# Speech Perception and Production in L2

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Edited by

Elena Kkese

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This book first published 2022

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

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## Contributors

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**George GEORGIOU** is a faculty member at the Department of Languages and Literature of the University of Nicosia and he is the coordinator of the Cyprus Linguistics and the Humanities Research Group. He has previously worked as a Postdoctoral Researcher and Assistant Lecturer in Linguistics at RUDN University, as a Postdoctoral Researcher in Speech-Language Pathology at the Cyprus University of Technology, and as an Associate Lecturer in Linguistics at the University of Central Lancashire. He has also served as the Head of RUDN University Phonetic Lab and Principal Investigator on speech acquisition projects. He has published more than 22 papers in high-impact international standing journals. He has been awarded two times the Research Recognition Award by the University of Nicosia and he was won three national and international research grants.

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**Efrat LAST**, MA, has been a Speech and Language Therapist since 2003 and is currently working at her privately owned clinic, as well as doing student supervision. Efrat specializes in pediatric speech therapy, focusing on articulation, language, stuttering and voice disorders. Efrat's Masters thesis on accent acquisition was inspired by her childhood as a diplomat's daughter who lived in 5 countries and was exposed to various languages and accents. Efrat is married and the mother of four girls and a boy.

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**Olga TARAROVA** (PhD, University of Toronto, Canada) is an Assistant Professor at the University of Western Ontario, Canada, where she teaches both at the graduate and undergraduate levels courses in *SLA and Third*

*Language Acquisition, Introduction to Linguistics, Comparative Analysis of Spanish and English, Sociolinguistics, Heritage Speakers and Bilingualism,* among others. During her Masters and PhD, she worked with a heritage Italian community, Chipilo in Mexico who has preserved their language for over 130 years, so she has extensive knowledge in heritage languages, issues concerning language maintenance and loss, grammar of heritage speakers. Her interests include sociolinguistics, languages in contact, heritage speakers, bilingualism, SLA, and methodology and teaching. Her current projects include 1) feature transfer in L3 from typologically different languages (Mandarin, Russian, English and Spanish) and 2) implementation of hybrid courses. In the past 5 years, she has published in 8 journals and presented at over 30 conferences, both locally and abroad.

# INTRODUCTION

# ELENA KKESE

One of the difficulties of second language (L2) users refers to phonological processing as L2 sounds are often difficult to be both perceived and produced. Some sounds may cause more problems than others while nativelike performance is very rarely achieved. Based on most speech perception and production theories, there is a relatively straightforward relationship between the two modalities, which enables them to share representations and processes. Speech perception starts with auditory processing of words; these sounds are then mapped onto phonetic and phonological representations, lexical representations, and semantic representations. Speech production, on the other hand, is described in reverse as the semantic representation needs to be accessed first, followed by the lexical representation, and then the sound structure before the word is produced using articulators. This volume examines the interaction between speech perception and production in L2 presenting evidence based on theoretical and empirical research on the linguistic situations in different countries -the United States of America, Greece, Northern Cyprus, Canada, the Republic of Cyprus, Israel, and Spain.

The book comprises eleven chapters, of which four focus on speech perception and production in L2 in Cyprus, a linguistically unique island in the Eastern Mediterranean Sea, which despite its minute size, its linguistic situation is of special interest due to its multilingual and multicultural character. The official languages of the Republic of Cyprus are Greek and Turkish while Cypriot-Greek is the vernacular or low variety; English, the language of the island's former British colonisers, is also widely used (Kkese, 2020). Further, in Northern Cyprus, the official language is Turkish while English is also used and the vernacular is Cypriot Turkish (Zheng, 2015).

The chapters in this volume are grouped under two themes. Five papers in Part 1 discuss theoretical issues related to speech perception and production in L2 while six papers in Part 2 are based on research conducted in different

linguistic L2 contexts concentrating on issues related to speech perception and production.

The five papers in Part 1 discuss how speech perception and production in L2 could affect different skills in the L2 classroom context such as structured literacy (when it comes to reading and spelling instruction), pronunciation, and generally bilingualism. It could further influence clinical contexts, where aptitude in linguistic diversity is interwoven with learning or therapy success. Even though speech perception and production have been characterised as categorical processes, these are affected by the speaker's face and gestures as well as the actual sound of the speech (Massaro, 1998).

