Before Learning the Code: A Commentary on Sargiani, Ehri, and Maluf (RRQ, 2022)

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Abstract

In this commentary, we argue the importance of the period before learning the alphabetic code and develop a new theoretical framework for the cognitive processes involved at the very beginning of learning to read. According to this new theoretical perspective, prereaders begin to learn to read by associating letter clusters with concrete phonological units such as syllables, a process we refer to as "building the syllabic bridge" (Doignon-Camus & Zagar, 2014). This procedure may trigger statistical learning to extract regularities of grapheme-phoneme correspondences. We assume that statistical learning facilitates access to phonemic awareness and then the acquisition of the alphabetic code. Our arguments are partly based on the comparison between the studies conducted by Vazeux et al. (2020) and Sargiani et al. (2022), whose results might have seemed contradictory at first sight. Finally, we suggest pedagogical implications and some perspectives for future research.

In this commentary, we argue that early literacy acquisition can be divided into two moments: before learning the alphabetic code and during learning the alphabetic code. We provide a new theoretical perspective for the period preceding learning the alphabetic code. According to this perspective, pre-readers can begin to learn to read with correspondences between letter clusters and phonological syllables which are more natural units than phonemes, as a preparatory step. We hypothesize that learning these syllabic associations can trigger statistical learning to extract regularities of grapheme-phoneme correspondences. This could be a promoting factor for future reading acquisition.

This new theoretical perspective is inspired by the "syllabic bridge" hypothesis (Doignon-Camus & Zagar, 2014), which assumed that learning associations between letter clusters and available phonological syllables may be a first step in learning to read, and the findings by Vazeux et al. (2020), which showed a greater increase in phonemic awareness in prereaders after learning letters-to-syllable than learning letter-to-phoneme correspondences. The arguments of this theory are also partly based on the comparison between the studies conducted by Vazeux et al. (2020) and Sargiani et al. (2022). The latter, recently published in *Reading Research Quarterly*, comparing whole-syllable decoding, grapheme-phoneme decoding, and individual grapheme-phoneme correspondence instructions, reported the opposite results to those reported by Vazeux et al. (2020). Their results showed that the individual grapheme-phoneme group performed better than the whole-syllable decoding group on phonemic awareness. Rather than contrasting these two studies, we propose that they document two different moments in early reading acquisition: before learning the alphabetic code (Vazeux et al., 2020) and during learning the alphabetic code (Sargiani et al., 2022), as we mentioned earlier. Since this point of view was not thoroughly developed in Vazeux et al. (2020), this commentary gives us the opportunity to highlight the importance of the phase preceding learning the alphabetic code.

In this commentary, we first outline the main differences between Sargiani et al.'s (2022) and Vazeux et al.'s (2020) studies, trying to figure out what could be causing the contradictory results. Next, we quickly review the origins of the syllabic bridge hypothesis (Doignon-Camus & Zagar, 2014), which serves as the starting point of our theoretical perspective. Then, we describe the new theoretical perspective, which places a special emphasis on the period preceding the acquisition of the alphabetic code. Finally, we discuss how this new theoretical account can lead to implications for learning to read and new empirical investigations.

Main Differences Between the Studies of Sargiani et al. (2022) and Vazeux et al. (2020)

Sargiani et al.'s (2022) and Vazeux et al.'s (2020) studies did not address the same issue. Vazeux et al.'s study (2020) relies on the assumption that learning the alphabetic code is preceded by an associative learning phase, during which prereaders simply learn associations between visual symbols and concrete phonological units (e.g., "PA" is associated with /pa/). As we will see in the theoretical section, the associative learning phase needs to be distinguished from the "alphabetic phase" in which prereaders are instructed in alphabetic code (e.g., "P" in "PA" corresponds to /p/ in /pa/). Vazeux et al.'s study (2020) concerned this associative learning. Two types of associations were compared: letter-to-phoneme and letters-to-syllable. In contrast, the aim of Sargiani et al.'s study (2022) was to compare three ways in which beginning readers learn comprehensively the alphabetic code to decode words: grapheme-phoneme decoding and blending instruction, whole-syllable decoding instruction, and individual grapheme-phoneme instruction only. Following the rationale behind the two studies, it is not informative to compare the grapheme-phoneme decoding and blending instruction group in Sargiani et al.'s study (2022) with the letters-to-syllable and letter-to-phoneme associative learning groups in Vazeux et al.'s study (2020).

