional target are provided deliberately, and extensive guided practice with contingent and appropriate feedback is encouraged until students have independently mastered the target skill (Archer & Hughes, 2010). A number of pedagogical studies have proposed and assessed systematic instructions and scaffolded activities targeting multiword units in the classroom at a wide range of proficiency levels (e.g., Liou & Chen, 2018; Murray, 2017; Nergis, 2021; Taguchi, 2007). These studies typically involve direct explanations of meaning and usage in context, various in-class tasks and activities that promote engagement and practice, and homework assignments that encourage guided or free production using the target chunks taught in class. These studies have generally achieved promising preliminary results, as L2 learners indeed show broadened and deepened collocational knowledge (Liou & Chen, 2018; Murray, 2017; Taguchi, 2007), increased usage of multiword units in speech (Taguchi, 2007) and writing (Liou & Chen, 2018; Murray, 2017), as well as improved conversational skills and overall oral fluency (Nergis, 2021).

It is recommended that chunk-based L2 pedagogy should not only focus on formulaicity and idiomaticity but also consider teaching multiword units that contain grammatical components rather than pure semantic information. For example, instead of teaching intransitive verbs as standalone words followed by a list of possible prepositions up for selection, a chunk-based L2 curriculum can introduce verb-preposition combinations as coherent, meaning-carrying units. Similarly, the lists can be expanded to include other grammatical chunks, such as prefabricated noun-preposition clusters (Craig, 2008), nouns with the associated number classifiers in Japanese and Chinese (Hansen & Chen, 2001; Paul & Grüter, 2016), article-noun pairs in languages with (or even without) grammatical gender (Arnon & Ramscar, 2012; Siegelman & Arnon, 2015), as well as noun-particle-verb associations with appropriate verb endings implicating different tenses and levels of politeness in SOV languages.

Offering Academic Support for ESL Students

In addition to standard English as a Second Language (ESL) courses, workshops, and writing consultation services, some institutions for secondary and higher education also provide extra

academic support for international students through student-led ESL speaking programs. Aware of the lack of opportunities for ESL students to speak up during lectures as well as the pressure associated with performance during seminars and discussions, these programs aim to encourage ESL students to practice English speaking skills in a relatively pressure-free and comfortable environment. Nevertheless, due to practicality concerns, these programs typically pair a whole group of ESL students with only one facilitator, who may or may not be a native speaker of English themself. Moreover, the facilitators are often specifically instructed to maximize participants' speech production by minimizing talking and avoiding correcting the grammatical errors that the participants make. Under such a design feature, the benefit that these programs can provide is oftentimes limited to the mere opportunity for the participants to speak up. Speech produced by L2 learners often lacks the appropriate chunks necessary for advancing language learning (McCauley & Christiansen, 2017) and is prone to various errors because of insufficient chunking and L1 transference (Benson et al., 1992; Nekrasova, 2009; Paquot & Granger, 2012). Therefore, the participants are not likely to learn coherent multiword units frequently used in conversations. Moreover, they are also at risk for occasionally picking up creative errors made by fellow L2 participants or even the non-native English-speaking facilitator in the group, as L2 learners are generally sensitive to raw frequencies in the input (Ellis et al., 2008).

Additionally, feedback represents an important catalyst for language learning from social interactions. Frinsel et al. (2020, 2024) confirmed in an artificial language learning study that the presence of feedback is conducive to language learning compared to having no feedback at all. In a Picture Guessing Game, native English-speaking participants were asked to guess which of the four scenes corresponded to what they heard in the target sentence. Participants who received either positive feedback (when they chose the correct scene) or negative feedback (when they chose an incorrect scene) showed improved learning over time, while participants who received no feedback on their responses were unable to learn the structural regularities of the artificial language. Although participants in the no-feedback condition showed some learning of the simple statistical patterns at the word level, as reflected by high scores on a noun test at the end, their lack of progress in learning at the construction level indicates that mere exposure paired with unguided retrieval practice is insufficient for robust syntactic learning.

Considering these aspects of language learning in practice, we suggest that in addition to offering a platform for ESL students to practice production, ESL speaking programs should also pay attention to what the participants can learn from the experiences provided. It might be beneficial to recruit more native English-speaking volunteers as facilitators and co-facilitators, reduce the group sizes to dilute the concentration of inputs from fellow L2 learners, and allow the native English-speaking facilitators to engage more with the conversations. This would provide both valuable L1 linguistic input and helpful feedback that emphasizes positive reinforcements for the correct usage of multiword units such as idioms, collocations, and formulaic sequences.

Conclusion

Chunking is crucial to overcoming the Now-and-Never bottleneck imposed by the fleeting linguistic input and general human cognitive constraints—both in L1 and L2 learning and

processing (Christiansen & Chater, 2016). In the context of L2 acquisition, while adults and other late learners have the capacity to chunk, they also face unique challenges due to the influence of their deeply entrenched L1 linguistic and conceptual representations, which can interfere with the utilization and development of Chunk-and-Pass processing in the L2. The incorporation of chunk-based practices in L2 education, featuring explicit instruction that fosters chunking skills and meaningful feedback that encourages the use of larger building blocks, thus presents a promising avenue to overcoming these challenges and improving L2 proficiency. In the spirit of MacWhinney's (e.g., 2002, 2005, 2008, 2012, 2015b, 2017) Unified Competition Model, we suggest that by recognizing the importance of chunking, educators can promote a better language learning experience and facilitate the achievement of native-like fluency in L2 communication.

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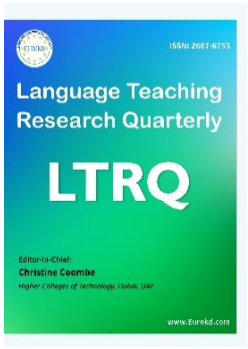

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Why was Hungarian so Important for Brian?

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Abstract

Brian MacWhinney started to study Hungarian for a psycholinguistic perspective from the 1970s on. The paper surveys his work on the unfolding of child morphology based on diary data, his experiments on morphological productivity in children of different ages, and his experiments on sentence processing in children and adults. By studying the unfolding of morphology, the emergence of sentence interpretation patterns, and the processing of relative clauses Brian MacWhinney certainly made two services to Hungarian psycholinguistics. He provided the domain with rich data for anyone coming from all theoretical orientations. At the same time, by relying on some peculiarities of the structure of Hungarian, he has put Hungarian into the center of discussions about the status of rules, the analytic and holistic approaches of sentence processing, and in general the import of a functionalist attitude towards language.

Keywords: *Case Marking, Competition Model of Language, Hungarian Grammar, Morphological Rules, Relative Clause Processing*

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[1]Introduction

Personal Reminiscences

Brian MacWhinney showed up on the Hungarian scene in the early 1970s. As part of the huge cross-linguistic project organized by Dan Slobin (1985) of UC Berkeley, involving detailed child language studies of 15 languages, Brian MacWhinney as a PhD student of Slobin, was

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responsible for the Hungarian branch of the huge enterprise, that resulted in an extremely rich dissertation of about 800 pages (MacWhinney, 1974). He explained to me at the time that his choice had a personal motivation as well. His maternal grandfather being an American farmer of Hungarian origin. Brian many times talked about the grandfather as a hard-working American farmer, occasionally also sipping his Hungarian style *pálinka*, a fruit-based strong brandy. Brian was assigned as part of an IREX US-Hungarian cultural agreement to the Research Institute of Linguistics (Nyelvtudományi Intézet) in Budapest, showing up with an incredible collection of up-to-date American papers on child language, impressing the nascent Hungarian psycholinguistic community. That was not the only amazing thing about Brian. Already at this stage, besides acquiring a good Hungarian, he had shown an incredible devotion to his work. During his dissertation years he did all the extensive reading and secondary data analysis that should have been done by Hungarian researchers. Becoming acquainted with many of us in the child language community, such as Zita Réger and Zsolt Lengyel, he continued to come to Hungary as a leading researcher of psycholinguistics, and collected more and more experimental data on Hungarian language processing in the 1980s. His contact with Hungarian as a target language and with Hungarian linguists and psychologists continues up to today. Altogether, he has over 40 papers where Hungarian figures either as a theoretical example for his general functionalist model (see for example Bates and MacWhinney, 1989), or as a target language for empirical studies. In the following I shall list some reasons why Hungarian continued to be so important for his efforts. His eternal presence in my psycholinguistic life is shown by the fact that he figures central in my review papers (Pléh, 1985, 2016) and textbook-like summaries (Pléh, 2000) over an entire generation. While I am trying to indicate below why Hungarian was important for Brian, we have to remember at the same time why Brian is important for Hungarian psycholinguists.

Aspects of Hungarian Grammar Studied by Brian MacWhinney

Hungarian is a Uralic language characterized by very rich grammatical morphology (over 15 nominal cases), acting in an inflectional manner, allowing for long multimorphemic words. Grammatical roles in a sentence are basically carried by nominal inflections, supported by number and object definiteness agreement. This is accompanied by a free word order of the major constituents along with a use of word order for coding Given-New and other pragmatic articulations. (Kenesei, Vágó and Fenyvesi, 1998 is a good descriptive source for these considerations.).

Morphological emergence and productivity in child language

The first works of Brian dealt with the early emergence of morphology, especially nominal case marking in child language. On the basis of a detailed reanalysis of the classical Hungarian child language diary studies, MacWhinney (1976) constructed an order of appearance of basic nominal and verbal morphology summarized in Table 1.

Table 1

Emergence of Hungarian Nominal and Verbal Morphology on the Basis of the Literature Survey of MacWhinney (1974, 1976; cited from Pléh, 2000).

Order	Nominal suffix	Verbal suffix
1.	Accusative, plural, diminutive, directional locals (into, to)	
2.	Dative, Instrumental	past, infinitive, 1st person indefinite
3.	-ON, 1. and 3rd possessive	2-3 rd Person indefinite, 1st person definite
4.	-FROM	Conditional, 3rd person definitive

Morphological smart errors

Hungarian has a very rich derivational morphology as well, that is acquired in its basics during the preschool years. Again, using data from the classical diary literature, MacWhinney (1985) identified the four types of overusing morphology in creating non-existent derivations. The errors show that children are using morphology in a productive manner. Errors appear because there is some lexical constraint towards using a morphological process productively. All the 4 types of errors mirror regular or idiosyncratic interactions between morphology and the lexicon.

The constraint principles are listed by MacWhinney (1985, p. 1131.)

A. The stem allomorph used is nonproductive or unique.

B. The suffix is competing with another suffix, and adult language has selected one of them.

C. There is a lexical item already for the given meaning, and lexical items inhibit the parallel derivation.

D. The meanings composed are not important for adult language.

Table 2. lists some examples for these types.

Table 2

Productive Smart Errors of Early Word Derivation by the Analysis of Diary Data (MacWhinney, 1985)

Type	Examples	Adult model
A. Non productive stem (rare)	*vakar**ós***'scratchy'	*viszket**ős*** 'itchy'
B. Rival suffixes	*tör**ős*** 'breaky'	*tör**ékeny*** 'breakable'
	*ebéd**ez*** 'dine'	*ebéd**el*** 'dine'
	*arany**ít*** 'golden'	*arany**oz*** 'golden'
C. There is a lexical item	*pillog**ó*** 'blinker'	*szempilla 'eyelash'*
	*füstöl**ő*** *'smoker'*	*kémény* 'chimney'
	*utcanéz**ő*** 'street looker'	*erkély* 'balcony'
D. Not important meaning	*ridegen**kedik*** 'sternize"	*ridegen viselkedik "stern manner behave'*

Derivational suffixes indicated by bold type.

There is a surprising manifold of derivational and compounding errors in Hungarian (MacWhinney collected the latter ones as well). They indicate that in the finer details of morphology children have to absorb a system of constraints besides rules by relying on rote learning and analogy formation when forming the mental representation of language.

Experimenting on noun morphology

Hungarian has not only a rich nominal morphology system, but it has many nominal classes as well. The case marking endings are the same in all of these classes, but some of the stems have several allomorphs, and the different case, plural and possessive markers take these allomorphs as starting points in a more or less regular manner. Some of the stem allomorph types are very frequent and productive such as lengthening (alma - alm**át** 'apple', kóla – kól**át**) while others like the -*v* insertion stem are rather rare, and non-productive having only 8 items (*ló – lo**vat** '*horse + Acc').

MacWhinney initiated a carefully designed study of morphonology in Hungarian children. A decade before the entire issue of regulars and overgeneralization has become theoretically so central in psycholinguistics regarding the English past tense like *learn-learned*, and *go-went* (Pinker, 1991, Pinker and Ullman, 2002), MacWhinney (1978) used a modified version of the classical Berko (1958) WUG test. He studied the acquisition of allomorph usage in 5 stem types in a picture-based suffixed form elicitation task. Children were supposed to provide suffixed form first to the names of pictured real objects. Then, to study the role of analogy in rule extraction, they were given a phonologically similar nonsense word as a name of a new toy, and they were triggered to provide a suffixed form to it. (*What is the man carrying?*)

MacWhinney (1978) showed the relative difficulty of the different allomorph types. The sequence was basically

- simple accusative adding *tigris-tigris**t*** 'tiger'
- lengthen the final vowel if it is short *kutya-kuty**át*** 'dog'
- insert a linking vowel after consonant ending stems *tánc-tánc**ot*** 'dance'
- shorten long stem wowels *kenyér -kenyer**et*** 'bread'
- finally -*v* insertion *ló-lo**vat*** 'horse'.

The last two achievements only arrive around 6-7 years ago. The sequence of acquisition would follow the scope of the given rules, with narrow scope rules being the last ones in the original interpretation of MacWhinney (1978). With the advent of connectionist models with their claim of avoiding rules altogether (Rumelhart and McClelland, 1986) another turn has arrived in the morphonology issue. Following the initial steps of Brian, originally phrased in terms of rules, Hungarian still figures as essential in this field. Based on English data, the basic debate is if there are only connection formation learning principles or rule extraction is also there, as claimed by dual process models like Pinker (1991). Testing these models has several empirical constraints difficult to resolve within English. Namely, the regularity and frequency factors are difficult to separate. A next generation of Hungarian studies (Pléh, Lukács and Racsmány, 2003, Pléh, 2006) used the variety of stem forms combined with considerations of item and type frequency following the heritage of Brian

from the 1970s: a language with rich morphology proved a better testing site for some radical claims about the reality of rules.

Hungarian sentence understanding and the competition model

In the early 1980s, Brian MacWhinney and Elisabeth Bates proposed a general functionalist model for language acquisition and processing. The *competition model* (MacWhinney, 1987, MacWhinney & Bates, 1989,for a review of its changes over a generation see MacWhinney, 2021) claims for language processing that understanding depends in an analytic manner on the combination of possible individual cues, such as word order, semantic animacy, case marking, stress. The combination of cues is mapped into the grammatical functions of Agent and Patient for example. The process of understanding is assumed to be an issue of a weighted sum of probabilistic mappings. There are competitions in this model in two respects: there is a competition of cues for functions, (what is more important for Agent role, word order or case marking) and a competition among the different noun phrases within each sentence for the role of Agent and Patient. In studying these competitions among the different possible cues to code grammatical relations, grammatical features like word order, case marking, and cognitive features like animacy for example, were manipulated in sentence interpretation studies on children and adults. In the first studies on English, Croatian, and Turkish (Bates, MacWhinney, Caselli, Devescove, Natale & Vanza, 1984) they observed that speakers in some languages rely more on one cue (order), while in others more on another (case marking), but these differences are always statistical in nature. Brian initiated to include Hungarian into these studies, basically because of the possibility of varying word order and case marking as independent factors within the language itself. One could also vary the accessibility of cues in Hungarian. The *-t* accusative marker is much less transparent in the form *tigris**t*** as compared to *kuty***át**. Further, though the case marking seems to be in a biunique correspondence with sentential roles in Hungarian, this is not full proof. There are some cases of Subject-Object case marking neutralizations, such as possessively marked forms like *ház-am* 'my house' that neutralize the Nominative-Accusative difference.

In a series of Hungarian experiments, Brian managed to contrast 4 factors of sentence understanding in Hungarian: Case marking, Word order, Animacy, and Stress. The results indicated several things that are specifically due to using Hungarian as the target language. Hungarian children start to rely on Animacy as a basic cue, but by 4 years of age they already rely mainly on case marking. They become formal grammarians very soon on. Another important aspect of these studies was the use of *variance explained* as an estimate of the weight of different factors. Many factors are significant, but their importance is sometimes radically different. In Hungarian, by 3.5 years of age, case was responsible for 60 % of the variance in sentence understanding decisions, while the importance Animacy dropped to 1.1. %.

Table 3 shows some languages studied within the competition framework regarding their mostly used cues. Hundreds of children and adults interpreted hundreds of sentences or sentoids) to arrive to this generalizations (MacWhinney & Bates, 1989).

Table 3

The Dominant Sentence Interpretation Cues in Different Ages in Different Languages (MacWhinney & Bates, 1989)

Language	Child	Adult
Turkish	Case > Order	Case > Anim > Order
Hungarian	Anim > Case> Order	Case > Order
Warlpiri	Anim > Case> Order	Case > Anim > Order
Serbian	Anim > Case> Order	Case> Agr > Anim > Order
Dutch	Order > Case > Anim	Case > Order > Anim
French	Order > Anim	Agr > Anim > Order
English	Order > Anim > Agr	Order > Anim > Agr

In Table 3 the upper part starts from languages that rely mainly or exclusively on Case marking, and at the bottom languages that only rely on Word Order. In this regard, one could also interpret these differences by saying that Hungarian is more analytic, non configurational, while English, for example, is more holistic, more configurational.

There are further differences even among languages that use case marking to code grammatical relations on noun phrases, and that is a further reason why it was important to use Hungarian for Brian. In Turkish, due to its clear case marking (the accusative is coded by vowels), children become proficient in agent assignment ("who-did-what to-whom") by 2 years of age. Hungarian children also attend a language that basically uses case marking, but in this language this feature is perceptually less transparent. Accusatives are coded by the *–t* stop consonant that results sometimes in difficult consonant clusters like *tigris-t* 'tigerAcc'. Thus, Hungarian children are tuned to the use of exclusive case marking in sentence interpretation only around 3½ years of age.

If we take Hungarian and Warlpiri, young children first use the cognitively based Animacy feature, and later they unlearn its use. We know from infancy research that children around eight-ten months already differentiate between animate and inanimate objects. Animates are those which have random changes in their pattern of movements, and inanimates are the ones which have an inertia–based pattern of movement. Since they have this cognitive template of animacy, children in all languages try to start using animacy to break the code in the language. In Hungarian, like in Warlpiri, animacy is important in 2 and a half year olds, but it soon loses its importance. Parallel to the decrease of the role of animacy, case marking increases its importance. As the importance of case marking increases in the mind of children, animacy loses its importance. In the language structure Hungarian, like in most Uralic languages, there are no grammatical animacy effects, like gender agreement, neither do we have lexical animacy. *Skin* and *leather* are the same word in Hungarian, *bőr*. Thus, in Hungarian and in Warlpiri, a cognitively available important resource, animacy loses its importance as the strategy of the children becomes tuned to the most reliable cues to function in the given language. Building up the process of understanding is a rather flexible project.

Comparing these two languages also shows clearly that the language-related analytic/holistic processing style issue is unrelated to these cognitively much-emphasized East-West differences (Nisbett *et al*., 2001). Warlpiri is an Australian Aboriginal language, both geographically and historically unrelated to Hungarian, while Hungarian and Warlpiri

speakers are the most similar in sentence processing. So it's not an East-West issue but a perceptual accommodation to the dominant feature of a given language (Pléh, 2016).

Word order in complex Hungarian sentences

The free word order of constituents makes Hungarian a useful language for studying the factors influencing the processing of complex structures. Brian in a very ambitious and courageous study entered Hungarian into the debates concerning the factors determining the processing of relative clauses such as *The dog that you like eats the sausage* versus *The dog eats the sausage that you like.*

Hungarian allows such relative clauses with varying the matrix clause and the position of the relative clause (S Relat V O, S V O Relat, SORelatV etc.) also varying the role repetitions (SS, OO, S0, OS) and the presence of demonstratives indicating focusing within the relative clause. Altogether, 144 sentence types were used (that is why I call the study courageous). The study showed that function repetition was the most important factor, S-S relativizations being the easiest ones, and processing was easier also when the focus in the main clause and the subordinate clause was also parallel (MacWhinney and Pléh, 1988). The inspiration of this study is still with us. Kas and Lukács (2012) a generation later are still looking for the relevance of these factors in children as well.

In concluding, I would emphasize that by studying the unfolding of morphology, the emergence of sentence interpretation patterns and the processing of relative clauses Brian MacWhinney certainly made two services to Hungarian psycholinguistics. He provided the domain with rich data for anyone coming from all theoretical orientations. At the same time, by relying on some peculiarities of the structure of Hungarian, he has put Hungarian into the center of discussions about the status of rules, the analytic and holistic approaches of sentence processing, and in general the import of a functionalist attitude towards language.

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Competing Interests

No, there are no conflicting interests.

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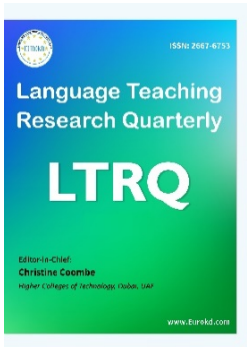

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Learning Chinese as a Second Language: Implications of the Character-Word Dual Function Model

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Abstract

Learning new words is fundamental in both first and second-language reading. There are, however, divided opinions on the best instructional approaches. Two widely used approaches across languages are whole-word focus and word-constituent focus. The appropriateness of each approach has varied historically, even within a single language (e.g., the debate between whole-word instruction and phonics in English). In teaching Chinese, both approaches are applied but to different learner groups. Whole-word instruction predominates in teaching Chinese as a second language (L2), while instruction for Chinese children focuses more on character-level mappings. It may seem reasonable in L2 Chinese instructions to focus on direct mappings between Chinese words and their L1 equivalent words. However, this raises a question: Is whole-word instruction the most efficient approach in L2 Chinese instruction? Based on an analysis of the Chinese writing system, we proposed a Character-Word Dual Function model of Chinese and tested its application of a dual-focus approach on both characters and words in L2 Chinese classroom instruction. Empirical findings support the advantage of this new approach compared to conventional whole-word instruction. We discuss the alignment between our findings and the Unified Computational Model and its implications for word instruction across languages.

Keywords: *Word Instruction, Chinese, L2, Dual Focus*

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[1]Introduction

Words play a critical role in learning to read (Perfetti, 2007), and vocabulary size is closely related to reading performance (Adlof et al., 2006; Braze et al., 2007; Cromley & Azevedo, 2007; Ouellette & Beers, 2010). However, differing views on word instruction often emerge regarding whether it should emphasize the whole word or its constituent parts—a phenomenon observed in many languages. For instance, in English, debates exist as to whether we should prioritize whole words or focus on grapheme-phoneme mappings (Bowers, 2020; Castles et al., 2018; National Reading Panel, 2000; Rayner et al., 2001). Similarly, such debates exist in Chinese instruction, where the question arises regarding whether Chinese word instruction should prioritize the entire word or its constituent characters (T. Li, 2005; Pine et al., 2003). These debates highlight the significance of word instruction and the pressing need to identify efficient approaches for learning and teaching words. Moreover, these debates raise questions about universal principles in word instruction across various writing systems and how a writing system influences word instruction (Verhoeven & Perfetti, 2017, 2022).

We address these questions by reviewing a classroom study on learning Chinese as a second language (L2) (Chen et al., in press). In this study, we proposed an instructional approach that has a dual focus on both the word and its constituent characters in Chinese word instruction based on our Character-Word Dual Function (CWDF) model (Chen et al., 2023) and tested its application in L2 Chinese instruction. In this review, we consider and discuss how the study's findings align with Brian MacWhinney's Unified Computational Model of language acquisition (2005, 2018) and explore the broader implications for word instruction across different writing systems.

In the following sections, we first review current instructional approaches in Chinese word instructions and their apparent rationales.

Word Instructional Approaches for Chinese Children and L2 Learners

There are two widely used approaches in Chinese word instruction: whole-word focus and character focus. These approaches are applied to different groups, with whole-word instruction for L2 Chinese learners and character instruction for Chinese children, respectively (T. Li, 2005; Pine et al., 2003). The application of different instructional approaches for different learner groups aligns with the assumption that instruction should take a learner's prior knowledge into account (MacWhinney, 2005). Thus, instruction for L1 children and L2 Chinese learners should differ because they have different prior knowledge before learning to read Chinese.

Chinese children typically acquire a number of words in spoken Chinese before learning to read and have established sound-meaning mappings of those words. Thus, the primary learning objective for children is to acquire mapping between written units and spoken units and, more generally, how a writing system encodes its spoken language. As characters serve as writing units in the Chinese writing system, Chinese children's word instruction heavily focuses on explicitly learning the character-level orthography-phonology mappings. Meaning instruction, however, is more complex. For words that children have never encountered in spoken

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language, the focus is on word meaning. For words whose meanings L1 children have already acquired via spoken language, meaning instruction sometimes also includes character meaning. Although characters represent meaningful morphemic units, their meanings are often somewhat inexact (as described in the following section, *The Dual Functionality of Chinese Writing*). As a result, the meaning of an individual character is not typically communicated explicitly. Instead, characters are introduced alongside several example words, all of which contain the same character and are commonly encountered in spoken Chinese. For example, since the character "工" cannot function independently as a word, the instructor will typically present words like "工人" (worker), "工作" (work), and "工厂" (factory), all of which are semantically related to the concept of work. Through repeated exposure to the character in various contextually related words, learners gradually develop an implicit understanding of its meaning.