In the first paper of this volume, a veteran speech-language pathologist and literacy expert describes how language science guides a best-practices approach to literacy instruction for all students, including students learning an L2 and students with language processing difficulties like dyslexia. In her paper *Research-to-Practice: Language Science as a Guide to Structured Literacy, Speech Perception, and Production*, Sandie Barrie Blackley delineates essential elements of a research-informed and scalable structured literacy approach. The chapter provides a checklist of features to look for in a science-backed, effective, and efficient word structure curriculum and concludes with a challenge for the future.

The second paper focuses on the phonetic elements influenced by bilingualism, as seen in various studies on bilingual speakers. Pagona-Niki Efstathopoulou writes about the relation of L1 and L2 by studying bilingual speakers having as L1 some of languages spoken in the Mediterranean Sea in her paper *Discussing Bilingualism Based on Phonetic Elements Attested in Speech Production*. The focus is on how bilingualism affects segmental and/or suprasegmental phonetic features in the L1 or in L2 speech production.

The author of the third chapter examines the multimodal nature of speech perception, namely, auditory-visual perception. In *Facilitation of L2 Instruction with Data from Auditory-Visual Speech Perception Research*, Doğu Erdener handles L2 as auditory-visual speech perception over three dimensions: (1) L2's relevance to cross-language speech perception theories and how they are revised from an auditory-visual perspective; (2a) how auditory-visual speech mediates the relationship between L2 speech perception and production; (2b) via the L1-L2 orthographic relationship. His paper emphasizes that knowledge from auditory-only speech perception and auditory-visual speech perception research can assist L2 instruction.

In her chapter *The Arcadian Greek Syllable*, Photini Coutsougera examines the syllable of Arcadian Greek in an effort to understand its prosody in more depth and compare it with the Standard Modern Greek (SMG) syllable. In her paper, she investigates Arcadian Greek, which is a nonstandard variety of the L1 SMG; until recently it was thought to resemble SMG too closely to be worthy of study or research (Newton, 1972: 14). In this context, the Arcadian Greek syllable is examined and analyzed on the basis of (a) Kahn's (1976) syllabification model based on the onset maximization principle and (b) sonority requirements and the Sonority Sequencing Principle. Based on the comparison, the onset maximization model accounts for the syllabification of Arcadian Greek more insightfully as it elegantly avoids assigning obstruent codas (with one or two rare exceptions) to the Arcadian Greek syllable.

The author of the final chapter in Part 1 of the book examines speech errors adult native speakers of Standard Modern Greek make when they speak in L2 English. In her paper *Speech Errors Greeks make in English: A Tutorial,* Elena Babatsouli provides a review of literature on L2 English speech production by native Greek speakers. The chapter continues with a comprehensive delineation of the speech errors occurring in individual sounds (segments) and their combinations across prosodic contexts (phonotactics) that native Greek speakers make when speaking English as an L2, providing examples from original data collected over the past ten years as well as on available published data to identify the contexts of such interlanguage errors. The practical significance of this is to provide a useful yardstick for use in L2 instruction settings, either in classrooms or for independent use, and in clinical contexts, where aptitude in linguistic diversity is interwoven with learning or therapy success.

Part 2 of this volume contains six chapters on research relating to speech perception and production in L2 in different linguistic contexts -Canada, Israel, the Republic of Cyprus, and Spain.

The first paper of this part is a sociophonetic pilot study comparing the phenomenon of complete elision in Spanish past participle *-ar* verbs among Latin American Spanish native speakers and English-speaking Spanish L2 learners. In their paper, *The Italian Palatal Lateral and Italian Palatal Nasal: How does English-Speaking Leaners' Production Differ from the Native Speakers?* Giulia Cortiana and Olga Tararova examine the L2 production of the Italian palatal lateral /ʎ/ and the palatal nasal /ɲ/. The stimuli included 48 Italian target words, and an acoustic analysis of 52 tokens was conducted. The findings of this study are important because they

show that L2 learners have difficulty acquiring the phonetic parameters of some L2 sounds.