Consequently, what could be compared in the two experiments is what Sargiani et al. (2022) called "the whole-syllable decoding group" and "the individual grapheme-phoneme group" versus "the letters-to-syllable group" and "the letter-to-phoneme group" in Vazeux et al.'s study (2020). A comparison of the two studies in terms of participants, design, material and main results is illustrated in Table 1. In this case, the opposite data were obtained: Sargiani et al. (2022) showed that the individual grapheme-phoneme group performed better than the whole-syllable decoding group on phonemic awareness; Vazeux et al. (2020) reported a greater increase in phonemic awareness in the letters-to-syllable group than in the letter-to-phoneme group (see Main Results in Table 1). However, we think that Sargiani et al. (2022) were too fast to jump to the conclusion that their results failed to support the syllabic bridge hypothesis. Indeed, there are many differences between the two studies, at least two of them could account for the discrepancy in the results.

Table 1

Comparison of the two Studies in Terms of Participants, Design, Materials and Main Results

		Vazeux et al. (2020)	Sargiani et al. (2022)
Participants	Number	222	60
	Mean age	5 years 4 months	6 years 5 months
	School level	Preschool	The first semester of first grade
	Language	French (France)	Portuguese (Brazil)
Design	Experimental conditions	Letter-to-phoneme association teaching Letters-to-syllable association teaching	Individual grapheme-phoneme (IGP) instruction Whole syllable decoding (WSD) instruction Grapheme-phoneme decoding (GPD) instruction
	Pretests	• Letter naming • Letter sounding • Syllable reading • Phonemic awareness (Final phoneme deletion)	• Letter naming • Letter sounding • Word reading • Phonemic awareness (Phonemic segmentation) • Syllabic segmentation • Writing words • Phonological memory
	Training sessions	Four sessions of associative learning and one introductory session to coding and decoding (each session lasted 25 minutes)	Between four and six sessions (each session lasted from five to 20 minutes)
	Posttests	• Letter sounding • Reading learned and unlearned syllables • Phonemic awareness (Final phoneme deletion) • Letter naming	• Letter sounding • Reading taught and untaught syllables • Phonemic awareness (Phonemic segmentation and phoneme blending) • Syllabic segmentation • Writing words • Phonological memory • Learning to read words from memory by sight • Memory for spelling • Pseudoword reading
Material	Number of grapheme-phoneme pairs	8	15
	Number of letters-syllable pairs	8	40
Main Results	Phonemic awareness	Letters-to-syllable > Letter-to-phoneme	GPD > IGP > WSD

First, the mean age of the population differed between the two studies (see Participants in Table 1). Vazeux et al.'s study (2020) was conducted in kindergarteners with a mean age of five years and four months. The population in the Sargiani et al.'s study (2022) was conducted "during the first semester of first grade when formal reading instruction began" (Sargiani et al., 2022, p. 632) with a mean age of six years and five months. According to the conception of learning to read in Vazeux et al.'s study (2020), the associative learning stage, i.e., learning letters-to-syllable associations, may arise prior to the formal reading instruction typically offered in the first-grade classroom. The syllabic associative learning involved simply linking a letter cluster to a phonological monosyllable, which is a concrete and accessible linguistic unit for prereaders (see next section for more details). It could be assumed that the letters-to-syllable associative learning is more effective for kindergartners who have hardly any experience with print-sound relationships. Indeed, prereaders have difficulty making the association between the consonant letter and the abstract phonemes. One would assume that prereaders associate the consonant letter with a more concrete speech sound that they are able to manipulate, e.g., the letter "T" could be associated with /tə/ instead of /t/ (see Liberman, 1973 for similar remarks). If we put children in a timeline of reading acquisition, as children move from kindergarten to first grade, they may have more opportunities to mis-assimilate reading knowledge through the school or home environment, such as mentioned by Liberman (1973), thus affecting the syllabic associative learning. That is why Vazeux et al.'s study (2020) was conducted in kindergarteners who had less opportunities to mis-assimilate that a letter corresponds to a syllable-like phonological unit. This may provide a possible explanation why the syllabic associative learning was not effective in improving phonological awareness in Sargiani et al.'s study (2022).

