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RESEARCH ARTICLE

The role of semantic activation during word recognition in Arabic

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Abstract
In the current study, the role of semantic activation in the process of word recognition was investigated among native Arab readers. Twenty-nine typical readers in third grade were tested in reading three lists of pseudowords. Each list consisted of thirty pseudowords (lists A, B and C). Each word in list A was matched with a real meaning, and each participant was trained during eight training sessions to learn the meanings of the pseudowords (the semantic list). For list B, the participants were exposed only to the phonological pronunciation of each word during eight phonological training sessions. List "C" was not used for trained at all, and the participants were not exposed to this list either semantically or phonologically. The training processes occurred aloud, and the participants were not exposed to the orthographic pattern of any pseudoword. The results showed that reading the semantic pseudowords revealed the highest accuracy levels and shorter reading times compared to reading the pseudowords from the phonological training trial and the unfamiliar pseudowords. The results support the assumption about the role of semantic activation in word recognition and shed light on the importance of vocabulary knowledge to the process of reading new words.

Keywords Reading · Semantic activation · Arabic orthography · Decoding

Introduction

Visual word recognition is thought to be affected by different cognitive and linguistic factors (Coltheart 2005; Geva and Siegel 2000; Frost and Katz 1989; McClelland and Rumelhart 1981; Nation 2009; Seidenberg and Tanenhaus 1979). According to different models of word recognition, this process begins through low levels of activation starting from visual perception of the orthographic components of written words, continuing to phonological decoding and ending with semantic activation (Stone et al. 1997; Ziegler et al. 1997).

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In light of this former assumption, the connectionist model of reading postulates that the word recognition process starts from visual activation according to the orthographic components of the printed word, while this process reveals the lexical access of the stored pattern in the mental lexicon and therefore enables later phonological and semantic activation as a result (see, for example, Zorzi et al. 1998). Accordingly, during this process of word recognition, activation streams from the lower levels of processing (orthographic and phonological levels) into the higher levels, i.e., the semantic level.

New description of the computational processes during the word recognition was suggested by Harm and Seidenberg (2004). According to such model, word recognition is considered as a result of computational of different mechanisms: orthographic, phonological and semantic. The meaning of a word is a pattern of activation over a set of semantic units that develops over time based on continuous input from both orthographic–semantic and orthographic–phonological–semantic components. Thus, access to meaning depends on cooperative computation in which semantic patterns reflect the joint effects of input from different sources. However, the model highlights the important role of pre-existing knowledge in reading words. According to this, during learning to read children utilize pre-existing perceptual, learning and memory

capacities that are not reading-specific, as well as pre-existing knowledge (e.g., of spoken forms of words and their meanings and knowledge of the world). Thus, recognition of written words is a process of computation of the relationships between the written, spoken and semantic representations.

However, interactive models of word recognition postulate that during the word recognition process, there is a continuous flow of bottom-up activation from the basic feature-level representations to letter-level representations and to word-level representations (see, for example, Jacobs et al. 1998). In addition, the model postulates that simultaneous top-down activation, which flows from word-level representations to lower levels of representations, is called feedback activation and depends mainly on semantic activation. This feedback activation has been explained in the former model of McClelland and Rumelhart (1981). McClelland and Rumelhart postulated that there is an impact of higher-level representations on lower-level representations during the process of word recognition and that this impact can hence explain why real words are processed faster than novel words or arbitrary letters, known as the word superiority effect.