In contrast with Chinese children, whole-word instruction is prevalent in learning Chinese as a second language. Whole-word instruction directs the learner's attention to the correspondences between the entire word and its pronunciation, as well as its meaning, whereas character-level mappings are not typically explicitly instructed (T. Li, 2005). This aligns with the nature of L2 learning, wherein learners can leverage shared knowledge components between their first and second languages to facilitate second language acquisition, transferring these components from L1 to L2 (MacWhinney, 2005; Odlin, 1989). Whole-word instruction is particularly beneficial for L2 learners who have well-developed word representations in their native language. This prior knowledge allows them to create word-level translation equivalencies between their first and second language.

While whole-word instruction may seem reasonable for L2 Chinese learners, whether whole-word instruction is the most efficient approach in L2 Chinese word learning remains unaddressed. Studies on learning English as an L2 have demonstrated that word constituent-based phonics instruction significantly enhances L2 English word learning more than whole-word instruction (Huo & Wang, 2017; Murphy Odo, 2021). In the reviewed study, we aimed to address this question by testing the effective instructional approach in L2 Chinese learning (Chen et al., in press). Before reviewing the study, we revisited the functions of characters and words in Chinese writing, which led to the development of the Character-Word Dual Function (CWDF) model. This model underpins our proposed character-word dual-focus instructional approach for learning Chinese.

The Dual Functionality of Chinese Writing

In the Chinese writing system, the writing unit, a character, typically corresponds to a syllable as well as a morpheme. Thus, Characters serve two functions, encoding both phonological and morphological information.

Encoding Phonology

Chinese characters have a high degree of consistency in their pronunciations. Among the 13,000 characters in the Dictionary of Modern Chinese, only 1,000 are polyphonic, and of these, only 100 are frequently used. Of these 100, the majority have a dominant pronunciation, which applies to 95% of the words in which they appear (Zhang & Chu, 2009). Further, words are typically pronounced as a sequential combination of their constituent characters. Thus, the

correct pronunciation of a Chinese word is often accomplished by concatenating the phonology of its characters. For example, the word "石柱" consists of the characters "石" (pronounced /shí/) and "柱" (pronounced /zhù/), and is pronounced predictably as /shí zhù/. From this perspective, Chinese writing is highly phonologically consistent, with straightforward mappings from characters to syllables and a simple concatenation of syllables to form word-level phonology. Indeed, a recent study confirmed the phonological consistency of Chinese writing using an artificial neural network model to evaluate consistency from written forms to pronunciations in 17 orthographies. This study found that the consistency score of Chinese—the character-to-syllable mapping across words—is higher than in alphabetic Dutch and English (Marjou, 2021). They place Chinese closer to "orthographic shallow" languages such as Spanish and Italian in terms of phonological consistency.

Encoding Meaning: Morphological and Lexical

Beyond encoding phonology, it is important to consider how the Chinese writing system represents morphology and meanings. Conventional views hold that the Chinese writing system codes meaning (morphology) directly in its characters. This idea holds some truth, as characters and their (semantic) radicals are associated with meanings in a way that basic writing units in other systems are not. However, the meanings of characters tend to be flexible or imprecise (Taft, 2003), while most characters are bound roots of compounds that cannot stand alone as words (Yuan & Huang, 1998). To understand this claim, it is useful to delve into how modern Chinese evolved. Words in Old Chinese (1200 BC-300 AD) were largely monosyllabic and usually corresponded to writing units (characters) (Arcodia, 2007). To accommodate language change (e.g., merging or eliminating phonemes of Old Chinese) and new meanings, Chinese adopted "compounding" (also called the "disyllabification" in the common case of two-syllable words, which constitute over 70% of Chinese characters) (Arcodia, 2007). Consequently, Chinese writing began to employ multi-character words with clear character boundaries to represent newly developed compounds. In effect, the salient boundaries between characters originally indicated the boundaries of single-character words rather than marking the morpheme as a special unit.

In modern writing, boundaries are retained, now marking syllabic morphemes[2]. Packard (2000) argued that when monosyllabic words were combined into compound disyllabic words, the characters lost their status as free words, resulting in a corresponding loss of specific meaning. This stands in contrast to Indo-European languages, including English, which tend to preserve the constituent morphemes of compounds as free words (Packard, 2000).

The way in which characters convey meaning has two potential consequences. First, the meaning of a character is highly word-dependent, contingent on the meaning of the word and, in effect, on other characters in that word. Thus, a character cannot represent meaning consistently among different words. For example, the translation equivalent of the English compound word "germinate" is "发芽" in Chinese. The first character, "发", has multiple meanings (such as "generate" or "feel"), and its interpretation is determined by the

[2]Although most morphemes are expressed by a single character, there are exceptions (e.g., 葡萄 /pú táo/, "grape", has two syllables and two characters but one morpheme).

compound word in which it appears. For example, in the word “发芽” (germinate), it is combined with the character character “芽” (“sprout”) and loosely conveys the meaning “generate”. In contrast, its contribution to the word “发痒” (itching) is more representative of a concept like “feeling” or “sensation” as it scopes the concept of 痒 (“itch”) to imply a physical perception.

This word-dependent phenomenon exists in English as well. For example, the interpretation of “watch” relies on the other morpheme in the same word (That is, “watch” encodes different semantic information in “watchdog” than it does in “watchmaker”). Nevertheless, the word-dependent meaning interpretation of characters is especially common in Chinese because of its high proportion of compound words and the flexible meanings carried by most characters. The second consequence is that the meanings of most Chinese words cannot be directly inferred from the meanings of their constituent characters (J. Li, 2011). Only 29% of compound words in the Modern Chinese Dictionary have completely transparent meanings, where the meaning of the word is a combination of the meanings of the constituent characters/morphemes (e.g., 阳光, or “sunlight”) (J. Li, 2011). These observations lead to what may seem a startling conclusion: Written Chinese is more consistent (and transparent) in its phonology than in its meaning.

The above analyses give rise to our conclusion concerning the dual functionality of characters in Chinese writing. Its characters function as both orthographic and morphemic units. However, the character encodes phonological and morphological meaning information unequally. As primary orthographic units, characters are consistent in coding syllable-level phonology but less inconsistent in coding meaning as morphemic units. Thus, it is words, not characters, that primarily encode meaning.

The Character-Word Dual Function (CWDF) Model

This dual functionality of the Chinese writing system lays the foundation of the Character-Word Dual Function (CWDF) model, which redefines the functionalities of characters and words and predicts their roles and processes in reading Chinese. The complete CWDF model introduced in Chen et al. (2023) rests on three assumptions: 1) the character is the basic unit of orthography, maps to the syllable-level pronunciation consistently, and encodes morpheme meaning variably. 2) The word functions as the primary meaning provider in reading. 3) The functions of the character and word depend on the quality of the reader’s lexical representations, which vary with the Chinese reading experience. We elaborate on these assumptions below.

1) The character functions as the basic unit of orthography. Aligned with the facts of consistency in character-syllable, the CWDF model proposes that characters are basic orthographic units and play a critical role in the process of learning to read Chinese. The precise character-level orthographic representations provide a foundation for developing high-quality word-level orthographic representations for skilled reading (Perfetti, 2007; Perfetti & Hart, 2002).

The importance of developing fine-grained representations of character orthography in learning to read Chinese is supported by findings indicating that orthographic knowledge and awareness are critical in early Chinese reading development (H. Li et al., 2012; McBride-

Chang & Ho, 2005). Chinese learners must be able to discriminate among more than six thousand commonly used characters to achieve reading proficiency (the State Language Commission of China, 2013).

The prominent role of character-level orthographic processes continues as novice readers develop into skilled ones (Cao et al., 2010; Tan et al., 2001). In skilled reading, characters act as the orthographic "gateway" to word identification. The activation of characters has been observed even when reading the alphabetic script of Pinyin in both skilled L1 and L2 readers (Chen et al., 2014; Chen, Perfetti, & Leng, 2019; Chen, Perfetti, Fang, et al., 2019).

2) The word functions as the primary meaning provider. In contrast to characters, which, as morphemic units, are less consistent in meaning interpretations, a word offers a more precise representation of lexical meaning. Word meaning plays a critical role in linking the subsystems of reading processes connecting word identification and comprehension (Perfetti & Stafura, 2014). Reading comprehension depends on the successful retrieval and integration of word meanings into the reader's mental representation of the text (Perfetti & Helder, 2021; Yang et al., 2007). An ERP study on reading Chinese supports this, showing that skilled Chinese readers rely on whole-word meanings rather than character meanings, for comprehension (Chen et al., 2017). Eye-tracking studies have produced similar findings (Shen et al., 2018).

3) The functionalities of characters and words rely on the quality of lexical representations.

The CWDF model extends the primary functions of characters and words by incorporating their dependency on their representation quality developed through reading exposure. With sufficient reading experience, readers develop well-established orthographic and meaning representations for both constituent characters and words, allowing them to contribute to reading efficiently.

The word superiority effect illustrates the simultaneous orthographic processes at both character and word levels. With very brief exposure, characters within real words are recognized more accurately and quickly than characters within non-words, supporting rapid access to the word-level orthography (Chen et al., 2018). This effect varies with character frequency: high-frequency characters show smaller word superiority effects than low-frequency characters. This suggests that orthography of high-frequency characters can be accessed rapidly, benefiting less from word-level orthography (Chen et al., 2018).

With sufficient reading experience, readers can also develop meaning representations of constituent characters in addition to the word meaning (Tsang & Chen, 2013a, 2013b, 2014; Wu et al., 2017). This development rests on the expansion of the reader's vocabulary (Rastle, 2019; Reichle & Perfetti, 2003). Knowledge of an increased number of words exposes the learner to the same character in diverse word contexts, resulting in the implicit acquisition of the character's meaning (Liu et al., 2017). Although character meanings are often imprecise and inexact, their representations can help recognize less familiar, low-frequency words for which the word-level meaning access is less automatic (Chen et al., 2023; Tse & Yap, 2018; Yan et al., 2006).

Character-Word Dual Focus: An Implication of the CWDF Model in L2 Chinese Word Instruction

The conceptual framework of the CWDF model redefines the roles of characters and words in Chinese reading. As a result, its implications merit the formulation of specific hypotheses and experimental investigation (Chen et al., 2023). One of its applications is in L2 Chinese word instruction. According to the CWDF model, Chinese instruction should create a dual focus on the character and the word, aligning with their roles in the structure of written Chinese.

Because characters are the basic orthographic units and map to the syllable-level pronunciation consistently, orthographic instruction should explicitly teach character-level orthography by mapping it to a spoken syllable. Learning these orthography-phonology mappings enables learners to develop character-level orthographic representations, which in turn build the word-level orthographic representations (word orthography being the simple concatenation of constituent characters' orthography), preparing them to become skilled readers. Furthermore, learning the character-level orthography-phonology mappings allows for the acquisition of the systematic structure of the Chinese writing system and supports learning new words. In this process, learners can directly transfer character-level associations between orthography and phonology to new words that include the learned characters, thereby supporting the acquisition of new vocabulary.

Meaning instruction should primarily focus on the word. This allows learners to develop more precise meaning representations, preparing them for rapid meaning retrieval and integration during reading comprehension. In Chinese children's instruction, character meanings are sometimes taught in addition to word meanings. Chinese children can learn the meanings of some characters implicitly through their knowledge of spoken words that share the same character. This approach, however, does not apply to less proficient L2 learners, especially beginners, whose vocabulary may not be sufficient to support such learning.

Testing the Character-Word Dual Focus Approach in a Study of Classroom L2 Chinese Learners

To test the application of the dual-focus approach in L2 word instruction, we conducted a two-session classroom study of learning Chinese as a foreign language (Chen et al., in press). Learners were American college students enrolled in an introductory Chinese course. The control group received conventional word-focus instruction by being presented with a two-character word as a whole, along with its two-syllable pronunciation and meaning in English (Figure 1). The experimental group received dual-focus instruction and was taught the exact words as the word-focus group but with visual space between the syllabic pronunciation of each character (Slide 1 in Figure 2). Both the word-focus and dual-focus groups learned meaning from the whole word presentation; they differed only on whether pronunciations were presented for the whole word or for each character separately.

Two features based on the CWDF model were highlighted in the instruction received by students in the experimental group. First, orthography to phonology mappings were instructed at the character level (Slides 2 and 3 in Figure 2), which benefits the development of both characters' and words' orthographic representations. The character representations can support learning new words that share the same character. Second, the mappings of orthography to

meaning were instructed to learn at the word level for beginning learners, not the character level.

Figure 1

An Illustration of Word-Focus Instruction

Figure 2

An Illustration of Dual-Focus Instruction

(Slide 1) (Slide 2) (Slide 3)

To evaluate the effectiveness of this dual-focus instruction, we compared the learning performance of students who received dual-focus instruction to that of students who received conventional word-focus instruction at both word and character levels. We hypothesized that dual-focus instruction, relative to word-focus instruction, would have two important outcomes. First, because of the instructional focus on building orthographic-phonological character representations, learners in the experimental group would develop higher-quality orthographic representations of both the word and its characters. The orthographic representations of characters enable learners to make more extensive character-based generalizations (i.e., learners will better recognize these characters when they appear in words they do not know). Second, despite its emphasis on character form, the dual-focus instruction on word meaning should lead to a level of word meaning learning comparable to that of word-focus instruction.

The results showed that the dual-focus instruction led to levels of word pronunciation and meaning learning comparable to the word-focus instruction, regardless of whether the test tasks were retrieval or recognition (as summarized in Table 1. Detailed results and statistical analyses are elaborated in Chen et al. in press). These findings suggest that word-level performance did not suffer due to a focus on character-syllable mapping. More importantly, the dual-focus instruction benefited learning character pronunciation and produced a greater transfer to learning novel words compared to the word-focus approach, with roughly 20% higher accuracy. The advantage of dual-focus instruction in learning pronunciation at both character and word levels aligns with the key assumption of the CWDF model, in which characters are basic orthographic units. Establishing character-level representations is crucial for developing high-quality orthographic representations at both character and word levels, as well as for facilitating the learning of new words.

Table 1

Instructional Focus and Learning Performance between Two Instructions

Instruction	Instructional focus		Learning performance			
	Pronunciation	Meaning	Word pronunciation	Character pronunciation	Novel word pronunciation	Word meaning
Dual-focus	Character	Word	Equal	Dual-focus outperforms	Dual-focus outperforms	Equal
Word-focus	Word	Word				

Our results support the application of the dual-focus approach to L2 Chinese instruction. In fact, this approach has clear parallels to current instructional methods for L1, albeit modified to account for differences between native speakers and second-language learners. As we noted previously, Chinese children explicitly learn the character-level orthography-phonology mappings, aligning with the dual-focus approach. Meaning instruction generally occurs at the level of the word. In the case of words that have already been acquired in spoken language, this can result in implicit instruction on the meanings of the constituent characters. However, for unfamiliar or new words, this implicit character-meaning instruction is less accessible (or may not occur at all). Thus, the approach for Chinese native speakers is akin to an updated version of the dual-focus approach tailored to more proficient learners, as meaning instruction still occurs at the word level but may focus on specific characters in some circumstances. Thus, while the reason for character focus differs between L1 and L2 learners, it is still the secondary source of meaning acquisition.

Learning Chinese as a Second Language and the Unified Competition Model

The Unified Competition Model (UCM) of language acquisition proposed by Brian MacWhinney (1987, 1997, 2001, 2005, 2018) provides an excellent theoretical framework for understanding both L1 and L2 acquisition. It has broad implications in L2 learning, including word learning and instruction. Analysis of the products of our own work shows two factors that clearly align with the principles of the UCM model: cue availability and reliability in language learning are critical to acquisition, and factors that support or hinder language acquisition may vary between L1 and L2 learners.

The general applicability of the dual-focus approach in both L1 and L2 Chinese learners is consistent with the importance of reliable and valid cues in language learning highlighted in the UCM model. In learning Chinese, focusing on reliable and available cues, which minimize competition, is crucial for both L1 and L2 readers. Because the character-level mappings between orthography and phonology are reliable, they provide a solid foundation for acquiring whole-word pronunciation and transferring this mapping to new words that include these learned characters. Thus, learning character-level orthography-phonology mapping is important in Chinese word instruction, necessitating explicit instruction, as the UCM model indicates. In contrast, although characters are meaningful, their mappings to meanings are less reliable, with more competition. Thus, character-meaning instruction serves only as a supplementary role.

While using a common approach for Chinese L1 and L2 instruction aligns with the UCM, the UCM also highlights the notion that L1 and L2 learners are supported and hindered by different factors (e.g., variations in prior knowledge). In Chinese word instruction, word

meaning learning can benefit from the different kinds of prior word knowledge that L1 and L2 learners bring to learning written Chinese. L1 learners bring spoken word knowledge to their learning, and L2 learners bring L1 word meaning to their learning. These differences in prior knowledge allow for slight variations in L1 and L2 meaning instruction within the application of the dual-focus model. Native speakers' knowledge of spoken Chinese vocabulary helps them develop morphological awareness of individual characters (McBride-Chang et al., 2004; Shu et al., 2006), preparing them for learning character-level meanings beyond the word meaning. This level of preparation is not typically present for L2 Chinese beginners.

Beyond aligning our work with the tenets of the UCM, the model also presents implications for future exploration. Its assumptions about the features of the target language constrain both first and second language learning. Similarly, the nature of Chinese characters as meaningful yet imprecise units suggests similar character-meaning instructional approaches for both L1 and L2 learning. Consequently, we predict that as L2 learners' vocabulary increases, they will benefit from meaning instructions of individual characters (Gao, 2020; Xu & Zhang, 2020), similar to L1 instruction.

We should note that character meaning instruction must be approached with deliberate design and acknowledge the inconsistent manner in which characters encode meaning (i.e., character meanings are less reliable cues from the UCM model perspective). Two principles derived from the model may guide designs for character meaning instruction. First, instruction should enable the reduction of the meaning competition from a character itself due to the meaning ambiguity of characters. Second, instructions should address the inconsistency between the meanings of a word and its constituent characters in acknowledgment of the reality that most Chinese compound words are not entirely transparent (Gao, 2020).

Implications of the Findings from Chinese Instruction for Word Instruction across Different Writing Systems

The advantages of Character-Word dual-focus instruction, compared to word-focus instruction, during Chinese learning, support the importance of learning the constituents of words to grasp the systematic structure of the writing system. This is similar to the essential practice of learning the phoneme-grapheme mappings of an alphabetic writing system like that of English. While the sub-word mappings have been particularly emphasized in learning to read alphabetic languages such as English, where a small number of written units (letters) and spoken units (phonemes) allow explosive productivity (the ability to read almost any word) (Castles et al., 2018; Rayner et al., 2001), the importance of sub-word units extends to other written languages. This holds true for syllabaries and even for the morpho-syllabic Chinese writing system, where acquiring a large inventory of orthographic characters mapped reliably to syllables and flexibly to morphemes is critical.

This similarity of learning to read languages as different as English and Chinese in the mappings of written-spoken units may reflect two general principles of learning to read identified in the analysis of 17 different orthographies (Verhoeven & Perfetti, 2017, 2022). First, although writing systems differ in how they map orthography to phonology, learning to read involves understanding how a writing system encodes its language, specifically, the mappings between written units and corresponding spoken units in a given writing system. In Chinese, these mappings occur at the character and syllable levels, while in alphabetic

languages like English, they occur at the letter(s) and phoneme levels. Importantly, learning these mappings benefits new word learning, as learning to read relies on acquiring new words, which can be enhanced by transferring shared word components from known words. Second, precise sub-word representations are essential in developing high-quality word representations that support rapid meaning retrieval during comprehension (Perfetti, 2007, 2017; Perfetti & Hart, 2002). In the case of the Chinese writing system, fine-grained representations of character orthography enable readers to identify a given character by distinguishing it from many other visually complex Chinese characters and to identify a given word by distinguishing its character constituents from those of other words. Similarly, in alphabetic writing, the fine-grained sub-word representations enable readers to identify words sharing similar letter strings.

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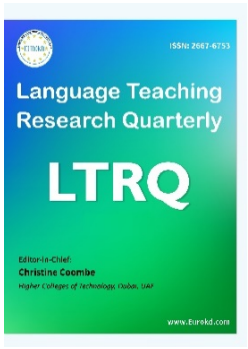

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Brian MacWhinney's 55 Years Research into Language Education and Psychology: A Systematic Review and Brian MacWhinney's Personal Reflection

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Abstract

Ali Panahi and Hassan Mohebbi systematically reviewed Brian MacWhinney's 55 years of research and publication in language education and psychology. The study was conducted in varying sections. Section 1 illustrates a methodology for the systematic review. It presents an impressionistic framework based on which the reviewers developed some exclusion and inclusion rules. Section 2 is concerned with MacWhinney's overall achievements and contributions; all his research publications were estimated to stand at 540 items. Section 3 presents the themes (micro-themes and macro-themes) in MacWhinney's research works and presents the extracted technical jargons, terms and concepts for both language education (1548 items) and psychology (447 items). Added to this, nine meta-themes were inferred and extracted for all of his research publications. Section 4 provides a systematic review of his research works. As a result, with reference to the subjective criteria and exclusion and inclusion rules, his research works, i.e., articles, book chapters and books, were systematically reviewed. In the end, Brian MacWhinney provided his own reflection and discussion.

Keywords: *Brian MacWhinney, Systematic Review, Language Education, Psychology, CHILDES*

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[1]Introduction

If the investigated areas over the course of ELT history are closely navigated, one can be potentially led to the understanding that Brian's MacWhhinney's 55-year contribution, research and publications rest inevitably somewhere in the middle between psychology and language. Accordingly, the fundamental principle behind the present systematic review is that ELT is inseparable from other disciplines and requires scholars in the field not to ignore the effectiveness of this inseparability. It appears that giving researchers and educators clear and brief access to a representation of research findings revealed over the course of 55 years by Brian MacWhinney would be potentially beneficial, however demanding. That is why the current systematic review emerged. Before outlining the ins and outs of MacWhinney works, at the outset, we would like to present some key issues.

A much closer look at Brian MacWinney's research literature, and a review of the micro-themes, macro-themes and meta-themes endorse his fair share in language education and psychology and reveal the vastness of his research scope. Approximately 55 years ago, i.e., in 1973 or so, the beginning research work of Brian MacWhinney emerged in the field of psycholinguistics and language education. The work was titled *"Glossolalic speech from a psycholinguistic perspective" (*Osser, Ostwald, MacWhinney, & Casey, 1973). Although the significance of glossolalia had already been hotly debated for decades, or even centuries (Goodman, 1964; Wolfram, 1966), Brian MacWhinney and his colleagues clarified other crucial facets of the issue and discussed glossolalia as a language-dependent psychosocial phenomenon and considered Glossolalia as a form of speech behavior. This was the beginning of a much longer journey. The reason why we first mentioned this research work is to point out that it heralds the width and depth of the investigated areas: Referring back to 55 years ago is not an easy task in terms of accessing the published works, as there existed no Google like this to record the publications. This being a guidepost for start, he proceeded with his much longer career of research areas.

One of his cogent and persuasive discussions and publications came to existence in 1991 (MacWhinney, 1991) in his reply to Woodward and Markman. In this work he did a fair share for researchers indicating that developmentalists are required to be extremely wary of theories that decouple underlying constructs from their empirical realizations. As a scholar professionally active both in psychology and language, MacWhinney could break the shackles of impressionism and personalization letting the trend of his professionalism move on the continuum of endorsed theories and scientific enterprises. This happened exclusively because he could bring about varying numbers of disciplines and subdisciplines and could effectively integrate them into his research productivity.

When computer stared to play an obvious role in corpus linguistics, MacWhinney (1989d, 1992a, 1994a, 2000c, 2000d; MacWhinney & Snow, 1992) established the CHILDES corpus, serving as a computational tool for varying purposes, such analyzing talk, language disorder, and as an essential resource for modern studies in language acquisition. To illustrate its significance further, in one of the research projects titled *AphasiaBank: Data and Methods*, Macwhinney, Fromm, Holland, and Forbes (2012) emphasize the importance of the use of

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corpora, particularly in the field of child language research and indicate a decade ago, over 3500 articles have been published using CHILDES database. In the same vein, Forbes et al.'s (2012) research work titled *"AphasiaBank: a resource for clinicians"* provides a brief account of the highlighted history and role of AphasiaBank and mentions that CHILDES (Child Language Data Exchange System) is an international cooperative venture originated and directed by Brian MacWhinney. As the scholars indicate, AphasiaBank involves some 800 active users and 4000 affiliated members located in over 30 countries and aims at extending the model established by the Child Language Data Exchange System (CHILDES) for the field of child language acquisition to include the study of adult language. As a reference digital guide, MacWhinney (2014a) in a research work titled "*Challenges facing a core outcome set development for aphasia*" indicates that the AphasiaBank Project organized at http://talkbank.org/aphasiabank is an example of a shared database of this type. Therefore, his research areas are more extensive. For example, nearly 2 decades ago, MacWhinney, Martell et al. (2004) proposed the design of a CC system for spoken language data and presented, and published varying research work concerning collaborative commentary. More recently, MacWhinney and Fromm (2023) published a related work titled collaborative commentary for understanding communication disorders. This indicates that whatever research work he has conducted continues to appear even nowadays nonstop, the implications of which are observed in SLA.

More practically, in most of his research works, Brian MacWhinney strives to relate the findings and implications to second language acquisition. Specifically, in his research work titled "*A shared platform for studying second language acquisition*", MacWhinney (2017b) relates the findings and implications to second language acquisition and recommends data-sharing as an effective area such as first language acquisition and aphasiology. Moreover, he believes that researchers in the field can work together to construct a shared platform that combines data from spoken and written corpora, online tutors, and Web-based experimentation. This latter point is vividly portrayed in his own research works, as he has jointly contributed to a vast number of research works.

In conclusion, the vastness of his research works and the scope of his contribution in terms of quantity and quality as well as theory and practice seem unlikely to be included in this brief introduction. The study is embedded in organized procedures containing the following sections. Section 1 illustrates methodology for the systematic review. Section 2 is concerned with MacWhinney's overall achievements and contributions. Section 3 presents the themes in MacWhinney's research works and section 4 provides a systematic review of his research works.

