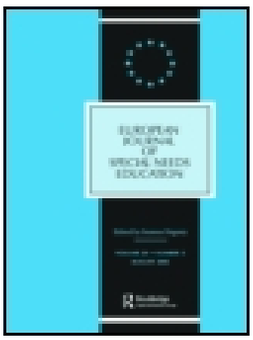

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Improvements in reading and spelling skills after a phonological and morphological knowledge intervention in Greek children with spelling difficulties: a pilot study

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ABSTRACT

In this pilot study, we evaluated the effects of the online computer-based training programme 'Lexilogy-Greek' on the reading and spelling performance of young poor readers and spellers. The training is based on psycholinguistic principles that emphasise the importance of acquiring efficient phonological as well as morphological knowledge in remediating reading and spelling difficulties. Our sample consisted of fifteen 5th and 6th grade primary school children. Reading and spelling were tested at three points, with a no-intervention period and subsequently an intervention period in between these time points. We adopted a single group repeated measurement design, and tested for intervention effects using repeated measures ANOVAs. The results revealed substantial treatment effects on spelling, word reading fluency and text reading fluency.

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Morphological knowledge; intervention; spelling disability

The importance of phonological awareness for reading and spelling achievement in alphabetic orthographies is well established (e.g. Ehri 2017). The ability to recognise and manipulate letter-sound correspondences plays a critical role in learning how to read and spell. Additionally, morphological knowledge, that is the knowledge that words may contain smaller units of form and meaning which are the morphemes (i.e. stems and affixes) seems to play an important role in literacy development as well (Carlisle 2010; Nunes and Bryant 2009).

When morphological knowledge is obtained, the consistency of the stem e.g. *act* in words such as *action – actual – react – interact* is recognised and the prefixes, e.g. *re* and *inter*, and the suffixes, e.g. *ion*, and *ual*, are identified (Marinova-Todd, Siegel, and Mazabel 2008). From a developmental perspective, morphological knowledge seems to foster the development of spelling and reading skills (Carlisle 2010; Nunes and Bryant 2009). Children's morphological knowledge starts to form in spoken language, and transfers in the efficient acquisition of written language (e.g. Caravolas 2004; Deacon and Kirby 2004).

Morphological knowledge seems to play a fundamental role in orthographic spelling, across languages, as morphemes can settle spelling choices (Desrochers et al. 2018; Nunes and Bryant 2009; Pacton et al. 2013). Morpheme recognition can incite the understanding of the relation between the orthographic word form and its spoken counterpart, especially in the

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case where the rules of letter-sound correspondences do not match with the orthographic word form. The recognition of the morphological structure helps to overrule these possible blurring phonological effects a derivative word can display (e.g. define – definition). The extent to which morphological knowledge settles spelling choices and influences reading performance, however, depends on the specific characteristics of an orthography (Aro, 2006).

Morphological knowledge in atypical spellers and readers across languages

It is proposed that difficulties with the application of morphological knowledge in settling orthographical ambiguities contribute to the persisting reading and spelling challenges atypical (i.e. dyslexic and poor) learners face (e.g. Koh et al. 2017; Tsesmeli and Seymour 2006). Research suggests that individuals with dyslexia show less morphological knowledge when compared to non-dyslexic peers (Schiff and Levie 2017; Leong and Parkinson 1995). Children who were at risk for developing spelling and reading difficulties showed a lack of use of inflectional morphological knowledge in their spelling (Koh et al. 2017). Studies concerning poor readers in different languages underline the importance of facilitating morphological information about e.g. root consistency and inflexional suffixes in words and stress the need to incorporate this in teaching instructions and remediation programmes for spelling (Angelelli et al. 2017; Tsesmeli and Seymour 2006).

The case of Greek

Greek is considered an orthographically transparent language, but while its alphabetic system has high feed forward (reading) consistency, it has substantial feedback (spelling) inconsistencies (Protopapas 2017). Consequently, relative to reading, Greek children have the most pronounced and persistent problems with spelling acquisition (Protopapas 2017).

