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Self-Organizing Model Of Reading And Orthographic Skills (MAAOD): An Integrated Developmental Framework

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Abstract:
This article presents the Self-Organizing Model of Reading and Orthographic Skills (MAAOD), an integrated theoretical framework addressing both reading and spelling. The model, grounded in dynamic systems theory, emphasizes the spontaneous emergence and interaction of phonological, morphological, lexical, and analogical processes. An extensive literature review of Greek and international research (post-2015) supports the model's dynamics, particularly in the emergence, self-regulation, and self-selection of phonological and morphological processes, through which the cognitive system of written language self-organizes.

Keywords: *Self-organization, Reading, Spelling, Phonological awareness, Morphological awareness, Orthographic development, Literacy, Dynamic systems*

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I. Introduction

The Self-Organizing Model of Reading and Orthographic Skills (MAAOD) conceptualizes reading ability and spelling accuracy as outcomes of a dynamic, self-organizing cognitive system. According to this approach, an individual's proficiency in written language emerges through the parallel development, coexistence, and interaction of various processing procedures, which gradually self-organize and self-select during reading and writing[16,17,18]. These fundamental processes—phonological, morphological, lexical, and analogical—work synergistically to construct an emergent cognitive system for processing written language. In other words, MAAOD argues that there is no single "path" for reading and spelling, but rather a set of interacting cognitive functions that the individual develops and automatically selects according to the demands of each linguistic stimulus (see Figure 1).

This perspective is supported by contemporary research findings in psycholinguistics and cognitive science. Since 2015, numerous primary studies have confirmed that the development of reading and orthographic skills is not a linear journey where a child simply learns rules; instead, it is a process of self-organization where various strategies emerge and are automatically engaged (self-selected) during reading and writing practice[22,31]. Each process (phonological, morphological, lexical, analogical) is documented separately in the sections that follow, based on recent empirical data. The contribution of each process to the development of reading fluency and orthographic accuracy will be discussed, along with quantitative and qualitative findings supporting their roles, and the dynamic interplay among them. Special emphasis is placed on the emergence of these strategies during child development and their self-selection—that is, how the student's cognitive system itself chooses when to use each process, without explicit guidance, to understand or spell a word.

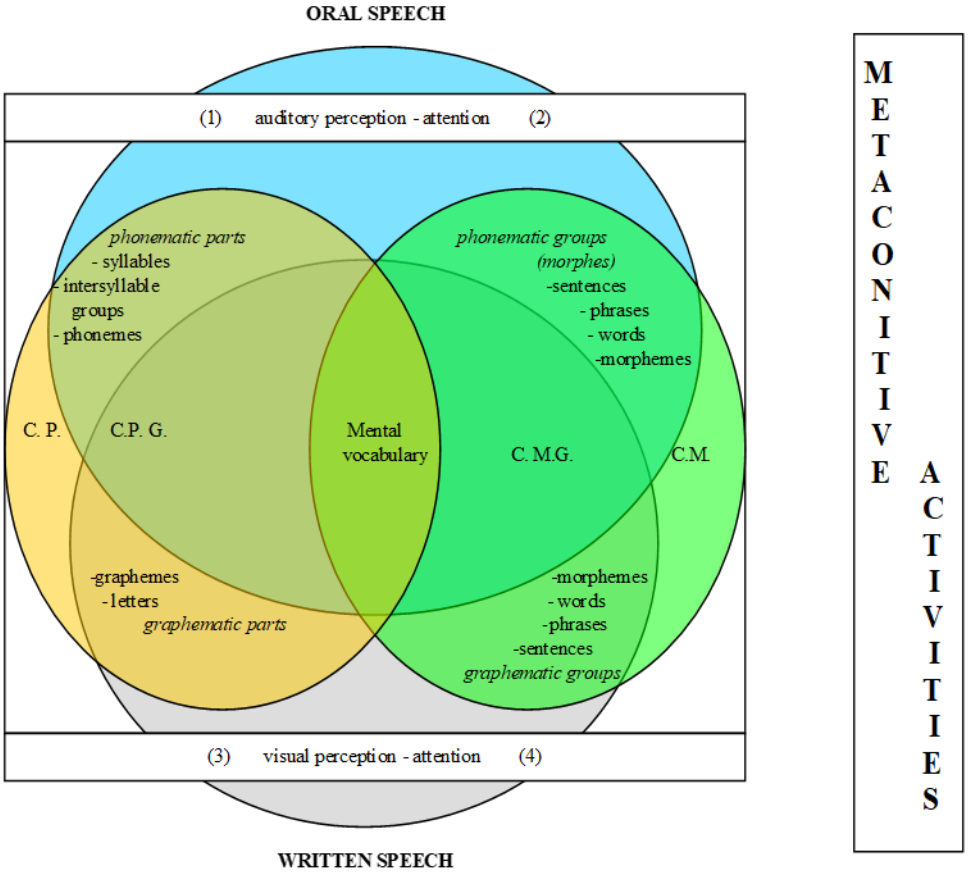

Figure 1: Self-Organizing Model of Reading and Orthographic Skills (MAAOD)

In the following sections, we sequentially examine: (a) the phonological process, involving decoding letters into sounds; (b) the morphological process, involving the use of structural components of words (morphemes) for reading/spelling; (c) the lexical process, referring to the direct recognition of words from memory (the "mental lexicon"); and (d) the analogical process, where reading/spelling new words is accomplished through analogies with known words or familiar orthographic patterns. Each process is substantiated with contemporary research (from 2015 onwards), and subsequently discussed as part of an integrated self-organizing reading and spelling system.

II. Structural Components Of The Cognitive System Of Written Language

MAAOD describes reading and spelling skills as the result of an emergent Cognitive System of Written Language (CSWL), which self-organizes as the child interacts with spoken and written language. The main structural components of this cognitive system include:

Connections: "Connections" are the fundamental associations formed between units of spoken and written language. Two main types of connections are distinguished (see Figure 2): (a) phoneme-grapheme connections – the matching between phonemes and graphemes, i.e., the links between individual sounds (phonemes) and the corresponding letter(s) representing them (e.g., the sound /a/ with the letter "a," /p/ with "p," /u/ with "ou," etc.); and (b) morpho-graphemic connections – the matching between entire sets of phonemes that carry meaning (i.e., morphemes, such as roots or suffixes) and their graphemic sets. In other words, a morpho-graphemic connection links a specific meaning (e.g., plural concept or a root meaning such as water) with a specific orthographic pattern (e.g., the ending -οι for masculine plurals or the morpheme hydr- for words related to water).