Section 1. Methodology for the Systematic Review

Panahi and Mohebbi developed a subjective framework and impressionistic criteria for the systematic review. The purpose of the framework was to offer a neat orientation to Brian MacWhinney's vast research works over his 55-year professional lifespan both qualitatively and quantitatively.

In the systematic review, which will be reported in Section 4 (Tables 7-9), we grouped in chronological order the publications located in our search. However, in the process of the current systematic review, we vividly observed that Brian MacWhinney's published research

works are too vast to be all included in the systematic review. Therefore, we developed some criteria and a framework under the general heading of "Exclusion and Inclusion Rules", according to which we specified what to include or exclude and why. That is to say, so as not to exceed the page limit of this article, we used inclusion rules (Table 1) and exclusion rules (Table 2), based on which we removed some research works from the systematic review.

Table 1

Inclusion Rules and Examples for the Systematic Review

	Inclusion Rule	Example
1	A publication was considered to be potentially eligible for inclusion if it was relevant to *at least one* of the nine meta-themes presented in the study. (see Table 6).	MacWhinney (1975, 1977, 1983, 2004a, 2004b, 2023a)
2	The publications having somewhat similar themes and researched issues were merged and analyzed together due to time, space and manageability considerations. On these occasions, the chronological order of the intended researcher's work was not considered. In other words, the systematic analysis was performed in a chronological order. However, in some cases, we disobeyed the rule just when the main themes of the articles published in different dates were somewhat identical and even merged the books, book chapters or journal articles.	- MacWhinney, Osman-Sági, and Slobin (1991) was merged into MacWhinney and Osman- Sági (1991) - MacWhinney (1995a, 1994a, 1996b), MacWhinney and Snow (1985, 1990, 1992, 2023) and Bernstein Ratner, Rooney, & MacWhinney (1996) were all reviewed together. - Li et al. (1992) was merged into MacWhinney et al. (1984) - MacWhinney's (1992b) and MacWhinney (1997a) as book chapters were merged and analyzed as they had a lot in common in terms of themes add and content. - MacWhinney's (2002a, 2002c, 2005g, 2005h, 2005j, 2008b) were all merged as they all provide an account of the competition model, new directions, and an extended formulation of the competition model.
3	A research work was excluded from the study because we could not tabulate its details from our online search. However, we included it in the reference list and in Brian MacWhinney's overall achievement.	- Unpublished manuscript MacWhinney & Bates (1994). The competition model and UG. Unpublished manuscript. - MacWhinney (2001a)
4	The systematic review of a journal article should have been included in the Journal Analysis Table, but we included it in the book or chapter analysis section. It was due to the length of the research work, and manageability, time, and space considerations associated with the extraction of the technical terms of this work.	- MacWhinney (1978) was analyzed in book analysis section - Lempert & MacWhinney (1984) was analyzed in chapter analysis section. - Bates and MacWhinney (1988a, 1988b) both deal with functionalism from varying aspects.
5	Conference proceedings were excluded from the systematic review due to time, manageability and space limitations. However, we included them in in Brian MacWhinney's overall achievement and in meta-themes.	MacWhinney (2005d)
6	We included journal articles, books and book chapters in the systematic review. All three were viewed and reviewed in terms of research, practice, meta-themes, macro-themes, and micro-themes. Also, we extracted the technical terms of just journal articles (not those of books and book chapters) due to time, space and manageability considerations. However, assuming	- MacWhinney (1994b) - MacWhinney (1995b)

	that two of the book chapters contained more practical technical terms, and they were also manageable, we extracted their technical jargons, concepts and terms.	
7	A commentary on varying topics and being two pages or so long were excluded from the study, but we included this in MacWhinney's overall achievements. Also, a commentary was exceptionally analyzed, as it was supposed that it contains much richer implications. Therefore, there existed two exceptions, such as MacWhinney (1984c, 2004a) which were reviewed and listed in the reference section, too.	- MacWhinney (1984a) - MacWhinney & Bates (1991) - MacWhinney (2005e, 2005f)
8	A book chapter appeared ambiguous with respect to the authors. We included it in the systematic review, but to clear up the potential ambiguity and to credit the authors of whatever kind, we detailed what we observed.	What we tabulated from his CV is "MacWhinney, B. (1994b). The dinosaurs and the ring. In R. Corrigan., S. Lima, M. Noonan (Eds.), *The reality of linguistic rules* (pp. 1-30). John Benjamins". However, on the article it appears to have been written by R. Corrigan, G. Iverson, and S. Lima. We included the first in the systematic review.
9	As regards TalkBank and the related research, we systematically reviewed some of Brian MacWhinney's research works and excluded all others due to the vastness of his research in this area, but included them all in the overall achievement and meta-themes section and would therefore like to refer the interested readers to http://talkbank. org	Research works systematically reviewed were: - MacWhinney, B. (2007, 2021) - MacWhinney, Bird et al. (2004) - Bernstein Ratner & MacWhinney (2019) - Koschmann & MacWhinney (2001)
10	A research work was a commentary, but due to its highly informative details, we analyzed it in the section of articles.	MacWhinney (1997b)

Table 2

Exclusion Rules and Examples for the Systematic Review

	Exclusion Rule	Example
1	A chapter was ineligible for inclusion if it was published in any book edited or co-edited by MacWhinney. It was assumed that since the book was systematically reviewed, it would be partially informative for the readers to search for their wanted content on the ground of the clues in the reviewed book. Added to this, due to the vastness of MacWhinney's research work, time and space factors as well as the manageability of the systematic review were main issues. Therefore, despite their innovativeness, differences in subject and high quality, we excluded them from the systematic review.	- A chapter in MacWhinney (1999a) was excluded (e.g., MacWhinney, 1999b, 1999c) - Two chapters in MacWhinney (1987b) were excluded (MacWhinney, 1987c, Bates & MacWhinney, 1987). - Three chapters in MacWhinney and Bates (1989) were excluded (McDonald & MacWhinney, 1989; Bates & MacWhinney, 1989; MacWhinney, 1989b). - All of the chapters, such as MacWhinney - MacWhinney's (1995c) book chapters in in his book titled *"The handbook of child language"* (Fletcher & MacWhinney, 1995) were excluded from the systematic review, his overall achievements and reference list. - A book chapter in MacWhinney (2013a) - All book chapters in Klatzky, MacWhinney and Behrmann (2008), such as MacWhinney, (2008a) as well as the book itself were excluded from the systematic review. We could not access the book. - Book chapters in MacWhinney, Malchukov, & Moravcsik, (2014), such as MacWhinney (2014e) were excluded from the systematic review, but the book itself was reviewed.

2	A chapter was ineligible for inclusion if it or part of it appeared in one of the research works of Bian MacWhinney. However, it was included in the reference list and also in Biran MacWhinney's overall achievement.	A portion of Bates, Thal, and Mawhinney (1991) appeared in MacWhinney and Bates (1989), so we excluded the former from the systematic review.
3	Brian MacWhinney's Research works (books, book chapters or journal articles) not tabulated from our online search were all excluded from the study. However, they were included in his overall achievements.	-
4	As regards the exclusion and inclusion rules for the extraction of the technical terms, there existed some limitations. We failed to extract the technical terms for his books, book chapters and poster publications. If performed, the number of the extracted terms would be vast enough to be accommodated in the study. Second of all, we did not extract the issues related to his research methods and approaches.	The research issues, methods and approaches, such as meta-analysis, test-res-test study, dependent variables, independent variables, correlation coefficient, specific demographics (e.g., age, education), stability metrics, etc., were excluded from the study.
5	A publication was excluded from the study if it was published in the form of a poster. Although it was innovative and informative, due to the brief nature of the poster published we were cautious not to communicate the required pedagogical implications to the readers.	Cator, Fromm, Johnson, & MacWhinney (2013) Dalton et al. (2019) Saylor et al. (2022)
6	Journal articles with no publication date or publishing company were excluded from the systematic review. Although they were not reviewed in systematic terms, they were considered in bibliographic terms as well as in terms of MacWhinney's overall achievements and meta-themes.	Fromm, D., Holland, A., Armstrong, A., Forbes, M., MacWhinney, B., Risko, A., & Mattison, N. (2011). Better but no cigar. Persons with aphasia speak about their speech.
7	(Some of the) articles with more than 9 or 10 co-authors were excluded from the systematic review due to space and manageability considerations. However, we included them in the overall achievement and meta-themes. The main reason for this was that it was required to consider space consideration so that the vastness of Brian MacWhinney's work demanded it to create internal rules and observe them.	Brassel et al. (2016) Release Collaboration (2020)
8	As regards the rules for the exclusion of technical terms, we excluded the methodological terms, concepts and jargons from the extraction section due to time, space and manageability considerations.	Since MacWhinney's research works were wide-ranging in terms of scope, quantity and quality, we failed to include the methodological concepts, notions, terms and jargons in the study. If performed, it would appear as stand-alone section next to the two meta-themes tackled.
9	Some research works (books, book chapters, or journal articles) were excluded from the study despite their innovativeness, differences in subject, and high quality, as we could not tabulate their full version from our online search. Of course, to avoid misrepresentation and faulty review, we excluded them from the systematic review, but they were included in his overall achievement and meta-themes section.	MacWhinney (1990) MacWhinney (1989c, 1989d)
10	A publication was ineligible for inclusion if it was in a foreign language that could not be understood by systematic reviewers.	MacWhinney's published books review that had been written in another language was excluded from the systematic review and from the reference list.

11	An article was excluded from the systematic review if reviewers did not understand their implications or for other reasons. However, their technical terms were extracted and they were also considered in Brian MacWhinney's overall achievements.	Bates, McDonald et al. (1991)
12	An article was published two times or in two formats: One time as a conference proceeding in 1990, then, as a journal article in 1991. We reviewed and cited the latter. Also, a publication appeared in both a journal article and in a book chapter with different dates. We considered it in the format of journal article, but included both in the reference section.	- MacWhinney & Leinbach (1991) - MacWhinney (1995a, 1996b) as a book chapter and journal article.
13	All tributes, guest editorials, test reviews, book reviews, and other very short pieces were ineligible for inclusion.	Oxford's short contribution to a multi-authored tribute article was excluded from the systematic review and from the reference list.
14	Some of the research works we tabulated from our online search had no page number and we could not access the full version of such works. Moreover, we had access to some research works, but it was unclear where it was published. So, concerning the related cases, we had to deviate from APA style and included them in the reference list without any page number. Also, such references were found to be published in different dates. We included just the recent one.	- A look at Brian MacWhinney's book chapter titled Competition model. In S. M. Gass & A. Mackey appeared to be ambiguous in terms of the date of publication. It seemed unclear to us either it was published in 1995 or 2012. So, we ignored 1995 and considered 2012 (see MacWhinney, 2012). - MacWhinney & Chang (2019) - MacWhinney, Bird et al. (2004)
15	A research work focusing on Hungarian language acquisition was excluded from the study due to the fact that we failed to provide implications for the study.	MacWhinney (2012b)
16	We did exclude book reviews from meta-themes section.	Since it was totally deleted from the review, we did not provide any examples.
17	Publications related to book reviews and comments were excluded from the systematic review. They were only listed in Brian MacWhinney's overall achievement section. Published in well-recognized journal, the reviewed works and comments are of pedagogical implications. Due to space, time and manageability considerations, they were excluded from the systematic review.	- Published comments: MacWhinney (1991) - Reviewed books: MacWhinney (1978b)
18	Due to time considerations and pressure, we excluded the issues related to research methodology in Brian's whole works, so from the study we removed data analysis and research issues, such as ANCOVA, MANOVA, etc.	For example, the extraction of the technical terms related to the methodology section of the journal articles were ignored in the study.

Section 2: MacWhinney's Overall Achievements and Contributions

This section presents MacWhinney's overall achievements in Table 3, as compiled by Panahi and Mohebbi. In the systematic review, we created some subjective rules. One of the fundamental rules for the study was that we included journal articles, book chapters and books in the systematic review, but excluded from the systematic review some of his research works. The excluded research works include book reviews, conference publications and presentations, research works published in a language other than English, poster-type publications and presentations, inaccessible research works, posters, research works with no publications date, research works with no journal details (journals where they were published), research works

having more commonality with those selected for the systematic review (28 items), and published commentaries. It is worth noting that approximately all of the excluded published works were included in his overall achievements and contributions (Table 3).

Table 3

Overall Achievements and Contributions

Type	Quantity
Total number of published research works	540
Research works included: Articles, book chapters and books	273
Research works excluded: Book reviews, conference publications and presentations, research works published in a language other than English, poster-type publications and presentations, inaccessible research works, posters, research works with no publications date, research works with no journal details (journals where they were published), research works having more commonality with those selected for the systematic review (28 items), and published commentaries.	267
Honors and research awards	176
Languages taught and published: English, Hungarian, German, French, Latin, Spanish, some Cantonese and Mandarin	8
Technical jargons, terms and concepts in psychology	447
Technical jargons, terms and concepts in language education	1548

As shown in Table 3, Brian MacWhinney's overall academic achievements and contributions stood at 540. Out of these, we excluded conference publications and presentations, book reviews, poster-type publications, inaccessible research works as well as those research works sharing commonality with other related reviewed works, and published commentaries and included in the systematic review his published articles, book chapters and books. In addition, an approximate number of technical terms and concepts in psychology and language education stood at 447 and 1548, respectively. On top of these all, the academic honors and research awards he received seem to be 176 (with reference to his CV). Among these all, he could teach and publish in 8 languages including English, Hungarian, German, French, Latin, Spanish, some Cantonese and Mandarin. A word of note regarding the implications of the technical terms and concepts is that the reasons why we extracted the technical terms are that they can help language teachers justify their practice in the classroom in both pedagogical and theoretical terms. Therefore, technical terms, as reference values, are one of the fundamental justifiers. For example, there is no balanced bilingual (Cook & Newson, 1996). The technical term 'balanced bilingual' is used when parents wrongly expect foreign language teachers to make their children (those learning English as a foreign language in a foreign context) speak English like a native speaker and be an undistinguishable member of the society. As it appears to be, it is highly unlikely in EFL context to be an exact native speaker: From our point of view, as inferred from Cook and Newson (1996), there lies degeneracy of input. Therefore, the technical issues are required for both novice and experienced researchers.

Section 3: Themes in MacWhinney's Research Works

A. Micro-Themes and Macro-Themes

In bibliographic terms, we grouped his research works into varying themes: micro-themes, macro-themes and meta-themes. First, we extracted macro-themes and micro-themes (Table 4

and Table 5). At the same time we were performing the systematic review, we also identified the kind of themes relevant to every individual under-review research work.

Table 4

Macro-Themes for MacWhinny's Research Works

Macro-Themes
1. Psychology
2. First language
3. Second language
4. Bilingualism
5. Trauma and brain disorder
6. Discourse issues
7. Psycholinguistics
8. Sociolinguistics
9. Skills/ subskills
10. Technology (e.g., computer)
11. Linguistics

Table 5

Micro-Themes for MacWhinny's Research Works

Micro-Themes
1. Information processing (and analysis)
2. Language emergence
3. Fossilization
4. Models (competition model, mental model, process model, etc.)
5. Connectionism
6. Simultaneous interpretation/translation
7. Talk analysis
8. Language therapy
9. Interaction
10. Theories
11. Pragmatics
12. Semantics
13. Phonology and phonetics
14. Morphology
15. Syntax – lexicon
16. Verb learning
17. Processing (sentence, word, etc.)
18. Case marking
19. Aphasia
20. Alzheimer
21. Acquisitional issues
22. Dementia
23. Neroemergintism / neurophysiological issues
24. Feedback
25. PsyScope
26. Strategy
27. TalkBank

Table 5 shows the micro-themes, which are wider in scope than the macro-themes. It needs to be mentioned that the micro-themes and macro-theme are reflected in the fifth and fourth columns of Tables 7-9 in the systematic section.

B. Meta-Themes Extracted from MacWhinney's Publications

Due to the variety of publications and research works, themes, disciplines and subdisciplines, we were required to put Brian MacWhinney's works in a simply understandable and neat order and considered their bibliographic basis. Therefore, after the review process was fully performed, for ease of clarification and understanding, we extracted nine meta-themes and subjectively called it meta-themes appearing as "stand-alone" words, but portraying the whole annotations and contents of a single research work. This was conducted with reference to bibliographic resources and with a view of factoring in all of his published works. We applied this to all of his research works, either included in the systematic review or excluded from the systematic review. The reason why we subjectively called it meta-themes is that the number of his research publications were immensely sizable, so we were required to use the word 'meta-theme" in order to organize the number of published works and areas of his research in a more sophisticated way. In total, we developed nine meta-themes serving as an umbrella term for organizing his areas of research. On some rare occasions, we failed to realize which category a specific term or concept belonged to and we impressionistically decided to include it in either one of the two themes. For example, the phrase "*initial mapping*" was difficult to decide whether it belongs to psychology or language education and research. We decided to include it in the theme of psychology. As such, every single meta-theme summarizes the title of the research work. Hence, we would like to provide an example of the way we proceeded to group and categorize all his research work into illustrated meta-themes below:

MacWhinney, B. (2012b). Syntax
MacWhinney, B. (2014a). Aphasia
MacWhinney, B. (2014e). Competition model
MacWhinney, B. (2017a). Language and psychology
MacWhinney, B. (2017b). Language acquisition
MacWhinney, B. (2017c). Language and psychology
MacWhinney, B. (2006a). Emergentist
MacWhinney, B. (2007). TalkBank
MacWhinney, B. & Fromm, D. (2016b). CHILDES

Table 6

Meta-Themes Extracted

Meta-themes	The Number of Research Works Published
Language and psychology	102
Syntax (and lexicon)	91
Language acquisition/learning	72
CHILDES and CLAN (Clarin)	46
Competition model (and unified model of language acquisition)	40
Others	38
AphasiaBank (aphasia issues, dementiaBank)	27
TalkBank (Phonbank, HomeBank, fluencyBank)	22
Emeregenticism (or emergentist)	21

As it is clear from Table 6, Brian MacWhinny's areas of concern and investigation are wide-ranging. The fundamental issues investigated include language and psychology, syntax,

language acquisition and learning, CHILDES and CLAN (Clarin), competition model and unified model of language acquisition, AphasiaBank (aphasia issues, dementiaBank), TalkBank (Phonbank, HomeBank, fluencyBank) and Emeregenticism (or emergentist). Added to this, it needs to be highlighted that, due to the vastness of his research areas, we included some of his research areas under the general heading of 'others' which includes connectionism, translation, functionalism, task bias, cognition, pragmatics, morphology, phonology, phonetics, bilingualism, collaborative commentary, interpretation (semantics), glossolalia, feedback, corpora, discourse, lexicon, language skills, technology, social sciences and humanity, and rule instruction. Therefore, we included these all under the general heading of "*others*" in Table 6 right under meta-themes to give a more organized order to the sequence and number the meta-themes we subjectively created.

C. Technical Jargons, Terms and Concepts

We established a subjective basis for the extraction of technical terms and concepts from MacWhinney's journal articles, i.e., those journal articles we systematically review. However, we failed to extract technical jargons of his books and book chapters due to space and manageability considerations. That is to say, we extracted the technical jargons or concepts which were assumed more significant and ignored those which were deemed subjectively insignificant. Due to time, space and manageability considerations, we grouped the technical terms into two categories: technical jargons, terms and concepts in psychology and technical jargons, terms and concepts in language education. As such, the way we calculated the number of technical concepts, jargons and notions after they were extracted was much simpler: We used a comma after every independent and single technical term or concept; we included the comma in the "Find" section of Word Program in computer and the number of the technical terms appeared and were enumerated easily. To be mini-plot-tested, we also counted them one-by-one. It is worth noting that we admit we failed to fully acknowledge what Bian MacWhinney has contributed to the field in both qualitative and quantitative terms, as space considerations and the vastness of his research works prevented us from undertaking a full-fledged systematic review. Therefore, as it was mentioned already, we created inclusion and exclusion rules in order to depict more visibly the contribution he has made to the field. We removed from analysis the appreciation notes, acknowledgement, edited special issues, edited articles, edited journals. Also, from MacWhinney's works, we removed aside those works which were merely syntactic, such as case markers. The main reason for this is that we are interested in ELT, applied linguistics, and psychology-relevant issues.

Technical Jargons, Terms and Concepts

1. Psychology: Technical Jargons, Terms and Concepts

Psychopathology, genetic psychology, psychology laboratory, signal waveform, pathology, nonsensical behavior, aphasia, aphasics, Broca's aphasia, Broca's aphasics, Wernicke's aphasia, Wernicke's aphasics, aphasic discourse, dementia, Alzheimer's disease pathology, Psychiatry, agrammatic aphasics, posterior aphasics, anterior aphasics, apraxia of speech, dysarthria, apraxia of speech, dyslexia, frontal–temporoparietal neural substrates, Newell's general cognitive model, cognitive growth, cognitive development, theory of embodied cognition,

theory of grounded cognition, neurophysiology, cognitive neuroscience, cognitive linguistics, rote-memorization, amplitude changes, pulse-frequency rate, self-control, psychosocial phenomenon, transcendental states of consciousness, clinical standpoint, clinical practice, information processing (model), formation-theory view of sentence processing, emotive sound making, acquisitional process, working memory, premotor working memory, schema-based memory, implicit memory, verbal memory span, phonological rehearsal, phonological rehearsal loop, comparative process, sound-meaning association, emotional disability, cognitive disability, cognitive apparatus, initial validation of the stimuli, word processing, sentence processing, computational processing, parallel distributed processing, cognition, explorations in the microstructure of cognition, simulation, back propagation, back propagation algorithm, nodes, patterns of activation, input units, output units, output phonetic processing, phonetic processing, phonological processing, paradigm extraction, interactive graphic system, conceptual building blocks of experimental design, psychology experiment, groups components of a psychology experiment, blocks components of a psychology experiment, trials components of a psychology experiment, factors components of a psychology experiment, graphic environment, laboratory microcomputer, psyScope, psyscript, acuity experiment, size factor, position attribute, stimulus attribute, declarative language, intertrial interval, precompile mode, pre-reviewing and prechecking trials, randomization, data output, subject input, built-in facility, timing, customizing psyscope, customizing the interface, scripting language, processing load, cognitive structures, cognitive reality, psycholinguistic theory, interactive activation networks, language therapy, specific language impairment, predictive processing, native processing, nonnative processing, Anticipatory processing, expectation-driven processing mechanisms, eye-tracking, electrophysiology, L1 processing, L2 processing, incremental processing, cognitive impairment, micro-linguistic impairments, trauma, traumatic brain injury, participation restrictions, social isolation, reduced quality of life, cognitive-communication deficit, macrostructural analysis, superstructural analysis, diagnosis of cognitive-communication disorder, speech-language pathology, dysarthria, diagnosis of impairment, Aphasia, aphasia assessment, aphasia rehabilitation, international classification of disability and health model, leadership team, executive leadership, perceptual magnet effect, perceptual contrasts, initial mapping, fast mapping, initial mapping process, complex relational concepts, auditory contrasts, auditory impairment, neural network modeling, self-organizing networks, self-organizing framework, auditory map, concept map, articulatory maps, serial order mechanism, conceptual coding, active processing, sentence processing, meaning as imitative construction, representation, sensori-motor stage, sensorimotor cognition, sensori-motor causal perspective, perceptual factors, relational factors ,sensori-motor schema for causation, attentional saliency, lexical markings, deixis, anaphora, ego-perspective ' to problem-solving, empathy, mental picking-up, mental model, sentence memory, naturalistic sentence processing, verbal planning, verbal planning time, closeness-to-ego principle, reaction time, non-autonomy of components, competition situations, conspiracy principle, conspiracy of weak vectors, convergence principle, memory for conversation, recognition memory, subjects' electrodermal response, subject's phasic electrodermal response (EDR), locus coeruleus, direct mapping, multiplicity of form-function mappings, two-level mapping, function-function mapping, form-form mapping, processing limitations, language impairments, lexical impairment, grammatical impairment, cognitive processing, cognitive

content, general psycholinguistic model, focus maintenance, bilingual aphasia test, syndrome-specific problems, aphasic patients, fluent aphasic subjects, non-fluent aphasic subjects, Boston diagnostic aphasia examination, Aachen aphasia test, paraphasia, syndrome-specific symptom patterns, inhibition, induction, facilitation, failure to parse, error- tracking, view of Broca's as agrammatic, view of Wernicke's as paragrammatic, aphasia battery, prototypic Broca, behavioral plasticity, neural plasticity, cognitive neurobiology, cognitive psychology, experimental psychology, STEP (System for the Teaching of Experimental Psychology), aphasic syndromes, closed-class impairment, neural specialization, selective apraxia of phonation, idiosyncratic symptoms, base rate performance, underlying shape of the distribution, strong agrammatism, functional neural circuits, local processing, neural connectivity, integrative circuits, masking process, local memory, temporal lobe, attentional processing, motor processing, dorsolateral prefrontal cortex, posterior cortex, immediate serial recall, short-term recall primacy, short-term recall recency, shadowing, simultaneous translation, speech monitoring, and utterance formulation, top-down inferential processes, higher-level integrative processes, auditory noise, auditory-verbal short term memory, auditory rehearsal process, short-term memory, articulatory control process, articulatory rehearsal, general processing capacity, auditory imagery, imagery strategy, auditory image, functional neuroimaging, information processing psychology, analogistic processing, lexical activation, self-organizing, catastrophic interference, fossilization, plasticity, pattern-based mode of activation, phonological receptors, conceptual receptors, motor activators, syntactic connections, cohort inhibitors, cohort formation, archisegmental representation, phonological memory, focal lesion, non-verbal intelligence, developmental plasticity, verbal short-term memory, self-organizing neural network, feed-forward neural networks, self-organizing maps, semantic map, phonological map, associative links, biological implausibility, psychological implausibility, parsing process, automatic parsing, morphological tagger, neuron, neuronal plasticity, neuronal processing, event-related brain potentials, electroencephalographic record, implicit processing, explicit processing, syntactic anomaly sensitivity, contralateral hemisphere, domain-general cognitive mechanisms, neuronal landscape, physiological landscape, theory of mappings, theory of code activation, coactivation process, AphasiaBank, conflict resolution, retrieval ability, from-meaning mapping, , selective attention, back-propagation algorithm, E-prime system, B/C Power Lab, ERTS, MacLaboratory, MEL, MacProbe, MindLab,MPS, Psych-Scope, SuperLab, psychology software tools, absolute threshold measurement, adaptation-level theory, Weber's law, Müller-Lyer illusion, Ponzo illusion, McCollough effect, McGurk effect, perceptual magnet effect, graphic user interface, mnemonic ability, visuo-spatial short-term memory, central executive, storage system, irrelevant speech effect, word length effect, chunking effects, concurrent articulation effect, backward priming effect, avalanche node, competitive queueing model (CQ model), serial order learning, input phonology, output phonology, neurophysiology, neuroanatomy, neuropsychology, neuroimaging, visual-spatial manipulation task, mental rotation of alphanumeric stimuli, auditory sentence comprehension task, mental rotation task, left hemisphere activation, right hemisphere activation, left hemisphere stroke, right hemisphere stroke, lateralization, auditory rehearsal skills, quick processing, quick activation, automatic processing, automatic activation, orthographic processing, parvocellular system, remedial intervention, early focal brain lesions, cognitive crowding, late rigidity, contralateral

recruitment, local recruitment, white matter commitment, connecting wires, psychometric profiling, maximally parsimonious discrimination, Stroop interference, staged processing, cascaded Processing, cascaded articulation, theories of information processing, parallel planning of speech, incremental planning of speech, semantic priming, ,functional magnetic resonance imaging, periventricular hemorrhages, neurocognitive networks, dorsolateral prefrontal cortex, pediatric brain lesions, enactive imagery, depictive imagery, egocentric frames, allocentric frames, geocentric frames, prefrontal cortex, medial structures, embodied cognition, ventral visual processing stream, dorsal visual stream, skateboarder perspective, depictive mental model, enactive mental model, direct experience subsystem, deictic spatio-temporal reference frames, fragmentary mental models, embodied situational model, unified embodied situation model, temporal lag, temporal Perspective, corollary discharge, reafference, low-level attentional processes, high-level attentional processes, multifocality of representations, multifocal chains, mimetic symbols, , expressive sighs, muscle control, attentional movement, iteration, goal direction, processing model, unilateral brain injury, prelinguistic injury, prelinguistic left-hemisphere, prelinguistic right-hemisphere damage, aanticonvulsant medication, domain-general cognitive skills, auditory word recognition, visual word recognition, inhibitory control model of bilingual performance, inhibitory control mechanism, priming interference effect, social neuroscience, neuroinformatics, attrition, attritional processing, stuttering, autism spectrum disorder, right hemisphere damage, poststroke aphasia