Second, participants were trained with different amounts of syllables (see Materials in Table 1). Participants in Vazeux et al.'s study (2020) were required to learn only 8 syllables in four learning sessions of 25 minutes. Indeed, the goal of Vazeux et al.'s study (2020) was not to study children's ability to learn all letters-to-syllable associations, but was to examine whether learning a small set of letters-to-syllable associations can trigger a mechanism for extracting regularities of grapheme-phoneme correspondences. Extraction of these kinds of regularities likely occurs via a type of implicit learning known as statistical learning – the human ability to extract regularities from the environment (see the theoretical framework section for more details). Over the approximately 100-minute training duration, a small set of syllables enables prereaders to easily and rapidly grasp the relations between letters and phonemes. For example, having learned "BA" corresponding to /ba/ and "BO" corresponding to /bo/, children may detect that the same initial component B in two letter strings corresponds to the same sound /b/. Vazeux et al.'s study (2020) aimed to find a balance between the condition that allows for good associative learning in a short time (less than 2 hours) and the condition that can trigger statistical learning to extract regularities between letters and phonological components. That is why a small set of 8 letters-syllable pairs was selected with a degree of variability (i.e., "BA", "BI", "FA", "FI", "SO", "SU", "TO", "TU") (Apfelbaum et al., 2013).

On the contrary, participants in Sargiani et al.'s study (2022) were trained with 40 syllables during four to six learning sessions of 5-20 minutes. The goal of their study was how best to learn to decode when beginning readers learn formally decoding instructions during the first semester of first grade. With 40 letters-to-syllable pairs, the quality and strength of the associative learning may be not guaranteed to trigger statistical learning[1]. It can be argued that learning a large number of syllables in such a brief period prevented the extraction of statistical regularities.

[1] We conducted a pre-experiment with a large quantity of syllables (60) prior to the experiment of Authors (2020) and found that there was no difference between letters-to-syllables associative learning and letter-to-phoneme associative learning on phonological awareness tasks.

Moreover, there were also other differences that could account for the divergent results in the two studies. It is first worth noting that, despite differences in age and educational level, the participants in the two studies were at the same literacy level. Hence, there may be instructional differences in literacy practices (e.g., Brazilian Portuguese students may have had less familiarity with the written language). At the linguistic level, French and Portuguese are two Romance languages with the same simple syllabic structure, although Portuguese is more transparent in terms of its orthographic depth (Seymour et al., 2003). In addition, it is worth acknowledging the socioeconomic and cultural differences between the participants of the two studies. Vazeux et al. (2020) had participants from four low socioeconomic status schools and eleven medium-high socioeconomic status schools, whereas Sargiani et al. (2022) only had students "from middle to lower-class families" (p. 632, Sargiani et al., 2022).

To summarize, the two experiments were too different to be directly compared. The reason for this, as we explained at the beginning of this section, could be that Sargiani et al. (2022) aimed to explore the best way to learn comprehensively the alphabetic code, while Vazeux et al. (2020) asked the question of the best way to prepare prereaders to learn the alphabetic code. It is before learning the code that the syllabic bridge hypothesis suggests that prereaders begin to learn to associate letter strings with available phonological syllables.

Where Does the Syllabic Bridge Hypothesis Come from?

The key point of the syllabic bridge hypothesis is that children are able to learn statistical properties of letter co-occurrences and then to spontaneously associate them to concrete speech sound (i.e., phonological syllables) to build the syllabic connections.

The ability to extract statistical properties of letter co-occurrences and to associate them to syllable units has been showed with a series of observations using the illusory conjunction paradigm. The illusory conjunction paradigm consists in very quickly presenting a word whose letters are written in two different inks. For instance, the word “ANVIL” is presented twice, either “ANvil” or “ANVil” (in which upper- and lower-case letters represent two different colors). Participants are instructed to detect a target letter and to report its color (the letter “v”/“V” in the example). Prinzmetal et al. (1986, 1991) have robustly shown that adults made more preservation errors (i.e., reporting the incorrect color of “V” in “ANVil”) than violation errors (i.e., reporting the incorrect color of “v” in “ANvil”). This result was assumed to reflect the influence of sublexical syllabic units on visual word perception. To explore on what information these syllabic perceptual units are built on, Doignon & Zagar (2005) compared the illusory conjunction error rates on two types of French words in adults. In congruent words (e.g., “MATIN”, in English, “morning”), the boundary of phonological syllables coincides with the orthographic boundary (“MA*/TIN”, where * represents the orthographic boundary and / represents the phonological syllable boundary), determined by positional bigram frequencies (e.g., the second bigram “AT” was of lower frequency than the third bigram “TI” in “MATIN”). On the contrary, in incongruent words (e.g., “RUBAN”, in English, “ribbon”), the boundary of phonological syllables does not coincide with the orthographic boundary (e.g., the second bigram “UB” was of higher frequency than the third bigram “BA” in “RUBAN”). The results showed that the preservation error rate was greater than the violation error rate for the congruent words, whereas this difference was dramatically attenuated for the incongruent words. These results suggested that phonological syllabic representations and orthographic redundancy cooperate to cluster letters into syllabic perceptual units.