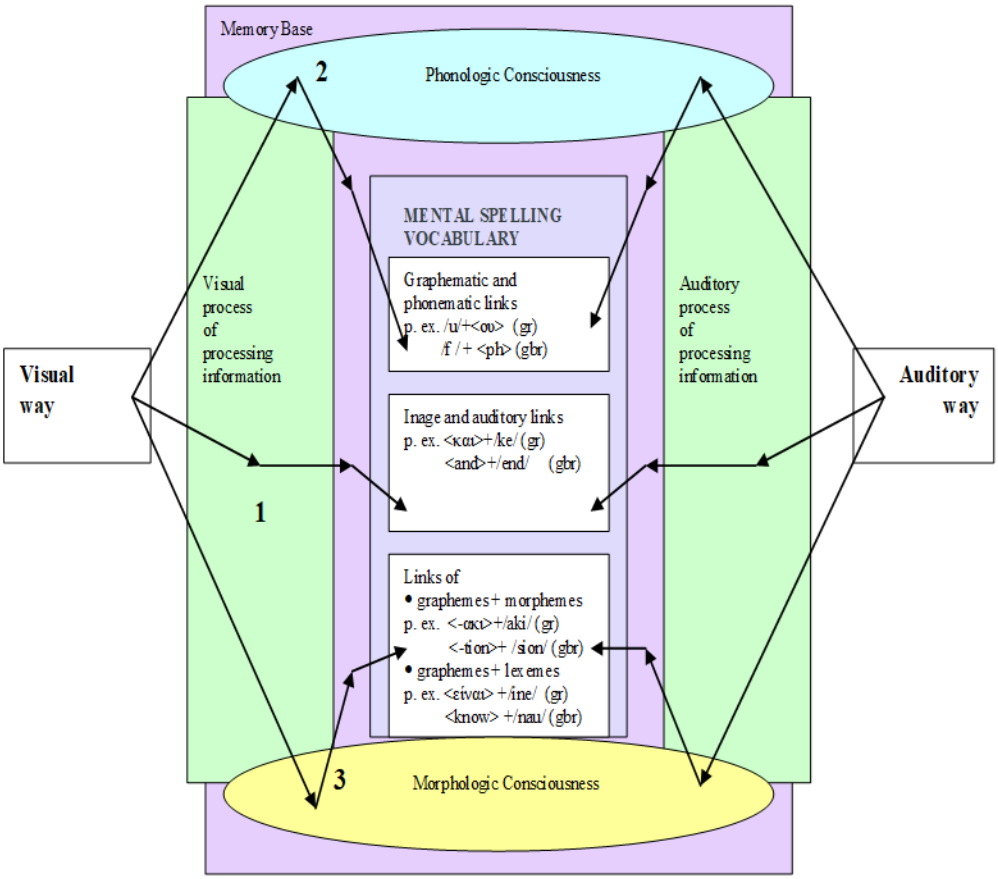

Figure 2: Cognitive levels of processing visual and auditory representations and formation of connections –

Contribution of linguistic awareness – Mental orthographic lexicon

Mental connections are formed as the child begins to encounter written language: the cognitive meeting of auditory with visual elements – phonemes with letters and spoken words with their written forms – leads to the creation of stable connections in the mind. These initial connections form the "foundation" upon which reading/writing functions will develop. Effective connection formation requires an adequate mental phonological lexicon and some basic metalinguistic awareness. Before learning to read, the child has already acquired a vocabulary of spoken words and has begun developing awareness of linguistic structures (e.g., recognizing word sounds, rhymes, simple morphemes). This allows the child, upon exposure to letters, to consciously begin matching sounds to letters. Teaching the alphabet and its sounds accelerates and strengthens phoneme-grapheme connections, while highlighting morphological elements (e.g., teaching suffixes, prefixes) reinforces morpho-graphemic connections. In this way, the child's initial phonological lexicon gradually transforms into an orthographic lexicon as each spoken word acquires an associated visual representation.

Mental Orthographic Lexicon: An internal lexical storage of all words known by the student along with their orthographic form. It is the memory of the visual forms of words (orthographic representations) that develops gradually (see Figure 3). The mental orthographic lexicon is built upon experiences of reading/writing: each word the child recognizes or writes is stored orthographically, thereby enriching their lexicon. Initially, this lexicon is phonological (containing only spoken words linking meaning and sound), but with the introduction of written language, it gradually becomes an orthographic lexicon as visual words are added.

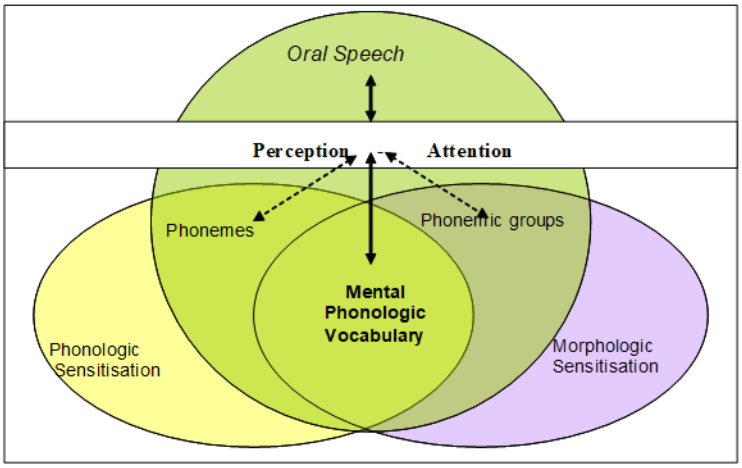

Figure 3: Development of the mental phonological lexicon and emergence of early linguistic awareness or linguistic sensitivity

Cognitive Orthographic Network: The entirety of connections and interdependencies among linguistic units (sounds, letters, syllables, morphemes, words) stored by the child. This network is essentially a neural knowledge network: it links letters to sounds, orthographic forms to their meanings, and words to each other (e.g., words sharing letters, common morphemes, or roots). The full development of the orthographic network occurs as the child's literacy matures. This network allows rapid dissemination of information during word recognition/spelling: for instance, seeing a word simultaneously activates its graphemes, corresponding phonemes, meaning, and other connected words.

In summary, the structural foundation of MAAOD is a self-organizing network of knowledge: letters, phonemes, and morphemes connect through links, forming a rich mental lexicon of orthographically represented words, collectively constituting a cohesive cognitive network. This network provides the necessary "resources" to accomplish reading and orthographic writing—resources corresponding to the individual cognitive processes that emerge from the system.

III. Formation Of Cognitive Connections Of Structural Elements Of Written Language

A central aspect of the MAAOD model is that the child forms cognitive connections linking the auditory, spoken forms of language with their written counterparts. Specifically, during the acquisition of reading/writing, phoneme-grapheme bonds and morpheme-grapheme bonds are formed in the learner's memory. These bonds represent the association between sounds and letters and between meaningful units (morphemes) and their orthographic representations.

International literature provides strong evidence for the importance of these bonds in developing reading and spelling skills. According to Ehri9, orthographic representations of words are stored in memory through letter-sound bonding. Each word a child learns is imprinted as a set of connections between graphemes and their corresponding phonemes. Thus, a word's orthography is "bonded" with its pronunciation, and these connections (letters-sounds) are used so the word is automatically recognized visually. This process, known as orthographic mapping, is crucial for both reading and spelling: the child learns to see a word and immediately recall its sound and meaning due to the strong phoneme-grapheme bonds formed.