2. Language (Education): Technical Jargons, Terms and Concepts

MacWhinney-Leinbach model for English, language learning, syntax, semantics, syntactic, syntactic processing, phonology, morphology, formulaic, vowels, consonants, psycholinguistics, sociolinguistics, linguistic creativity, semantic components, intonation, pitch rate, glossolalic speech, MacWhinney's psycholinguistic model, informal interview, formal interview, natural language, international phonetic alphabet, phonetic transcription, generative grammar, utterance, sentence, glossic words, Glossolalia, glossolalic phonation, glossolalic grammars, recurring partials, phonological strings, formulaic glossalia, innovative glossalia, linguistic styles, pseudo-linguistic styles, pseudo-phonetic features, phrase structure, formulas, innovative glossolalic sequences, expressive language, repetition, pause, turn-internal pauses, reduplication, triplication, rhyming, alliteration, syllable, enclosing syllables, babbling, markedness, unmarkedness, parameters, threshold of onset, phonation, glottal stops, medial consonants, medial clusters, consonant clusters, nonsemanticity, nonsemantic speech, morphological formation, word formation, rules, analogy, analogic formation, rule-operation, inflection, verb middle inflection, verb final inflection, reversive verbs, generalization, over-generalization, generative-transformational aspect, transformational grammar, morphological learning, morphological boundary, lexeme, lexical information, syntactic information, lexical encoding, morphological context, process model, amalgams, phonetic simplification, semantic levels, semantic complexity, analogical formation, fundamental frequency, allomorphs, plural allomorphs, allomorphic pair, primitive tendency, voice assimilation, denominator plural, prefix, suffix, suffix superimposition, plural suffix, progressive assimilation, final vowel lengthening, internal vowel deletion, vowel shortening, inflectional morphology, segment, suprasegment, input amalgams, phonological rules, bound rules, free variation of allomorph,

disambiguation of the features, unification of allomorphs, suffix-initial vowel deletion, v-insertion, warm-up period, pitch, rhyme, morpheme, unified plural morpheme, rounding harmony, fronting harmony, tape-recording, video-tape recording, child language data exchange system, coding convections, language production, wireless microphones, using directional microphones, recording technology, sampling strategies, non-intrusive recording methods, and detailed systems for coding, coding schemes, analytic techniques, hand-written transcripts, typewritten transcripts, transcription methodology, and cross-investigator reliability, microcomputer software, microcomputer word-processing systems, standard data-processing techniques, transcript data exchange system, automation of coding, automation of analysis, data-processing hardware, data-processing software, tense, aspect, data collection process, data transcription process, data coding process, data analysis process, semantic categories, agent, patient, instrument, transferred object, created entity, removed object, location, realized adjective, action, pragmatics, pragmatic categories, pragmatics aspect of notion, pragmatic aspect of comment, semantic coding scheme, interactional features, individual differences, imitation, acquisition, language acquisition, language acquisition theory, and second language acquisition theory, parental speech acts, CALARSP system for data, PEPPER system for data, DBMS systems for data, datatrieve system for data, RS-I system data, INGRES system data, child language development, informal speech, formal speech, line headers for data, unmarked utterance, declarative utterance, dialectal variation, stylistic variation, colloquialism, word stress, contrastive stress, time marking, ergative marking, morphemic semantics, cross-linguistic study, morpho-phonological comment, oblique, compound, contraction, metathesization, ellipsis, dummy morpheme, empty morpheme, structural coding, subject, object, topic, comment, coordinate clause, subordinate clause, foregrounded clause, backgrounded clause, appositive, prosody, paralinguistics, paralinguistic criteria, alternative transcription, situational contextual coding, interactional qualifiers, response, imitations, affirmative answer, negative answer, answer to yes-no question, answer to wh-question, completion, request for repetition, compliance, denial, refusal, noncompliance, question command, request, invitation, prompt, suggestion, repetition, expansion, elaboration, break-down, rephrasing, gesture, proxemics, free translation, errors, incorrect morpheme order, agreement error, affix semantic extension, stem semantic extension, blend, malapropism, secondary stem overgeneralization, primary stem overgeneralization, consonant assimilation error, harmony error, selection error, sandhi error, tone error, allomorphy, allomorphy errors, allomorphic resolution, segmentation error, superfluity, contradiction, redundancy, grammatical redundancy, over-analysis, neologism, anticipation, perseveration, exchange, omission, stranding, hesitations, retraced false start, word repetition, syllable repetition, drawling, consonant repetition, filled pausing, incompletions, systematic analysis of language transcripts, Oxford Concordance Programs, computational formalism, corpus-driven computational modeling, connectionist algorithm, connectionist model, connectionist approach, neural modeling, generative grammarians, three-dimensional word-class, syntactic cues, phonological cues, morphological cues, lexical semantic cues, word order cues, and intonational cues, converging cues, competing cues, systematic interactions between cues, cue prepotency effects, cue availability, accusative, accusative marking, nominative, Instrumental, Comitative, dative, genitive prepositions, subject-verb agreement, word order, word agreement, free parameters, phonological representation, orthographic representations,

pseudo-homophone, phonological activation, phonological pattern generator, word recognition, phonological recoding, naming task, naming accuracy, feedback, corrective feedback, negative feedback, feedback loop, universal grammar (UG), conservatism, item-based learning, item-based constructions, indirect negative evidence, competition, cue construction, emergentist theory, emergentist model, grammatical competition, competition model, unified competition model, functionalist model, the poverty of the linguistic input, poverty of stimulus, input degeneracy, input gain, logical problem of language acquisition, Plato's Problem, Chomsky's Problem, Gold's Problem, Baker's Paradox, negative evidence, positive evidence, species-specific innate hypotheses, congenital specialization for language, innate knowledge, learnability theory, generativist analyses of learnability, finite-state grammar, non-finite grammar, phrase-structure grammar, error-free learning, the empty category principle, structural dependency, the binding conditions, subjacency, negative polarity items, that-trace deletion, c-command, nominal compound formation, control, auxiliary phrase ordering, non-parameterized features, parameterized features, theory of barriers, the repositioning of the auxiliary, embedded relative clauses, item-based auxiliary frames, structural compositionality, compositional production, conjugation, complex-NP constraint, low-error constructions, stative progressives, binding theory, binding conditions, innateness of the binding conditions, medial arguments, theory of parameter setting, marked parameter, unmarked parameter, parallel approach to learnability, optimality theory, optimality theory phonology, optimality theory syntax, revised end-state criterion, end-state grammar, item-based finite-state grammar, subset principle, topicalization, wh-movement patterns, recovery mechanisms, morphological competition, lexical competition, syntactic frame competition, formalizing competition, modelling competition, Kohonen's self-organizing feature map model, developmental sentence scoring, morpho-syntactical measure, morpho-syntactic development, language assessment, morpho-syntax, communicative development inventories, grammatical acquisition process, elliptical null-argument language, argument structure, grammatical complexity, index of productive syntax, elicitation, acquisitional timing, copula, mean length of utterance, case marking, pronominal case, mono-transitive constructions, ditransitive constructions, monolingual processing, head-final languages, canonical condition, scrambled condition, accusative condition, recipient, theme, distractor, computerized language analysis, proposition density, computerized propositional idea density rater program, discourse tasks, communicative adequacy, communicative competence, communicative dynamism, communicative context, automated approaches, Automated analyses, nonautomated approaches, oral-language sampling, type–token ratio, T-unit, micro-linguistic analysis, macro-linguistic analysis, narrative discourse, picture description task, discourse assessment tasks, discourse function, discourse strategies, conversations, monologic genres, Monologic tasks, concurrent visual-auditory tasks, semi-spontaneous tasks, task switching, task-switching paradigm, mixed-task, single-task, Simon tasks, anti-saccade tasks, stop-signal tasks, flanker tasks, change card sort task, communication assessment, spoken discourse, aphasia spoken discourse, extended discourse, microstructural information, and macrostructural information, lexical-semantic structure, cohesion, coherence, connected speech samples, single picture description, picture sequence description, procedural description, interviews, story recall, story retell, picture description, filmstrip narration, personal narratives, systematic analysis of language transcripts, monolingual , bilingual,

emergence of language, models of emergence of language, Chomsky's Universal Grammar, principles and parameters model of language structure, parameter-setting, cognitive module, species-specific communication, inductive approach, deductive approach, nativist approach, genetically-wired modules, neural network modelling, dynamic systems theory, perceptual contrasts, species-specific language gift, language-specific prosodic patterns, trochaic bias as a pattern of sound leaning, audition , inferior parietal, superior temporal, articulation, motor cortex, lexical principles, child-based agenda, child-based meaning, decontextualization, core-periphery model of lexical structure, vocabulary spurt, vocabulary size, vocabulary depth, connectionism, self-organizing connectionist model, lexical feature map model, articulatory gestures, articulatory sequences, output phonology, phonological output, speech output planning mechanisms, operating principle, output, input, input units, output units, input levels, immediate serial recall, serial ordering mechanisms, interference effects, rehearsal, cryptotype, cryptotypic meanings, mini-cryptotypes, Rosch's theory of prototypes, fuzzy categories, inflectional marking, dual-route models, U-shaped learning, two-process connectionist approach, episodic support, initial state, internal state, current state, , agglutination, vowel harmony, morphological analysis, neologisms, acquisition of the first inflections, morphophonemics, diary data, diary observation, stressed syllable, morpheme segmentation, denominator strategy, morphological segmentation, word segmentation, segmentation error, under-extraction, over-extraction, over-analysis, under-analysis, suffix reduplication, suffix redundancy, contradiction, semantic under-analysis, semantic over-analysis, verb-complement agreement, processing universal, universal mechanism, morphophonemic errors, phonemic restoration effect, flexional suffixes, formative suffixes, neologisms, child neologisms, accusative pronouns , Possessive personal pronouns, general denominative, de-adverbial, deverbative, semantic-pragmatic factors, locative, locative deictics, Indefinite suffixes, definite suffixes, dative, suffix assimilation, metathesis, Prefix ordering, segmentation, bound morpheme order errors, semantic information, syntactic information, intonational information, Object agreement, subject agreement, double agreement, agreement marking, Intransitive verbs, transitive verbs, quantifier agreement, auto-tutorial Instruction, A-T instruction, A-T teaching/learning, A-T method, evaluations of auto-tutorial teaching, A-T course structures, video auto-tutorial (video-AT) method of instruction, visuals, printed materials, instructional methods, The American College Test (ACT), unit-mastery grading, individualization, individualized program, perspective hypothesis, perspective taking, ratings approach, elicited production approach, problem-solving approach, verification approach, comprehension approach, recall approach, starting point in production, starting point in comprehension, sentence perspective, intonational stress, contrastive focus, curricular validity, self-report information, frequent testing, advance organizer, mathemagenic devices, interactional content, low interactional content, high interactional content, ecological validity, macrorhythms, procedural semantics, semantic network systems, pragmatic theory of reference, hesitation phenomena, sententional devices, givenness and newness, pronominalization, pronominal referents, emphatic stress, cleft construction, indefinite article, definite article, initialization, extra-grammatical knowledge, semantic strategies, syntactic strategies, pragmatic strategies, competence-to-perform, message processing, syntactic processing, Core grammar rules, penumbral grammar rules, Grammatical processing, semi-grammatical processing, semi-grammar, functional grammar, functionalism, topicalization, coalition of function, topic-agent,

coalitions of surface forms, breakdown of coalition, unity of the surface subject coalition, Vector weighting, conventionalization, optional rules, obligatory rules, form/function mappings, direct mapping, animacy, animacy hierarchy, noun animacy, unnatural situations, prototypic input, best input, qualitative shifts from one strategy to another, quantitative shifts from one strategy to another, plausibility of their combinations, sentence interpretation, induced introspection procedure, non-canonical orders, plausibility of certain lexical combinations, propositional information, pragmatic information, interaction, face-to-face interaction, high interaction statements, low interaction statements, hesitation placement, lexical choice, intonation contour, paralinguistic markers, constituent ordering, social interaction, social intercourse, universal operating principles, a miniature linguistic system, linguistic naturalness, linguistic referentiality, language acquisition device (LAD), continuous morphemes, discontinuous morphemes, pseudomarked forms, unmarked forms, consistent forms, inconsistent forms, referential content of the items, error assimilation, errors as auto-input, free-speech corpus, learner's own productive formations as inputs, baby errors, similar errors, formal overgeneralizations, substitutions, functional substitutions, omissions, Incorrect word order, morpheme placement, performance, competence, performance grammar, communicative function, cue strength, cue validity, cue utility, conflict validity, conflict reliability, device validity, device availability, cue applicability, cue reliability, computational simulation, language typology, topological cues, local cues, medium cue, local processing of grammatical cues, topological processing of grammatical cues, deletion, non-addition (haplology), haplology, stem-end haplology, suppletion, accidental repetition, repetition through reduplication, morph repetition, activation theory, morphophonology, mental lexicon, affix-checking, avoidance (blocking of derivation), schema, false derivational, affix haplology, stem boundary plus clitic, stem boundary plus derivational affix, prefixal inflection after clitic, suffixal inflection before clitic, Inflectional plus derivational suffix, free grammatical morpheme plus clitic, clitic-raising rule, locative clitic, stem-end repetition, circumlocution, ambimorphemic, tolerance of repetition, stem-end duplications, repeated morph constraint, over-marking, under-marking, analytic bead-stringing' model, analytic 'bead-stringing view, shwa-insert affixes, zero morphological marking, acceptance of partial regularity, over-regularization, syllabic allomorph, back-formation, dialectic model, competition system, category-sensitive affix-checker, holistic template-matching, linguistic metatheory, output constraint, extra-syllabic consonants, CV phonology, shwa insertion rule, shwa deletion rule, inflectional processing, temporarily extra-syllabic consonants, permanently extra-syllabic consonants, CV-tier for motor programming, permanently extra-syllabic segments, temporarily extra-syllabic segments, nonsyllabic allomorph, extra-grammatical knowledge, parsing strategy, chunking (analysis), inflectional cues, lexical semantics, animacy manipulation, Child Language Data Exchange System (CHILDES), CHILDES database of transcripts, CLAN programs for analyzing CHAT files, CHILDES system, non-computerized analyses, computerized analyses, English glosses, morphemic coding, syntactically-coded corpus, non-continuous interactions, continuous interactions, lingua franca, a single-character phonemic transcription system, MS-DOS, UNIX, VMS, XENIX, , phonological detectability, cross-linguistic data, cognitive development, minimalist model, ongoing updating, competition-type models, cue competition, information-integration approach, integrated model, principle of detectability, principle of segmentability, visual-auditory cross-modal processing, form-

oriented inflectional errors, form-oriented errors, function-oriented errors, no-marking errors, pseudo-indefinites, low-frequency allomorph, high-frequency allomorph, lexical storage, high-frequency lexical items, low-frequency lexical items, irregular inflected forms, regular inflected forms, morphological accommodation, lexical representations, phonological representations, open-class lexical items, phonological error, transfer, positive transfer, negative transfer, formal level, functional level, co-occurrence, non-prototypical situations, universal built-in prepotency, grammar as anti-nativist, grammar as anti-linguistic, symbolic relation, indexical relations, sign-referent relations, meaning driven analysis, distributional analysis, innateness, domain-specificity, indirectly innate, linguistic Darwinism, Eastern European functionalism, , British functionalism, generative semantics, cognitive grammar, construction grammar, role and reference grammar, role identification, restrictive relative clauses, processing of relative clauses, subject-modifying relatives, object-modifying relatives, sentential relatives, subject-extracting relatives, object-extracting relatives, extraposed relative clauses, non-extraposed relative clauses, parallel function, adjacency strategy, perspective maintenance, accessibility, conjoined clause, clausal unity, fragment construction, morphological marking, self-embeddings, right embeddings, left embeddings, multiple center-embeddings, configurational analyses, enactment technique, fragment construction determinant, clausal unity determinant, crosslinguistic assessment, crosslinguistic comparisons, orthographical depth hypothesis, cyrillic graphemic system, lexical plausibility factors, foreign language acquisition, duration of exposure, amount of exposure, time on task, transfer effect, proficiency test, achievement test, orthography, standard lexical decision task, lexical decision vocabulary test, multiple-choice test, test-taking strategies, familiarity/meaningfulness values, Balota's and Chumbley's model, explicit lexical access stage, postlexical decision stage, Seidenberg and McClelland's interactive activation model, pseudoderivatives, grammatical competence, grammatical impairment, theory agrammatism, given-new task, universal pragmatic tendencies, lexical expletives, dummy subject, discourse context, lexicalization, pragmatic coding, probe task, nonreferent probe, referent probe, non-pronoun sentences, non-pronoun baseline, alternative probe word baseline, pre-pronoun baseline, pre-anaphor control, cross-modal probe response task, reaction time, reaction time method, reaction time analysis, premature reaction time, ambiguous reference conditions, anaphoric reference, anaphoric relations, poverty of the stimulus, uniqueness principle, principle of contrast, pidgin, creole, CHIP framework, automatic coding, conversational interaction, nature/nurture, facilitative input, nativist position, cognitive facilitator, CLAN data analysis, operant conditioning, non-finite-state languages, no-negative-evidence hypothesis, communicative facilitator, levels of learning, learning-on-error mechanism, feature frequency model, agglutinating language, sublative, superessive, inessive, ablative, language-specific content, language-specific prediction, Cross-linguistic variation, Performance deficits, language-specific knowledge, selective vulnerability of morphology, closed-Class theory of agrammatism, diagnostic category, information value, processing speed, closed-class theory, grammatical morphology, activation pattern, receptive dissociation, expressive dissociation, data-limited processes, resource-limited processes, semantic relatedness, priming effects, maximum likelihood procedure, nine-parameter approach, single-case approach, multiplicative formulae, additive formulae, access model, loss model, verb learning model, verb-driven processing, back-propagation algorithm, hornonymy, cue-based connectionist models,

perceptron convergence procedure, u-shaped learning problem, The R&M model, Stemberger's model, auto-segmental phonology, algalgal model, brag-grab problem, lexical identity, convergence problem, crypto-rule problem, slit-silt" problem, early noise problem, phonological regularities problem, input representation, input corpus, zero-marking verbs, homophony problem, regular pattern problem, direct access problem, compounds, derivational status, symbolic model, Semantic grounding, covering meaning, enclosing meaning, surface-attaching meaning, computational lexicography, Whorfian hypothesis, crosslinguistic psycholinguistic analysis, Defense Language Aptitude Battery or DLAB, skill analysis, language reversals, learner reversals, stage reversals, skill reversals, higher-level strategic processes, phonemic recoding, graphemic visualization, translational equivalents, vocal tract models, monitoring or error-checking, auto-support strategies, auto-support mechanisms, input maximization, articulatory control, orthographic learning, phoneme-grapheme correspondence, mapping simplicity, mapping similarity, computational models, receptive phonology, contrastive analysis, match-to-sample test of prosodic contrasts, match-to-sample test of segmental contrasts, same-different tests of prosodic contrasts, same-different tests of segmental contrasts, syllable shadowing, EFL/ ESL, verbal rehearsal, articulatory rehearsal, articulatory loop, auditory loop, articulatory loop model, closed loop, cognate mapping, analogic mapping, semantic transparency, semantic overlap, lexical learning, lexical decision task, verbal learning technique, paired-associate learning, marking complexity, class membership complexity, conceptual complexity, category membership, superordinate, Chomskyan parameter-setting theory, Local marking, nonlocal marking, conservatism, anaphor resolution, immediate pronoun resolution, implicit verb causality, cross-modal probe, causal conjunction, probe recognition methodology, cross-modal technique, unimodal technique, cross-modal probe resolution paradigm, probe reaction time, stimulus-experiencer verbs, experiencer-stimulus verbs, semi-morphological marker, concurrent articulation, phonological loop, phonological store, phonological production planning, articulation-based process, irrelevant speech effect, word length effect, phonological similarity effect, visual presentation, non-articulatory task, finger-tapping, auditory resources, dual-task difficulty, auditory interference, articulatory resources, external auditory interference, internal bone conduction, scalability, generativity, crispness, hand-wiring , gradation, leakage, constrain symbol passing, lexical categories, cognitive models, symbolic dinosaurs, Lamb's stratificational grammar, Markov Model, Constraint models, G-B theory, hand-wired systems, LISP-based production system architecture, AI programs, critical periods, critical period hypothesis, modularity, statistically-oriented models, polysemy, valence bridges, garden-path sentence, learning curve, the power law of practice, time-on-task effect, foreign language tutoring systems, learning strategies, scaffolding, non-word repetition, word density, semantic similarity, Rumelhart and McClelland's pioneering model of the English past tense acquisition, phenomenon of catastrophic interference, naming deficit, auto-association task, semantic-to-phonological association links, plasticity-stability dilemma, DevLex model, WCD-based meanings, WordNet-based meanings, age-of-acquisition effects, Word co-occurrence detector, conversation analysis, classroom discourse, legal oral argumentation, l XML schema, linguistic consortium, TalkBank, clinical Bank, TalkBank data-sharing model, fluency Bank, SLABank, BilingBank, ClassBank, RHDBank, (right-hemisphere bank), dementiabank, conversation analysis bank, CABank, CABank, SCOTUS, SamtaleBank, code-switching corpora, data-

sharing ethics, Truscott's and Sharwood Smith's APT model, Chomsky's theory of Principles and Parameters, Hebbian Learning (comprehension or production), lexically-based transfer, phonological transfer, syntactic annotations, automatic syntactic annotations, sentence annotations, grammatical relations, initial grammatical relations, deep grammatical relations, actual grammatical relations, surface grammatical relations, dependency structures, dependency-based scheme, constituent structures, content words, function words, lexical functional grammar, inter-annotator agreement, definiteness agreement, dependent-head links, rule-based approaches, data-driven approaches, error-driven transformation based learning, word skipping, tree-node insertion, verbal input, syntactically parsed utterances, semantically parsed utterances, automatic syntactic parsing, tagging, data-mining, content analysis, treebanks, statistical disambiguation models, Eve corpus, grammar-driven robust parsing, statistical disambiguation. Grammar-driven parsers, rule-based parser, context-free rule, statistical disambiguation module, transcribed spontaneous speech, agenda-driven bottom-up chart parser, bottom-up parsers, pseudo-context sensitive, onomatopoeia, newspaper-style text, lexical ambiguity, task-specific grammar, corpus-based techniques, grammar coverage, grammar ambiguity, competing modules, early simultaneous bilinguals, late bilinguals, topography-preserving feature map, MacArthur–Bates Communicative Development Inventory, emergentist approach, competition construct, parasitism construct, resonance construct, entrenchment construct, hard-wired modules, grammaticality judgement task, automatic response, nonreflective response, implicit responses, implicit knowledge, explicit knowledge , cross language mismatches, Interactive activation models, word-pseudoword pairs, bilingual mental lexicon, shared model, distributed model, asymmetrical model, shared meanings, separate meanings, separate storage model, word-type effects, concept mediation model, association model, revised hierarchical model, associative priming effects, emergence of linguistic forms, phylogenetic emergence, epigenetic emergence, developmental emergence, processing emergence, social emergence, interactional emergence, diachronic emergence, homeorhesis, homeorhetic process, loose coupling, error propagation, social landscape, linguistic diversity, dialect diversity, initial lexical mapping, auditory map, spatial deixis, extraposition, anaphora, passivization, relativization, phylogeny, ontogeny, acquisition and learning distinction, auditory arena, lexical arena, morphosyntactic arena, interpretive arena, arena of message formulation, arena of expressive lexicalization, arena of sentence planning, arena of articulatory planning, inter-language phenomena, core–periphery distinction, generative theory, cognitive linguistics, computational linguistics, neurolinguistics, emergentist thinking, developmental timescales, interactional timescales, source-filter model of speech production, bilingual input, theory of pivot grammar, agent-based modeling, complexity theory, voice recognition, prosodic analysis, anthropology, ethology, microanalysis of videos, gesture, proxemics, props, prosodies, microgenetic studies, dynamic modeling, TalkBank Browser, indeterminacy in transcription, tedium in transcription, lack of standards in transcription, collaborative commentary, field linguistics, cultural anthropology, Human-computer interaction, cue word frequency, target word frequency, word-frequency, word-length effects, translation ambiguity, interlanguage, imageability, concreteness, dynamic Self-Organization, DevLex-II model, DevLex model, social-communicative awakening, auto-association model, cross-situational learning, type-token, input-output exemplars, output sequence map, input phonology map, input-driven self-organization, MacArthur-Bates