How do these associations between phonological and orthographic representations emerge with reading acquisition? Do they emerge gradually, with familiarity with spelling, or do they appear early with learning to read? Surprisingly, illusory conjunction errors have shown that the influence of orthographic redundancy appeared during the first year of learning to read and that the intensity of this influence did not vary with reading level (Doignon & Zagar, 2006;

Doignon-Camus et al., 2013). This result reflects a process whereby children use the distributional properties of written language to cluster letters that compose a concrete phonological unit (i.e., a syllable), which is called the unitization process.

Further investigations with prereaders showed that a few minutes of presentation of letter co-occurrences (e.g., "NA") was enough for children to process letters as reading units (Doignon-Camus & Zagar, 2014), reflecting sensitivity to orthographic redundancy. Moreover, when letter clusters were displayed with the pronounced syllables they denoted, the unitization process appeared more efficient than when they were displayed without hearing the pronounced syllables. Thus, prereaders are able to spontaneously associate letter clusters to phonological syllables, thereby building the syllabic bridge. In other words, the unitization process is consolidated when the letter cluster is associated with concrete phonological representation, i.e., syllable representation.

How Does the Syllabic Bridge Facilitate the Access to the Alphabetic Principle?

The next question is whether prereaders' ability to aggregate letters that compose a syllable and to associate them to mental representations of phonological syllable is able to facilitate the acquisition of the alphabetic code.

Vazeux et al.'s study (2020) was designed to address this issue. Their data showed that the letters-to-syllable association learning led to better phonemic awareness than the letter-to-phoneme association learning. The authors interpreted their results with the assumption derived from the syllabic bridge hypothesis: from a bundle of letters-to-syllable connections, prereaders could build phoneme representations in mirror of letters, and therefore acquire and master the alphabetic code. Here, we would like to further explain theoretically how learning letters-to-syllable associations facilitates the acquisition of the alphabetic code.