Simultaneously, as learning progresses, the child begins utilizing morphemic bonds – understanding that certain word parts (roots, endings) retain consistent orthographic forms due to semantic/morphological consistency. The Greek orthographic system, being morphophonological, requires the learner to comprehend that orthography is not always obvious from pronunciation and often follows morphological rules. For example, the ending *-εις* in verbs remains consistent (*εσύ τρέχεις*, *εσύ βλέπεις*), despite the pronunciation /-is/ potentially being represented differently. Awareness of such morphological consistencies constitutes morpheme-grapheme bonding. Recent studies emphasize the importance of these bonds. An intervention teaching students morphological word analysis found that enhancing their ability to recognize morphemes within words significantly improved their reading and spelling performance[24]. This demonstrates that when children learn to connect a morphological element (e.g., a suffix) with a specific graphemic sequence, their orthographic memory is strengthened, and spelling errors decrease.

Moreover, developmental research confirms that children increasingly utilize morphological information as they grow older. A large-scale longitudinal study with Greek-speaking populations[6] showed that morphological

awareness in preschool significantly predicts later spelling performance in primary school. Especially in Greek, where correct spelling often depends on grammatical endings or roots, children who exhibit early morphological awareness (e.g., singular/plural forms, verb tenses) from kindergarten tend to make fewer spelling mistakes later. In conclusion, contemporary literature supports the MAAOD viewpoint that establishing phonological and morphological bonds between spoken and written language forms a foundation for orthographic learning.

IV. Metalinguistic And Epilinguistic Ability

The role of linguistic awareness—the ability to think about and become aware of language—is central to the MAAOD model. Two levels are distinguished: epilinguistic and metalinguistic ability. These terms describe different degrees of consciousness in language processing.

Epilinguistic processes are automatic, unconscious language processes carried out by the child. The term "epilinguistic" (introduced by Culioli in 1968) describes early linguistic activities that occur without conscious control by the child. In other words, epilinguistic ability reflects a spontaneous sensitivity to language. For instance, a young child aged 3-4 might spontaneously correct a word they mispronounced without explaining why—an internal, implicit linguistic knowledge is at work. As Gombert[11] notes, epilinguistic processes allow the subject's implicit knowledge to influence language processing even without conscious oversight. We might say the epilinguistic function represents the child's "early linguistic awareness"—the stage where the child intuitively feels the language and its rules before explicitly articulating them.

Metalinguistic processes are consciously controlled acts of thinking about language. Metalinguistic ability manifests when the child thinks and talks about language explicitly as an object. For example, a child aged 6-7 who can say, "the word 'dog' starts with the letter d," or who can explain a grammatical rule, is utilizing metalinguistic skills. According to the MAAOD model, metalinguistic ability allows conscious control and active guidance of orthographic processes. The distinction between epilinguistic/metalinguistic levels is crucial: epilinguistic processes form the background upon which conscious metalinguistic reflection later emerges.

This theoretical distinction is supported by research findings. Many scholars (e.g., Gombert[11]) have demonstrated that children exhibit epilinguistic reactions before fully developing metalinguistic ability. For example, preschool-aged children might perceive a sentence "sounds wrong" (e.g., "water drinks the child") due to an implicit "discordance," even though they cannot metalinguistically explain the inversion of subject and object. This is an epilinguistic judgment. Gradually, around the age of 5-6, explicit metalinguistic discussion appears: children learn concepts such as "letter," "word," count syllables, and engage in language games. Gombert and Colé[12] note that metalinguistic activity becomes possible only after certain epilinguistic restructuring in the child's memory. That is, the child first spontaneously assimilates and reorganizes informal language knowledge (epilinguistic phase), and later brings it to a conscious level (metalinguistic phase).

Within orthographic skill development, epilinguistic abilities are reflected in actions such as a child correctly spelling a word "because it seems right," without knowing the explicit rule—they have internalized the orthographic pattern epilinguistically. In contrast, metalinguistic ability emerges when a child explicitly states: "I put an accent because the word is borrowed," or "I write the verb ending -εις with -ει- because it's second-person singular."

The MAAOD model emphasizes the role of both levels. Epilinguistic processes operate supportively in the background whenever a child applies their knowledge intuitively (frequent in spontaneous learning). Metalinguistic ability, however, enables conscious strategic coordination: stopping to consider a rule, correcting recognized errors, or discussing a word's spelling. Research shows children with learning difficulties often lag in metalinguistic awareness (e.g., lower phonological or morphological consciousness), contributing to spelling difficulties[5]. In short, the distinction is validated. Epilinguistic perception lays the groundwork for developing metalinguistic awareness, which subsequently serves as a tool for further refinement of the child's orthographic system.

V. Phonological Processing In Reading And Orthographic Writing

Phonological processing is the cornerstone for the development of reading and spelling skills. It involves an individual's ability to recognize and manipulate language sounds (phonological awareness) and apply grapheme-phoneme rules—that is, the mapping of letters or letter combinations to their corresponding phonemes. During the early stages of reading acquisition, children primarily rely on phonological strategies: they "decode" words letter-by-letter, linking letters to sounds and blending them to pronounce the word. This process is often called phonological decoding or phonological mediation[9]. Extensive research has demonstrated that phonological awareness in preschool and early school age is a strong predictor of future reading performance[1]. For example, meta-analyses indicate that children who enter school with well-developed phonological skills learn to read faster and more effectively1. Conversely, difficulties in phonological processing are strongly linked to reading difficulties—inefficient phonological decoding is considered a primary cause of dyslexia according to current scientific consensus[1].