communicative development Inventory, homographs, homophones, binary representation, real-value representation, lesion method, associative learning, dual-code theory, picture superiority effect, general capacity theory, serial position effects, readiness potential, problem-based learning, paired associates, paired-associate learning, interference tasks, concurrent articulation, imaging technology, sentence processing strategy, expressive–receptive language impairments, specific language impairments, comprehension strategies, test of receptive grammar, pseudo-homophone, visual word recognition, grapheme-phoneme correspondences, rapid temporal perception, phoneme segmentation, phoneme deletion, phoneme blending, self-teaching device, stimuli individuation, temporal ordering of stimuli, reading impairment, reading disorders, self-paced reading, phonological priming, incrementalist approach, output phonological buffer, lexicalization process, phonological encoding, picture-word interference task, Stroop-like interference effect, interfering stimulus, repetition primes, just-in-time incremental processing strategy, Phonological priming effects, identity priming effects, lexical competition effects, standardized test, language sparing, auditory detection task, task-dependence, speech error, stimulus–onset asynchrony, cognition–action relationship, initial phoneme criterion of response initiation, whole-word criterion of response initiation, noncanonical views of stimuli, time deixi, space deixi, transitivity system, partial independence, accusative-nominative languages, relativization, co-reference, c-command, theory of government and binding, binding theory, clitic assimilation, syntactic ambiguity, interpersonal frames, social frames, social scenarios, observational learning, implicit causality, stimulus-experiencer, classical theory of rhetoric, situation models, prelinguistic period, co-occurrence learning, semantic vectors, NTL framework, PatPho, PatPho representations, PatPho program, phonological learning model, binary codes, hierarchical cluster analysis, representational scheme, teaching practice, developmental norms, non-engaging lessons, Peabody picture vocabulary test, receptive vocabulary, word-reading skills, medium of instruction policy, continuous cognitive decline, English–French immersion, between-language switching, within-language register switching, operations–word task, bilingual lexical processing, semantic competitor priming, within-language priming, cross-language facilitation effect, tonal language, perceptual input stimulus, visual pitch contours, traditional computer interface, pinyin spelling, high-level tonal, rising tonal value, low-falling-rising tonal value, high-falling tonal value, mid-flat value, componential feature of training, dual-modality feature of training, inclusionary feature of task training, full-form retrieval, full-form chunks, metalinguistic feedback, analogical feedback, L1 hybrid models, dual-route model, retention, narrative comprehension, narrative production, collaboratory workspaces, Lardiere's feature reassembly, core set standard, core outcome set, Bayesian optimization, prototypicality, diversity, bootstrapping, multilingual competition, analytic forms, combinatorial forms, synthetic form, rote form, minimization, formulation, early differentiation, Genetic variation, epigenetic variation, language sparing, vulnerability of timing, articulatory challenges, individual variation, simple input, input variability, degenerate input, universal phonology, mutual exclusivity, back propagation, s event-related potential, near-infrared spectroscopy, preferential looking, eye-tracking, home-bank, cloze test, translation test, schematic diagram feedback, metalinguistic rule feedback, incrementalism, neuroemergentism, articulatory phonology, child language, child phonology, bilingualism, and

at-home daylong recordings, computerized language analysis, gesture–speech integration, communication commentary, The PhonBank project,

Section 4: The Systematic Review

Now we present three highly substantive tables of the systematic review associated with journal articles, book chapters and books. The tables (Tables 7- 9) contain 5 columns: type of research work containing the authors and date of publication, research which summarizes the main content of the investigated work, practice portraying the implication and application of the research work, and macro-themes and micro-themes. As noted, in the systematic review, all three tables contain a qualitative analysis which is concerned with research and practice or an abstract and implication. We now turn to the results of the systematic review below.

Table 7

Analysis of Articles

Articles	Research	Practice	Macro-Themes	Micro-Themes
Osser, Ostwald, MacWhinney, & Casey (1973)	The article investigates glossolalia from psycholinguistic perspectives, and examines acoustic patterns on the basis of four speakers: Three of the four speakers had higher vowel-to-consonant ratios than are found in English speech.	The study has implications for the linguists and researchers. They can discover and explore varying representations of glossic behavior as a ground for a typology of speech behaviors.	8, 9	12, 13, 14, 15, 16
MacWhinney (1975)	The article investigates the role of rote-memorization, analogic formation and rule-operation in the production of plurals by Hungarian children: The effect of rote-memorization was seen to be more than that of analogic formation.	The study has potential implications for researchers and linguists as well as language teachers. They can use the strategies suggested for morphology and word formation: This can contribute to both education and research.	1, 2, 3, 7	4, 14, 21
MacWhinney (1976a)	The study reviews an array of data on the acquisition of Hungarian morphology and syntax and examines topics such as morphological analysis, neologisms, acquisition of the first inflections, morpheme order, word order and agreement.	One of the main implications is for researchers; they need to further investigate case markers which can probably be associated with verbs in pre-lexical structure and they also need to investigate the factors governing pragmatic ordering.	1, 2, 11	11, 12, 13, 14, 15, 16, 18
Fisher & MacWhinney (1976)	The study provides two brief reviews including an impressionistic evaluation of Autotutorial (A-T) teaching in the California and a paper by Mintzes reviewing 20 studies. Therefore, it examines A-T as an effective method of instruction.	One of the implications is that A-T method can be applied to other subject areas, so teachers need to perform needs analysis in applying A-T instruction and evaluation.	1, 2, 9, 10	21, 25
Fisher, Guenther et al. (1977)	The paper presents the results of the evaluation of a video-autotutorial (video-AT) method of instruction employed in teaching an introductory genetics course with use of a comparative gain in knowledge of the subject as measured through objective tests of achievement.	There exist varying potential implications in the study for teachers. Fr example, they need to value video-autotutorial (video-AT) method as an important method of instruction, and also consider frequent testing and individualized programs needed for students' progress.	2, 3, 9, 10	9, 21

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Keenan, MacWhinney & Mayhew (1977)	The study examines the difference between sentence processing in the context of natural communication and in laboratory experiments: A dramatic difference in memorability between statements classified as high and low interactional content is observed.	Researchers need to consider the relative significance of various factors required for controlling the interactional context, such as the degree of previous involvement with the speaker, the amount of active participation and the formal identity of speech acts, etc.	2, 3, 6, 7, 8	1, 9, 11,
MacWhinney & Osser (1977)	The study investigates the role of communicative explicitness, sex, and social class upon children's utilization of a wide variety of hesitation phenomena. It was found that hesitations served 3 major functions: preplanning, co-planning, and avoidance of superfluous verbalization.	The study has varying implications. It motivates interested researchers to investigate a huge variety of hesitation phenomena as used in different communicative situations.	1, 2, 3	1, 9, 11
MacWhinney (1977)	The article draws on a number of linguistic and psycholinguistic studies and examines perspective as the starting point of the sentence. It also explores the way sentence processing depends upon the active construction of a perspective, i.e., a speaker's or a listener's active involvement in a sentence.	The study has implications for researchers; it facilitates further investigation into the relation between the abstract, but highly motoric imagery of the perspective hypothesis and the abstract mental code proposed by Clark and others which demands further clarification.	1, 11	1, 12, 14, 15
MacWhinney, & Bates (1978)	The study examines a set of devices in functionalist theory including ellipsis, pronominalization, emphatic stress, the indefinite article, the definite article, and initialization: The results showed that increased givenness was marked most clearly by increased ellipsis and the use of the indefinite article.	The general implication is that researchers need to consider that there is a fair degree of consistency in the functional determination of the use of the sentential devices across both languages and ages.	1	15
MacWhinney et al. (1982)	The study aims to determine whether the difference in memorability between high and low-interaction sentences was in fact due to the interactional content of the sentences or whether it was due to some other property of the test sentences: The difference did not vary as a function of involvement in the conversations.	In terms of memory, there exist implications for language teachers and learners; teachers can provide language learners with chances and properties associated with interactional content and involvement: The more they involve learners in the interactional content, the more conversational they can possibly be.	1, 2, 3	9

Bates et al. (1982)	The study examines functional constraints on sentence processing in the light of the competition model and a functionalist approach to grammar in a principled way: The results from different performance domains can be unified within a single, coherent performance grammar.	The study can potentially have multiple implications. It initiates linguists and researchers into carrying out some production and acceptability judgment studies using the competition or convergence approach adopted in the article.	1, 11	1, 4
MacWhinney (1983)	This study examined four universal operating principles for first language acquisition and the applicability of these principles to second-language acquisition: The four principles functioned significantly in the learning of the system by 5- to 7-year-olds, but not by adults.	Teachers for young learners can use playful techniques, such as games, families of animals, hotels, etc., to maximize the referential richness of the communicative context in which the miniature linguistic system is acquired.	2, 3, 11	9, 11, 21
Butler Platt & MacWhinney (1983)	This article tests the hypothesis that a lot of grammatical errors observed during the course of language development can serve as 'auto-input' leading to the acquisition of new expressive forms. The results support the findings that errors can serve as auto-input and affect language learners' competence and performance positively.	The study is rich with pedagogical implications. One main implication is that teaching oneself is an important way of learning so that large segments of the language proficiency of adults and children derive from auto-instruction. This means that they can teach themselves both their own errors, and their own correct productions.	1, 2, 3, 9	7, 9, 21
Bates et al. (1984)	This article compares sentence interpretation in American and Italian children aged 2-5. Italians relied primarily on semantic cues, whereas American children relied on word order. In general, the data did not support claims regarding the existence of universal hypotheses about language structure.	There are psychologically inspiring implications for researchers; they are required to further investigate the fact that whether it is true children first tend to rely on pragmatic and semantic strategies, whereas, later on, they rely primarily on word order to determine the basic grammatical relations.	2, 3, 6, 9	9, 11, 12, 13, 15, 21
MacWhinney et al. (1984)	Linguistic and psycholinguistic accounts concerning the study of English may prove unreliable guides to sentence processing in even closely related languages, such as German and Italian with reference to word order, agreement, animacy, and stress. A related work by Li et al. (1992) in Chinese context is suggested for further study.	The study has multiple implications. One of the implications is for teachers of German and Italian. They need to focus on stress which plays a role in terms of complex interactions with word order and agreement.	2, 3, 7, 11	9, 14, 15

Menn & MacWhinney (1984)	The study examines repeated morph constraint. It presents a psycholinguistic processing model driven from language acquisition, draws on activation theory and affords a unification of the linguistic data while allowing for their variety.	The main implications of the study are that there exist no strong universal constraints against morph repetition. Therefore, linguists and researchers should consider parameters in addition to universal principles.	11	15, 18, 21
Stemberger & MacWhinney (1984)	The study investigates the role of extra-syllabic consonants in CV phonology: If a rule of shwa insertion or shwa deletion is considered, the errors can only be accounted for by assuming that temporarily extra-syllabic consonants exist and that permanently extra-syllabic consonants are not pronounceable.	The study has implications for researchers in the field of syntax and linguistics. They can further investigate the issues with reference to somewhat similar features with other languages.	11	13, 14, 15
MacWhinney, Pléh & Bates (1985)	The article investigates three experiments on sentence understanding by Hungarian preschool children with use of competition model. Experiments 2 and 3 supported the ecological validity of the experimental method. Closely related to case marking, articles by Kempe and MacWhinney (1998) and Mitsugi and Macwhinney (2016) are more informative.	The study has implications for further research, as researchers can investigate the question whether it is possible to provide a full account of sentence processing based upon the competition between a set of cues.	1, 2, 3, 11	1, 4, 10, 12, 13, 14, 15, 16, 17, 18
Stemberger & MacWhinney (1986a)	The article examines speech errors as a way of understanding key features of cognitive processing and focuses on form-oriented errors in production tasks, and the failure to add an inflection. It indicates that language processing is sensitive to the form of the output. It provides support for an interactive activation view of cognitive processing.	The study has implications for researchers and linguists. It can motivate the researchers and linguists to more specifically deal with the details of the workings of inflectional rules and further explore how speakers process unintended words that are similar in form to the intended word.	11	1, 4, 13, 14, 15, 16, 17, 18
Stemberger & MacWhinney (1986b)	This article examines the ways in which speakers store regularly inflected forms and focuses on the use of these forms in production. So, the study raises two questions: First, are inflected forms such as "walked" stored in the lexicon? Second, do	The study has varying implications. Since children can potentially store their own errors, for example, *'ated'*, as new lexical items, teachers should raise their consciousness of this issue and avoid the potential fossilization.	2, 3,11	13, 14, 15, 16, 21

	speakers analyze such forms into their component morphemes?			
MacWhinney (1987a)	The article brings together a set of papers devoted to the experimental study of sentence processing by bilinguals in their second language. It shows the usefulness of viewing sentence processing in terms of cues whose strengths and interrelations vary as a result of learning and processing. The result is that learners transfer their LI sentence processing strategies onto sentence processing in L2.	One of the main pedagogical implications of the study is that researchers can potentially investigate the Competition Model as a useful tool for research in second language acquisition. If researchers bring to the forefront the pedagogical implications of the findings from the model, they can help teachers have a realistic picture of the second language learner.	2, 3, 4	1, 4, 6, 13, 14, 15, 16, 17, 18, 21
MacWhinney & Pléh (1988)	The study reports on possible determinants associated with the processing of relative clauses. It examines the grammatical role of the head, the shape of surface order configurations, the occurrence of interruptions of the main clause, the importance of perspective maintenance, the conflict between focusing on the relative clause and focusing on the main clause, morphological cues, and object/subject-modifying relatives.	The study has implications for syntacticians who conduct research into the processing of relative clauses in Hungarian. It can help teachers realize the differences between the processing demands of relative clauses in Hungarian and provide numerous tasks for lowering down the cognitive demands related to processing the clauses and facilitate their application in communicative context.	11	1, 14, 15, 16, 17
MacWhinney& Leinbach, Taraban, R., & McDonald, (1989)	The study examines the development of a computational model of the acquisition of the gender, number, and case paradigm for the German definite article with use of the computational formalism, i.e., connectionist algorithm. The models are compared. Also, closely connected to the study, research works by MacWhinney, (2010b) and Macwhinney and Li (2008) provide an informative background to computational model.	The study has implications for German language researchers; it can help them understand German-related data on the acquisition of definite article in German and provide communicative tasks which can facilitate the production and use of definitive articles for interactional purposes.	1, 2	1, 4, 5, 13, 14, 15, 17

Wulfeck et al. (1989)	The study examines how the forms of reference are used by aphasic patients influenced by universal pragmatic principles, syndrome-specific symptom patterns and language-specific constraints. Pragmatics of reference was observed in both Broca's and Wernicke's aphasics. Concerning aphasia issues, Fromm et al. (2022) is more informative, too.	There exist implications for researchers. For example, the issues of lexical and grammatical impairment can provide further evidence and strong motivation for researchers to investigate the finding that knowledge is preserved in aphasia.	1, 2, 3, 5, 6, 7, 8, 11	1, 8, 10, 11, 12, 14, 15, 19,
Bohannon, MacWhinney, & Snow (1990)	The article sheds light on three main themes: learnability proof and innateness of language, innate restraints and language learning, and feedback.	EFL teachers are required to take into account the key role of corrective feedback, as this can lead to a highly effective outcome of learning.	1, 2, 9	9, 10, 21, 24
MacDonald & MacWhinney (1990)	Two cross-modal experiments investigated changes in activation levels for pronominal referents and non-referents. In both experiments, responses to probes corresponding to non-referents were slower in the presence of an unambiguous pronoun compared to the no-pronoun condition. The results in brief indicate that pronouns inhibit non-referents.	The implication can be for researchers. They can further investigate the discourse shifts associated with pronominal reference, and the sensitivity of probe response tasks in varying contexts.	6, 11	10, 11, 12, 14, 15
Sokolov & MacWhinney (1990)	The study examines CHIP as a computer program for the automatic coding and analysis of parent-child conversational interaction. It used three longitudinal corpora from CHILDES: The results indicated a high degree of contingency between parental and child language for different word classes across a large span of development.	One of the main implications is for researchers. They can replicate the study or reanalyze the data for other related purposes. Also, they can do further research into conversational interactions between parents and their children maintained across word classes.	1, 2, 3, 8, 10	6, 7, 9, 24
MacWhinney & Leinbach (1991)	The study examines a series of 13 problems raised by the verb learning model. As a result, connectionist models are considered extremely useful ways of justifying the learning of inflectional systems.	There exist varying implications for researchers and linguists. They can study the article and enjoy the applicability of connectionist models to language processing or learning.	1, 2, 3, 11	4, 5, 13, 14, 1516, 17, 18
Bates, Wulfeck & MacWhinney (1991)	The study examines cross-linguistic research in aphasia and reviews issues such as cross-linguistic variation, performance deficits, selective vulnerability of morphology,	The study has implications for linguists and researchers as it can provide a brief review of fundamental issues associated with cross-linguistic method. Also, it broadens their understanding of	1, 5, 9, 11	1, 4, 8, 10, 12, 14, 15, 19,

	patient group similarities and differences, similarity of lexical and grammatical symptoms, competition Model and cross language contrast. In this connection, research works by Guan et al. (2022), Fromm, Holland et al.'s (2011) and Holland, Fromm et al. (2017) are equally insightful.	language-specific and universal symptom patterns in aphasia and offers a promise for the future of aphasiology.		
MacWhinney, & Osman-Sági (1991)	The study uses the picture description task and examines the use of inflectional markings in Broca's and Wernicke's aphasic speakers of Hungarian. It focused on subject, direct object, indirect object, and locative nominal arguments. And pictured a group of individuals whose grammatical abilities are damaged and noisy, but still largely functional. Closely related to the theme of the study is a research work conducted by MacWhinney, Osman-Sági, and Slobin (1991) which is suggested for further study.	The study has implications for linguists and teachers of Hungarian. In instructional terms, it can help them comprehend how to deal with teaching the rich inflectional marking available in agglutinative languages like Hungarian.	11,5	13, 14, 15,18, 19
McDonald & MacWhinney (1991)	The study examines levels of learning with respect to concept formation and language acquisition and within the framework of the Competition Model. This paper extends the domain of the model to the nonlinguistic realm by examining the acquisition of categories in a concept learning task.	There are implications for teachers: They are required to realize that not all errors are soon detected and removed. When errors persist, teachers can help learners accommodate and restructure the errors with reference to their schemata.	1, 2, 3, 11	4, 21
Cohen et al. (1993)	The study examines PsyScope as an integrated environment for designing and running psychology experiments on Macintosh computers; it provides an example of how a simple experiment can be constructed within its graphic environment.	The study has implications for psychology students and researchers in the field of psychology and allows novice and experienced psychologists alike to design and implement psychology experiments without any need for programming.	1	1, 25
Li, Bates & MacWhinney (1993)	The study examines how Chinese speakers use varying cues (e.g., semantic cues, syntactic cues, and semi-morphological cues which all work together) to interpret sentences and offer an interactive model which indicates how cues converge and compete to specify the timing and outcome	The study has implications for syntacticians and linguists. The study can raise their awareness to numerous techniques and help them understand that reaction time method is effective for sentence interpretation, so it can be further investigated.	1, 2, 3, 11	1, 4, 6, 7, 9, 12, 13, 14, 15, 16, 17, 18

	of sentence processing. Also, another informative work by Gao et al. (2022) is recommend which deals with the acquisition of Chinese verb separation by adult L2 learners.			
Gupta & MacWhinney (1994)	The study examined a series of experiments associated with the effect of concurrent articulation on immediate serial recall which serves as a basis for the development of articulatory loop model.	One of the main implications of the study is that there exist some inadequacies in working memory model, thus further research is required to detect the inadequacies.	1, 2, 3, 11	1, 4, 6, 15, 23
McDonald & MacWhinney (1995)	The article examines time course of the use of implicit verb causality and gender agreement information which helps determine the antecedent of a pronominal pronoun; it used a cross-modal probe paradigm and presented a model of anaphor.	Reading the article can be beneficial for researchers. Since the study offers a model of anaphor resolution which can be used as a source of thought and investigation, studying the content of the study can be though-provocative for the researchers.	11	1, 4, 12, 13, 14, 15, 16, 17
Kempe & MacWhinney (1996)	Focusing more on lexical sensitivity, the experiment aimed at establishing a native speaker baseline for both languages and examined whether the selected word material yielded similar results in terms of word frequency effects, error rates and the size of the lexicality.	The study has implications for researchers and teachers; researchers can further research lexical processing in children, and aphasics as a topic in its own right. Teachers should design and develop related tasks for learners and assist them to be more strategic in performing a task.	1, 2, 3, 5, 11	1, 4, 10, 14, 15, 17, 19, 26
Li & MacWhinney, (1996)	This study evaluates the semantic basis for the overgeneralization in language acquisition with a main focus on three simulations. In the first two simulations, the network was unable to recover from overgeneralizations, despite repeated training, but in simulation 3, the network could recover from overgeneralizations with a number of words.	The study can help educators and researchers well-realize the role of the plasticity and stability of network learning in the network' s ability to recover from overgeneralizations.	1, 2, 3, 11	4, 12, 13, 14, 15, 16, 17

MacWhinney (1996a)	The article investigates the ways in which target language structures (e.g., orthography, phonology, lexicon, morphology and syntax) interact with individual differences in language learners and reviews psychological and neurology evidence which points toward a wide variety of individual differences in language learning mechanisms.	The study has implications for teachers in the classroom context. They need to realize the profiles of individual differences and value the specific types of styles and preferred kinds of strategies triggered to the individuals. Also, studying the content of the study can help learners improve functional language learning skills.	1, 2, 3, 7, 8, 9, 11	9,13, 14, 15, 21
Gupta & MacWhinney (1997)	The study examines human vocabulary acquisition processes and verbal short-term memory abilities with use of behavioral evidence and using the computational models and the way vocabulary acquisition and verbal short-term memory might be related. Concerning receptive vocabulary, Shing, Perry et al.'s (2012) work is equally more informative.	The study has implications for researchers and educators, as it offers an integrated model or a conceptual framework which identifies factors which relate verbal short-term memory and vocabulary acquisition and solves problems regarding vocabulary acquisition, and verbal short-term memory.	1, 2, 3, 9	4, 15, 21, 26
Macwhinney, Cohen & Provost (1997)	The study surveys PsyScope as a system for building behavioral experiments on the Apple Macintosh computer using a graphic user interface requiring no computer programming. It supports a wide variety of experimental designs, multimedia formats, and stimulus control.	The study provides researchers with additional user control over psychophysical properties of the screen display currently addressed by systems such as Morphonome.	10, 11	25
MacWhinney, & Pléh (1997)	This study used two dependent variables—choice and reaction time and examined the processing of five major types of cues including subject–verb agreement-marking, object–verb agreement-marking, case-marking, animacy and word order. In syntactic terms, other works by MacWhinney and Osmán-Sági (1997), Yoshimura and MacWhineny (2011), Presson et al. (2012), Presson, Sagarra et al. (2013), Andreu et al. (2012) and Walter and MacWhinney (2015) are highly informative.	The implications of the study can help syntacticians to realize that, in Hungarian language, there exist clear limits to the morphosyntax of language, as the morphosyntax of Hungarian language is not always fully functionally determined.	11	1, 4, 14,15, 16, 17, 18
MacWhinney, (1998a)	The study surveys the nature, varying stages, syntactic and semantic factors and numerous models associated with language, indicating	The main implication is that the article can help the readers to realize the way neural network models contribute to our growing understanding of varying	1, 2, 11	1, 2, 4, 5, 12, 13, 14, 15, 17, 21

	that the successful learning of human language is a tightly copyrighted component of our basic human nature, as all of the main social accomplishments of human culture depend on language use.	aspects of language development, such as auditory, articulatory, lexical, inflectional, and syntactic development.		
Booth, Perfetti & MacWhinney (1999)	The study suggests that children make quick, automatic, and general use of both orthographic and phonological information to recognize written words. One of the results is that older and good readers use phonological and orthographic information sooner and more effectively compared with younger and poor readers.	Teachers can use both phonological and orthographic representations for improving the reading skills of their learners. Also, researchers need to realize that there exists no absolute measure and instrument for children's knowledge of orthographic forms and their naming ability, so researchers should consider the results of such findings with caution.	2, 3, 9	13, 17
Booth, Perfetti, et al. (2000)	The study administered a battery of orthographic and phonological tasks, a rapid auditory task, and a rapid visual task to adults and children with reading impairment. As a result, adults displayed a strong relation between rapid auditory ability and both orthographic and phonological processing.	The study can help educators understand that children and adults with deficits in phonological and rapid auditory ability would potentially benefit from an extensive intervention program, as they can design the relevant task and trigger it to the needs of the adult or younger learners.	1, 2, 3, 9, 11	1, 13, 14, 15, 17
Evans & MacWhinney (1999)	The article investigates the sentence comprehension strategies used by children with expressive (E) and expressive–receptive (ER) specific language impairments (SLI) within a language processing framework. As a result, children with E-SLI and ER-SLI differed from each other in the comprehension strategies they employed.	The study can potentially help researchers realize that in contexts where processing demands are low, children with expressive specific language impairments may appear unimpaired. Scholars can design tasks which are more demanding to see what happens with much large sample size.	1, 2, 3, 5, 9, 11	15, 21, 26
Booth et al. (1999)	The study used whole brain FMRI imaging and three cognitive tasks including auditory sentence comprehension, verb generation to line drawings, and mental rotation of alphanumeric stimuli and examined patterns of brain activation: significant bilateral activation was observed in all three cognitive tasks.	The study has implications for researchers. They can replicate the study on children with a left-hemisphere stroke as well as right-hemisphere stroke.	1, 5, 10	1, 19, 22