Spelling in Greek is based on etymology which goes back to Ancient Greek (Porpodas 1991), and on spelling rules related to the inflectional system and on assimilation effects. To spell each word part (e.g. root, prefix, suffix) different kinds of information is needed. Before presenting specific word part-related spelling rules, explicit teaching has to precede the recognition of these different word parts. Accordingly, research of Nikolopoulos and collaborators (2003) indicate that morphological knowledge contribute significantly to spelling development.

The present study

Taken together, the aforementioned studies suggest that morphological based learning strategies, in addition to phonological ones, can be beneficial remediation strategies targeting at risk and diagnosed poor readers and spellers. The present study aims to provide a window on the ecological validity of the benefits of morphological based learning strategies, by evaluating the effects of an extensive intervention for low-performing Greek spellers that, following a short phonological training of the alphabetic principle, extensively trained all aspects of morphological knowledge that are relevant for spelling and reading in Greek. Our research question in this pilot study was: what are the gains of an intervention that mainly focuses on morphological based learning strategies on struggling children's spelling and reading skills?

Method

Participants

We recruited children in grade 5 and grade 6 from two private primary schools in Athens. To be selected for the study they had to meet the following criteria: (1) spelling skills at least 0.5 SD below the mean; (2) IQ ≥ 85; (3) normal or corrected to normal vision and hearing; (4) no diagnosis of any sensory or neurological problems; (5) fair access to educational opportunities. Based on these criteria, 24 children were selected. Four children withdraw their participation in the first month of the intervention period due to difficulties in combining the intervention schedule with school demands. For five children the research team deactivated the login during the intervention period due to a very low login frequency that resulted in extreme programme progression delays. Our final sample therefore consisted of 15 children (9 boys and 6 girls; 2 from grade 5 and 13 from grade 6; see Table 1).

Procedure

The study consisted of a single-group cross-over design (control first). In this within-subject design, participants serve as their own controls. Considering our small sample size, this design is more powerful than between subject comparisons. Additionally, it provides a control for regression to the mean effects (Morton and Torgerson 2005). Reading and spelling skills were tested on three time points, with six-months intervals in between. During the initial phase of the study between the first and second time points (6-month period), the children received no intervention. This period thus constituted the control condition. In the second phase between the second and third time points (6-month period), the children received the intervention: participating children therefore acted as their own controls in this design. Participants received a basic differential diagnostic baseline assessment at the first time point. The intervention programme consisted of approximately 24 weeks of online training involving three 25-minute sessions per week.

Measures

Outcome measures

Three outcome measures were assessed at pre-test, midtest and post-test in order to evaluate the effects of the intervention.

Table 1. Baseline characteristics of the sample.

	M	(SD)
Sex ratio (M: F)	9: 6	
Age (in months)	130.07	(5.23)
Intelligence (Percentile)	55.18	(25.20)
Phoneme Awareness – Synthesis (Z-score)	−0.51	(1.05)
Phoneme Awareness – Segmentation (Z-score)	−0.82	(1.18)
Digit Span (Z-score)	−0.64	(0.84)
Spelling (Z-score)	−1.75	(1.31)
Word Reading (Z-score)	−0.99	(1.08)
Text Reading (Z-score)	−0.97	(1.23)

Word reading fluency was assessed by a 100 word-test, consisting of a chart of four columns, each containing 25 words that are not related. The score used for this test is the total number of correctly read words within one minute (r = .88 to .92, test-retest; Hoette, Mixopoulou, and Tijms 2009).

Text reading fluency. This test requires the oral reading of a story containing 30 lines of coherent text. Children are instructed to read the text as quickly and as accurately as possible. The words used represent the various characteristics in the Greek written language. The text reading score is the time required to read the text (r = .98 to .99, test-retest; Hoette, Mixopoulou, and Tijms 2009).

Spelling skill. This dictation contains 5 long sentences. The words making up the sentences are familiar to all elementary-school children. The collection of words is a representative sample of the various orthographic properties in Greek spelling. Scoring is based upon the total number of spelling errors (r = .94, test retest; Hoette, Mixopoulou, and Tijms 2009).

Baseline measures

Additionally, we administered four extra measures at pre-test only, in order to gain further insight in the characteristics of our sample.