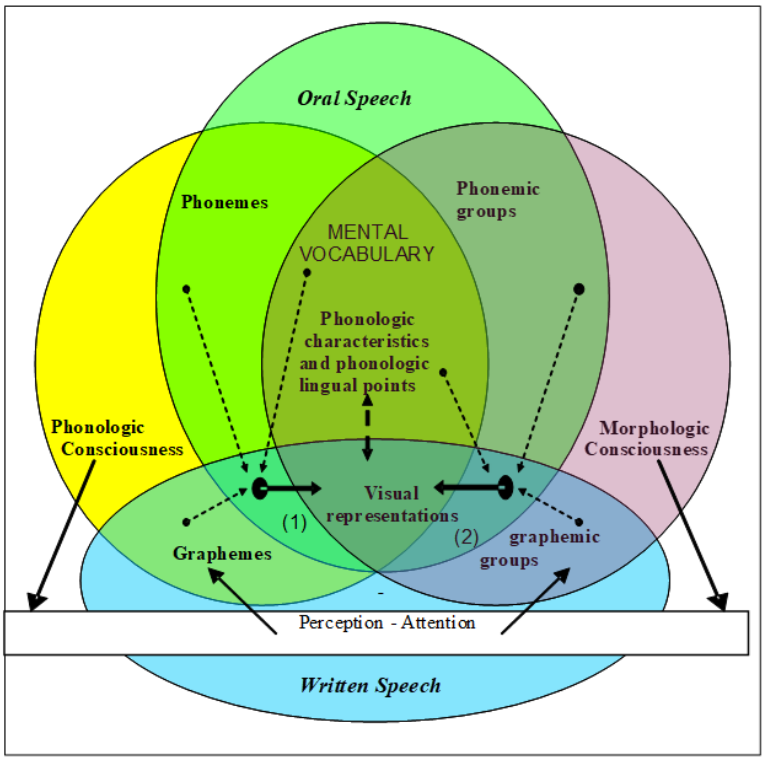

Figure 4: Emergence of new cognitive functions

Quantitative data from various languages after 2015 further highlight the central role of phonological processing. In a large-scale study involving 1,344 elementary students in a transparent orthography (Russian), Rakhlin et al.[29,30] found that children's phonological processing skills in 2nd and 6th grade were associated with word decoding accuracy, while orthographic skills (the ability to process visual orthographic patterns) correlated more strongly with reading fluency. Specifically, in less skilled readers, phonological ability (measured through pseudoword reading tasks) directly affected reading speed, whereas proficient readers' speed relied primarily on their ability to recognize words as whole units (unitization)[29,30]. This finding suggests that initially, students rely almost exclusively on phonological decoding to read, but later, as they gain experience, they develop more direct strategies. Nevertheless, even at advanced levels, phonological processing remains active in the background: proficient readers still activate phonological representations during word recognition, though this process becomes automatic and very rapid[1].

Besides reading, phonological processing also plays a critical role in orthographic spelling. Children initially learn to spell words based on sound—they "write as they hear." This phonetic approach to spelling is evident in early grades: students often spell words as pronounced (e.g., writing "nero" if they heard /nero/ instead of the correct Greek form "νερό"). Although these spellings often deviate from conventional orthography, they indicate the child's application of phonological knowledge. Studies have shown that early phonological awareness positively relates to a child's ability to learn word spelling: children with strong phonemic awareness spell more consistently according to sounds, setting the foundation to learn orthographic rules[19,20]. In fact, intervention studies have shown that intensive training in phonemic analysis and sound synthesis improved not only decoding but also spelling performance in children with difficulties[1,21].

Qualitative findings also confirm the critical importance of phonological strategy. Observations in classrooms and error analyses reveal that beginner readers try to "hear" words during reading. For example, a child attempting to read the word "cinema" might sequentially articulate the phonemes "c"-"i"-"n"-"e"-"m"-"a" and then blend them. This process is clearly documented in audio recordings of young children's reading attempts[24]. In spelling, characteristic errors have been noted where children write words as heard: for instance, in English, writing "keept" instead of "kept" or "sofed" instead of "soft," exaggerating the regular addition of the -ed ending due to phonemic capture[1]. Such errors show the child uses phonological knowledge (hearing /t/ at the end of "kept" and writing it as "t"), despite the orthographic deviation. Over time, as they become familiar with orthographic peculiarities, children reduce these errors. However, implicit phonological strategy persists throughout development: even adults exhibit phonological influences (e.g., adult readers are influenced by the sound of letters when reading pseudowords).

Overall, phonological processing represents the primary emergent strategy in reading (see Figure 4). In the initial stages, students self-select this strategy almost exclusively because it is the most accessible way to access written text: by learning the alphabet and sounds, they can pronounce words they have never encountered[33]. This phonological decoding capability paves the way for the phenomenon known as the self-teaching hypothesis: each successful independent decoding attempt provides the child an opportunity to learn the spelling of the word[35]. Repeated exposure through phonological decoding eventually leads to permanent orthographic representations. Thus, phonological processing acts as a "bridge": from phoneme decoding, it gradually leads to storing entire words in memory. Subsequent sections will explore exactly how this happens through other processes (lexical and analogical), as well as how morphological awareness simultaneously unfolds.

VI. Morphological Processing In Reading And Orthographic Writing

Morphological processing involves the reader's/writer's ability to recognize and utilize meaningful structural units within words, known as morphemes (roots, prefixes, suffixes). In morphologically rich languages like Greek, where words often feature complex morphological structures (inflectional endings, productive suffixes, compounds), morphological awareness can provide crucial cues for reading and spelling. For example, a child recognizing the root "phil-" (friend, friendship, friendly) and the suffix "-ikos" can more easily read or spell the word "philikos" (friendly), even if encountering it for the first time, because they understand its constituent parts and their combination. This processing emerges gradually: children begin developing morphological awareness orally in preschool years (e.g., understanding that "dog" and "little dog" are related due to the suffix "-aki"). However, using morphology in reading and spelling becomes more pronounced after fundamental phonological skills are established.

Recent studies post-2015 have thoroughly examined the role of morphological awareness in reading development. A consistent finding is that morphological ability becomes significantly influential after the initial stages of reading—once children have mastered the basics of the alphabetic system4. Specifically in Greek, which has transparent phonological-orthographic yet complex morphological characteristics, morphological awareness contributes significantly to reading fluency and comprehension. In the longitudinal study by Manolitsis, Grigorakis, and Georgiou[24], tracking children from kindergarten to second grade, morphological awareness scores (productive and inflectional) in first grade significantly predicted text comprehension in second grade. Interestingly, when factors such as vocabulary and Rapid Automatized Naming (RAN) were considered, morphological awareness still accounted for additional variance in comprehension (approximately 2–5%). Conversely, word reading fluency in second grade appeared more influenced by phonological skills and RAN than directly by morphology. These findings suggest that, in early school years, morphological awareness mainly supports higher-level reading skills like comprehension, whereas its direct impact on word reading speed emerges later, following the initial decoding stage.

More recently, Giazitzidou, Mouzaki, & Padeliadu[10] examined specifically the pathways through which morphological awareness influences reading fluency among Greek second graders. They found the impact of morphology is not straightforward but mediated by other factors: children's morphological awareness (both productive and inflectional) improved reading fluency indirectly through phonological awareness and vocabulary. Specifically, children with higher morphological skills typically showed better phonological awareness, which in turn led to faster text reading. Additionally, morphological awareness enhanced their lexical depth (word comprehension), further contributing to silent reading fluency[10]. This research highlights that in a transparent, morphologically rich orthography like Greek, children "utilize morphological skills as activators of existing phonological and semantic abilities to support reading fluency"[10, p.1125]. These findings reinforce the theory that morphological processing appears concurrently with phonological processing during development: once a child establishes a decoding foundation, morphological knowledge begins to play a complementary role.