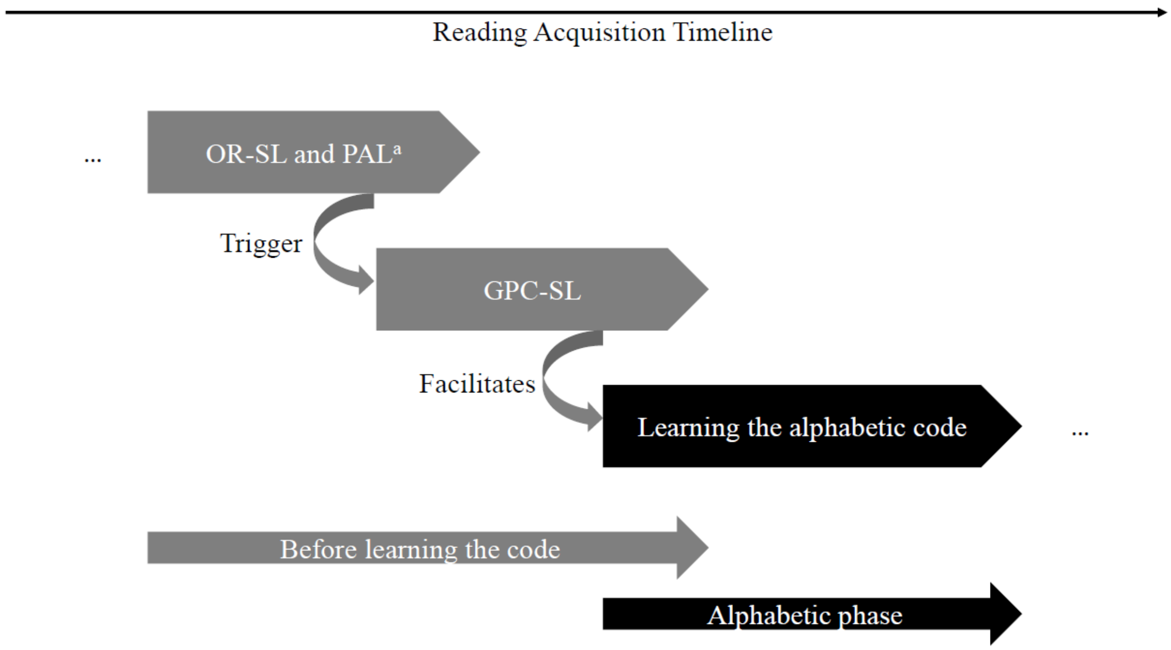
Statistical learning mechanism is probably also involved in learning letters-to-phonemes correspondences. Statistical learning, as a human ability to detect and extract regularities in sensory input, has been shown to be related to reading ability (Arciuli & Simpson, 2012; Frost et al., 2013). One possible explanation of this relationship is that statistical learning enables the detection of probabilistic correspondences between letters and phonemes given the quasi-regular characteristic of writing systems. In Vazeux et al.'s study, children were exposed to regular correspondences between letters and phonemes, for example, the letter "B" in letter strings "BA" and "BO" corresponds always to the phoneme /b/, the letter "A" in letters strings "BA" and "TA" corresponds always to the phoneme /a/. We assume that the contrast of two different phonological syllables that have the same phoneme at the beginning or the end makes the common phoneme emerge. Then, exposed to such a small set of regular correspondences between letters and phonological syllables, prereaders would be able to detect that two letters-to-syllable associations shared a same written component (e.g., "B" in "BO" and "BA") and a same phonological component (e.g., /b/ in /ba/ and /bo/), and thereby to extract that a letter corresponds to such a phoneme (i.e., the letter "B" corresponds to the phoneme /b/). In this process, as prereaders learn letters-to-syllable associations, the statistical learning mechanism is probably triggered to extract regularities of grapheme-phoneme correspondences (e.g., Apfelbaum et al., 2013; Seidenberg & McClelland, 1989). We call this statistical learning as the grapheme-phoneme-correspondence statistical learning (GPC-SL).

Blueprint for a Theoretical Framework Before Learning the Code

We assume that three cognitive mechanisms (see Figure 1) are involved before learning the alphabetic code (i.e., the pre-alphabetic phase, according to Ehri, 1995, 2005).

Figure 1

Schematization of the Beginning of Learning to Read With Three Cognitive Mechanisms Involved Before Learning the Code



Note. This figure demonstrates the reading acquisition timeline. Three cognitive mechanisms are involved before learning the code (OR-SL: orthographic redundancy statistical learning; PAL: paired-associate learning; GPC-SL: grapheme-phoneme-correspondence statistical learning).

[a]The syllabic bridge concerns the involvement of the OR-SL and PAL mechanisms.

First, as we saw earlier, the syllabic bridge is set up by two mechanisms: statistical learning and paired-associate learning mechanisms. The statistical learning mechanism (e.g., Pacton et al., 2001; Singh et al., 2021) operating at the unitization process allows children to use distributional properties of written language to cluster letters that compose a phonological syllable (Seidenberg & McClelland, 1989). We call this statistical learning the orthographic redundancy statistical learning (OR-SL). The associative learning mechanism consists in simply learning the associations between letters and phonological syllables. We can refer to this associative learning as a cross-modal visual-verbal paired-associate learning (PAL) mechanism (e.g., Hulme et al., 2007; Windfuhr & Snowling, 2001).