Booth, MacWhinney et al. (2000)	The article investigated the development of neurocognitive networks in two cognitive paradigms. One of the results was that healthy children and adults activated similar neurocognitive networks, but there were developmental differences in the distribution of activity across these networks.	The study has implications for researchers and educational psychologists. They can replicate the study in other settings in the light of global findings without any regards to generalization.	1, 2, 3, 5, 7, 11	1, 17, 23
Brooks, & MacWhinney, (2000)	The study used two experiments to examine phonological priming in children and adults, using a cross-modal picture-word interference task: Priming effects reach a peak during a time when articulatory information is internalized in the output phonological buffer. Closely connected to this, Brooks et al.'s (2015) work is also informative.	The study can help teachers use visual input for engaging learners in phonological tasks. Also, it can help them teach phonology-related tasks more effectively.	1, 2, 3, 11	13, 14, 15
Kello, Plaut & MacWhinney (2000)	The study investigated the online relationship between the central processes of speech production and overt articulation with use of two experiments manipulating the timing of Stroop interference in color naming. Depending on task demands, naming behavior can shift between exhibiting a staged or cascaded mode of processing.	The study has implications for educators. They need to help their learners understand how to exert strategic control and realize effectively the link between cognition and action and the way related cognition triggers the related action.	1, 2, 3, 9, 10	1, 4, 9, 17, 21
MacWhinney, Feldman et al. (2000)	The article examines online measures of basic language skills in children with early focal brain lesions. These results advocate a model in which damage to the complex functional circuits gives rise to only minor deficits in process efficiency because of the plasticity of developmental processes.	The content of the article supports and recommends the use of online measures of basic language skills and considers them much more effective than and much better than standardized measures. Thus, researchers can replicate the study in other local setting.	1, 2, 3, 5, 7, 9, 10	4, 8, 9, 22
MacWhinney (2000)	This paper examines the effects of perspective-taking on the processing of sentences and grammar. The perspective hypothesis is on the claim that language allows us to shift perspective on varying cognitive levels.	The study is beneficial for language teachers. It can potentially awaken the imagination of the listener leading to successful sharing of ideas, impressions, attitudes, and narratives.	1, 2, 3, 6, 7, 8, 9, 11	1, 10, 11, 12, 16, 17, 21

Koschmann, & MacWhinney (2001)	The study investigates a new initiative in medical education research, documenting the range of practices used in various implementations of problem-based learning. Medical educators use the tradition commonly employed in linguistics and communication studies of creating shared data corpora.	The study is potentially informative for researchers, as it can enable them to conduct contrastive studies of numerous aspects of problem-based learning associated with varying local contexts.	10, 11	27
MacWhinney, James et al. (2001)	The study examines system for the teaching of experimental psychology, the goal of which is to provide instructional materials facilitating the use of E-Prime in various learning contexts and to construct a Web-based resource for a wide range of instructional materials.	The study has implications for researchers; it can help them provide input to the development of system for the teaching of experimental psychology and the selection of materials for the experiment database.	1, 10	1, 10, 17, 25
Feldman, MacWhinney, & Sacco (2002)	This study examined how children use word order and animacy cues to determine the agent of the action in an on-line sentence-comprehension task.	It can possibly motivate scholars to replicate the study with a much larger group of children in varying settings and on children with both right-hemisphere and left-hemisphere lesions.	1, 2, 3, 5, 11	15, 16, 17, 19
Li & MacWhinney, (2002)	The study introduces a phonological pattern generator (PatPho) and aims at providing an accurate representation system for the phonology of English words and a computational tool (PatPho) that facilitates the generation of phonological patterns. In this connection, Rose and MacWhinney's (2014) research work concerning software-assisted methods for the study of phonology and phonological development is informative.	The study raises the awareness of researchers in syntactic field to the fact that the learning of linguistic structure in neural network models depends heavily on accurate encoding of the statistical regularities implicit in the phonological properties of words.	11	4, 13, 14, 15
Gupta et al. (2003)	The study examines eleven children with early focal lesions compared to 70 age-matched controls to assess their performance in repeating non-words, in learning new words, and in immediate serial recall: All proved to be relatively demanding tasks.	There are possible implications for researchers. It motivates them to further investigate the fact that those abilities remaining more impaired are those which are either more demanding, or less amenable to neural reorganization, or both.	1, 2, 3, 5	13, 21

MacWhinney (2004a)	The commentary explores Truscott's and Sharwood Smith's APT model for SLA; they indicate how SLA can occur without any learning depending only on the tuning of innate principles. While Brian MacWhinney finds some interesting features in their model, he criticizes some other characteristics and claims of their perspectives.	There exist potential implications for teachers. They need to consider motivational and environmental features of SLA process. Therefore, they are required to fully comprehend that no one is perfect, as there is evidence that even advanced learners have problems learning to place the adverb before the verb.	2, 3, 11	4, 12, 13, 14, 15, 16, 21
Sagae et al. (2004a)	The study describes an annotation scheme for syntactic information in the CHILDES database containing transcribed dialogs between parents and children. The scheme is based on grammatical relations composed of bilexical dependencies.	The study can benefit the researchers and syntacticians, as it briefly and informatively addresses the needs of the child language acquisition community and provides data for researchers to replicate the study in varying settings with numerous related areas.	11	7, 9, 15,16
Sagae et al. (2004b)	The study examines parsed corpora of child language input data and attempts to automate this process with use of a system that combined the morphological tagger, a rule-based parser, and statistical disambiguation techniques. The resultant system obtained nearly 80% correct parses for the sentences spoken to children.	The study can inspire researchers to investigate the effectiveness of the proposed techniques on other corpora in the CHILDES database and facilitates the construction of a particular processing sequence that minimizes problems caused by the coverage/ ambiguity trade-off in parser design.	1, 2, 3, 11	4, 6, 14, 15, 26
Li, Farkas & MacWhinney (2004)	The article investigates a self-organizing neural network model (a growing semantic map and a growing phonological map) of early lexical development called DevLex. The study portrays a dynamically changing linguistic environment in language learning.	The study has implications for researchers, as it provides impetus for researchers to further investigate a number of fundamental phenomena associated with early lexical acquisition by children.	1, 2, 3	4, 5, 12, 13, 21, 23
MacWhinney, (2004b)	The article examines a logical problem associated with language acquisition theory, according to which the input to the learner is too inconsistent and incomplete to determine the acquisition of grammar. Therefore, it elaborates on alternatives such as conservatism, item-based learning, indirect negative evidence, competition, cue construction, and monitoring.	Researchers need to consider that the logical problem provides guidelines for child language research. However, it cannot serve as a deterministic guide for research, so researchers need to take caution in generalizing the related findings. The main implication indicates that just one solution is not sufficient; they need to consider varying solutions altogether.	2, 3, 7	1,4,5,10,12, 13, 14, 15, 21

Hernandez & MacWhinney (2005)	The study examines the emergence of competing modules in bilingualism and deals with varying related issues such as early simultaneous bilinguals, late bilinguals, resonance within emerging modules, DevLex model, and neurolinguistic and emergentist issues. For further elaboration on emergentist approach, MacWhinney's (2006a, 2019d, 2023b) other research works are informative.	One of the inferred implications is that in addition to hard-wired modules, the process and product of language acquisition are nurture-driven rather than born. Therefore, teachers should take the environmental and motivational issues into account.	1, 2, 3, 4,7	2, 4, 5, 6, 21
Dong et al. (2005)	This paper proposes a distributed, asymmetrical model for the bilingual mental lexicon with use of two experiments: Experiment one used the classical priming paradigm with specific methodological innovations. Experiment two examined the details of meaning separation.	Educators can use the contents of the article and help bilinguals realize the significance of integrating conceptual differences and representations into translation equivalents. At the same time, they should inform the bilinguals that they should maintain their L1 conceptual system.	1, 2, 3, 4, 11	1, 4, 6, 11, 12, 13, 14, 15, 16, 17, 21
MacWhinney (2002a, 2002c, 2005g, 2005h, 2005j, 2008b, 2018); Zhang & MacWhinney (2023a, 2023b); Li & MacWhinney (2013); MacWhinney, & Bates (1994)	The studies detail the competition model, some new directions, and an extended formulation of the competition model called the unified competition model which accounts for a much wider range of issues in L1 and L2; the related issues such as arenas, mappings, chunking, storage, codes, support, codes, cues, transfer, age-related effects, and resonance are detailed.	The studies provide us with a high-level road map of a very large territory that can potentially lead to the understanding that there are varying interactive and resonant factors involved in language development rather than just one fixed single factor.	1, 2, 3, 4	1, 4, 5, 9, 10, 21, 26
Tokowicz & MacWhinney, (2005)	The article investigates the contributions of explicit and implicit processes during second language sentence comprehension with use of event-related brain potentials and L2 grammaticality judgment task.	The study can contribute to the development of adequate tools to isolate problem areas in L2 learning that could inform L2 teaching techniques and it also helps teachers to identify what students know, what they should know and what they do not know.	2, 3, 11	1, 4, 15, 16, 17, 21, 24

MacWhinney (2005b)	The study examines issues on linguistic forms which are shaped by forces operating on varying time scales and attempts to comprehend the challenge that how forces mesh together to determine the emergence of linguistic form.	The study can have potential implications for syntacticians, as it can help them note the systemic interactions in varying aspects of language development and language processing.	11	2
MacWhinney (2006b, 2007)	The studies investigate TalkBank which seeks to harness the new information technology to study the great complexities of human talk and details TalkBank research issues, methods, tools and circles. Moreover, Ratner and MacWhinney's (2019), Liu et al.'s (2023) and Zhang and MacWhinney's (2023a) research works are recommended for further study.	The study has implications for educators, as it can help them engage in the multidisciplinary study of human communication and build a new system giving rise to a qualitative improvement in research on communicative interactions.	1, 2, 3, 4, 6, 10	8, 27
Li, Zhao, & MacWhinney (2007)	The article presents a self-organizing neural network model, the input of which is sampled from actual parent-child interactions. It accounts for developmental patterns, such as vocabulary spurt, word-length, word-frequency effects, individual differences in lexical development, and word learning after early brain injury.	Since the study proposes a new computational account of the vocabulary spurt, it can be potentially informative to teachers: After reading the article, teachers will be more capable to raise learners' awareness to the ins and outs of vocabulary development.	1-7, 11	1-15, 23
Prior, MacWhinney, & Kroll (2007)	The study presents a set of translation norms for English and Spanish words in accord with a single written translation for each word presented to bilinguals. Closely connected to this, Prior et al's (2011, 2013) works on translation ambiguity are more detailed and informative.	The effective norms introduced in the study can help bilinguals identify lexical variables that impact on the outcome of translation and help them realize the types of translations they prefer when given the choice.	2, 3, 4	6
Wong & MacWhinney, (2009)	The article investigates the substantial role of phonological instruction in early second language English learning. It reviews and explores the issue that younger learners seem to have a greater facility with sound learning and older learners or adults can efficiently acquire grammar and vocabulary.	The study has implications for teachers and program managers. It can help them notice articulatory skills for younger learners and that the teaching of articulation should not be reduced to non-engaging lessons characterized as a drill or a skill.	2,3, 9	13, 21

Mitsugi & MacWhinney (2010)	This study used self-paced reading to investigate the processing of Japanese ditransitive scrambling by native speakers and L2 learners of Japanese. Relevant to sentence scoring in Japanese context, Miyata et al.'s (2013) work is equally insightful.	The study has implications for researchers, as it can further test the hypothesis that there are no significant differences in reading times among word-order types.	2, 3, 11	1, 17, 18, 21
Prior & MacWhinney (2010)	The article investigated lifelong bilingualism and enhanced efficiency in the light of a task-switching paradigm. The advantages of bilinguals extend beyond inhibition of competing responses, and includes flexible mental shifting as well.	The study can motivate researchers to further investigate the cognitive consequences of lifelong bilingualism through variations in executive function.	2, 3, 47	21
Yoshimura & MacWhinney (2010)	This study examined adult English native speakers' processing of sentences and a conflict between pronominal case marking and word order is observed.	The article has implications for the study of second language acquisition, as it helps educators understand various patterns in second language learning of English pronominal marking.	1, 2, 11	4, 6, 17, 15, 21
Andreu, Sanz-Torrent, et al. (2011)	The article examines narrative production and comprehension in children with specific language impairment (SLI) with use of an eye-tracking experiment intended to report on online narrative comprehension and production in Catalan- and Spanish-speaking children with SLI. Closely connected to this, Andreu e al.'s (2011, 2013) formulation of argument structure in SLI is highly informative.	The study has implication for educators as they can consider the kinds of semantic and syntactic errors associated with retelling and also, scholars can further investigate children's information processing capacity and working memory limitations.	1, 2, 3, 5, 11	1, 15, 17, 19, 21
Liu, Wang, et al. (2011)	The study examines learning a tonal language by attending to the tone in a vivo experiment using three learning conditions. Some results were observed, such as more error reduction in the Contour + Pinyin condition.	The study has potential implications for students of Chinese as a second or foreign language, as it can help them understand the features of the Chinese tone system and use the required techniques and strategies.	2, 3, 9, 11	13, 15, 17
Hong & MacWhinney (2011)	The study reports three studies of bilingual lexical processing, learning experience and working memory in the light of the semantic competitor priming method. In the end, it presented findings in relation to cross-language priming.	The study has implications for educators. They are required to notice individual differences in vocabulary development and help their learners boost vocabulary-learning strategies required for both vocabulary size and vocabulary depth.	1, 2, 3, 4	21

Miyata, et al. (2013)	This paper examines the development and use of the developmental sentence scoring for Japanese as a new morpho-syntactical measure for Japanese: the developmental sentence scoring for Japanese is a helpful and valuable device, more particularly for the language acquisition research.	One of the main implications of the study, among many, is that the researchers doing research into the developmental sentence scoring for Japanese need to consider that it should be used with samples larger than 50 sentences.	1, 9	7, 14, 15
Presson et al. (2013)	The article trained learners of Spanish in a task requiring the production of regular and sub-regular verbs, for forms of sub-regular verbs with and without a transformation related to dual-route model and hybrid models.	The study has implications for educators in Spain context. It can help them understand that learners can be in need of deliberate production practice with difficult patterns, without which they may not potentially achieve full mastery of the various regular, sub-regular, and irregular patterns and verbs.	2, 3, 11	4, 15, 16, 21, 24
Arbib et al. (2014)	The study examines the challenges of action and language mechanisms in the brain. Overall, it provides a novel perspective on neuroinformatics and integrates the development of databases for encoding neurocomputational models and empirical data serving systems and cognitive neuroscience.	One of the implications of the study is that scholars can be encouraged to share their data with others concerning action and language mechanisms in the brain.	1, 2, 3	4, 23
MacWhinney (2014a)	The study examines a core set standard for evaluating the outcomes of treatments for aphasia. It represents varying challenges and dangers associated with a core outcome set that is responsive to conflicting goals and offers more significant guidelines.	There are varying implications implicit in the study. For example, the study can motivate the related agencies and organizations to emphasize and invest in international standardization efforts for dealing with challenges relevant to medicine, education, and technology.	1, 2, 3, 5	19, 21
Mitsugi & MacWhinney, (2015)	This study expands predictive processing to L2 learners of Japanese and compares sentences under three word-order conditions: canonical, scrambled, and accusative. The results underscore the efficiency of morphosyntactic information in processing Japanese.	One of the potential implications of the present study is for researchers; they need to investigate predictive processing with L2 learners at varying proficiency level; this will help teachers realize the fact that L2 learners fail to make full use of case markers predictively.	1, 3	1, 14, 15,17, 18

Fromm et al. (2016)	The article uses much larger sample size, procedural discourse and personal narratives and investigates proposition density and aphasia and subtypes of aphasia with individuals. Closely connected to this, MacWhinney, Fromm, Holland, et al. (2010), MacWhinney, and Fromm (2016a), MacWhinney, Fromm, et al. (2011) MacWhinney, Fromm, Holland, et al. (2012), Dalton, Stark et al. (2022) and Fornes et al. (2012) are informative.	Researchers need to realize that access to automated analysis tools and the large AphasiaBank database can help further research into proposition density and its link to other aphasia measures.	1, 5, 6	19, 20, 22
Fromm, Greenhouse et al. (2016)	This study investigates the way proposition density can differentiate between persons with aphasia and individuals in a control group. Also, it examines subtypes of aphasia with reference to personal narratives and procedural discourse resulted from large sample size.	The study can be effective for neurologists, linguists and psycholinguists working in the field of aphasia. It can help them realize that proposition density is sensitive to aphasia type and differentiates individuals with Broca's aphasia from the other groups.	1, 2. 3, 5,6, 7, 8, 11	8, 15,19, 21, 23
Tsvetkov et al. (2016)	The study examines Bayesian optimization to learn curricula modeled by a linear ranking function for word representation. The study indicates that the curriculum improves performance on a variety of downstream tasks.	The study has varying implications. For example, educators can study the article and note the issue of choosing the order of learning, i.e., curriculum learning and reformulate and reframe it in a way that they can trigger the curriculum and the related tasks to the needs of learners.	1, 2,3, 11	1, 17, 21
VanDam et al. (2016)	The study examines HomeBank as an online database of daylong audio recorded in naturalistic environments. It is a repository for raw audio files and is an open repository for processing and analysis tools for HomeBank or similar data sets.	There exist varying implications in the article. For example, it can make primary data available to researchers, especially those in child development, linguistics, and audio engineering.	1, 2, 3, 10	7, 13, 14, 15, 21
Williams et al. (2016)	The study investigates a multidisciplinary aphasia dataset of individual patient data for the rehabilitation and recovery of people with aphasia after stroke.	The study motivates scholars and psychologists, and psycholinguists to examines issues related to aphasia and stroke in varying local contexts with much larger sample size.	1, 5, 6	19

MacWhinney (2017a)	The study summarizes crucial issues related to the dialog between emergentist and nativist approaches, and the related problems, language attrition and competition model. Other articles refreshing a shared platform in SLA (MacWhinney, 2017b, 2017c) are also more informative.	The study can be beneficial to educators, as it can help them realize the key issues related to the way children and adults learn a language; it helps them justify language attrition and guides the learners through learning process.	1, 2, 3, 7, 8	2, 4, 21
MacWhinney (2019b)	The study reviews the issue that nature is replete with emergent processes so that all structures in the natural world emerge from the force of constraints on different levels. The study surveys the mechanisms that determine the shape of the emergent patterns.	It can help educators to realize that varying forms of natural languages are in the service of communicative functions. Therefore, whatever theory is coined should be connected to practice.	1, 2, 3, 5, 11	1, 2, 4, 23
MacWhinney (2019c)	The study reviews the TalkBank system providing online multimedia data for 14 types of spoken-language data, such as language in aphasia, child language, stuttering, child phonology, autism spectrum disorder, etc. Also, those more interested in the issues related to dementia, Liang et al.'s (2022) and Zhu et al.'s (2023) research works are more informative.	The study has implications for researchers and educators. It helps them get familiar with data analysis methods with reference to TalkBank and it contributes to language therapy, clinical diagnosis, and second language teaching.	1, 2, 3, 5, 6, 10	1, 4,7, 8, 19, 22, 27
Fromm, MacWhinney & Thompson (2020)	The current article seeks to implement a new, single, composite computerized language analysis command for the full set of 51 northwestern narrative language analysis codes and evaluates its reliability for coding aphasic language samples. In the same vein, MacWhinney, Roberts et al.'s (2020) and Yang et al.'s (2022) research work on computerized language analysis–index of productive syntax is more informative to reflect over.	The study can motivate scholars and educators to replicate the study and examine analysis of spontaneous speech samples for determining patterns of language production in people with aphasia in their own local context.	1, 2, 3, 5, 10	7, 19, 27
Power et al. (2020)	The study examines the pattern and nature of narrative discourse impairment in people with severe traumatic brain injury (TBI) during early recovery and describes the communication abilities of a group of individuals with severe TBI. The patterns	The study has implications for psychologists, researchers and educators. The performance of people with severe traumatic brain injury can change according to the nature of task and context; realizing this can help educators to reconceptualize cognitive-communication disorder in classroom context.	1, 5, 6	8, 19

	and change in narrative discourse behaviors following severe TBI are highly individualized. Closely connected to this, research works by Brassel et al. (2016), Stubbs et al. (2018), Togher et al. (2023), Power et al. (2020), and Minga et al. (2021) are informative.			
Minga et al. (2020)	This study examines the impact of right-hemisphere brain damage (RHD) on pragmatic aspects of communication and tests the hypothesis that adults with RHD differ from neurologically healthy adults in the types of questions asked during a structured task. In this connection, Minga et al.'s (2022) work is also more insightful.	Educators can benefit from the study and enjoy ways of asking varying types of questions as a significant part of pragmatic communication. Scholars can be also encouraged to replicate the current findings.	1, 2, 3, 5, 11	1, 9, 11, 15, 16, 21
Fromm, Katta et al. (2021)	The study is concerned with the creation and evaluation of an automated program to score the results of the quantitative production analysis, an approach for measuring structural and morphological characteristics of connected speech.	The study has implications for application in clinical settings as a tool for assessment, treatment planning, and treatment outcome measurement.	1, 2, 3, 11	1, 7, 17
Luz et al. (2021)	The study examines Alzheimer's disease classification for distinguishing individuals with Alzheimer's disease from healthy controls, and cognitive test score regression to infer the patient's Mini Mental Status Examination score.	The study can serve as a basis for understanding the reasons for Alzheimer's disease and the prevention of Alzheimer's disease progression. Also, it can serve the purpose of further research into the related fields.	1, 5	20
Release Collaborators (2021)	The study described recovery of overall-language-ability, auditory comprehension, naming, and functional-communication across participants' age, sex, and aphasia chronicity in a large, multilingual, international aphasia dataset.	Scholars can replicate the study and examine the extent to which earlier intervention for post-stroke maximizes language recovery across a range of language domains.	1, 2, 3, 5	8, 19
Stark, Dutta et al. (2021)	The article examines the development and structure of a working group and addresses major gaps in the spoken discourse aphasia literature, including a lack of standardization in methodology, analysis, and reporting, as well as nominal data regarding the	The study has varying implications. Researchers can help improve the state of research in spoken discourse in aphasia and facilitate the application of research in aphasia that goes beyond the single-word and sentence levels of processing.	1, 2, 3, 5, 6, 7, 9	7, 19

	psychometric properties of spoken discourse outcomes.			
MacWhinney (1994a, 1995a, 1996b, 2000c, 2000d, 2014c); MacWhinney & Fromm (2016b); MacWhinney & Snow (1985, 1990, 1992, 1994, 2023); MacWhinney & Wagner, 2010); Bernstein Ratner, Rooney, & MacWhinney (1996);	The articles deal with an international system for exchanging and analyzing child language transcript data, the formation and nature of Child Language Data Exchange System (CHILDES), CHILDES tools for clinical analysis, and the types of computer programs. CHILDES contains three major tools for child language research: the CHILDES database of transcripts, the CHAT system for data transcription/coding and the CLAN programs for analyzing CHAT files. Some of the references listed here (e.g., Sagae, MacWhinney et al., 2004a) deal with CHILDES and linguistics-related issues such as syntactic annotations, child-parent dialog and CHILDES.	The process of collecting, transcribing, and analyzing naturalistic data is extremely time-consuming and often quite unreliable. The study facilitates the sharing of transcript data, automates the process of data analysis and increases the reliability of transcription. The CHILDES can also facilitate the comparison of experimentally generated data with spontaneous data and help the children attain their full potential.	2,3,6, 9, 10	1, 7, 9, 11, 12, 17
Yao et al. (2022)	The article examines gesture–speech integration among adolescents who are deaf or hard of hearing and those with typical hearing. The results of the study revealed stronger gesture–speech integration effects among deaf or hard of hearing participants than hearing participants.	The study can potentially motivate researchers to investigate the impact of gesture on communication and language processing.	1, 2, 3	1, 8, 9
Ratner & MacWhinney (2023)	The article investigates a free software system (Computerized Language Analysis [CLAN]) that can enable fast, thorough, and informative language sample analysis. To this end, methods for eliciting, transcribing, analyzing, and interpreting language samples are described and a diagnostic report is generated.	The study can have potential benefits for researchers in the field as it provides an introduction to the use of free CLAN software and can help researchers address specific aspects of grammatical structure.	1, 2, 3, 5, 10	7, 9,19, 21, 27