In addition to its role in fluency and comprehension, morphological processing is crucial for spelling accuracy. Many orthographic conventions rely on morphology. In Greek, for example, the verb ending "-oun" (e.g., "trehoun," meaning "they run") maintains morphological consistency across verb forms, despite sounding identical to other endings. A child with developed morphological understanding can spell "trehoun" correctly, knowing it derives from "treho" (to run) and recognizing that all plural present-tense verbs end in "-oun". Research shows children apply morphological rules to spelling early, albeit initially with overgeneralizations. A classic study26 found that 6–7-year-olds attempted to apply morphological patterns to spelling (e.g., writing "sofed" for "soft" by incorrectly adding a past-tense suffix). By age 10, their morphological use became more precise. Recent data confirm morphology's increasing impact on spelling in later elementary years. Levesque et al.22 noted that around 80% of English words are morphologically complex, thus understanding morphemes significantly benefits spelling acquisition. They suggest that once children grasp that specific letter groups convey meaning (e.g., "-er" as in "teacher, singer"), they interpret and spell new words by combining known morphemes. Thus, morphological processing helps create an "orthographic map" in a child's mind: words are not memorized arbitrarily but organized meaningfully[9].

Quantitative studies confirm the importance of morphological strategies in spelling. A longitudinal study in Chinese (a morphosyllabic system) found a reciprocal relationship between morphological awareness and spelling ability: high morphological awareness predicted better spelling subsequently, while early spelling skills modestly predicted morphological awareness improvement in subsequent years[23]. This suggests that as children learn to spell words, they better understand morphological components—and vice versa. Although this study concerned Chinese, similar phenomena have been observed in alphabetic languages: children explicitly taught morphological rules significantly improve their spelling compared to control groups (Goodwin & Ahn, 2013, cited in Levesque et al.[22]). In Greek, where morphological consistency is critical, morphological awareness is key to spelling mastery. Indeed, Greek studies show students with spelling difficulties often exhibit lower morphological awareness[40], while morphological interventions (teaching word families) significantly enhance their spelling skills.

In conclusion, morphological processing emerges as a crucial complement to phonological processing in literacy development. Children gradually self-select morphological strategies: they begin to recognize patterns (such as tense endings and productive suffixes) and use them to read or spell challenging words. This automatic morphological utilization becomes evident when a child encounters unfamiliar long words, effortlessly decomposing them into known components. The MAAOD emphasizes morphological processing emergence: rather than assuming that phonological instruction alone suffices, it acknowledges that children naturally exploit internal word structures as they encounter more vocabulary. As Levesque et al.[22] emphasize, morphology multiplies system efficiency, facilitating access to meaning and phonological form, thus enhancing overall fluency and comprehension. The parallel and reciprocal development of morphological and phonological processing constitutes a central feature of the self-organizing model.

VII. Lexical Processing In Reading And Orthographic Writing

As readers gain experience, a new process emerges and begins to dominate fluency: lexical processing, which involves the immediate, visual recognition of words from memory, without needing phonetic decoding. This process is associated with the development of a mental orthographic lexicon—an internal "storage" where an individual has stored the written forms of words frequently encountered. Once a word is familiar and its visual representation formed in memory, the reader can recognize it in less than half a second without having to spell it out or analyze its sounds. This sight word reading characterizes the proficient, skilled reader: reading becomes fast and automatic.

A central question addressed by the MAAOD model is how this lexicon is created. How does a child transition from laboriously decoding each word letter-by-letter to instantly recognizing thousands of words? Contemporary research converges on the explanation that this transition occurs through autonomous reading experience—each time a child successfully decodes a new word, they provide themselves with an opportunity to orthographically "map" that word into memory[33,1]. This is known as the self-teaching hypothesis: phonological processing teaches lexical processing. For example, a child encounters the word "karavi" (boat) for the first time. Through phonological decoding (/k-a-r-á-v-i/), they pronounce it and recognize its meaning from context. At that moment, the visual form "karavi" is associated in the child's mind with its oral and semantic information. After several successful exposures (research indicates that 4-6 exposures may suffice), the word "karavi" will subsequently be stored as a complete entry in the child's lexicon[35,1]. Thereafter, it will be recognized immediately on sight.

Primary research has explored this mechanism. Pritchard et al.[28] developed a computational model incorporating self-teaching within a Dual Route Cascaded framework (DRC). This model (ST-DRC) successfully simulated how the interaction between phonological and lexical routes can lead to orthographic learning of new words. Simulation results indicated that when encountering an unfamiliar word, the model used the sublexical (phonological) route to activate possible known words in the lexicon (e.g., partial similarity or context), allowing the system to store the new word in its orthographic lexicon. Remarkably, the model could learn even irregular words through partial decoding and context use—a process analogous to reality where children learn difficult words through repeated contextual encounters (e.g., the irregular English word "one"). These results reinforce the notion that lexical knowledge (visual recognition) gradually builds upon phonological decoding and text exposure experience[29,30].

Quantitative studies in natural readers demonstrate the shift from phonological to lexical processing with age progression. As previously mentioned, Rakhlin et al.[29,30] found that among proficient older readers, whole-word recognition (unitized reading) predominantly determined fluency, whereas phonological decoding played a secondary role. Practically, these children had developed a robust orthographic lexicon: they recognized most words at first glance. In contrast, among less proficient readers of the same age, accurate phonetic reading ability (e.g., correctly reading pseudowords) continued to correlate with reading speed[29,30]. These data confirm that with practice, cognitive resources shift: skilled readers preferentially use the lexical route whenever possible, while keeping phonological decoding as a backup for unfamiliar words.

A critical element of lexical processing is orthographic knowledge: awareness of permissible and frequent letter patterns within the language. This includes familiarity not only with specific words but also with common letter combinations or structures. For instance, an English-speaking child encountering multiple words ending with "-ight" (light, night, fight) develops a sense that "ight" is a valid and recognizable unit. Later, encountering "sight," the child quickly recognizes it as a combination of "s" + "ight". This semi-lexical strategy involves recognizing word components previously seen. Such pattern knowledge is part of the orthographic lexicon—some researchers term this mid-level orthographic processing between graphemes and whole words[38,1].

In orthographic writing, lexical processing appears as the child's ability to remember how to spell words correctly from memory. As children frequently read and write, they store both the pronunciation and orthographic form of words. This explains why reading supports spelling learning: the more a child reads, the more words are visually imprinted, enhancing spelling. A longitudinal study[39] showed that early orthographic knowledge in first grade predicted subsequent spelling improvement up to sixth grade. Similarly, Ouellette and Sénécha[43] found that children developing a strong lexicon through reading also had superior spelling: there is a reciprocal interaction where reading reinforces spelling, and spelling practice further strengthens reading[23].

Therefore, lexical processing represents the fruit of the self-organization of the reading system through experience. It is not taught directly—no one can explicitly teach a child all words needed for literacy. Instead, children independently learn most words, provided they have effective initial strategies (phonological) and sufficient text exposure[34]. This explains why two students with the same instruction might develop different lexical ranges: it depends on how much they automate reading and how extensively they read beyond the curriculum. Hence, MAAOD emphasizes creating conditions for rich reading experiences, through which lexical skill naturally emerges.