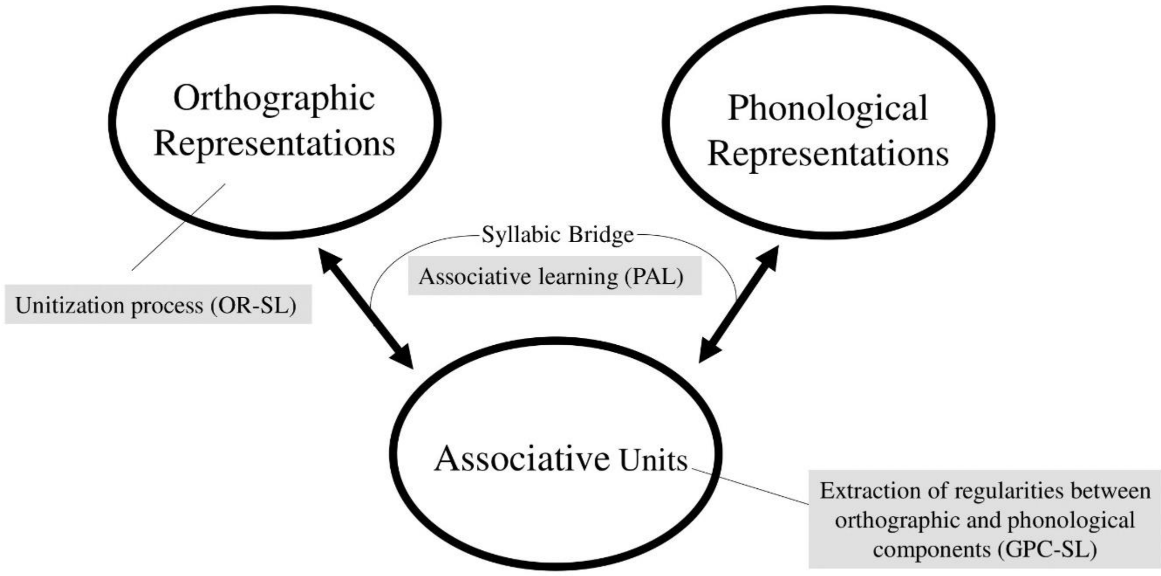
Then, the GPC-SL mechanism is triggered when the syllabic bridge is set up and leads to the first extractions of correspondence regularities between the letters and phonemes.

What we described above is in accordance with the connectionist model of word reading (Seidenberg & McClelland, 1989) that deals with "*the acquisition and use of knowledge concerning orthographic redundancy and orthographic-phonological correspondences*" (Seidenberg & McClelland, 1989, p. 525). The OR-SL mechanism captures the orthographic redundancy (see Seidenberg, 1987) and the PAL mechanism refers to the mapping process between orthographic input and phonological output representations (Hulme et al., 2007; Windfuhr & Snowling, 2001). The letters-to-syllable units, or associative units, are in some way similar to the hidden units whose role emerges as a result of learning orthographic-phonological correspondences by the accumulative training procedure and which generates the GPC-SL mechanism.

Inspired by the connectionist model of Seidenberg and McClelland (1989), we have brought a theoretical framework which is illustrated in Figure 2. The framework assumes that the very first beginning of learning to read involves two levels: the orthographic and phonological representations. An important feature of the model is that they are not directly connected but are mediated by a set of associative units. Learning occurs in the model in the following way. An orthographic representation is presented, and the unitization process takes place, using distributional properties to cluster letters into a reading unit via the OR-SL mechanism. Immediately, the written unit is mapped onto an available phonological unit which is the syllable via the PAL mechanism. In this process of building the syllabic bridge, a certain number of letters-to-syllable associative links are learned. At some point, the learning of orthographic-phonological syllabic correspondences triggers the GPC-SL mechanism to extract regularities of grapheme-phoneme correspondences between orthographic and phonological components.

Figure 2

The Theoretical Framework



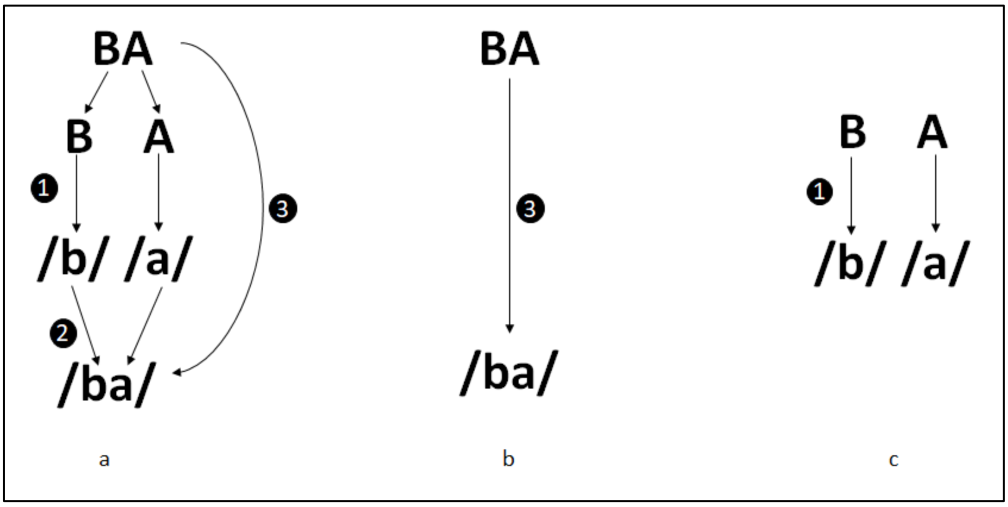
Note. The unitization process via the OR-SL mechanism occurs at the orthographic representation level. The syllabic bridge is built through the two big arrows (between orthographic representations and associative units, and between phonological representations and associative units) where the PAL mechanism is involved. When the syllabic bridge is set up, the GPC-SL mechanism is triggered to extract regularities between orthographic and phonological components at the level of associative units.