Table 8

Analysis of the Book Chapters

Book Chapters	Research	Practice	Macro-Themes	Micro-Themes
Bates & MacWhinney (1981)	The chapter explores varying issues on second language acquisition, performance grammar, competition model, functional perspectives, pragmatic and semantic issues, cross-linguistic experiments, production and comprehension experiments and processing strategies related to grammar acquisition.	One of the potential implications is for teachers and researchers. Teachers can use the content of the chapter and help learners understand the significance of strategy use in grammar acquisition. Also, it can serve as a basis for researchers to further investigate performance grammar.	1, 2, 9	1, 4, 11, 12, 15, 17
Bates & MacWhinney, (1979, 1982)	The studies review the details of main themes such as linguistic and psycholinguistic theories, diachronic relation between syntax and topic-comment functions, formalist-functionalist controversy, perspective/salience and the device of initialization in adult English, topicality and syntactic devices, syntax and pragmatic functions, competition model, criterial attribute model, and prototype models and theories.	The study has numerous implications. Researchers and syntacticians can potentially enjoy the considerable evidence proposed for functionalistic approaches, as these approaches can serve the purpose of the acquisition and use of grammar.	2, 3, 7, 11	4, 15, 21
MacWhinney (1982)	The present chapter extends the computational model of the acquisition of morphophonology presented to the acquisition of word-order patterns. Also, it explores six alternative strategies in word-order processing: rote, analogy, predispositions, bound patterns, free patterns, and class-bound patterns.	One of the potential implications of the study is for researchers. They are required to go beyond the analogy and begin to conduct research into the fundamental patterns that govern the acquisition of cognitive systems.	2, 3, 11	1, 4, 11, 12, 13, 14, 15, 17, 21, 26
Bates, MacWhinney & Smith (1983)	The study presents main issues on functionalism and discusses varying themes, such as nativist position, autonomy, anomalist approach, biological feasibility of modern-day analogism (i.e., functionalism), communicative and non-linguistic issues, learnability theory, ecology of grammar, linguistic Darwinism, formal causality and emergent form, vestigial learning, and automatic and controlled processing. Concerning functionalism, Bates, McNew et al. (1982) is more informative, too.	The study has multiple implications for educators, researchers and linguists: They need to study the content of article for the purpose of broadening their views of the main issues in syntax and pragmatics and apply their findings to their research and instruction context.	1, 2, 3, 11	1, 2, 4, 10, 11, 12, 15, 21
Lempert & MacWhinney (1984)	The study reports on the outcomes of three experiments associated with a sentence form. It identifies whether acquisition of word order relations for this form would be affected by pragmatic ordering principles and whether referent animacy would be included in children's rules for word order: pragmatic factors appeared to play a critical role in the acquisition of word-order knowledge.	Educators need to note that children's acquisition of a form can be affected and controlled by appropriate contextual manipulations and linguistic and nonlinguistic variables. Therefore, they are required to consider teaching and helping learners develop syntax in the light of context.	1, 2,11	11, 15, 21

MacWhinney (1984b)	This chapter deals with specific devices from the point-sharing system. It lists and explores 12 major devices from the point-sharing system including definite article, indefinite article, pronominalization, ellipsis, relativization, stress, initialization, preverbal positioning, subject-verb agreement, verb selection, case marking, and particles.	There exist potential implications in the study, as it can be informative to teachers to help learners acquire the various point-sharing devices and their polysemes; it will help organize learners' understanding of the devices for a successful communication which will give rise to new ideas.	1, 2, 3, 11	1, 9, 15, 21
MacWhinney (1984c)	The study examines varying numbers of categories and subcategories resulting from numerous sources, such as children's cognitive processing of direct perceptual interactions with the world, and their social interaction with their parents and peers.	The categories can help teachers realize how to help young learners develop the range and level of their words with use of categorization principles and the concrete items around them.	1, 2, 3, 8, 11	1, 2, 9, 11, 12, 15, 21
MacWhinney & Anderson (1986)	Th chapter offers a model of language use and acquisition which provides a reasonable account of the fundamental principles underpinning language acquisition. It covers five main themes including general architecture, lexical activation, syntactic processing, monitoring, and acquisition and then summarizes nine acquisitional strategies.	The nine acquisitional strategies which the study outlines and summarize can be potentially informative to teachers, educators, researchers and course designers and can be also used as a part of syllabus or part of an instructional course.	2, 3, 9, 11	4, 9, 11, 12, 15, 21
Keenan & MacWhinney (1987)	The chapter mainly outlines the possible analysis of the component processes in comprehension and production. It reveals the way this framework can be potently used to distinguish between numerous types of comprehension and production tasks.	The chapter can help teachers understand the relation between production and comprehension and the related tasks. This can be practically effective in providing language learners with required input for the purpose of developing their spoken proficiency.	1, 2, 3, 7, 8, 9	1, 9,15, 21
Stemberger & MacWhinney (1988)	Lexical items are a fundamental part of a speaker's knowledge of language, but it is not clear what (inflectional) items should be listed and stored in the lexicon and that whether they should be stored or not and how. The present chapter examines these issues from a psycholinguistic perspective.	The study has implications for language teachers. It helps them decide what high-frequency and low-frequency words to include in the lexical syllabus of the course they teach.	2, 3, 7, 11	14, 15, 21
Bates & MacWhinney (1988a)	The study compares and contrasts the principles of Straw Man Functionalism summarized in six beliefs. Overall, it brings the findings of language acquisition in children and language processing in adults within a framework for the study of linguistic performance called the Competition Model, a model inspired by functionalism. Regarding what functionalism is, Bates and MacWhinney (1988b) is highly informative.	The study provides a clear position for linguists regarding the definition, application and research into the concept "functionalism". It helps understand and clarify the extent to which nature and nurture play a role in language acquisition.	2, 3, 9, 11	4, 15, 21
MacWhinney (1989a)	The chapter is mainly concerned with competition model. It first reviews the shift from Classical Theory to Prototype Theory and presents an approach to categorization theories. In fact, it first deals with how competition provides a way of understanding the semantic	There exist varying implications: knowledge of competition and categorization theory can help teachers and researchers understand the crucial aspects of language learning, language	1, 2, 3, 7, 8, 9, 11	1, 2, 11, 12, 15, 21

	ranges of words, then it discusses the acquisition of basic word meaning by children; next, it indicates how words take on various polysemic and extended meanings. Regarding the Competition Model, Li and MacWhinney's (2013) and MacWhinney's (2022a) book chapters are informative.	extension, and language change and the way polysemy can allow learners to use language creatively and dynamically.		
Taraban, McDonald & MacWhinney (1989)	The study examines a connectionist model and explores the mechanisms underlying the learning of grammar by children. It therefore investigates cue learning and cue competition, paradigm formation, learning in a connectionist architecture, and simulation issues. Similar to the main theme of the study, MacWhinney (1993) is also informative.	The coding of the semantic features and sampling in this study are incomplete and insufficient. Therefore, researchers can replicate the study and conduct some research on a somewhat similar issues tackled in the study.	1, 2, 3, 11	4,5,6,10, 13, 14, 15, 16, 21
Klahr & MacWhinney (1997)	The chapter provides a short historical account and overview of the emergence of computational approaches to cognitive development, lays out three classes of computational models and details two types of computational models: production systems and connectionist systems.	Language teachers can use the new tools for computational modeling and broaden their understanding of cognitive development and help their learners develop cognitive techniques and strategies for learning.	1, 2, 3, 7	1, 4, 5
MacWhinney (1992b, 1997a)	The chapters deal with nativist approach, empiricist approach and competition model. They indicate that L1 acquisition and L2 learning are driven by the competition model. The model is characterized by lexical functionalism, connectionism, input-driven learning and capacity limitations in terms of short-term memory.	Reading these two chapters can provide an informative background for language teachers and researchers and help them adopt a balanced position between nativism and empiricism. The competition model can help them adopt this position.	1, 2, 3, 7	1, 4, 5, 21
MacWhinney (1992c)	The study explores the application of the Competition Model to the study of second language acquisition and distinguishes between transfer from L1 and direct learning of L2. The model predicts certain typical varieties of transfer during the process of phonological, syntactic, and lexical learning. In this connection, syntactic transfer in English-speaking Spanish learners by Morett and MacWhinney (2013) is also informative.	The study has implications for teachers and researchers. Teachers are required to realize the way transfer can negatively affect their learner's learning outcome if feedback is not appropriately performed. Also, researchers can further investigate the construct of transfer.	1, 2, 13,7, 11	3, 4, 11, 12, 13, 15, 18, 21, 26
MacWhinney (1994b)	The study charts out a path that helps escape from the dangers of hand-wired complexity, and reviews cognitive models based on rules and symbols. It offers a connectionist networks extension of the competition model which relies on lexical item and lexical categories as ways of managing processing and learning.	The study has implications for linguists and researchers. They need to mind that there exists a danger in insufficient clarity and evidence. Whatever they research should be on the basis of multiple evidence in order to be justifying.	1, 2, 3, 11	1, 2, 3, 4, 5, 10, 12, 13, 14, 15, 16, 17
MacWhinney (1995b)	The study focuses on the design of foreign language tutoring systems within the framework of varying lessons from experimental and cognitive psychology, developmental psycholinguistics and SLA research. It pinpoints the significance of error diagnosis, feedback, transfer, time on task, context, communication, and learning strategies.	The study provides a reasonable and practical guidepost for educators and teachers in classroom context. They are encouraged to study SLA research findings and justify their real teaching activities in the class.	1, 2, 3, 7, 8, 10	4, 5, 9, 10, 11, 21, 24, 26

MacWhinney, (1998b)	The study examines a consistent framework and methodology for elicitation, recording, transcription, and analysis of data, i.e., the CHILDES (Child Language Data Exchange System) Project and also deals with the development of research methodology from the pre-computer period into the current period of connectivity and exploratory reality. The effectiveness of technology is represented in MacWhinney's (2022b) two-page elaboration on the future of digital language learning.	One of the potential implications of the study is motivational. It can inspire researchers in the field to replicate the study and further investigate language disorder in the light of the CHILDES. Also, it can provide neuro-linguists a rich source of information about how language is processed in the brain.	1, 2, 3, 5, 7	1, 4, 8, 19, 21, 23
MacWhinney (2000a)	The chapter surveys issues related to a rigid set of social conventions or rules which affect the linguistic behavior of the members of the society: These conventions make a contribution to the mutual understating and communication of the members of the society.	The study has implications for sociolinguists and classroom teachers, as they need to analyze the social rules and conventions and raise the communicators' awareness of the nature and significance of social rules in their effective communication.	8, 11	9
MacWhinney, (2001c)	The study reviews and surveys a general framework for language learning in the light of a three-way interaction between the input, the learner, and the context. It also explores other fundamental issues such as roles of transfer, automatization, plasticity, commitment and parasitism in the learning of L2.	The study can help language teachers to realize the significance of auto-support compensating for the adult learner's loss of neuronal plasticity and social support. Also, it can help them move beyond a uniform structure in which interaction is controlled by the instructor.	1, 2, 3, 7	1, 4, 9, 21
Sasaki & MacWhinney (2006)	The chapter deals with the Competition Model. The model seeks to integrate the traditions of L1 acquisition, L2 acquisition, and adult processing research without relying on the principles from Universal Grammar. Then, it reviews some of the major findings of research it has inspired with a focus on sentence comprehension in Japanese and Korean. For further reflection, MacWhinney's (1997c) further investigation into simultaneous interpretation in the light of the competition model is more informative.	The chapter can help teachers clarify the main issues on human language and bring to the forefront the clear perspectives on L1 and L2: This can in turn help learners to realize their preferred style and strategies for learning.	1, 2, 3	1, 2, 9, 10, 21
MacWhinney (2002d, 2005i, 2008c)	The chapters present a fairly detailed account of gradual emergence of and cognitive precursors to language with reference to the advantages, and neural modifications of bipedalism, social Cohesion, mimesis, systematization, and the related issues such as cultural evolution, social-developmental consequences, and disorders of Communication. Closely related to emergentist accounts, MacWhinney (2001b, 2002b) and Caldwell-Harris and MacWhinney 's (2023) works are informative.	The studies can be of potential implication for researchers and those interested in the emergence of language. So, it can broaden their horizon of the ins and outs of the processes and varying periods during which numerous factors led to the emergence of language. Also, it can help them widen their knowledge of varying cognitive precursors to language.	1, 3, 9, 11	2, 21
MacWhinney (2003a)	The study examines language acquisition with reference to issues such as network model of language acquisition, Chomskey's perspectives,	The study can help researchers how to develop techniques for learning a vast number of words	1, 2, 3, 4, 7, 9, 11	4, 5, 9, 21, 26

	and five main related challenges such as dual route, lexical learning, syntax, neuronal realism and embodiment.	for meeting multiple purposes and further examine the way lexical items can be stored in the brain.		
MacWhinney (2003b)	Due to the significance of language development and that children need to know language for multiple purposes, the chapter examines technical issues in language study, theoretical and empirical review of the language literature, developmental stability of language, and factors that affect the development of language.	The implication of the study is for educators, as they can read the chapter and well-realize the close relationship between knowing a language and children's overall well-being. This will encourage them to help children understand the value of language use for varying communicative objectives.	2, 3, 4, 8	9, 21
MacWhinney (2005a)	The chapter examined a set of hypotheses regarding the age of acquisition and fossilization. The hypotheses include lateralization, neural commitment, parameter-setting hypothesis, metabolic, reproductive fitness, aging, fragile rule, starting small, entrenchment and balance hypotheses.	One of the significant implications of the study is for educators; they are required to realize that it is the age of arrival, rather than length of residence, which can predict the extent of achievement of nativelike proficiency in L2.	1, 2, 3, 7, 8	3, 26
MacWhinney (2005c)	The chapter examines an approach called perspective hypothesis which builds on recent advances in cognitive linguistics, embodied cognition, cognitive neuroscience, anthropology, and developmental psychology. It indicates that perspective taking is at the center of language structure and higher-level cognition.	The study helps educators understand the linkage between the brain, society and language and can possibly broaden their horizon of the fact that communication is viewed as a social interaction that activates mental processes of perspective taking.	1, 2, 3, 7, 8	8, 9
MacWhinney (2009)	The chapter surveys recursion as an emergent property of a set of adaptations that involve six processing systems and explores subsystems such as audition, articulation, lexicon, syntax, storage, and mental models. Out of the interplay of all six of these systems, linguistic complexity arises. As a result, an account of neurolinguistic processing is provided.	The implication of the study is that for producing complex syntax, in both educational and research terms, researchers and teachers should note that the subsystems work together and are integrated and in interaction with each other rather than separated.	1,11	1, 2, 10, 15, 17
Wintner et al. (2009)	The study models the development of language by a series of formal grammars and examines the linguistic capacity of children at the very early stages of mastering language. In terms of the innate, language-specific mechanisms, the approach provides a testbed for evaluating theories of language acquisition.	The study can help researchers examine the sequence of grammars adequately covering the first stages of the emergence of syntax in the language of one child.	1, 2, 3, 11	2, 15, 17, 21
MacWhinney (2010a)	The study reviews the tale of two competing paradigms: Universal Grammar and emergentism. These two paradigms take different positions on these eight core issues in the field. In this connection, a chapter by MacWhinney (2014d) dealing with second language acquisition and the competition mode is highly informative.	Although short, the chapter can have implications for researchers, language teachers, graduates, and post-graduates: It can provide an informative coverage of the main issues regarding UG and emergenticism as well as the eight core issues.	1, 2, 3, 7,11	2, 4, 10

MacWhinney (2011)	The study investigates corpus linguistics. It is concerned with developing easily used methods for each of the examined analytic methods and emphasizes constructing a unified database for language studies and related sciences.	The study has theoretical implications for teachers and researchers, as it can widen the horizon of educators to corpus analysis and corpus linguistics.	2, 3, 6, 10, 11	7, 21
Presson & MacWhinney (2011)	The study examines the competition model and language disorders and contrasts disordered language processing with normal language processing. Considering the properties of language acquisition, the chapter helps understand the dynamics of communication disorders and the challenges associated with language disorder.	The study can be beneficial for teachers, researchers and psychologists doing research into language disorder, as it can help explain behavioral and neural patterns of language disorders.	1, 2, 3, 5	1, 2, 19, 21, 23
MackWhinne, Fromm et al. (2012)	The chapter examines AphasiaBank, electronic corpora and the use of computerized data base, i.e., corpora, which are accessed over the internet and then analyzed for content, function and language. It details issues such as protocol standardization, GEM, lexical and morphological coding, MORtable, lexical frequency analysis, COMBO, and error analysis.	The study is effective for scholars interested in research into CHILDES database and CHILDES issues as an international cooperative venture.	2,3,6, 9, 10	1, 7, 9, 11, 17
Presson, Davy et al. (2013)	The chapter is concerned with improvements in computer technology, recommends the integration of web-based language learning into classroom and focuses more on experimental computer-assisted language learning (eCALL) methods which can make student learning more efficient.	The study has more practical implications for classroom teachers: They can integrate technological and digital tools into the classroom teaching and provide deeper support for second language learning.	2, 3, 10	21
MacWhinney (2014b)	The current chapter presents an account of first language acquisition based on the child's learning of item-based patterns, which involve grammatical dependencies between a lexical predicate (such as more) and its arguments (such as milk) to form a new cluster (such as more milk).	The study can be of use for language teachers, as it can help children use inductive operations to acquire these patterns. Researchers can also use the presented framework to construct computational simulations of children's syntactic development.	2, 3, 11	15, 21
MacWhinney (2015)	The study reviews key issues on psycholinguistics and examines six core areas including spoken word recognition, message construction, sentence production, sentence comprehension, crosslinguistic comparisons and neurolinguistics.	The study can help language teachers to realize how to help their language learners to use varying techniques in a dynamic way to process and learn language skills and subskills.	1, 2, 3, 5,7, 9, 11	1, 10, 11, 21, 23
MacWhinney (2015b)	The chapter examines multidimensional SLA, and explains the linkages between theory and practice. To this end, it accounts for second language learning as a multidimensional emergent process in the light of the principles of competition, hierarchical structure, and timeframes. Regarding language and psychology, MacWhinney's (2015b) research work concerning psycholinguistics and the related issues is suggested for further study.	The study provides an efficient background for educators more interested in creating a connection between theory and practice; the chapter, in fact, helps them consider multidimensional view of second language acquisition in the classroom context.	1, 2,3	2, 4, 21

MacWhinney (2017d)	The study explores the role of entrenchment in second language learning. It accounts for how language learning success declines with age. It reviews the findings from the critical period concept, and neural network models and finally resolves the paradox in the light of the Unified Competition Model.	The study has implications for language educators and language learning counselors. They can review varying models and help learners with the process of language learning and with age-sensitive factors.	1, 2, 3, 11	4, 10, 21
Walter & MacWhinney (2018)	The study explores language processing, focuses on predictive capabilities in anticipating words, and examines the predictability of separable verb prefixes in German. The results are compared to statistics drawn from a corpus associated with German speakers' accurate prediction of sentence-final prefixes.	The study has a number of possible implications for researchers and educators. It can broaden their horizon of the way to use corpora for the creation and assessment of language testing procedures.	1, 2, 3, 6, 7, 8, 11	1, 13-17
Wong et al. (2018)	The article investigates the effects of teaching English prepositions using competition model and schematic diagrams inspired by cognitive linguistics in a computer-based tutorial system. Results showed that instruction was effective in all three feedback groups, as measured by a cloze test and a translation test.	The study has implications for educators and scholars. They can use and investigate the three types of feedback including schematic diagram feedback, metalinguistic rule feedback, and correctness feedback in varying contexts.	1, 2, 3, 10, 11	4, 13-15, 21, 14
Zhao & MacWhinney, (2018)	The study investigates the instructed learning of the English article system by L2 learners using a theoretical framework related to the competition model for analyzing the cues to article usage and for designing effective computer-based article instruction.	There are implications for educators in terms of both theory and pedagogy. The article can help them realize the value of explicit instruction in its own place and use the type of feedback learners need for improving their accuracy problems.	1, 2, 3, 11	4, 15, 21, 24
MacWhinney (2019a)	This chapter deals with the Competition Model and the way it can help us understand language attrition. It elaborates on four puzzles arising from empirical studies of language attrition: Puzzle 1: Permastore, Puzzle 2: Variation across levels, Puzzle 3: Childhood forgetting and Puzzle 4: Catastrophic interference. It then offers solutions to these puzzles. For further reading on competition model, MacWhinney's (2012a) work is also informative.	Studying the chapter can lead every individual teacher or educator to the understanding that language is a dynamic and emergent system based on a complex variety of inputs, systems and sub-systems. To solve the problems with language learning and loss, (the combination of) all of the related processes should be taken into account.	1, 2, 3, 9, 11	1, 2, 3, 421
Bernstein Ratner & MacWhinne (2019)	The belief is that a network of linked linguistic open data can contribute to the study of language structure, usage, processing, and acquisition. The study is hence concerned with TalkBank system which has its origins in 1985 with the Child Language Data Exchange System (CHILDES) functioning successfully and used for data analysis purposes.	The study helps researchers understand TalkBank system, gain automatic access to large corpora that can be automatically analyzed and compute a wide variety of measures such as MLU, IPSyn, DSS, TTR, and many others.	1, 2, 3, 10	1, 27
MacWhinney & Chang (2019);	The studies examine connectionism and language learning with the main themes including symbols and connections, grand pretensions, modest reality, lexical items, homophony, compounds, derivational	The studies can potentially help teachers realize that input to the presented model contains a corpus of syntactic frames,	1, 2, 3, 11	4, 10, 11, 12, 13, 14, 15, 17, 21

Macwhinney, (2000f)	status, and early irregulars. Then, they offer a solution to the lexical learning problem with a view of lexicalist connectionism, maps for retrieval, lexical representation, inflectional morphology, the logical problem, masking mechanism and processing, and a modification system.	phonological association, semantic constructs and pragmatic representations and that all of these constructs are interdependent and intertwined. When they put them in operational definition, the inseparability of the construct is visible.		
MacWhinney (2021)	This chapter surveys TalkBank which provides data during spoken language interactions and attempts to meet individual researchers' needs and their research communities. Also, concerning TalkBank, a research work by MacWhinney, Bird et al. (2004) is informative.	The study can help researchers understand TalkBank and CLAN and accurately perform error analysis developed based on experience in coding errors in aphasia and child language learning.	1, 2, 3, 5, 10	7, 9,19, 21, 27
MacWhinney (2022c)	The study explores the psycholinguistic aspects of second language processing and learning in the light of examining the issues of the trade-off and interaction between implicit and explicit processing and learning, the role of working memory, and processes of proceduralization.	The study can be highly beneficial for teachers and help them understand L2 learning as an emergent process with limitation associated with social inputs, linguistic levels, neuronal support, language competition, neuronal support, and social inputs.	1, 2, 3	2, 21

Table 9

Analysis of the Books

Books	Main Tenet	Implications	Subdiscipline(s)	Domain(s)
MacWhinney (1978a)	The study presents a model detailing the ways in which children in varying language communities acquire the morphophonological structure of their languages. In this model, the processes of combination, rote, and analogy are integrated into a single processing goal stack.	The implications can help educators realize that learning is a cyclical process which leads to application, application leads to correction, and ultimately, correction leads to renewed acquisition: This can help educators get engaged in needs-analysis approach and develop needs-based syllabus and materials.	1, 2, 11	10, 11, 12, 13, 14, 15, 16
MacWhinney (1987b)	The book contains 13 chapters and discuses main themes such as the principles of contrast, SLA theory and machine learning, simplicity and generality of rules in language acquisition, novel word learning and phonology, competition model, variation, and language learning, acquisition of implicit arguments, parsability and learnability, bootstrapping problems in SLA, and a commentary on mechanisms of SLA.	The book is of varying pedagogical applications and implications. Professors can use it as part of course syllabus and materials developers can use it as a key materials-development basis for producing coursebooks.	1, 2, 3, 11	1, 4, 10, 11, 12, 13,15, 21
MacWhinney & Bates (1989)	This volume is a collection of articles representing the state of the art in the competition model. It deals with the issues that crystalize the real-world and linguistic knowledge required for comprehending and generating sentences, and the related psychological processes and cognitive principles within the framework of the competition model and functionalism.	The book can be used as an effective source of input for educators and researchers; it can potentially engage them in understanding the details of the competition model, functionalism, cue-driven learning, sentence processing and language acquisition principles and processes which can lead to varying implicit and explicit justification of educational agendas.	1, 2, 3, 11	1,2,9, 10 15, 17, 21
Fletcher & MacWhinney (1995)	The book contains 25 chapters on language development issues and reflects the up-to-date complete sourcebook on all aspects of child language development, such as phonetics, phonology, grammar, lexical development, connectionism and government-binding theory.	Studying the present book can help researchers and educators gain profound knowledge of the significance of input, social factors and cognition to language development. Also, it can be potentially used as a part of course syllabus.	1,2, 3, 7, 8, 11	1, 4-18, 21

MacWhinney (1999a)	This book presents an emergentist account of language acquisition. It introduces varying approaches and theories and examines the aspects of language such as auditory representations, phonological and articulatory processes, lexical semantics, ambiguity processing, grammaticality judgment, and sentence comprehension.	The book has implications for professors, professionals and researchers. The professors and professionals can use it as a coursebook and as a part of course syllabus. By the same token, researchers can use it as a basis for research in the field of child language acquisition.	1, 2, 7, 9	2, 4, 10, 12, 13, 15, 21
MacWhinney & O'Grady (2015)	The book covers the latest integrated theory, and empirical, and methodological issues for understanding human language. In general, it focuses on the ways in which the learning, processing, and structure of language emerge from a competing set of cognitive, communicative, and biological constraints.	The book can be used by graduates and postgraduates as a more comprehensive source providing effective background for further research and practice in the field of language emergence.	1, 2, 3, 11	2, 4, 5, 10
MacWhinney (1992a, 2000b, 2023a)	The studies deal with CHILDES project which comprises computational tools offering data on second-language learning, adult conversational interactions, and child language acquisition. It contains three parts: The CHAT (Codes for the Human Analysis of Transcripts), the CLAN (Computerized Language Analysis) package of programs, and the CHILDES database (both English speakers' data and non-English data).	The implications of the studies are implicit in understanding the fact that the availability of CHILDES has revolutionized research on language data. Therefore, the books can enable researchers to establish a database, automate the process of data analysis, increase the reliability of transcriptions and share transcript data.	1, 2, 3, 10	1, 7, 21
MacWhinney, Malchukov, & Moravcsik, (2014)	The book is concerned with conflicting factors shaping the content and form of grammatical rules in language usage. The chapters analyze grammar and usage in L1 and L2 and the incentives associated with historical change.	The book will be of interest to linguists, graduates, undergraduates and postgraduates more interested in psycholinguistics, historical linguistics, philosophy of language, and language acquisition.	1, 2,3, 7, 8, 11	1-21

Discussion and Reflection (Brian MacWhinney)

Ali and Hassan have provided a remarkably well-organized and comprehensive review of my work. To round this out, they have asked me to add some further discussion and I am very happy to do that. Given the inclusion of this systematic review in LTRQ, it seems that the most helpful form of this discussion would be to highlight those aspects of my work that have the greatest relevance to language teaching research. Toward that end, I can list the following 11 contributions.