In summary, lexical processing corresponds to the stage where readers can process words holistically. According to Linnea Ehri[9], this constitutes the "consolidated alphabetic phase," where readers use multi-letter units instead of individual letters. Words are recognized as wholes or familiar segments. In this stage, reading becomes rapid, freeing cognitive resources from decoding and allowing a focus on comprehension. From a self-organization perspective, the child's system has rearranged its resources: word recognition becomes an automatic background process, resulting from thousands of small "self-lessons" acquired through previous reading experiences[1]. In the subsequent section, we examine analogical processing, an additional means by which readers leverage knowledge of known words to handle new words.

VIII. Analogical Processing In Reading And Spelling

Analogical processing refers to a reader's ability to use similarities between known and unknown words to understand or produce the latter. In other words, the child reads an unfamiliar word "by analogy" using a "key-word" already known and orthographically similar. For instance, a child who knows the Greek word "αίμα" (blood) and encounters the word "ρέμα" (stream) for the first time might notice they both end in "-έμα". Through analogy, the child may infer that "ρέμα" is pronounced similarly (/réma/) and relates to something that "flows". This process requires the child to have already established certain orthographic patterns from prior experiences. Analogies can be based on phonological patterns (e.g., rhymes like "-ight" in English) and/or morphological patterns (e.g., familiar suffixes like "-τιά," "-ούλης" in Greek).

The idea of analogical reading was proposed by researchers like Usha Goswami since the 1990s as an alternative/complementary path to phonological processing[15]. According to this perspective, even before reaching a fully lexical stage, children can partially apply lexical knowledge to new words. For example, an English-speaking child knowing the word "peak" could read "beak" by analogy ("peak" without the /p/, adding a /b/). This partially bypasses the need to decode letter-by-letter, using the familiar orthographic unit "-eak".

Subsequent research explored the extent to which children use such analogies. Findings indicate children can employ analogical strategies, depending on their developed orthographic lexicon and the transparency of the language. In languages with opaque orthographies (e.g., English), analogies with rhyming endings are considered significant for learning[14]. In more transparent languages (e.g., Italian, Greek), analogical strategies may appear predominantly within morphological pathways (e.g., recognizing a familiar suffix).

Although the analogical process is not always defined as distinct in classic dual-route models, we can view it as a subcategory of lexical processing: when a full word is not stored, the child utilizes stored segments to manage the new word. This has also been observed in qualitative error studies: a child might guess an unknown word by substituting it with a similar known word. For example, if a sentence reads, "The wizard held a staff," and the child does not know "staff," they might say "stick," seeing the initial segment and associating it with a known similar word. This "morphological analogy" (the root "staff/stick") allows them to approach the word correctly based on context.

Another form is orthographic analogy: the child sees a challenging orthographic pattern and recalls a known word to remember its spelling. In spelling, for instance, a Greek child unsure whether "ευχή" (wish) starts

with ευ- or εφ- might think of the known word "ευτυχία" (happiness) to determine the correct letters (ευ-). This method is often taught explicitly as a mnemonic strategy (e.g., "spell it like in ευ-τυχία").

Recent research data have shifted focus from analogy alone to strategic flexibility more broadly. The contemporary view is that as children self-organize their reading cognitive system, they become flexible in strategy selection, often combining phonological, morphological, and analogical cues. A study of Spanish-speaking students[31] showed children simultaneously applied various strategy types from early on, not strictly in sequential stages. Specifically, Salas[31] measured how often students used "non-phonological" strategies for syllabically spelling unusual words. He found that even in early grades, children attempted morphological and lexical strategies (though with less success than phonetic strategies), and their capability increased with grade level. Indeed, these strategies (morphological, "morphophonological," orthographic, lexical) significantly contributed to correct spelling, independently from pure phonological skills. Though focused on spelling, this study implies children do not learn in isolated stages (first phonological, then morphological, etc.) but rather utilize every available resource to achieve their goal. Within this context, analogical thinking is another "piece of the puzzle" the child uses as needed.

In the MAAOD model, analogical processing can be viewed as an outcome of "pattern formation". As the child's cognitive system self-organizes, it identifies recurring sequences of letters with common sounds or meanings. These sequences automatically become processing units. The next time the system encounters the same sequence embedded in a new word, it recognizes and assimilates it into a familiar pattern. Essentially, this represents learning through emerging generalizations: the child generalizes knowledge to new instances analogically. This supplements the other two primary pathways (phonological and lexical), granting adaptability to the reading system. For instance, if a word is entirely unknown (absent from the lexicon) but phonologically regular, the child uses the phonological route. If the word is familiar, they use the lexical route. If the word resembles a known one or contains a large familiar segment, the child might employ a hybrid strategy, phonologically decoding the unfamiliar part and directly recognizing the known part—this precisely characterizes analogical processing.

Empirical data confirm skilled readers' flexibility: they can switch strategies as needed. In an experiment with German-speaking second and fourth graders, researchers[41] asked children to read words aloud and analyzed their strategies (phonemic decoding, whole-word recognition, guessing from context, etc.). Even in second grade, not all children exclusively used phonemic decoding: many with extensive vocabularies read many words directly, others combined strategies (e.g., in compound words, reading one part directly and decoding another). By fourth grade, this mixed strategy (partial decoding plus analogical use of known segments) was even more frequent among skilled readers. This aligns with the idea that analogical skill grows with experience, as children acquire more familiar patterns to utilize.

Analogical thinking also benefits spelling. Many spelling programs encourage children to group words into families and use known words as guides for unknown ones. This practically teaches the child autonomy that their cognitive system would naturally develop: e.g., "if you know "τρέχω" (run), remember "έτρεξα" (ran) is spelled with -ε- due to its connection with "τρέ-". Such morphological analogies help resolve spelling doubts. An intervention study by Goodwin et al. (2018) with dyslexic students (grades 3-6) showed that teaching analogical connections between words significantly improved reading and spelling, more than approaches solely focused on phonemic training. This emphasizes that analogical/morphological strategies can compensate for inadequate benefit from purely phonological instruction.

IX. Linguistic Awareness And Metacognitive Ability In The Development Of The Cognitive System Of Written Language

Linguistic awareness—specifically phonological and morphological awareness—as well as the broader metacognitive abilities of the student significantly influence the development of orthographic skills. Linguistic consciousness essentially represents metalinguistic ability applied to specific linguistic levels (sounds, words, morphemes). It includes skills such as recognizing rhymes, distinguishing syllables/phonemes in words (phonological awareness), or identifying the parts of compound words and understanding root-derivative relationships (morphological awareness). On the other hand, metacognitive ability encompasses broader self-monitoring and learning regulation skills, such as recognizing errors, correcting them, selecting appropriate strategies, and planning effective ways to learn.

