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The Importance of Morphological Knowledge in the Reading Comprehension Difficulties in a Highly Agglutinative Language: Evidence from Poor Comprehenders

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Abstract
This study examined the importance of morphological knowledge in the reading comprehension difficulties of poor comprehenders reading in a highly agglutinative language, Turkish. Participants were 56 students recruited from the second and third grades. In the assessment process, we applied three experimental paradigms addressing the participants' morphological and morpho-syntactical knowledge at the lexical and the supralexical levels. Data were collected in individual sessions and analyzed by running a series of GLM ANOVAs and calculating the Spearman–Brown correlation coefficient. Findings suggest morphological knowledge is an important indicator of reading comprehension difficulties in Turkish, a highly agglutinative language. The acquisition of adequate reading comprehension seems to be modified by particularities of the morphological knowledge.

Keywords Reading · Reading comprehension · Morphology · Morpho-syntax · Morphological decoding

Introduction

Reading is a basic skill that starts to develop in early childhood and shapes the entire academic life of an individual. Generally defined as the process of constructing meaning for graphemes, it involves both cognitive and linguistic skills. In the Simple View of Reading (SVR) model, reading is considered the joint product of two dimensions: word decoding and language comprehension (Gough & Tunmer, 1986; Tunmer, 2008; Tunmer & Greaney, 2010). Word decoding is the ability to derive efficiently a mental representation from printed text, such as isolated word reading or nonword reading accuracy and fluency

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(Lonigan et al., 2018), while language comprehension involves understanding the linguistic features of the language being read (Tunmer & Chapman, 2012a, 2012b). Hoien and Lundberg (2000) argue decoding requires the ability to exploit the alphabetic principle (e.g., grapheme-to-phoneme conversion) and, as such, is the technical side of reading. Although it is accepted as an important prerequisite skill, decoding alone does not guarantee comprehension (Tunmer & Greaney, 2010). Language comprehension is a linguistic-based skill, and three different types of linguistic information (semantic, syntactic, and morphologic features) are required to process written material (Kamhi & Catts, 2012). In successful reading, decoding and language comprehension are reciprocally dependent, and arriving at a sufficient level in both dimensions is the most important point of the process (Tunmer & Chapman, 2012a, 2012b).

As stated in SVR's reading formula (reading comprehension = decoding × language comprehension), reading comprehension is the ultimate goal of functional reading (Tunmer, 2008). It is generally in direct proportion to readers' language competency (Kamhi & Catts, 2012), including level of vocabulary, syntactic knowledge (assigning appropriate syntactic structures to sentences), and morpho-syntactic skills (deriving meaning from the rule system governing how words are combined into larger meaningful units, such as phrases, clauses, and sentences) (Brimo et al., 2018; Chik et al., 2012; Siu et al., 2016; Tong et al., 2014; Yeung et al., 2011, 2013). These skills, all of which construct meaning from written material, act as a bridge between graphemes and comprehension. Readers, especially young or unskilled ones, who have limitations in one or more skill are thought to encounter more difficulties in reading comprehension (Bishop & Snowling, 2004; Cain & Oakhill, 2006; Cutting & Scarborough, 2006; Goff et al., 2005; Kamhi & Catts, 2012; Scarborough, 2005; Siu et al., 2016; Tunmer & Chapman, 2012a, b).

In research investigating the factors underlying reading comprehension difficulties, vocabulary is accepted as the strongest common predictor of difficulties in all languages (Biancarosa et al., 2020; Capin et al., 2020; Fernandes et al., 2017; Hirsch Jr., 2010; Protopapas et al., 2013; Zhang & Anual, 2008). Agreement does not extend to the role of syntax and morphology, however, especially for languages with diverse orthographic characteristics such as English and Turkish (Brimo et al., 2017, 2018; Cain, 2007; Catts et al., 2006; Muter et al., 2004; Tong et al., 2013).

English is an opaque orthography, and written expressions are understood by following the word order of sentences. As soon as vocabulary is under control, syntax becomes a determinant factor in reading comprehension (Brimo et al., 2017, 2018; Catts et al., 2006; Cutting & Scarborough, 2006; Tong et al., 2013). In contrast, Turkish is a highly transparent and agglutinated orthography. In this case, morphological and morpho-syntactic knowledge are more important for reading comprehension (Akbulut, 2019; Durgunoglu, 2003; Guldenoglu et al., 2015; Kargin et al., 2019; Lacin et al., 2018; Miller et al., 2013). Although this issue has been emphasized in many studies, the number investigating the effect of morphological knowledge on Turkish primary and secondary school students' reading comprehension skills is limited. To the best of our knowledge, only one (Guldenoglu et al., 2015) focuses on the effects of morpho-syntactic skills of students with reading difficulties on reading comprehension skills, while three others (Kargin et al., 2019; Lacin et al., 2018; Miller et al., 2013) focused on hearing-impaired students. All studies report sentences can be formed with a small number of words in Turkish, but these words take many suffixes, and those suffixes are ultimately the most important determinant of comprehension. The studies also emphasize that poor decoders who have difficulties analyzing the morphological and morpho-syntactic structures of words and sentences during reading tasks do not perform as well in reading comprehension. Although limited research confirms