Implications for Learning to Read

Through all the years of research into learning to read, reading scientists have drawn incrementally a clearer picture of how students learn to read. The core of teaching to read consists of explicitly teaching the reading rules determined by the nature of the alphabetic writing system—the alphabetic code—that is, the visual symbols of the writing system (graphemes) represent the sounds of the language (phonemes) (e.g., Castles et al., 2018; Ehri, 2020). The most common explicit instruction for teaching the alphabetic code can be schematized, as in Figure 3a. It entails three learning processes: 1) sounding out two phonemes corresponding to graphemes (for example, B-/b/ and A-/a/); 2) blending phonemes to form a phonological syllable (for example, /b/+/a/=/ba/); and 3) reading whole phonological syllables (for example, BA-/ba/). It could be assumed that instructing prereaders directly and explicitly in grapheme-phoneme decoding skills is sufficient for them to learn to read and enables them to become aware of abstract phonemic units. In the study by Sargiani et al. (2022), the performance of the grapheme-phoneme decoding group was consistent with this assumption, as this group improved phonemic awareness better than the individual grapheme-phoneme group (Figure 3c) and the whole-syllable decoding group (Figure 3b). As has been observed, phonemic awareness grows alongside the beginning of mastery of decoding skills (e.g., Morais et al., 1979).

Figure 3

Schematization of Three Instructions a) Grapheme-phoneme Decoding Instruction b) Syllabic Bridge Instruction c) Letter Sound Instruction



Note. In Figure 3, the numbers are labelled with three learning processes.

[1] sounding out phonemes corresponding to graphemes

[2] blending phonemes to form a phonological syllable

[3] reading whole phonological syllables

If explicit instruction of the alphabetic code can be a clear and efficient way to help students move into the alphabetic phase, however it can be challenging for some prereaders to process this multi-component task. Due to the characteristic that phonemes are abstract units, prereaders do not manipulate phonemes naturally by the time they are instructed to read. This causes difficulties when prereaders are taught to sound out phonemes corresponding to graphemes that compose a syllable (see Learning process 1 in Figure 3a). In addition, the consonants are followed by a vocalic schwa when they are pronounced individually. This complicates the blending of phonemes (see Learning process 2 in Figure 3a). For instance, when prereaders are asked to blend sounds /b/, /a/, and /t/ to form a syllable, they would say /bə.a.tə/ instead of /bat/, as observed in Liberman (1973) (see also Ehri et al., 2001). It is thus suggested to prepare prereaders with preliminary training before learning formally the explicit instructions of the alphabetic code. One perspective generally discussed in the literature is to propose training prereaders with letter-sound knowledge (e.g., Byrne & Fielding-Barnsley, 1989) and with phonemic awareness tasks so that they can analyze spoken words into phonemes (e.g., Bradley & Bryant, 1983; Castles et al., 2018; Liberman et al., 1974).

Our above-described theoretical framework (see Figure 2) provides an alternative and complementary perspective, assuming that paired-associate learning via the syllabic bridge can trigger GPC-SL to extract regularities from connections between written syllable components (graphemes) and phonological syllable components (phonemes). This syllabic paired-associate learning can be considered not only as a promotive factor for future reading acquisition and also as a protective factor for students with poor statistical learning abilities. This is why our theoretical account proposes the paired-associate learning task via the syllabic bridge as a preparatory step, with the aim of triggering GPC-SL before explicitly learning the alphabetic code. Vazeux et al.'s findings (2020) indicated not only the potential involvement of GPC-SL in the letters-to-syllable association learning but also its influence on the subsequent alphabetic code learning. Vazeux et al. (2020) introduced a short session on coding and decoding after either letter-to-phoneme or letters-to-syllable associative learning. The results showed that the letters-to-syllable group kept its advantage in phonemic awareness after the alphabetic code session and tended to improve phonemic awareness more than the letter-to-phoneme group, even though the interaction was not significant (see the result of the L-H group in Figure 4 in Vazeux et al., 2020). We can interpret this result by hypothesizing that the explicit instructions of the alphabetic code can be viewed as a conceptualization of what has been implicitly acquired by GPC-SL during the letters-to-syllable association learning. GPC-SL is used to prepare pre-alphabetic students' cognitive mechanisms to better receive explicit instructions concerning the relationship between graphemes and phonemes.