Numerous contemporary studies have investigated predictive factors for orthographic learning, consistently highlighting the importance of both specific linguistic abilities and metacognitive skills. As previously noted, phonological awareness during preschool is among the best predictors of a child's ease in learning to read and write[6]. Without phonemic awareness, the sound-letter correspondence becomes problematic. Similarly, morphological awareness gains increasing importance beyond the initial school years. Research by Diamanti et al.[35] found that as early as first grade, awareness of morphemes (e.g., grammatical endings) contributes independently to spelling performance, beyond phonological skills. In higher grades, as words become

more complex, morphological awareness distinctly emerges as a factor. International studies[3] indicate that children's ability to identify roots within word families is associated with fewer spelling errors in derivative words of those families. Collectively, a child's linguistic sensitivity (to sound and word structure) constitutes a foundation upon which orthographic knowledge builds.

Metacognitive ability manifests in spelling as strategic handling of difficulties and self-correction. A child with advanced metacognitive skills encountering a challenging word will consciously question: "Is there a rule? Can I recall something similar?" They will review the word after writing it, possibly comparing it with a familiar one. Conversely, a child with limited metacognitive regulation may impulsively write the word as heard without reevaluating or applying any strategy, resulting in more errors. A recent Greek study[27] examined self-reported strategies by sixth-grade students with and without spelling difficulties. Findings revealed insightful differences: proficient spellers frequently reported employing morphological strategies (considering parts of words or rules), whereas weaker spellers relied primarily on phonological strategies (writing as heard) or simply tried to visually remember the word without applying any rule. Moreover, proficient students mentioned self-check strategies, such as recalling specific rules for tricky endings. These metacognitive strategies (e.g., correctness checking, strategy adjustment) correlated with higher spelling accuracy. Conversely, reliance solely on phonological strategies without rule application or memory correlated with poorer performance. These findings empirically confirm that conscious awareness of linguistic structures (linguistic consciousness) combined with strategic selection and regulation (metacognition) is crucial for orthographic development.

An interesting case is that of children with special speech or language difficulties, such as speech sound disorder or Specific Language Impairment. Studies indicate that these children, even when improving their reading skills, continue to lag in spelling, partly due to deficits in metalinguistic skills such as phonological and morphological awareness[25]. Research by McNeill et al. demonstrated that 6-8-year-old children with a history of speech sound disorder had lower spelling performance than peers with similar reading abilities, despite comparable metalinguistic skills. This suggests additional factors like reduced short-term memory for spelling or fewer spontaneous learning opportunities, though it confirms that lower metalinguistic awareness certainly does not help these children bridge the gap. Conversely, interventions aimed at improving metalinguistic skills and teaching metacognitive strategies (e.g., self-checking, using symbols to remind checking endings) have proven effective. In a study with Israeli students with language disorders, teaching metacognitive strategies notably enhanced their spelling compared to children receiving traditional phonological instruction alone[32].

In conclusion, conscious linguistic awareness (phonological, morphological) is a cornerstone for orthographic learning. Without it, children lack understanding of the "rules of the game." Conversely, broader metacognitive abilities—knowing how to learn, self-check, and utilize knowledge—are mechanisms optimizing linguistic knowledge. The MAAOD model integrates these concepts, emphasizing their combined action: metacognition activates linguistic awareness, guiding the orthographic system toward higher levels of success.

X. Emergence And Self-Selection Of Processes: Dynamic Integration Of The System

Having examined the four core processes of the MAAOD separately, it is crucial to view them as an integrated dynamic system (see Figure 5). The central idea of the Self-Organizing Model is that these processes do not operate in isolation or in a strict sequence; instead, they co-emerge and cooperate during the child's development. Although each process emerges at different degrees according to age, they do not represent successive stages where one replaces another. Rather, strategies coexist, and the reading system self-regulates their involvement depending on the task at hand.

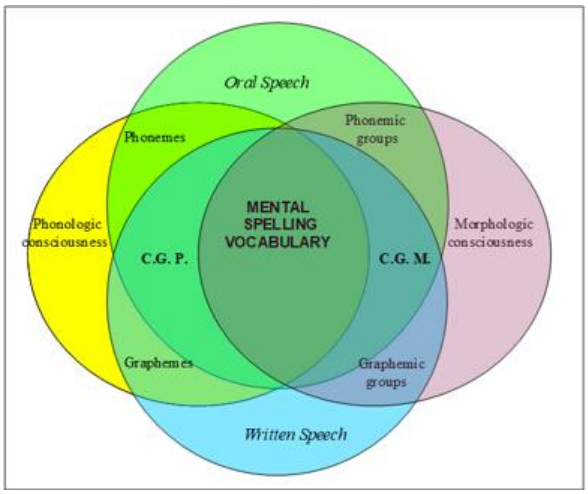

Figure 5: The Cognitive Orthographic Network

The ultimate goal of developing reading/spelling skills—as described in the self-organizing model—is to achieve a self-sufficient, self-regulating system where individual orthographic processes are either automated or consciously selected according to the demands of the task. The MAAOD model emphasizes that, through auditory and visual stimuli and maturation, the cognitive system gradually develops structural elements and functions and becomes capable of sustaining itself autonomously. This is achieved via two complementary mechanisms:

Automation of Processes: An automated process is performed rapidly, without conscious effort or oversight. When we say, for example, that a proficient adult automatically writes correctly, we mean that many aspects of writing (e.g., the spelling of most words, the application of basic rules) happen "on autopilot." The MAAOD model describes how internal or automatic control within the cognitive system (automation) allows immediate retrieval of words and execution of processes without consuming attention resources. Ehri similarly notes that at the final developmental stage, words are recognized or produced "at first glance," and the writer no longer needs to syllabicate or blend phonemes to write them. Such automation results from numerous repetitions and learning experiences. The significance of automation is also evident in its connection with other skills: studies show that when spelling is not automated (e.g., in slow/insecure spellers), the quality of written expression suffers because the student dedicates so much cognitive effort to correct spelling that few resources remain for content and syntax[13]. Complete automation of spelling thus frees the student to focus on ideas. Contemporary neuroimaging studies suggest that as an individual practices spelling, brain activity changes: lower-level processing areas (visual-perceptual) strengthen their connections, and involvement of prefrontal areas (conscious control) decreases, indicating automation.

Conscious Control, Self-selection, and Regulation: Despite the automation of many processes, a fully proficient speller does not operate solely automatically—they also possess a "supervisor," a metacognitive oversight that intervenes when necessary. The MAAOD model describes the system as having a conscious perception-attention control mechanism activated when a word or situation lacks an automated solution. Then, metalinguistic knowledge is employed: depending on the problem, the child directs their thought either towards phonological information (e.g., syllabication—"let me pronounce it in syllables to hear its parts") or morphological information (e.g., "perhaps it is a verb, thus requiring -ω?"). This allows the system to self-regulate. Most cases are automatically resolved through self-selection of the appropriate process based on frequency, but when a new challenge arises, the conscious mind takes over, selecting the correct process and inhibiting inadequate ones. Thus, the system (the child) itself decides which orthographic strategy to use based on available cues.