a relationship between morphology and reading comprehension difficulties in Turkish, the level of the relationship has not been clarified. In addition, considering that Turkish has a completely agglutinating structure and the decisive role of this condition in reading comprehension, of particular interest is the effects of morphological awareness skills of Turkish readers on reading comprehension. Given the scarcity of research, additional studies are required, especially to determine how morphological features affect the reading skills of those with poor comprehension.

Morphological awareness defined as readers' understanding of the structure of words as combinations of morphemes, has particular significance for accessing the meaning of derived words experienced while reading (Carlisle & Kearns, 2017; Castles et al., 2018; Duncan, 2018). It works as a mechanism specified by decomposing morphologically complex words into constituent morphemes. This mechanism requires the integration of the combination of particular suffixes at the lexical level with the metalinguistic ability to recognize and dissect them. Given that reading comprehension is an interactive developmental process of extracting meaning from text, there are at least two conditions in which morphological awareness can be hypothesized to influence this process. First, the specific knowledge involved in morphological awareness may facilitate the comprehension of texts involving particular morphologically complex words, i.e., understanding of morphological relationships may influence reading comprehension (Apel et al., 2022; Deacon & Kirby, 2004; Deacon et al., 2014, 2017; Kieffer & Lesaux, 2008, 2012; Levesque et al., 2021). Second, the ability to decompose morphologically complex words may lead to an increase in breadth of vocabulary and thereby equip readers better to succeed with reading comprehension (Carlisle, 2010; Deacon et al., 2009, 2011; Foorman et al., 2012; Rastle, 2018). Given this to be true, we might claim that morphological awareness would also explain individual differences in reading comprehension performance. This perspective was a key rationale for our study. More precisely, if this relationship exists, it is important to examine how the use of complex and intense morphology has an effect on reading comprehension in an agglutinative language such as Turkish. Although decoding is relatively easy in Turkish, it is necessary to explain why Turkish students with typical vocabulary development still have low reading comprehension performance. In line with this requirement, this study aimed to contribute the literature with additional explanations, other than vocabulary and word decoding, regarding the limitations experienced by Turkish students in the process of reading comprehension.

Turkish is a particularly interesting orthography to use for this purpose. In this language, complex words are formed by combining numerous suffixes (Akbulut, 2019). Its many iterative loops can technically produce words of infinite length using diverse suffixes and their combinations (Aydın & Yıldırım, 2017). Each suffix has a distinct range of meaning (see Fig. 1), and the phonological and/or semantic roles of words differ (e.g., *kitap*—book*, kitap/lar*—books, *kitab/ım*—my book*, kitap/lar/ım*—my books, *kitap/lar/ım/da*—in my books, *kitap/lar/ım/dan*—from my books, *kitap/lar/ım/da/ki*—those in my book*s*) in the sentences to which they are attached (Durgunoglu, 2003).

In Turkish, it is a common and natural condition to have a series of suffixes attached at the end of a noun or a verb (e.g., *ellerimdekile*r (a root with 5 suffixes—*el/ler/im/de/ki/ler*)—in my hands (3 words)), and readers are exposed to complex multi-morphemic words from the very early stages of language and literacy development (Acarlar & Johnston, 2011; Durgunoglu, 2003). Thus, a basic knowledge of when, how, and which suffixes can be used in specific contexts is useful. While suffixes may load various meanings (e.g., possessive (*ben*—I / *ben/im* –my), plural (*kitap*—book / *kitap/lar* –books), derivational (*göz*—eye / *göz/lük* – eyeglasses) etc.) to the added words, they can also create gerundial