The Republic of Cyprus is the context of the seventh, eighth and ninth papers. In the seventh paper, High Variability Phonetic Training (HVPT) is proposed as a way to provide naturalistic exposure to L2 learners in order to facilitate the formation of L2 phonetic categories. In her paper *Perceptual Training Effects on the Perception and Production of L2 English Vowels by L1 Greek-Cypriot Learners,* Dimitra Dimitriou examines the effect of eight sessions of High Variability Phonetic Training (HVPT) on the perception and production of English vowels by adult Greek-Cypriot (intermediate) learners, in the absence of any production training. The paper also examines the generalisability of any acquired knowledge to new speakers and contexts.

The learning of English in the Republic of Cyprus at the tertiary level is a topic that has been understudied and it is of particular interest that the focus of the eighth paper in this section throws light on the *Effect of Talker Gender Information on Speech Perception in L2 English.* In this chapter Elena Kkese and Sviatlana Karpava examine how talker gender could influence L2 speech processing, like phoneme categorisation of English consonants and vowels by Cypriot-Greek speakers. The findings indicate that performance is significantly better regarding vowels when the talker is female but when the talker is male, performance is significantly better concerning consonants.

In their chapter *L2 Phone Perception on a Syllabic Level might be Driven by L1 Transfer Mechanisms and/or Universal Patterns of Phone Acquisition,* Elena Kkese and George Georgiou examine how contrastive L2 English plosives on syllable-level are perceived by Cypriot-Greek speakers and how the use of L2 affects these perceptions. The data suggest syllables are important in segmental perception of spoken L2 English, while L1 transfer and universality of phone perception may be influential factors.

The penultimate paper in Part 2 examines the factors influencing the perceived foreign accent of American immigrants to Israel. In their paper *Perception and Production of Hebrew Accent among Female American Immigrants to Israel*, Efrat Last et al. found a nonlinear effect of age of immigration, and an additional factor of time spent daily speaking Hebrew. The acoustic features best correlated with accent were F2 of /u/ and /e/, F1 of /e/, and the VOT of unvoiced plosives. Finally, they found that immigrants had difficulties in acquiring the native /l/, as compared to /r/.

This volume concludes with *The Role of Acoustic Memory and Phonological Short-Term Memory in Non-Native Perception: Which Memory Matters More and When?* Vita Kogan discusses phonological short-term memory (PSTM) and acoustic memory (AM) in their relation to non-native speech perception. PSTM is thought to facilitate the development of target-like cue-weighting and is an important factor in the acquisition of L2 categories (Cerviño-Povedano & Mora, 2015; MacKay, Meador & Flege, 2001) while AM is believed to be responsible for storing acoustic information at a pre-categorical level, and it also contributes to the task of L2 speech perception and learning (Safronova, 2016). In her study, monolingual Spanish speakers were asked to discriminate between two members of an unfamiliar (L0) Russian contrast /i - ɨ/ that does not exist in Spanish. The results indicate that naïve listeners rely on AM and not on PSTM when discriminating an unfamiliar vocalic contrast. L2 learners seem to employ both PSTM and AM in the same task.

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# PART I:

# THEORETICAL PERSPECTIVES OF SPEECH PERCEPTION AND PRODUCTION IN L2

CHAPTER ONE

RESEARCH-TO-PRACTICE:
LANGUAGE SCIENCE AS A GUIDE
TO STRUCTURED LITERACY, SPEECH
PERCEPTION, AND PRODUCTION

SANDIE BARRIE BLACKLEY

## Abstract

Spoken language underpins literacy. Computational modeling has described how reading skills grow, how spoken words trigger learning, and how novel printed words are learned through a combination of context (semantic and syntactic knowledge) and phonological recoding. Across languages and individuals, science is illuminating how beginning readers become proficient readers, leading to some specific, best-practice guidance for teaching students to read and spell. The chapter provides a checklist of features to look for in a science-backed, effective, and efficient word structure curriculum and concludes with a challenge for the future.

**Keywords:** reading, spelling, literacy, statistical learning, reading science, simple view of reading

## 1. Introduction

Education and literacy rates have grown steadily worldwide over the past century, enabling rapid economic and social progress and fostering health and wellbeing (Roser & Ortiz-Ospina, 2016). While the definition of literacy is broad, reading, the oral interpretation of written language, is central to all types of literacy and is a major driver of economic and social well-being worldwide (Castles, Rastle, & Nation, 2018). At the same time, there are now many more bilingual or multilingual individuals in the world than there are monolingual individuals, as well as many more children who

are educated through a later-acquired language than there are children educated exclusively through their first language (Tucker, 1999). English is the most common second language in the world and serves as the world's lingua franca (Paulesu et al., 2021). Yet, in the United States alone there are almost five million public school students whose English language proficiency is limited (National Center for Educational Statistics, 2021).