Intelligence was assessed with Raven's Coloured Progressive Matrices (Raven, Court, and Raven 1995), a nonverbal intelligence test.

Phonological awareness was assessed with a phoneme synthesis test (r = .81 to .86, test-retest) in which the child has to name the word that results when the separate phonemes are blended, and a phoneme segmentation test (r = .65 to .85, test-retest), in which the child has to segment a word in a sequence of separate phonemes (Hoette, Mixopoulou, and Tijms 2009). The number of correct responses represents the score on both tasks.

Phonological short-term memory was assessed with the WISC-III subtest digit span (r = .78 to .85, internal consistency). The number of digits that a child is able to repeat in correct or reversed serial order immediately after hearing them represents the score.

Intervention

Lexilogy-Greek is an online, computer-based training programme. In this programme, children are able to visualise the derivational changes, the compounding processes and inflectional changes via interactive interfaces. This interface aims to facilitate the mastery of morphological knowledge and instrumental use of it in reading and spelling. The intervention programme aims at mastery learning. Therefore, tests are implemented to evaluate the progress of the student at every stage, with a threshold of 80% correct required for advancing to the next level. In Table 2, we provide an overview of the content of the intervention.

Table 2. Overview of training topics.

	Stage	Used word group	Task	Description	Online sessions of 20′
1	Phonemic knowledge Exercises with 2-syllable words without a spelling difficulty	nouns	Writing with sound board, Recognition of heard word. Reading words in sound structure	Training focuses on the corpus of Greek phonemes and the category they belong to (vowel, consonant, 2-token sound)	5
2	Morphemic knowledge Exercises concerning all different word parts. string type: 1–7	verbs – nouns – adjectives	Writing and reading in morphemic structure with colours	Training focused on the recognition and manipulation of the different word parts	42
3	Word composition Exercise asks user to build the heard word. string type: 1–7	nouns – verbs – adjectives	Writing and reading in morphemic structure with colours	Training focusing on string recognition by composing strings by yourself	9
4	Stem spelling based on etymology. string type: 1–7	nouns – verbs – adjectives	Writing and reading in morphemic structure with colours	Training focused on the stem spelling per vowel difficulty	9
5	Verb conjugations and their spelling string type: 1	verbs	Writing and reading in morphemic structure with colours	Training focusing on spelling of verb conjugations	6
all	Phonemic knowledge Exercises with 2-syllable words with different consonant clusters	nouns	Reading words that are flashed on screen in syllables or as whole word	Training focusing on speed reading with an ascending grade of difficulty in time and clustering	5′after every session

Results

The descriptive characteristics of the sample at the time of baseline assessment are presented in Table 1. As can be seen at this table, both spelling and reading skills were at a poor level. That is, although the participants were selected on poor spelling, their reading skills are, on average, approximately 1 SD below the (age-related) population mean. Additionally, the phonological skills are between 0.5 SD and 1 SD below average, which is typical of children with dyslexia.

For the analyses of the intervention outcomes, standardised scores (Z-scores) were used instead of raw scores, in order to assess the child's position within the distribution of the age-related normative sample and to control for normal growth in reading and spelling skill during the intervention period. We conducted the d'Agostino-Pearson test for the outcome measures on all time points (pre, mid, post) to test the assumption of normality. No significant effects were present (all $p > .06$), indicating data did not violate this assumption. Both Z-scores and raw scores for spelling and reading skills at pre-test, mid-test, and post-test are presented in Figure 1. To test the intervention effects, we conducted repeated measures ANOVA (Greenhouse-Geisser) with Time as the within-subject factor for each outcome measure.

Spelling

The results of the analysis, presented in Table 3, show a significant effect of Time. Contrasts between the levels of time revealed that this main effect was due to a significant gain in