Inflectional Suffixes			Derivational Suffixes		
Suffix	Type	Example	Suffix	Type	Example
-ler/-lar	Plural	okullar - **okul + lar** **(schools)**	-lık	Morphemes attached to nouns that produce nouns	kitaplık - **kitap + lık** **(bookshelf)**
-(ı)m	1st Person Singular possessive	okulum - **okul + (u)m** **(my school)**	-ci	Morphemes attached to nouns that produce nouns	kaleci - **kale + ci** (goalkeeper)
-(ı)n	2nd Person Singular possessive	okulun - **okul + (u)n** **(your school)**	-li	Morphemes attached to nouns that produce nouns	şekerli - **şeker + li** **(sugared)**
-u	3rd Person Singular/Plural possessive	okulu - **okul + u** **(his/her/their school)**	-siz	Morphemes attached to nouns that produce nouns	tatsız - **tat + sız** **(tasteless)**
-(ı)mız	1st Person Plural possessive	okulumuz - **okul + (u)muz** **(our school)**	-cıl	Morphemes attached to nouns that produce adjectives	insancıl - **insan + cıl** **(humane)**
-(ı)nız	2nd Person Plural possessive	okulunuz - **okul + (u)nuz** **(your school)**	-u	Morphemes attached to verbs that produce nouns	soru - **sor + u** **(question)**
-(ı)nı	Objective case	okulunu - **okul + (u)nu** **(your school)**	-lık	Morphemes attached to adjectives that produce nouns	sıcaklık - **sıcak + lık** **(temperature)**
-e	Dative case	okula - **okul + a** **(to school)**	-le	Morphemes attached to nouns that produce verbs	gözle - **göz + le** **(observe)**
-de	Locative case	okulda - **okul + da** **(at school)**	-ıcı	Morphemes attached to verbs that produce adjectives	şaşırtıcı - **şaşırt + ıcı** **(confusing)**
-den	Ablative case	okuldan - **okul + dan** **(from school)**	-ar	Morphemes attached to adjectives that produce verbs	kara - **kara + r** **(turn black)**
-le	Instrumental	okulla - **okul + la** **(with school)**	-ıl	Morphemes attached to verbs that produce verbs	kırıl - **kır + ıl** **(be broken)**

Fig. 1 Examples of the functions of the inflectional and derivational suffixes

structures and provide meaning integrity with fewer words without the use of relative clauses (e.g., *Caddede yürüyen kadın, büyükannesine yardım eden kıza çikolata verdi* (9 words)—The woman who was walking down the street gave some chocolate to the girl who helped her grandmother (18 words)). In this respect, starting quite early on, Turkish readers need sufficient morphological and morpho-syntactic knowledge to analyze the connections between suffixes and words in sentences and thus comprehend the message in the written text while reading (Babayiğit & Stainthorp, 2010; Durgunoglu, 2003; Miller et al., 2013). The reading comprehension in agglutinating languages which have a linear sequence of morphemes and systematic morphosyntax such as Turkish are more appropriate to morpheme-based approaches. However, due to this linguistic feature of Turkish, it should not be forgotten that in order to be successful in reading comprehension, one needs to have sufficient morphological knowledge besides a strong phonological awareness to decode the words accurately and fluently.

In sum, Turkish, considered an almost completely transparent orthography (one-to-one relationship between graphemes and phonemes), is an agglutinating language with a complex morphology. Word formation, in terms of both inflection and derivation, is almost exclusively accomplished through suffixation, resulting in long word-forms that can, in some cases, only be expressed by a large number of words in analytic languages like English. This formation in Turkish is always in the direction of making the target word more complex. Turkish morphological structures have various functions, such as changing or expanding the meaning of words, and, as such, are important to ensure successful reading comprehension and fluent decoding of words. Increasing the number of suffixes added to a single word increases the number of phonemes to be decoded during reading. Arguably, this characteristic of Turkish complicates the decoding process; it takes more time and effort to be able to decode the words in written materials.

On the one hand, when the relationship between morphology and decoding is considered from this point of view, we could argue that inexperienced Turkish readers will face limitations in the decoding process because of the complex morphological structure of Turkish. On the other hand, according to the orthographic depth hypothesis (e.g., Frost, 2006; Frost et al., 1987; Seymour et al., 2003), given the transparency

advantage of Turkish, the single word decoding process is easier and faster in Turkish. In a language such as Turkish where there is extensive use of suffixes, and the suffixes are at the center of meaning transfer, decoding alone will not guarantee adequate reading comprehension. However, consistent with orthographic advantage, even if Turkish students decode words accurately and fluently in the first years of schooling, they may not be successful in the reading comprehension process because of their limited understanding of complex morphological structures. Hence, morphological knowledge may support the comprehension of complex words when a phonological strategy fails. Given the evidence of this specific relationship between morphology and comprehension, the question is whether morphological knowledge plays any significant role in languages with transparent orthographies, such as Turkish. Yet as suffixes play a central role in reading comprehension in Turkish, we might expect morphological knowledge to be especially relevant in its development.