Recent studies have explored the role of semantic activation in word recognition and reading words aloud. For example, McKay et al. (2007) examined the impact of semantic loss on reading-aloud performance in 7 patients with semantic dementia. The results of their research were explained by the relationship between semantic loss and increased reading errors, supporting the models of reading that include a role for semantics in the reading-aloud process. In another study, McKay et al. (2008) trained 53 introductory psychology students to read aloud 2 sets of novel words, some with meanings (semantic) and some without (nonsemantic). The results showed that reading-aloud performance became faster and more accurate for novel words in the semantic condition than for those in the nonsemantic condition. This semantic advantage was retained when the participants were tested again 6–12 months later. In a similar paradigm of semantic training of novel words, Taylor et al. (2011) performed an experiment to explore the influence of semantics on orthographic processing in an artificial language. In one experiment, sixteen university students (6 men, 10 women, age 20 ± 2.34) learned to read novel words that were written in novel characters. The participants were pre-exposed to the sounds of all items (*lexical phonology*) and to novel definitions for half of these items (*semantics*). The results showed that pre-exposure to either lexical phonology or semantics boosted the early stages of orthographic learning of the novel words. By the end of training, facilitation was restricted to the semantic condition. These findings suggest that semantic knowledge supports word reading processes and that item-specific phonological knowledge is important in the early stages of learning to read.

The abovementioned review supports the notion that semantic knowledge enhances orthographic activation and boosts reading. Different studies have mentioned the role of vocabulary knowledge in enhancing reading acquisition (Muter et al. 2004; Ouellette 2006; Walley et al. 2003). Children with poor vocabulary were found to encounter more reading difficulties than children with higher verbal skills and semantic knowledge (Scarborough 1990).

The most common types of language development and verbal acquisition usually occur within the dominant language context of the individual, i.e., in his first language context. Usually, this language context is the one used in order to learn to read and write during the formal years of education. However, in some cases, such as in Arabic, the daily spoken language (hereafter SL) is not the language that the individual uses to learn to read and write (Taha 2013; Saiegh-Haddad 2003, 2004). Reading in Arabic is learned in the Standard Arabic (hereafter SA) context, which is different from the SL at the phonological, semantic and morphological levels. This situation of two distinct but not structurally independent forms of the same language is considered as main unique feature of the Arabic language and refers to the will-known linguistic phenomena called diglossia (Ferguson 1959). The term diglossia in Arabic refers to the distance between the SL, which is the daily language for communication, and the SA (the standard language), which is used for formal and written communication in general (Saiegh-Haddad 2003, 2004; Taha 2013). This linguistic situation has been considered in different studies to be a main challenge for children in early stages of reading acquisition, and it might play a causal role in reading difficulties among children with poor readiness to read (Abu Rabia et al. 2003; Saiegh-Haddad 2003).

Accordingly, based on the former review of the role of semantic activation in word recognition, it will be interesting to explore this effect in the Arabic language context. That is, does semantic knowledge improve the ability to read unfamiliar orthographic patterns in Arabic?

Method

Participants

Twenty-nine native Arab children in third grade (15 boys and 14 girls; age $= 8.57 \pm .45$ years) participated in the current study. All participants fall above the 75th percentile for reading scores according to their grade-level reading fluency (according to their school database reading scores). All participants learn in Arab schools, while the SA language is the main instructional context in their schools. The parents' consent for their children to participate was collected for each participant before beginning the study. For each participant,

neurological, sensory or other disabilities were excluded; accordingly, none of the children had hearing impairment, attention-deficit disorder or any other neurological or emotional disorder, as reported by the school staff and the families' developmental reports. All participants came from low-mid socioeconomic backgrounds according to the standard socioeconomic measures in Israel.

Procedure

Each participant was tested in reading aloud three pseudoword lists in Arabic that were created for the purposes of the current study. List A consisted of thirty pseudowords and was considered the "semantic pseudowords" list (hereafter SP). The pseudowords of this list were matched with real meaning for each pseudoword. The meanings which were matched to the pseudowords in the SP list were all common nouns only (like farm, table, garden); there were no verbs, adverbs or adjectives. Such common nouns were selected after familiarity judgment process which was implemented by using three language teachers. For each pseudoword, three alternative common nouns were suggested and each teacher was asked to rate the familiarity of each common noun to children in the third grade using a scale of 1 into 5 degrees (1 not familiar at all–5 very familiar). Common nouns which revealed the highest scores were selected and matched randomly for each pseudoword, one common noun for each pseudoword. Each participant learned the meanings of each of these pseudowords during 8 semantic learning trials. The length of each learning trial was 20 min. The learning process occurred aloud, and the participants were not presented with any orthographic pattern of the learned pseudowords. In fact, during the semantic training trials, the participants were also exposed to the phonological pronunciation of each pseudoword; accordingly, these trials cannot be considered semantic trials only but should be regarded as semantic–phonological trials.