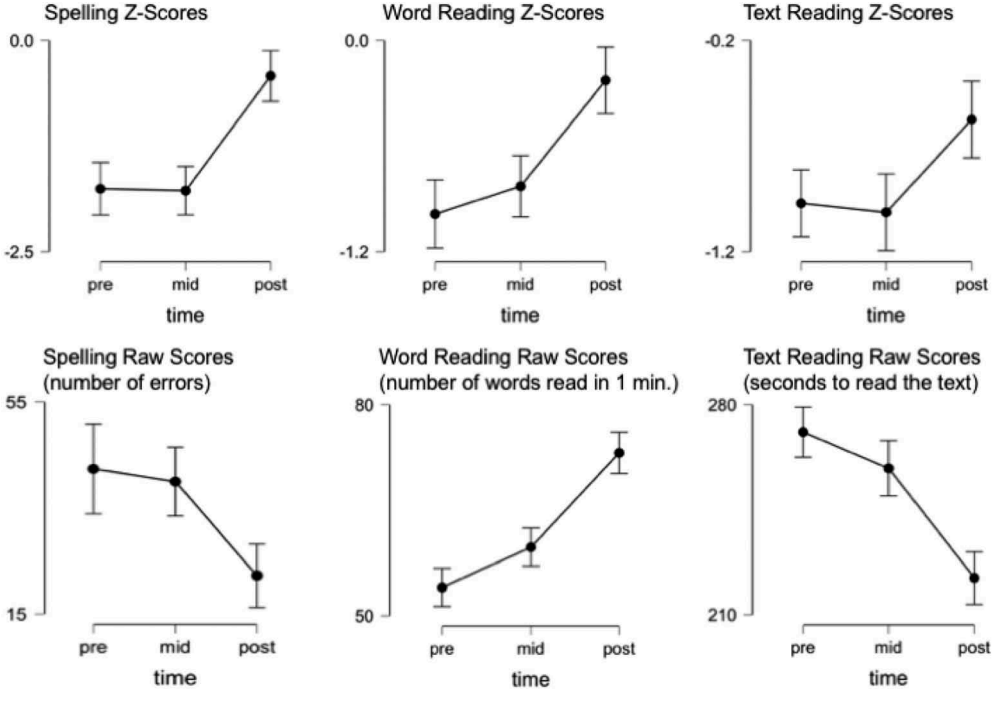

Figure 1. Z-scores and raw scores for spelling, word reading and text reading at pre-test, mid-test, and post-test.

Table 3. Repeated measures ANOVA for spelling (in Z-scores).

Time	M	(SD)	F	p	Partial eta
Pre-Test	−1.75	(1.31)	31.19	< .001	0.69
Midtest	−1.78	(1.20)			
Post-Test	−0.42	(0.94)			
CONTRASTS (repeated)	Mean Difference		(95% CI)	*t*	*p*
Pre-mid	−0.02		(−0.56–0.51)	−0.11	.91
Mid-post	1.36		(0.88–1.87)	6.90	< .001

Note. N = 15

standardised spelling score between mid-test and post-test with a large effect-size (Cohen´s d = 1.86), whereas no significant differences were present between pre-test and mid-test. The results thus show a positive, substantial effect of the intervention on children's spelling skills.

Word reading fluency

The results of the ANOVA are presented in Table 4. The results revealed a main effect of Time. Contrasts between the levels of time showed no significant gain in standardised word reading score in the no-intervention period (pre – mid). During the intervention period (mid – post), however, a significant gain in word reading was revealed with a large effect size (Cohen´s d = 1.33). The results thus show a positive, substantial effect of the intervention on word reading fluency.

Text reading fluency

The ANOVA (see Table 5) revealed a main effect of Time. Contrasts between the levels of Time showed no significant gain in standardised text reading score in the no-intervention period (pre – mid). During the intervention period (mid-post), however, a significant gain in text reading fluency was revealed with a large effect size (Cohen´s d = 0.91). The results thus show a positive, substantial effect of the intervention on text reading fluency.

Discussion

The importance of integrating morphological training in intervention programmes for poor readers has been advocated by a number of authors (e.g. Nunes and Bryant 2009; Tsesmeli and Seymour 2006; Bowers, Kirby, and Deacon 2010). Studies focusing on the

Table 4. Repeated measures ANOVA for word reading fluency (in Z-scores).

Time	M	(SD)	F	p	Partial eta
Pre-Test	−0.99	(1.08)	21.44	< .001	0.61
Midtest	−0.83	(0.98)			
Post-Test	−0.23	(0.79)			
CONTRASTS (repeated)	Mean Difference		(95% CI)	*t*	*p*
Pre-mid	0.16		(−0.17–0.49)	129	.21
Mid-post	0.60		(0.28–0.92)	4.91	< .001

Note. N = 15

Table 5. Repeated measures ANOVA for text reading fluency (in Z-scores).