In this study, our overall goal was to take a closer look at this issue. The ever-increasing research evidence notwithstanding, when decoding is controlled, a great deal about the relationship between morphological knowledge and poor reading comprehension in Turkish remains to be investigated. Despite previous studies conducted in morphologically complex languages, examining the role of morphological awareness in Turkish, an entirely transparent orthography, is needed. The uniqueness of Turkish morphological structures also makes this situation even more interesting. Finally, taking into account the importance of collecting data from various languages to learn about the similarities and differences in reading and morphology relationships, it is thought that this study will contribute to the understanding of the relationships in languages with different linguistic features.

Research Questions and Hypotheses

The study was designed to shed light on the following research questions. (1) Is there a statistically significant difference in the morphological knowledge of poor and proficient comprehenders? (2) Does the sentence comprehension score of poor and proficient comprehenders differ in terms of the morphological structure (simple or complex) of sentences? (3) Is there a significant relationship between morphological knowledge and sentence comprehension skills of readers?

To answer these questions, we used three research paradigms to examine a sample of second- and third-grade Turkish readers grouped as poor or proficient comprehenders based on their reading comprehension performance. The first two paradigms focused on morphological knowledge at the lexical level, and the third examined the importance of morphological knowledge in the reading comprehension process at the supralexical level (sentence level). Because of the highly agglutinated status of Turkish, we hypothesized proficient ones would perform better than poor comprehenders in lexical paradigms related to deriving words by using appropriate suffixes and deciding the appropriate derived word according to the semantic structure of sentences. We further anticipated the gains from morphological knowledge would contribute to sentence comprehension and hypothesized that in direct proportion to the level of morphological knowledge, the proficient ones would have higher scores in the comprehension of sentences with more complex morphological structures than the poor comprehenders.

Finally, we anticipated gains from morphological knowledge would increase in proportion to reading comprehension skills.

Method

Participants

Participants were 56 elementary students recruited from the second and third grades. They were classified into two reader groups, as poor or proficient comprehenders, based on their reading comprehension performance. At the time the data were collected, there were no standardized tools to assess reading comprehension disorders for specific levels (e.g., for specific grade level or specific educational level, i.e., elementary, junior high or high school) in Turkey. For this reason, to determine the research groups, we used an informal reading assessment based on a reading task. In this process, teachers made evaluations using texts determined by the researchers. The texts were two stories (one for the second grade and the other for the third grade) in books approved by the Ministry of Education at each grade level. During the assessment, the students were asked to read the texts aloud and then answer the comprehension questions. The decoding and reading comprehension performances of the students were scored, and those who did not have decoding errors, but who performed below or above in their class average in terms of reading comprehension were included in the study. Selection of participants and scoring of their reading performance were based on three basic criteria: (1) according to informal reading assessments conducted by teachers, poor comprehenders consisted of students who decoded 90% of the text correctly but had lower reading comprehension performance than their peers with average academic achievement, while proficient ones were in the top 25% of their class for reading comprehension; (2) according to their school files, students were not diagnosed as having specific hearing or visual disorders; (3) there was a balanced distribution of students by grade level (see Table 1).

Stimuli

Three paradigms were developed in a national reading project funded by Turkish Academy of Science to determine the effects of morphological awareness skills on reading comprehension performance in Turkish: (1) Morphological Adjustment paradigm; (2) Morphological Compatibility Decision paradigm; (3) Sentence Comprehension paradigm.

Table 1 Distribution of participants by reader profile and level of education

Reader profile	Grade 2		Grade 3		Total	Age Mean (SD)
	M	F	M	F		
Poor Comprehenders	9	4	8	7	28	8.53 (.50)
Proficient Comprehenders	5	8	6	9	28	
Total	14	12	14	16	56	

Paradigm 1: Morphological Adjustment (MA)