Empirical evidence supports the ability for strategic self-selection. As noted earlier, more mature students adapt their strategies: if a word is familiar, they trust their visual memory (lexical process); if unfamiliar, they syllabicate it (phonological); if it contains known morphemes (e.g., plural endings), they apply morphological rules; if it resembles another word, they may use analogies. An interesting finding from Pantazopoulou, Polychroni, Diakogiorgi & Ralli[27] is that students may combine strategies even within the same word: for example, when asked how they wrote the word "περπάτημα," some students said they remembered the first part "περ-" (lexical strategy) but wrote "-μα" using a morphological rule. This demonstrates high flexibility and self-regulation. In the same study, the importance of self-correction was highlighted: proficient spellers reported trying different spellings if uncertain until "it seemed right" or recalling a rule independently, while weaker spellers rarely did this (many did not even recognize errors). Recognizing and correcting errors is essentially a metacognitive skill distinguishing mature writers.

Overall, contemporary research agrees that full mastery of spelling involves: (a) automated knowledge of most frequent words and rules, (b) strategic flexibility and self-selection—the writer has multiple strategies available and consciously selects when to apply each, and (c) self-regulation/metacognitive control—the writer monitors performance and intervenes upon recognizing a problem. These elements are precisely what the dynamic self-organizing model describes. Unlike models that rigidly separate pathways (e.g., "lexical vs. phonological"), MAAOD integrates a holistic view. It sees the speller as an active, self-regulating learner who combines speed and awareness. This is supported by contemporary literacy research, emphasizing cultivating both spontaneous fluency and strategic language thinking.

Educationally, understanding this parallel development and self-selection is critical. It implies that a literacy program should support all processes and allow children to practice each one. Experts in the "Science of Reading" since 2015 advocate for an integrated approach—there is no longer a dichotomy between "phonics vs. whole words"; both are essential. As Castles et al.1 put it, "learning the alphabetic principle is non-negotiable, but reading involves much more than phonics." The MAAOD precisely embodies this philosophy: phonological foundations are essential, but other critical factors (morphology, orthographic patterns, vocabulary) also emerge and must be supported. Over time, the dynamic relationship among factors changes—for example, phonological awareness initially mediates morphology[10], while later morphology assumes a more direct role.

Moreover, each student may have a slightly different "mix" of preferred or challenging processes. A self-organizing model explains why different reader profiles exist: a child with exceptional memory may easily store many words and seem to "read holistically," while another with less robust memory relies longer on phonology. Both profiles lie within typical development; the dynamic system simply balances differently. Ultimately, however, full literacy mastery requires synergy among all processes. Effective teaching practices thus encourage accurate decoding and morphological and orthographic knowledge. The aim is to cultivate a reader autonomously and automatically utilizing all available word information: letters, sounds, patterns, meaning.

In sum, the Self-Organizing Model of Reading and Spelling Skills (MAAOD) offers a framework for understanding literacy as an evolving living system. Phonological, morphological, lexical, and analogical processes are its structural components. Research post-2015 has reinforced the view that these components interact dynamically rather than independently or statically. Quantitative models like Pritchard's ST-DRC28 illustrate that integrating multiple pathways yields superior learning outcomes. Qualitative studies show children employ various strategies early on, using phonological, morphological, orthographic, and lexical knowledge[2]. These findings fully align with the MAAOD perspective: an emergent, self-regulating system of reading/writing, continuously evolving through interaction.

XI. Conclusions

In this review, we have seen that the development of reading and spelling is not a passive accumulation of knowledge but an active process of self-organization within the child's cognitive system. When encountering written language, the child employs multiple cognitive processes: phonological processes for mapping letters to sounds, morphological processes for understanding and utilizing structural relationships among words, lexical processes for storing and automatically recognizing words, and analogical processes for exploiting similarities and recurring patterns. Each of these processes is supported by contemporary research:

• The phonological process is considered a central prerequisite for reading and has strong empirical support[1,29,30].
• The morphological process is now recognized as a critical contributor to reading fluency and comprehension[24, 10], as well as correct spelling[22,1].
• The lexical process, or the acquisition of a rich visual lexicon, has been explained through self-teaching mechanisms[28] and is seen as essential for the transition from novice to skilled reader[1].
• The analogical process, although less directly studied in recent work, exists as an indicator of reader flexibility and is indirectly supported by studies on strategies[31] and the emphasis on orthographic patterns/families[22].

The MAAOD integrates these findings into a coherent theory, emphasizing that reading and spelling skills emerge from the interaction of all these processes. These are not competitive pathways but cooperating components of a unified cognitive network. Readers self-organize this network through engagement with written language, self-selecting the optimal processing pathway for each task.

Quantitative findings confirm that no single factor alone suffices to explain performance—rather, multi-factor models provide greater predictive power (e.g., multi-factor SEM models in Rakhlin et al. [29,30]). Qualitative findings illustrate how children experience this complexity: through mistakes, corrections, experiments, and strategic combinations, they learn how to learn words, eventually reaching a point where reading becomes as natural as speaking.

It is noteworthy that the MAAOD also aligns with neuroscientific evidence. Imaging studies (fMRI, EEG) have shown that as children learn to read, their brain networks reorganize, with some regions specializing in word-form recognition (Visual Word Form Area) while maintaining connections with phonological and semantic areas[42] . This neural self-organization supports the idea that reading is not localized in a single brain area but is a product of an educated network.

Overall, contemporary scientific research provides extensive evidence aligning with the theoretical principles of the MAAOD self-organizing model. Initially formulated through interdisciplinary reasoning, this model accurately predicts findings in cognitive psychology and linguistics: spelling learning is a multidimensional, dynamic process involving both implicit brain self-organization and explicit teaching, automatic mechanisms and conscious thought. This complex view is confirmed today and offers fertile guidance for educational practice: by strengthening all aspects (spontaneous reading and teaching, phonological and morphological activities, automation, and metacognitive empowerment), we can help students develop their spelling skills more fully.

In conclusion, current research strongly supports a holistic and dynamic model of reading and spelling. The Self-Organizing Model of Reading and Spelling Skills (MAAOD), backed by primary studies from the past decade, provides an appropriate framework for understanding: literacy is an ongoing learning process where the cognitive system constructs knowledge through reading and writing practice. The emergence and self-selection of phonological, morphological, lexical, and analogical processes empower students to become autonomous, active language users. This has profound practical implications, suggesting education should foster this multidimensional development, offering opportunities for children to decode, discover patterns, enrich their

vocabulary, and make connections. Such multidimensional teaching optimally supports the natural self-organization of the reading brain, resulting in capable and flexible readers and spellers.

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