Time	M	(SD)	F	p	Partial eta
Pre-Test	−0.97	(1.23)	8.90	.001	0.39
Midtest	−1.01	(1.41)			
Post-Test	−0.57	(1.12)			
CONTRASTS (repeated)	Mean Difference		(95% CI)	*t*	*p*
Pre-mid	−0.04		(−0.34–0.26)	−0.37	.71
Mid-post	0.44		(0.10–0.78)	3.83	< .001

Note. N = 15

effects of morphological training for low performing readers and spellers in other languages than English (e.g. Lyster 2002 in Norwegian) have supported the potential of morphological knowledge in more transparent orthographies as well. For example, an evaluation study of an intervention for Dutch children with reading and spelling difficulties (Tijms 2004) confirmed the necessity of focusing on the relationship between morphemic structures and orthographic representations (on top of phonological representations), as suggested by Snowling (2000). The study showed that only when the focus of training shifted from instructing the phonetic structure of the Dutch word to the morphemic structure, morphemic-related spelling errors reduced.

The present pilot study evaluated the effects of a Greek reading and spelling intervention programme, Lexilogy-Greek, in which training of morphological knowledge was the focal point. Our results revealed significant intervention effects on both reading and spelling skills. As anticipated, the children did not change in their standardised reading and spelling skills during the no-intervention period. During the intervention period, however, they showed a substantial progress in terms of standardised reading and spelling scores. These results confirmed findings reported in earlier studies suggesting that morphological strategies alongside phonological can be used effectively with low-performing spellers, even in more transparent orthographies (Tijms 2004).

Concerning intervention for Greek children with spelling difficulties, the findings of this study confirmed the importance of incorporating teaching strategies that systematically explain the morphemic structure of the word from the simplest form to the more complicated words, as reported by Tsesmeli and Koutselaki (2012). In line with the importance of the morphemic structure to decipher the Greek orthography, our study suggests that both spelling and reading skills of struggling learners benefit from teaching explicit morphological knowledge.

The results of study provide a tentative indirect window on the on-going question of when to introduce morphological training, as there is a lack of consensus on the timing of this introduction. Our data on 11 and 12 year old children shows that morphological training seems to be effective for struggling readers and spellers in upper elementary years as suggested by Adams (1990). However, future studies should explore whether such teaching instruction produces the same benefits for younger children as argued for example by Carlisle and Stone (2005).

Additionally, the results indicated that online training could be a form of effective intervention. Despite the absence of one-to-one tutoring, a substantial increase in reading and spelling performance was achieved in our online intervention.

Limitations

Whilst the results of our intervention study are promising, we need to acknowledge some limitations. Given the relatively small sample size, the study can be considered exploratory rather than confirmatory, although the results we obtained and the patterns inherent in those results are clear and consistent.

Future research should thus entail a larger sample of poor readers and spellers and preferably with a separate control group to increase external validity, instead of having participants acting as their own controls. Moreover, a future randomised control trial should include a delayed post-test to explore the retention of learning effects.

Finally, a detailed analysis of reading and spelling errors at multiple measure points during the intervention programme could give more insight in pinpointing the stage at which certain type of errors reduce and if this reduction can be attributed to phonological or to morphological knowledge (Tijms 2004). Given that each morphological component carries a different type of information, it may be the case that each component follows a marked developmental trajectory. Baring that in mind, performance on each of these components needs to be recorded and analysed separately in morphological training and other relevant intervention materials.

Conclusion

Considering limitations, the results from our intervention programme and the reported subjective experiences of children and their families support the proposition that an online computer-based intervention addressing morphological knowledge can have substantial positive effects on both spelling and reading skills of struggling learners. In the light of this, we conclude that Lexilogy-Greek could be an effective treatment option for low-performing Greek readers and spellers.

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Disclosure statement

H.H. is director of the organisation providing the lexilogy intervention program. The other authors report no conflict of interest.

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