List B also consisted of 30 pseudowords. This list is considered to be the phonological condition of exposure (i.e., the phonologically familiar pseudowords, hereafter PP). The phonological exposure was implemented during 8 phonological training trials. Each trial lasted approximately 10 min, where the students repeated the pronunciation of each pseudoword as it was heard from the examiner. These trials are considered phonological learning trials because the participants were exposed only to the phonological pronunciation of each pseudoword. The learning process occurred aloud, and the participants were not presented with any orthographic pattern of the pseudowords.

List C also consisted of 30 pseudowords that were not trained at all. Accordingly, those pseudowords were considered unfamiliar pseudowords, representing the unknown condition of pseudowords (hereafter UP).

For the three lists of pseudowords, matching based on the number of letters in each full word was conducted to control for word length, while the average length for each list was $4.77 \pm .43$. The pseudowords in the different lists were matched also according to syllable length as follows: the SP list $2.26 \pm .63$ syllables in average, the PP list $2.03 \pm .61$ syllables and $2.23 \pm .5$ syllables for the UP list. There was no significant difference between the three list regarding the syllables length [$F\ (2, 28) = 1.1$, $p = .34$]. The pseudowords in the tree lists did not share any phonological or orthographic neighborhood.

The phonological and semantic learning trials were implemented in parallel. After finishing the learning trials, all participants took the pseudoword reading test. During the reading stage, each participant was presented with the different pseudoword lists and asked to read the words in each list aloud. The order of the lists was changed from one participant to another in order to control for any effects of the stability of presentation order. Accuracy and reading times were recorded for the reading of each list of pseudowords.

Results

A repeated-measures analysis of variance was used to test the differences in reading accuracy and time for the reading of the three lists (i.e., the SP, PP and UP lists). When significant differences were found, post hoc analysis using the LSD post hoc test was performed to identify the source of the significant difference between the conditions. Table 1 presents the means and SDs for the accuracy and time (s) in the reading of the different lists.

Accuracy

The analysis of variance revealed a significant effect of the reading list on reading accuracy [$F\ (2, 56) = 7.04$, $p < .01$]. The LSD post hoc test showed that significant differences in reading accuracy were found between the SP reading list ($M = 82.14$) and the PP list ($M = 79.15$) and UP list ($M = 74.21$). In addition, significant differences in accuracy levels were found between the PP list and the UP list.

Table 1 Means and ± SDs of the reading accuracy and time in reading the three list conditions

	SP	PP	UP
Accuracy	82.14 ± 9.7	79.15 ± 10.88	74.21 ± 12.49
Time (s)	52.01 ± 15.21	54.62 ± 13.28	60.38 ± 17.22

SP semantic pseudowords list, *PP* phonological pseudowords list, *UP* unknown pseudowords list

Time

The analysis of variance revealed a significant effect of the reading list on reading time [F (2, 56) = 8.24, $p < .01$]. The LSD post hoc test showed that significant differences in reading time were found between the UP reading list ($M = 60.38$) and the SP list ($M = 52.01$). In addition, significant differences in reading time were found between the UP and PP lists ($M = 54.62$). However, no significant differences in reading time were found between the SP and PP lists.

Discussion

The contribution of semantic activation to word recognition in Arabic was investigated in the current study. The main assumption of the current study was that reading new orthographic patterns is supposed to be more accurate and faster when these patterns have semantic representations. The performance of the readers reinforced this assumption: Reading the SP items was associated with the highest accuracy levels and faster reading times than reading the PP and UP targets. This finding is consistent with previous findings in other studies of other languages (McKay et al. 2008; Taylor et al. 2011).