1. The Classic Competition Model

Beginning in 1978, Elizabeth Bates and I worked on the construction of a crosslinguistic model of language learning and sentence processing. Empirical work on this model has continued to the present day, including data from child and adult speakers of 20 languages and resulting in over 120 publications. Most of these studies focus on ways in which listeners and speakers use grammatical cues such as word order, case-marking, stress, or honorifics to mark grammatical roles such as agent and patient. Other studies look at cues to co-reference such as pronoun gender or verb causality. Methods have included eye-movement tracking, EEG, fMRI, object manipulation, picture choice, picture description, and cross-modal matching. The core finding of this research is that, for both first and second language learners, cue validity, as measured in corpus analysis, is the principle and final determinant of cue strength and usage. During early stages of learning, the transfer of strong cues from L1 will impact L2 production and comprehension. However, over time the strengthening of L2 cues weakens the effects of transfer. This basic finding seems obvious, but working out the details of how this work has involved studies and measures in many of the following 10 contributions.

2. Item-Based Patterns

In 1974, I spent a year in Budapest studying how Hungarian children learn their grammar. Based on this data and ideas from Martin Braine, I developed a model of grammatical learning as based on item-based patterns (IBPs). For example, a child who knows the word *cookie* could hear the phrase *more cookie* and realize that the combination refers to getting more of something they want. They would establish an IBP for the word *more* which would then generalize to *more milk*, *more blankets*, and even *more hugs*. Next, the child would compare IBPs for words such as *more*, *this*, or *nice* to form the modifier class as a generalization. There is evidence that second language learners go through a similar process, although it is speeded by the ability to match up with similar structures from L1. It is also promoted by language teaching methods such as pattern drills and build-ups.

IBP theory also links up closely to grammatical dependency models of language structure that are now in the mainstream for computational linguists working on NLP (natural language processing), including recent work on large language models (LLMs) like BERT or ChatGPT, as further discussed in contribution #9 below.

3. E-CALL

Between 2004 and 2014, NSF provided funding for the Pittsburgh Science of Learning Center that included support for studies of language learning. We used this support to create several online language learning tutors and tests that are openly available at https://sla.talkbank.org.

The online tutors include the Pinyin Tutor, the Jyutping Tutor, the English Preposition Tutor, the English Articles Tutor, the German Grammar Tutor, the Spanish Verb Tutor, the Wikipedia German Article Tutor, the VR Tutor, and the CapVid Captioned Video Tutor. There are also resources for designing "Language in the Wild" experiences such as a tour of Pittsburgh or reading of a dimsum menu.

For each of these tutors, patterns of student usage on the web are stored in a structured database that can then be analyzed to discover learning challenges and patterns. In tutors such as the Pinyin Tutor, this data can be used by the program to customize the course of learning for each student to avoid repetition of easy items and to focus on problem areas. This training follows rules for graduated interval recall , as computed by a model for each student (Pavlik, Bolster, Wu, Koedinger, & MacWhinney, 2008). The tutors can also be configured to run online experimental comparisons between different learning conditions, using within-subject designs. The addition of this feature led us to characterize this work as *e-CALL* or experimentalized computer assisted language learning.

Often these experimental comparisons contrasted explicit rule feedback, basic correctness feedback, and no feedback during training and testing. Across studies, we showed that both explicit rule feedback and correctness feedback are initially equally effective. However, after a delay of two to three weeks, rule feedback is better retained and more effective. These tutors also use score icons and other "gamification" methods to bolster a sense of **mastery** of a given target language structure.

4. A Shared Platform

In 2017, based on the wide usage and extensive findings from our e-CALL tutors, I proposed the construction of a shared platform for research on second language learning (MacWhinney, 2017b). By configuring methods for online delivery and experimental control, researchers and instructors could work together to improve language teaching pedagogy and theory. Sites such as IRIS at iris-database.org illustrate the range of methods that could be implemented. Paul Cobb's Compleat Lexical Tutor at https://lextutor.ca shows how well these methods can be implemented on the web. Adding the ability to harvest and share the data from such efforts across learners and learner types internationally would be a great boon for language teaching and learning theory. However, organizing such an effort would require major grant support, and granting agencies currently believe that the promulgation of commercial efforts such as DuoLingo or Rosetta Stone make it unnecessary to fund alternative platforms, even though commercial platforms are not designed to further the analytic study of language learning.

5. TBLT, CALF, CLAN, and ASR

The study of task-based language teaching (TBLT) (Wen & Ahmadian, 2019) has highlighted the measurement of the four learning dimensions of complexity, accuracy, lexical richness, and fluency which are summarized in the abbreviation CALF. The assumptions and methods of TBLT are highly compatible with the findings and formulations of the Competition Model, as discussed in detail in MacWhinney (MacWhinney, 2019e). Moreover, as Lambert (Lambert, 2019) has shown, the CLAN programs used in the TalkBank system can be used to compute each of these dimensions from transcribed corpora. Using our Batchalign2 program (Liu, MacWhinney, Fromm, & Lanzi, 2023) at https://github.com/talkbank, audio recordings in up

to 70 languages can be transcribed automatically in the CHAT format required for analysis by CLAN and inclusion in TalkBank. Batchalign2 can also apply automatic morphosyntactic tagging for grammatical dependency relations based on the Universal Dependencies (UD) framework from https://universaldependencies.org in ways that are very compatible with the IBP framework mentioned in #2. At that point, one can measure grammatical complexity based on the dependency structure. Lexical richness can be computed in CLAN using either the vocD measure (Malvern, Richards, Chipere, & Purán, 2004) or MATTR (Covington & McFall, 2010). Based on the accurate time alignment produced by Batchalign2, fluency can be measured using CLAN's FLUCALC program. Computation of accuracy is more complicated, but we are working on the use of AI (Artificial Intelligence) methods to tackle this fourth dimension of CALF analysis.

6. Age Effects and Emergentism

Although the Classic Competition Model explained many important patterns in first and second language learning, it was not able to account for four aspects of second language learning. First, it ignored the role of social forces on second language learning and input to the learner. Second, it provided little detail on the ways in which the brain supports language learning. Third, it failed to explain ways in which fluency, complexity, and accuracy compete in learners' productions. Fourth, it failed to fully address the evidence pointing to a role for a set of sensitive or critical periods (Werker & Hensch, 2014) putatively blocking nativelike attainment of a second language.

To deal more effectively with these issues, it was necessary to broaden the scope of the Competition Model to include findings from additional research programs. This extended version of the model now formulates language learning as an emergent process, based on evidence from across the sciences that structures emerge across multiple levels because of competing constraints. The emphasis on emergentism is in accord with the dynamic systems approaches articulated by Ellis et al. (2015), Larsen-Freeman (2020), and others. For the level of articulatory phonology, many of these constraints come directly from neural, motor, and physical structures. For other levels, constraints come from memory and processing systems, along with a range of social forces. Applying this analysis to understand age effects in second language acquisition, Caldwell-Harris and MacWhinney (2023) were able to construct an emergentist alternative to the theory of a Critical Period for L2 acquisition. This analysis in terms of levels, constraints, and social inputs has wide-ranging relevance to approaches to language teaching, suggesting that with the proper support mechanisms second language learning can become markedly more effective.

7. TalkBank and ClassBank

Online tutors, captioned video, and immersion experiences provide excellent avenues for second language learning. However, teacher support through classroom or hybrid instruction can serve to bind these experiences together. Unfortunately, there is almost no publicly available data on actual teaching in second language classrooms. This contrasts markedly with the richer tradition of the study of classroom discourse in other subjects. Within the framework of the TalkBank project, the ClassBank system at https://class.talkbank.org provides direct access to a large database of classroom interactions through the custom-made TalkBank

Browser. The TB Browser relies on the fact that the video media is time linked to the transcript so that each utterance can be highlighted as the corresponding interaction plays in the video window. This allows users to study interactions and teaching methods directly. This ability further supports a system called Collaborative Commentary which allows users to comment and code specific utterances or strings of utterances while watching interactions online. For example, the collection of 50 videotaped interactions from K-11 classrooms contributed by the APT (Academically Productive Talk) study group can be coded using the LIDO system (Al-Adeimi & O'Connor, 2021), and agreements on each code can be measured to evaluate the overall validity of the analysis system. This same method can also be applied for training language teachers and can be used by language learners seeking to understand the pragmatics of native language interactions.

8. SLABank

SLABank is a further resource within TalkBank. It includes transcripts linked to audio from studies of second language learning of Czech, English, French, Hungarian, Icelandic, Italian, Mandarin, and Spanish. Of particular interest are large learner corpora from projects such as LANGSNAP, SPLLOC, and Nebrija, along with the classic ESF multilingual corpus. Unlike other systems which provide access primarily to student writing, all SLABank data derive from oral production and most of the corpora are linked to the audio. Because all the corpora are in CHAT format, it is possible to analyze SLABank data through many of the CLAN programs.

9. CHILDES

The largest databank within TalkBank is CHILDES (CHIld Language Data Exchange System) which has been providing access to child language data since 1984. The corpora in CHILDES provide information on language learning from 42 languages across the full age range of the first six years of life. Recently, we have begun intense elaboration of the data to allow crosslinguistic analyses across lexical, phonological, morphological, syntactic, and conversational structures. Using the Universal Dependencies framework mentioned in #5 above, we have tagged the data from 27 languages for part-of-speech, grammatical/semantic features, and grammatical dependency relations. In addition, the complete compatibility of the Phon and CLAN programs allows us to provide accurate IPA codes for many of the transcripts. Using these additional coding tiers, we are now able to examine crosslinguistic differences in the acquisition and usage of a wide variety of language patterns. In the future, we hope to be able to apply similar methods to SLABank data.

10. BilingBank

BilingBank represents the fourth case of TalkBank data that are relevant to language teaching. The interactions in BilingBank focus on adult multilingual speakers engaged in code-switching. Three corpora of particular interest are the Eppler corpus of Jewish children who fled to London during the Nazi occupation of Vienna, the Miami corpus of Spanish-English code-switching in Miami and the Bangor corpus of switching between Welsh and English. To facilitate analyses of these corpora, we have developed a method of utterance-level and word-level tagging based on the idea that there is usually a matrix language (Myers-Scotton, 1997) for an utterance which is then shifted at certain points to the other language. Study of

BilingBank materials can illuminate language teaching in terms of sociolinguistic perspectives, as well as ways of thinking about comparisons between interlanguaging and code-switching. It can also be used to elaborate our understanding of language attrition.

11. Perspective and Mental Models

Underlying my interests in language structure is a certain curiosity regarding the ways in which we go from the acoustic signal to mental models in comprehension and how we convert mental models to spoken forms in production. For each of these processes, the least well understood dimension of processing is the part that involves mental model construction and usage. The theory of Cognitive Grammar provides schematic ways of thinking about mental models, but that theory has failed to incorporate newer evidence from neurolinguistics about embodied and dynamic cognition. As early as 1977 (MacWhinney, 1977), I suggested that, on both the utterance and discourse level, it is the agential human perspective that serves as the primary organizer of mental models and utterances and that the function of grammatical devices is to track shifts of perspective across the three dimensions of actors, space/time, and reference.

I hope that this summary of contributions illustrates the relevance of these tools and findings to second language teaching. Although learning to use these tools, concepts, and data requires a commitment of time and effort, it could help researchers and instructors develop a fuller view of how people learn languages and how to measure and promote that development. To that end, interested readers can find the original papers involved in the construction of each of these contributions at https://psyling.talkbank.org/guides .

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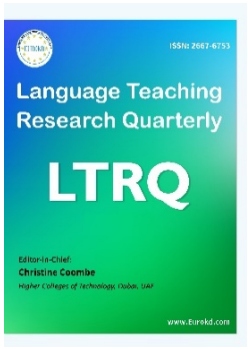

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AFTERWORD

In Honour of Brian MacWhinney: A Personal Account

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Abstract

While this volume and the writings have made it amply clear what significant contributions Professor Brian MacWhinney has made to the field at large, in this afterword, we begin with a senior member of our author team (Ping Li, PL) followed by a mid-career member (Helen Zhao, HZ) and an early career member (Zhe Gao, ZG), to provide our personal accounts of Brian not only as a leading scholar but also as a role model who touches and changes people's lives.

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[1]Ping Li:

I always tell people that if there is anything I have done well, that is because I have met the right person at the right time in the right place. This is so true of meeting and getting to know Brian as a teacher, a mentor, and a friend.

Anyone who knows Brian would describe him as an easy-to-talk, down-to-earth, and friendly professor. As one who has worked with him extensively spanning a 35-year period, this simple characterization is deeply grounded in countless experiences, impressions, and feelings, big and small. When I was in graduate school, I became one of the first cohort of users

[1] This paper is part of a special issue (2024, 44) entitled: In Honour of Brian MacWhinney's Five-Decade Contributions to Language and Psychology Research (edited by Zhisheng (Edward) Wen and Hassan Mohebbi).

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of the Child Language Data Exchange System (CHILDES), then a new idea and new system with some simple codes and a less-than-complete manual (note, that's 1988!). CHILDES allowed me to code all my child language data for my dissertation in a uniform format, and to learn about the convenient tools such as automatically counting of word occurrences in texts (e.g., "freq") – something everyone takes for granted today; more importantly, the use of CHILDES enabled me, then a young graduate student, to see the power of data and programming for language research, and it further inspired me to pursue a more computational oriented research agenda in my career. Over the process of my dissertation work I had asked Brian many technical questions, and I was amazed how helpful he was in providing the answers via emails and WOW, so promptly would this little graduate student (me not even as his own PhD student) get answers from a big professor! – an experience I'm sure many still have today.

Brian was also the gateway for me to know Liz Bates -- to study with Liz and later Jeff Elman was clearly the highlights of my academic career. Because of the inspiration of the Competition Model and my own interests in connecting first language (L1) acquisition (PhD work with Melissa Bowerman and Wolfgang Klein), second language (L2) acquisition/bilingualism (postdoc work with Liz) and computational modeling (postdoc work with Jeff), I had the good fortune to continue my discussions with these good people throughout my later years of research. And it's them who I met at the right time and the right place, and who showered me (and many others of my peers) with not only academic knowledge and skill, but also kindness and friendship.

Brian always has his students in mind. Like Liz Bates, he genuinely provides support to students and peers, for their welfare and success rather than for his own gain. He does not impose his ideas onto others but asks us to think collaboratively and creatively, whether it be a small idea or a big project, as also clearly attested by HZ and ZG below. As a scholar of many accomplishments, Brian is such a low-key person when it comes to honors and recognition; he cares only about science and education instead of fame. Interestingly, seeing this we sometimes did act with joint grassroot efforts to discuss how we could recognize him. My personal experience in this regard involved two events: The nomination of Brian for the Roger Brown Prize (with Annick De Houwer, Aliyah Morgenstern and Yvan Rose), and the organization of the Symposium Honoring the Impact of Brian MacWhinney on Language Research at Carnegie Mellon University (CMU) (with Roman Taraban, Patricia Brooks, Rick Gilmore, Vera Kempe and Janet McDonald), both of which were the results of his colleagues and students spontaneously chatting at meetings and later taking actions.

Brian is not only a technically sophisticated scholar who has a strong interest in technical details (e.g., CHILDES and TalkBank), but also a theorist who wants to and can see the big picture, from the Competition Model to Connectionism to Emergentism. Many scholars are good at one but not the other, and it takes true dedication and hard work (and perhaps a bit of luck) to achieve excellence on both fronts. These are the qualities I aspire to have but never have had, and I have also kept reminding my own students to work on them. We will continue to benefit from Brian's academic insights, wisdom, and humor in the many years to come.

Helen Zhao

I embarked on my PhD journey at CMU with Brian in August 2008. Establishing the supervision wasn't without its challenges. For at least half a year, I struggled to define the

direction and topic of my dissertation. Brian's expertise spans a wide range of areas, from first and second language acquisition to experimental psychology, aphasia, corpus linguistics, computational linguistics, online tutoring systems, etc. On whichever topic I proposed for discussion, Brian would introduce me to at least three new researchers whose work was miles away from what I was familiar with. This led to extensive reading after each supervision meeting, yet I still lacked a clear dissertation topic. This period of uncertainty was marked by stress and anxiety. Eventually, Brian reminded me of my original intention to pursue a PhD: to assist millions of second language learners of English, particularly those from Asian language backgrounds like mine, in acquiring complex English grammatical features. This commitment won Brian's ultimate approval, and we settled on the topic of English article learning. This overarching theme has guided my research and teaching ever since. It keeps me focused on the important meaning and value of my work.

As I've come to know Brian better over the years, I've learned that his academic journey is also one deeply rooted in his passion for exploring his language and cultural heritage. Many may wonder why someone with such a solid Irish name as Brian MacWhinney seldom publishes research on the Irish language but extensively covers Hungarian studies. In fact, fully half of Brian's heritage is Hungarian, with his mother's family having emigrated to New York in the early 20th century. Although Brian's mother spoke Hungarian as her first language, she did not teach it to Brian. It wasn't until Brian attended graduate school at UC Berkeley in the late 1960s that he began learning Hungarian. At Berkeley, where Chomskyan linguistics dominated during that period, Brian became fascinated with child language acquisition but struggled to reconcile the literature on this topic with Chomsky's theory. Encouraged by Dan Slobin, John Gumperz, and Susan Ervin-Tripp, Brian decided to do his PhD dissertation on the acquisition of a language whose structure was very different from English. Hungarian, his heritage language, became his natural choice. He was fortunate to receive a dissertation grant from the Ford Foundation, which enabled him to conduct extensive fieldwork in Hungary. This trip brought back approximately 100 hours of dialogues from five Hungarian-speaking children, resulting in one of the earliest and most valuable collections of spoken and transcribed child language data. It was this dataset that became the source for some of the most fundamental and influential concepts of usage-based approaches to language acquisition, including bottom-up item-based learning and input-driven syntactic learning. Alongside his academic pursuits, Brian never wavered in his dedication to learning Hungarian. Despite being an adult learner way past the critical period, he is now fluent in Hungarian and has authored one of the most comprehensive and widely cited English descriptions of Hungarian grammar.

Brian imparted to me a crucial lesson through his own academic journey: the importance of perseverance in breaking new boundaries in our work. I was initially educated as an English major at a Chinese university famous for cultivating language translators and diplomats. Before doing my PhD, my academic focus centered on linguistics and applied linguistics. The CMU PhD program that I enrolled in specialized in Second Language Acquisition (SLA), a sub-area of applied linguistics. I originally envisioned my dissertation to be safely enclosed within this sphere. However, this perception changed upon working with Brian.

Throughout his academic career, Brian consistently expanded his intellectual horizons across various disciplines. His undergraduate studies encompassed Spanish, Rhetoric, and Geology, followed by a Master's degree in Speech Science, and a doctoral degree in

Psycholinguistics. His initial academic position was not in linguistics but in Developmental Psychology at the University of Denver. Despite lacking a formal degree in general Psychology, he quickly adapted and managed to learn developmental psychology on his first job. He became more as a psychologist than as a linguist. In 1981, Brian secured a position at CMU Psychology and began to work with cognitive psychologists like Herbert Simon and John Anderson. He and Anderson proposed to collaborate on the construction of a computational model of grammar learning, which introduced Brian to the realm of computational linguistics. He started to learn to do computer programming. It was this collaborative project that triggered his idea of building a computerized corpus of English child language data, which later became one of the most influential corpora worldwide, CHILDES. This corpus solidified his global reputation in corpus linguistics. Brian remains a persistent pioneer in exploring new theoretical frontiers and creating innovative research tools. For him, that is just the way it is.

Under Brian's mentorship, I realized the necessity of transcending my limited comfort zone. Advised by Brian, I pursued coursework in both the Department of Languages, Cultures & Applied Linguistics and the Department of Psychology for my PhD, a departure from the norm among my peers. His support led me to join the Pittsburgh Science of Learning Center (PSLC), an interdisciplinary hub comprising scholars from psychology, computer science, natural language processing, and human-computer interaction. The exposure to diverse methodologies and perspectives at PSLC expanded my intellectual horizons beyond linguistics. As I engaged in stimulating intellectual exchanges with scholars from diverse fields, I recognized the value of interdisciplinary collaboration. These experiences during my doctoral studies greatly influenced my career trajectory and approach to mentoring students.

In an interview, Brian advised young researchers, "Learn how to expand your thinking gradually and purposefully. The world of thought is full of hundreds of bridges and valleys, each of which connects to other bridges and valleys. By slowly moving across these bridges and valleys without abandoning old territory, you will expand your understanding and consciousness." Over the years beyond my PhD life, I have come to deeply appreciate Brian's philosophy on life, work, and thought. Implementing this philosophy is not easy, but I am grateful to have Brian as a lifelong role model, a source of inspiration and citation, and a guiding beacon.

Zhe Gao

I studied as a PhD student with Brian MacWhinney and Seth Wiener (Brian led to my contact with Seth) at CMU from 2017 to 2022. Even though I have graduated from CMU for a year and a half, my experience and fast growth there have been so precious for me and made Pittsburgh my academic hometown.

Brian guided me to find hard but important problems and ways to solve them. This journey broadened my horizons, ignited my own passions, taught me to ask questions, and sharpened my problem-solving skills. Observing the challenges in learning Chinese compounds by my students from Chinese classes and considering the large number of the compounds in Chinese language, I chose Chinese compounds as the topic of my PhD research.

Brian's broad research interests have guided me to pursue a highly interdisciplinary approach when developing technology-enhanced innovations for language learners. He encouraged me to break the boundaries and define my own field. Human-computer interaction

provides human-centered designs with various platforms such as Apps, websites and virtual reality; cognitive neuroscience, psycholinguistics and learning science jointly lay a theoretical foundation; and quantitative experimental methods test my hypotheses. And I truly hope that the tools really help the learners. To prepare myself for such work, I took and audited courses offered by multiple departments, including Languages, Cultures and Applied Linguistics, Psychology, Statistics, Computer Science, Language and Technology Institute, etc. Despite the huge challenges of pursuing Grade As, I gained knowledge and skills in those fields and learned how to communicate and work with people from different backgrounds. Side but important effects were that I developed the ability to juggle multiple tasks, deal with stress, and make a lot of friends.

Brian truly cares about students' development and success, so he adjusted his advising approach based on our needs. I was so fortunate to have Brian and Seth as my advisors. They both adjusted their own styles to fit this co-advising team, and they were actually so willing to advise me in a collaborative way that I was able to take the most from their joint efforts.

Besides Brian's enormous scholarly work and broad research expertise, I have been inspired by working with him daily as a PhD student. My learning occurred in my email tradings with him, my countless stopping-bys at his office, going to conferences with him, and having coffee chats with him. To quote a lyric from a classical Chinese poem, Brian's influences on me are like spring rain, "moistening and nourishing the nature/me, exquisitely and silently" (润物细无声, run4 wu4 xi4 wu2 sheng1, moisten-object-gently-no-sound). Let me share two snapshots.

Similar to a lot of professors at CMU, Brian had an open-door policy: as long as his office was open, students could stop by his office and have a chat with him. But different from most professors, he seemingly scarcely closed his door, unless he needed to meet someone or do serious writing. I had benefited well from this policy. Whenever I had a question, I walked to Brian's office in Baker Hall. Brian usually shifted his gaze from his desktop screen to me, smiled and had a ten-minute chat with me. The topics of the chats were never limited to SLA and psycholinguistics. For example, I once mentioned that a lot of ground-breaking scientific findings that were counter-intuitive for the people in their initial eras have become common knowledge nowadays. Brian raised examples like the theory of continental drift and linked this claim with the development of psycholinguistic theories. Suddenly, the chat became a discussion on the history of science.

The punctuality of Brian's responses never decreased their quality because of his very careful thoughts. Right after the extensive reading period, as HZ mentioned, I started an experimental study on L2 learning of Chinese compounds. Without any experience of running an experiment with interventions, every step from problem formulation to writing was just tough for me. At the end of that semester, I told Brian in an upset tone: "I don't have confidence in surviving another semester like this." Brian responded: "The fact that you have done so well and overcome so many challenges this semester should in itself give you confidence." His words provided me a data-driven strategy of dealing with future difficulties and boosting my confidence. All account. The accumulated experience, knowledge and skills from previous setbacks and failures are my ladder to move forward. In addition, he reminded me that self-confidence came from my own hard work, not from anyone or anything else. Paying attention

to the process and enthusiastically learning from failures have become my way of practicing the model, “what does not kill you makes you stronger”.

For Brian, mentoring goes beyond teaching knowledge and guiding research. It is about students’ development as a person, and we all have greatly benefited from this philosophy.

Ending note from Ping Li

Brian is personable, unintimidating, and always open to new ideas. In a world where personal relationships and societies are rifting apart due to the pandemic, political conflicts and views, and different academic traditions and opinions, Brian sets a remarkable role model as a person on top of his scholarship, which is inspiring, and which I hope becomes contagious. We firmly believe that, for academic success as well as other domains, it is absolutely crucial to work with the right people, and therefore we all need to aspire to be that right person as Brian is.

Group photo at the Symposium Honoring the Impact of Brian MacWhinney on Language Research



Photos: Brian with Helen Zhao, Ping Li, and Zhe Gao

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