Reading and writing is a cognitive feat unique to humans (and, recently, the computers humans build). As Grainger and Holcomb (2009) as well as Grainger and Ziegler (2011) have pointed out, reading requires extraordinarily complex, multidimensional processing:

> ".... visual word recognition is a mixture of two worlds: one whose main dimension is space – the world of visual objects; and the other whose main dimension is time – the world of spoken language. Skilled readers might therefore have learned to capitalize on this particularity, using structure in space in order to optimize the mapping of an orthographic form onto semantics, and using structure in time in order to optimize the mapping of an orthographic form onto phonology." (Grainger & Ziegler, 2011, p.4).

## 2. The Science of Reading

The Simple View of Reading (Gough & Tunmer, 1986; Hoover & Gough, 1990; Hoover & Tunmer, 2018; Tunmer & Hoover, 2019; Hoover & Tunmer, 2020) is a theoretical model for how people learn to read, with strong, consensus research support (Petscher et al., 2020) and applicability across languages, cultures, and time. It involves two main, interdependent processes: 1) word recognition processes and 2) oral language comprehension processes. The famous Reading Rope infographic (Scarborough, 2001) illustrates these two processes and how they interact (see the infographic on the webpage of the International Dyslexia Association: Scarborough's Reading Rope: A Groundbreaking Infographic). In this chapter, we will focus on word recognition processes.

In alphabetic systems, the phonemes of the language are represented by letters or groups of letters. In these languages, regardless of the consistency of their spelling-sound correspondences (orthographic depth), phoneme isolation and phoneme-grapheme association trigger the acquisition of the alphabetic principle, which underpins the word recognition process described in the Simple View model.

The ultimate goal of learning to read is to comprehend what is read, and to do that, students must understand how their language's writing system

codes spoken language. Even when reading silently, there is good evidence that reading involves the activation of phonology (Brysbaert, 2019). Since the 1970s, cognitive scientists have described with increasing specificity how beginning readers in alphabetic languages become proficient readers using a dual route to word identification: 1) a sub-lexical route that requires using letter–sound relationships to identify the pronunciation of a novel printed word and 2) a lexical route in which words are automatically recognized, without requiring phonological recoding (Coltheart, 2005). Connectionist models hypothesize that three interrelated domains make word reading possible:

- phonological (pronunciation)
- orthographic (spelling)
- semantic (meaning)

Computational modeling has further described how reading skills grow, how spoken words trigger learning, and how novel printed words are learned through a combination of context (semantic and syntactic knowledge) and phonological recoding (Pritchard et al., 2018). The idea that learning to read involves learning statistical mappings between spelling, sound, and meaning is well-established in reading science (Arciuli, 2018; Qi et al., 2019; Treiman & Kessler, 2021), though not in education (Seidenberg, 2017).

The extent to which readers rely on each route may vary as a function of the orthographic consistency of a language (see Marinelli et al., 2020; Schmalz et al., 2015). Fluent word recognition requires more years in languages like English that have less transparent, more complex orthographies (e.g., Seymour et al., 2003), but when decoding is taken into account similar developmental trajectories are found across orthographies (Frost, 2012; Megherbi et al., 2018).  For English, the importance of direct, systematic instruction focused on speech sounds and letter symbols and, specifically, on letter-sound associations (i.e., phonics) has been repeatedly demonstrated. For a review, see Castles, Rastle, and Nation (2018).

The way with which graphemes and phonemes are associated during reading acquisition also shapes the development of the reading system (Ziegler et al., 2005; Ziegler et al., 2020). Research addressing the core mechanisms involved in cross-linguistic transfer of print-to-sound mappings is in its infancy, but recent research (Paulesu et al., 2021) suggests that for high-proficient bilingual Italian-English adult readers, learning the relatively consistent orthography (Italian) first establishes more efficient sets of

orthographic representations for reading and, hence, is beneficial. However, it should be noted that in this otherwise well-controlled study, one thing that was not controlled was the instructional approach used to teach the research subjects the foundations of reading as children (e.g., a phonics versus a whole-language approach).