Semantic activation represents the impact of higher-level representations on lower-level representations and can explain why the SP words were processed with high accuracy levels than the PP and UP targets and faster than the UP targets. In the case of SP targets, activation for processing the written patterns flows in both directions, from the top-down (semantic) and from the bottom-up (letter-phoneme correspondences). Both parallel activations facilitate the word recognition process and contribute to the accuracy and time of processing (McClelland and Rumelhart 1981).

In the current study, in order to examine the contribution of the semantic knowledge to the process of reading new words, we trained the participants for meanings of pseudowords without any orthographic exposure during the training trails. All the training process was implemented in an auditory manner only. During this process, the participants were also exposed to the phonology of such words as a direct result of the semantic training process itself, and they were asked to pronounce the trained pseudowords during the semantic learning process. Accordingly, after the process of training on the SP words, these targets were processed from two levels of representation, semantic and phonological. Both representations together improve the orthographic processing of SP words. This finding explains why the SP processing was more accurate and faster than the PP processing, for which only bottom-up processes contributed to word recognition.

The role of semantic activation while reading familiar orthographic patterns arises because activation itself may begin from the orthographic–semantic association alone (Coltheart 2005). However, in the present case, there was no prior acquaintance with the orthographic patterns that would enable such orthographic–semantic association. Nevertheless, it can be assumed that at the beginning of the phonological decoding process, an associative-semantic excitation process is initiated according to the phonological information decoded. Such phonological information stimulates and initiates a parallel semantic activation process, which in turn facilitates the phonological coding process. In this way, a process of mutual phonological–semantic feedback occurs and contributes to the reading process (Harm and Seidenberg 2004).

Considering the implications of the current research for the linguistic situation in Arabic learning, i.e., diglossia, it might be assumed that earlier exposure to the SA language might contribute to establishing semantic and phonological representations of SA words prior to the orthographic stage of learning and that such exposure could make reading acquisition in early grades much easier than it has been reported in existing studies. Other researchers suggest that this linguistic difference between the SL and SA in Arabic makes reading acquisition for young readers a challenging process, with readers with poor reading readiness potentially failing to pass these early stages and being unable to reach the fluent reading stages (Abu Rabia et al. 2003; Saiegh-Haddad 2003). This possibility is supported by the notion that SL is different from SA at two major levels, the semantic and phonological levels (Taha 2013).

The study of Abu Rabia (2000) might strengthen this assumption about the need for earlier exposure to SA to improve reading skills among children in the early stages of reading acquisition. In his study, Abu Rabia examined the influence of SA exposure of preschool children on their reading comprehension of SA stories in grades 1 and 2. Some of the participants were exposed to SA throughout their preschool period, while others (the control group) were not exposed to literary SA during that period. These children were tested for reading comprehension at the end of grades 1 and 2, and their performance was compared with that of the control group. The results generally indicate better reading comprehension results for the children who were exposed to literary Arabic than for the children who were exposed only to spoken Arabic. These results reinforced the assumption of the current study in which previous exposure to SA might reinforce reading skill acquisition among Arab readers.

In sum, the results of the current study provide an understanding of the important role of semantic knowledge in the process of word decoding in Arabic. These results contribute to the pedagogical field of reading in Arabic. According to the current results, improving the SA vocabulary of

kindergarten children will contribute to the process of reading acquisition later. Further research might be needed to confirm this conclusion.

Compliance with ethical standards

Conflicts of interest The authors declare that there are no conflicts of interest that could have direct or potential influence or impart bias on the work.

Ethical standards The current study and all its ethical standards were approved by the research and ethical committee of Sakhnin College.

Informed consent The authors of the current manuscript declare that all parents of the participants in the current study gave their informed consent in writing prior to the inclusion of their children in the study.

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