Guidelines for Future Research

Central to our theoretical framework is the introduction of PAL and SL, the two cognitive mechanisms involved at the beginning of learning to read. Our main assumption is that learning syllable associations through PAL enables students to extract regularities of grapheme-phoneme correspondences through SL. In this section, we will discuss future research directions in two aspects. One aspect of future research directions is the new questions raised by these two cognitive mechanisms. The other aspect concerns how the theoretical framework inspires the instructions we provide to students.

Our theoretical framework suggests starting to learn to read by building the syllabic bridge via PAL. A key question is when the best period is to build the syllabic bridge. It has been found that Korean children read more than half their syllables by the age of 3 (Cho, 2009; Cho & McBride-Chang, 2005). The precocity of reading acquisition in Korean Hangul would find an explanation in the fact that letters composing a syllable are clearly defined into perceptual units; then, building the syllabic bridge would only involve pairing a printed syllable with its pronounceable sound. This learning is also probably feasible at a very early stage of learning to read in children who learn a linear alphabetic writing system. Further research is needed to determine this period in the reading acquisition timeline (see Figure 1).

Secondly, if building the syllabic bridge through PAL can trigger GPC-SL, the key question concerns the type and number of syllables needed to be learned in PAL to efficiently trigger GPC-SL. The types of syllables can be defined in terms of variability and regularity. Apfelbaum et al. (2013) have shown that regularities of grapheme-phoneme correspondences for English vowels embedded in various consonantal frames rather than in similar consonantal frames helped children learn phonic skills in first-grade students. Then it is worth investigating what degree of variability and regularity should be given to best supply the GPC-SL in pre-alphabetic students. The number of syllables was one of the main differences between the studies by Vazeux et al. (2020) and Sargiani et al. (2022), and we think that this may be the key factor that can explain the discrepancy in their results. However, far too little attention has been paid to the issue of item quantity in GPC-SL. Future research is required to examine whether the number of syllables taught to students influences the triggering effectiveness of GPC-SL.

Once GPC-SL is setup to help students understand the alphabetic code, the optimal moment of intervention for decoding instructions must be determined. This question and the other above-listed questions pertain to an intriguing topic about cognitive measures that can be used to track the progress of learning regularities through GPC-SL. Previous research has established the correlation relationship between statistical learning ability and reading ability in children and adults (e.g., Arciuli & Simpson, 2012; Frost et al., 2013). They commonly employed statistical learning tasks to measure the general capacity of statistical learning, such as artificial grammar learning, serial reaction time, and statistical learning embedded-pattern tasks (for a review, see Bogaerts et al., 2021). These tasks may be not suitable for the measurement of the ability of extraction of well-defined grapheme-phoneme correspondence regularities. The study by Vazeux et al. (2020) used phonemic awareness to capture the first signs of the mastery of the alphabetic code, which may be also a good indicator of the progress in extracting regularities.

The last but not the least question is about how our theoretical framework inspires the instructions we teach explicitly to students. According to our theoretical framework, it is suggested to trigger GPC-SL by the syllabic bridge before instructing formally the alphabetic code, especially for prereaders that would have difficulties acquiring the alphabetic code by the explicit grapheme-phoneme decoding instructions. However, considering individual differences in statistical learning ability (see Bogaerts et al., 2022; Siegelman et al., 2017; Siegelman et al., 2020), perhaps certain students also have difficulty extracting regularities in learning syllabic associations. In this case, it may be necessary to provide additional training to assist in the triggering of GPC-SL during syllabic paired-associate learning. Phonemic awareness may be a good supplement that can be parallelly trained in "poor" statistical learners.

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Conflict of Interest

The authors declare no conflicts of interest.

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