While word recognition is achieved with unconscious ease by most people, a significant percentage of people struggle with it. The most common reason for reading problems in otherwise cognitively normal individuals is dyslexia, a difficulty related to word recognition processes as opposed to language comprehension processes. Shaywitz (1998) and Shaywitz et al. (1999) noted that dyslexia is perhaps the most common neurobehavioral disorder affecting children, with prevalence rates as high as 17.5 percent.

In what they referred to as the Lexical Quality Hypothesis (LQH), Perfetti (2007) and Perfetti and Hart (2002) postulated that less skilled readers have difficulty with reading comprehension due to inaccurate and laborious word reading caused by weak (poor quality) connections among the three domains of phonology, orthography and meaning. Across orthographies and educational contexts, difficulty with phoneme isolation and categorization tends to be predictive of reading problems, especially in less than transparent orthographies (Cook et al., 2016; Richlan, 2014; Solheim et al., 2021). Phonological awareness and specifically phoneme isolation is a foundational skill for reading acquisition (Georgiou et al., 2021; Milankov et al., 2021), even in non-alphabetic orthographies (Ho et al., 2011). Even in languages that are not alphabetic such as Japanese, the reading acquisition process can be disrupted when a student has difficulty with phoneme isolation (Hoeft et al., 2015). What exactly drives the relationship between reading ability and phonemic skills is not entirely clear (O'Brien et al., 2018). For example, the difficulty may be related to the accessibility of phonological representations or to difficulties with discrimination or perception (Boets et al., 2013; Virtala et al., 2020). In any case, one of the strongest predictors of reading difficulties across languages is actually rapid automatized naming (RAN) (Araújo et al., 2020; Vataja et al., 2021), which is viewed as a measure of the efficiency of phonological retrieval.

Further, Nora et al. (2021) found that students at genetic risk for dyslexia had underspecified, left-hemispheric lexical phonological representations and poorer long-term explicit memory for novel word forms. Since students with word reading difficulties like dyslexia typically avoid reading (Haft et al., 2019), there has been speculation that their weak phonological skills may be a result and not a cause of their reading difficulties. However, in a

longitudinal study using structural magnetic resonance imaging techniques, Kuhl et al. (2020) found that compared to controls, children with dyslexia had significantly lower phonological processing skills and altered functional and structural connectivity within a left-hemispheric network, both before and after literacy instruction, supporting the conclusion that dyslexia originates from an atypical maturation of the speech network. They further noted, "...individuals with dyslexia hyperactivate the ventral premotor cortex during speech processing, presumably because they have to rely more strongly on articulation strategies to compensate for faulty encoding of phonemes…" (p.8).

It is clear that specific guidance for literacy instruction is relative to a number of factors, including the orthography of the language being learned, the reading subskill (i.e., word identification vs. spelling) being taught, and student factors such as bilingualism or dyslexia (Petscher et al., 2020). Nevertheless, across languages and individuals, some general principles pertain to the practice of teaching word identification and spelling.

## 3. The Practice: Language Science as a Guide to Word Reading and Spelling Instruction

Seidenberg et al. (2020) identify six challenges to connecting reading science and practice:

1. Pursue cross-disciplinary collaborations.
2. Work toward a new science of teaching.
3. Avoid a narrow focus on phonics.
4. Invest in early learning.
5. Develop a science of reading that applies to all readers.
6. Examine existing systems of learning. (p. 9)

As suggested by the sixth item in the list above, it is important to recognize the overarching principles related to teaching and learning in general. Dehaene (2020) has summarized these basic principles in his "Four Pillars of Learning":

- Attention
- Active engagement
- Error feedback
- Consolidation (through sleep)

With these four overarching principles in mind, we will consider the science-backed principles for teaching students to read words and spell proficiently.

Words are central in both oral communication and written communication. Whether communicating orally or in writing, knowing the meaning of a word is essential. But unlike spoken language, learning to read requires developing mental representations for internal (sublexical) word structures. As reviewed above, the mental representations needed for proficient word reading fall in three domains:

- phonological (pronunciation)
- orthographic (spelling)
- semantic (meaning)

These domains are not separate. They interrelate and intertwine (e.g., Llompart, 2021). Further, much of the knowledge in these domains tends to be unconscious. Examples from English include:

- The past tense suffix is always spelled -ed. When it is added to a base word that ends with a voiceless consonant, the suffix is pronounced /t/. When it is added to a base word that ends with a voiced consonant, it is pronounced /d/ unless the base word ends with a /t/ or /d/, in which case it is pronounced /əd/ or /ɪd/.
- In the word *sign*, the <g> is not pronounced, but it is pronounced in the affixed word *signal*.
- In the noun *record* the first syllable is stressed: /ˈrɛ.kərd/. But in the verb *record,* the second is stressed: /rɪ.ˈkɔrd/.

The instructional process is designed to raise the student's awareness of each mental representation, illustrate how it connects to mental representations in the other domains and then, through adequate practice, allow for its automatic and, ultimately, unconscious use. This process is complex and takes a period of years but, as described above, providing instruction using research-backed principles can greatly improve reading and spelling proficiency.

Following is a checklist of features to look for in an effective and efficient word structure curriculum:

- Uses a connectionist approach that identifies the elements or structures in multiple domains and connects them to one another (e.g., Afacan et al., 2017; Donegan & Wanzek, 2021; Ramus et al., 2013; Rayner

et al., 2001; Saletta et al., 2016; Seidenberg, 2005; Ziegler et al., 2020). For example, predictable patterns for pronouncing letters are explained (e.g., the letter <c> is pronounced /k/ as in *call, cup, common* unless it comes before <e>, <i>, or <y>, in which case it is pronounced /s/ as in *cell, city, cycle*. Pronunciation and spelling patterns are connected to meaning through morphology (e.g., the words *city*, *civic* and *citizen* have a common base element).

- Begins early, with a focus on the oral language underpinnings of literacy in preschool (Byers-Heinlein & Lew-Williams, 2013; Jin et al., 2020; Lyster et al., 2020; Scarborough, 2001).

- Begins with a small set of the most consistent and frequent elements (Vousden et al., 2011). Build systematically from simple word structure elements to more complex elements (Petscher et al., 2020). For example, a beginning step is teaching phonemes that are both frequent and that have consistent spellings, such as /s/, /l/, /t/, /æ/. A later step in teaching the multiple ways to spell the tense (aka, long) vowel sounds (e.g., m<u>ai</u>l, m<u>a</u>l<u>e</u>, m<u>ay</u>) should be introduced as a later step.

- Provides phonemic awareness practice as a regular part of foundational lessons, even when teaching a consistent orthography (Georgiou et al., 2021). Establishes clear and precise mental models of phonemes with special attention to those that are difficult for the individual to separate or perceive (Chládková & Paillereau, 2020; Liberman, 1973; Liberman et al., 1990).

- Uses a speech-to-print framework (Moats, 2020). In a speech-to-print framework, the teacher begins with a speech sound (e.g., /k/) and after being sure the student can isolate and differentiate it from similar sounds, s/he introduces the way(s) it is spelled (e.g., <c>, <k>, <ck>, etc.). In contrast, a print-to-speech framework begins in the opposite direction, showing the student a letter (e.g., <c>) and then telling him/her how it is pronounced (e.g., /k/). Of course, sound-letter associations are bidirectional, but starting with the speech sound rather than the written symbol provides an opportunity to focus solely on the speech element (e.g., a phoneme), to contrast it to similar elements (e.g., /b/ versus /p/ or /ɛ/ versus /ɪ/).

- Provides enough instruction and practice in writing letters, using a movement pathway approach, to allow consistent, automatic, and effortless letter writing for spelling words (e.g., Feng et al., 2019; Pritchard et al., 2020). Each letter formation has its own mental representation.

- Provides enough instruction and practice with letter-sound association to allow consistent, automatic, and effortless word identification (Petscher et al., 2020). Each letter-sound association is a mental representation. There are networks of letter-sound and sound-letter associations. Each time a new spelling pattern is introduced, the previous patterns are reviewed.
- Provides direct and explicit instruction and practice in how to spell words using predictable orthotactic patterns (Castles, Rastle, & Nation, 2018; Treiman & Kessler, 2019). Not all patterns are equal in their frequency of occurrence nor in their potential to improve performance, so it is important to target the most useful patterns. Taking one of the most complex examples from English orthography, the patterns for spelling /k/ would be introduced over time from basic to advanced:
  - /k/ is spelled <c> before an -a-, -o- or -u- (Examples: *cat, cot, cute*).
  - /k/ is spelled <k> before an -i-, -e- or -y- (Examples: *kit, key, sky*)
  - /k/ is spelled <ck> after a one letter short vowel sound at the end of a one syllable base word (Examples: *back, lick*).
  - /k/ is usually spelled <c> at the end of a multisyllable base word (Examples: *attic, panic*).
  - /k/ is part of a consonant blend /ks/, spelled <x> after a one letter short vowel at the end of a base word (Examples: *wax, tax*).
  - /k/ is spelled <q> in the <qu> spelling pattern before a vowel (Examples: *quiz, squash*).
  - /k/ is spelled <c> when it is the first sound in a consonant blend (Examples: *clip, creek, pact*).
  - /k/ is spelled <k> when it is the second sound in a consonant blend (Examples: *skate, tank, walk*).
  - /k/ is spelled <ch> in words that come from Greek (Examples: *Christmas, choir*).
- Provides direct and explicit instruction and practice with morphology to support vocabulary growth, word use and spelling (Yadav & Yadav, 2021).
- Provides direct and explicit instruction and practice to support vocabulary growth, connecting pronunciation and spelling to meaning (Austin et al., 2021; Baxter et al., 2021; Petscher et al., 2020).
- Provides direct and explicit instruction and practice with sentences, reading sentences fluently and with expression, combining sentences

with (e.g., Walter et al., 2021) and writing sentences with correct spelling and sentence conventions (Graham & Alves, 2021).

- Provides opportunities to read connected text aloud, with feedback and opportunities for repeated practice (Stevens et al., 2017; Therrien, 2004).
- Provides immediate error correction in all practice exercises (Ericsson & Pool, 2016; Roberts et al., 2008; Torgesen et al., 2001).
- Uses a scope and sequence and a set of materials to facilitate teaching an explicit and systematic connectionist approach with cumulative review (Saletta et al., 2016; Spear-Swerling, 2019).
- Provides for differentiated instruction and practice. Students with reading disorders need more explicit instruction and more practice (Kaganovich et al., 2021; Saletta et al., 2016; Treiman, 2018; Ziegler et al., 2005; Ziegler et al., 2020). Students being educated via a L2 (second language) benefit from contrasting mental representations in their L1 (first language) with those in their L2 (Kkese, 2020; Lindner et al., 2021; Llompart, 2021; Ziegler, 2020).

Together, these features describe the structured literacy approach to reading and spelling instruction (Spear-Swerling, 2019). Traditionally, structured literacy (a.k.a., Orton-Gillingham) guidelines included the use of "multisensory" methods (Birsh, 2011). However, there has never been much research supporting this guidance, in part because it is very difficult to separate the effects of multisensory input from the effects of simply better engaging attention. In a small study focused specifically on the question of the value that multisensory input adds over and above the use of explicit, systematic phonics instruction, Schlesinger and Gray (2017) demonstrated that multisensory intervention did not provide an advantage over the structured intervention for participants with typical development or those with dyslexia. While we do not yet fully understand if and how multisensory input operates to impact outcomes, recent brain imaging research has consistently revealed that learning to read and write requires the interconnection, sometimes referred to as "functional connection", of the brain centers responsible for processing various components (e.g., speech sounds, letter symbols, word meanings). These centers are connected through focused practice.

# 4. Summary

The checklist above can be summarized in three main elements:

- *A curriculum* that includes the multiple components of word structure with an explicit, systematic and cumulative but flexible scope and sequence;
- *A teacher* who knows the language's word structure elements and can actively engage, coach and differentiate lessons for students;
- *A system* that facilitates the delivery of direct, explicit, engaging lessons coordinated with a platform that provides brief, daily practice with immediate feedback and that automatically collects key data.

While the proposed checklist potentially addresses the challenges listed by Seidenberg et al. (2020), implementing such a program is a formidable task. The real challenge for the future will be creating systems to manage this complexity.

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