This paradigm was a fill-in-the-blanks word production task with a total of 18 sentences with a simple sentence structure and no more than eight words. Each sentence contained a blank, and at the right side of each sentence, target words to fill in the blank were presented in order (e.g., "*Senin kızın çayı …… içiyor.* (*şeker*)—Your daughter is drinking ……. tea. (sugar)"). Participants were asked to read the sentences and fill in the blanks in the sentences by adding the appropriate derivational or inflectional suffix to the target words (e.g., "*Senin kızın çayı..şekerli/şekersiz…. içiyor.* (*şeker*)—Your daughter is drinking..sugared/unsugared…. tea. (sugar)"). Nine sentences tested the participants' ability to apply derivational morphological knowledge, and nine tested their ability to apply inflectional morphological knowledge. In the process of determining the inflectional and derivational suffixes we used in the paradigm, we paid attention to the most frequently used suffix types in the Turkish language textbooks at the grade levels of interest. To this end, we analyzed the Turkish language textbooks published by the Ministry of National Education for the second and third grades looking specifically at the frequency and variety of suffixes used in the books. We determined the most commonly used inflectional and derivational suffixes and applied them in the paradigm. The most frequently used inflectional suffixes were for noun cases (-e, -de, -den). For derivational suffixes, the most frequently seen morphemes were attached to nouns producing nouns (-cı, -lık, -inci, -lı, -sız).

In the paradigm, all target words used for the derivational and inflectional suffixes were nouns. There was only one correct answer to nine questions on inflectional suffixes. Three answers to the questions on derivational suffixes had two possible correct answers (see above, e.g., *şekerli / şekersiz—sugared / unsugared*), and the remaining six had only one correct answer. For the former three questions on derivational suffixes, when participants wrote one of the two possible answers, the response were scored as correct. At the scoring stage, each correct response was scored as 1 and the wrong response as 0.

Paradigm 2: Morphological Compatibility Decision (MCD)

This paradigm was a morphological compatibility decision task with a total of two paragraphs (see Fig. 2). Each paragraph consisted of seven sentences suitable for Turkish written linguistic structure; five sentences in each paragraph had a blank space inside. At the top of each paragraph, target words derived from the same root with proper suffixes (e.g., ***göz***, ***gözlük***, ***gözlüğüm*** etc.) fitting the blanks in that paragraph were presented in mixed order. During the development of the paragraphs, we ensured the events described in the paragraphs (e.g., a doctor's appointment and a morning routine) and the words comprising the sentences were familiar to all participants by getting expert opinions from teachers working in the second and third grades.

Example		
TEST VERSION		ANSWER KEY
Target Words:	kalem / kalemi / kalemini / kalemlikten / kalemliğimi	
Text with blanks	Bugün Türkçe dersinden sınavımız var. Sınıfa geldiğimde silgimin de içinde olduğu ..... evde unuttuğumu fark ettim. Arkadaşım Ayşe'ye "bana bir ..... verir misin?" dedim. Ayşe ..... istediğini al dedi. Ayşe'nin birçok ..... vardı. Ben kırmızı olanı aldım. Sınav bittiğinde teşekkür ederek arkadaşıma ..... geri verdim.	Bugün Türkçe dersinden sınavımız var. Sınıfa geldiğimde silgimin de içinde olduğu **kalemliğimi** evde unuttuğumu fark ettim. Arkadaşım Ayşe'ye "bana bir **kalem** verir misin?" dedim. Ayşe **kalemlikten** istediğini al dedi. Ayşe'nin birçok **kalemi** vardı. Ben kırmızı olanı aldım. Sınav bittiğinde teşekkür ederek arkadaşıma **kalemini** geri verdim.

Fig. 2 Example of MCD task

Target words used in each paragraph contained similar morphological structures (e.g., (1) root word, (2) root word + derivational suffix, (3) root word + two derivational suffixes, (4) root word + inflectional suffix + derivational suffix, (5) root word + inflectional suffix + two derivational suffixes). Participants were asked to read the paragraphs and fill in the blanks by selecting the appropriate derived target words according to both the morpho-syntactic structures of the sentences and the sentences' message. In terms of semantic properties, each blank had only one correct response; at the scoring stage, each correct response was scored as 1 and the wrong response as 0.

Paradigm 3: Sentence Comprehension (SC)

This paradigm was comprised of 12 sentences; six had a simple sentence structure consisting of four words (S + V + O, e.g., "*Ayşe kitabını Mehmet'e verdi*—Ayşe gave her book to Mehmet"), and six had one relative clause with six or more words (e.g.,"*Kantine giden Ayşe Mehmet'ten para aldı*—Ayşe who went to the canteen, received money from Mehmet"). The questions took two forms. Six were developed in an active form (e.g., "*Kitabı kim verdi*?—Who did give the book?") and six in a passive form (e.g., "*Kimden para alındı*?—From whom was money received?"). All sentences (active and passive) were presented to all participants. In the implementation of the paradigm, participants were asked to read all the sentences aloud. In this way, the experimenter could determine that none of the participants had decoding problems. All sentences and questions were built from simple words within the vocabulary of the youngest participants; this criterion was controlled by getting expert opinions from teachers working in the second and third grades Thus, we assumed the participants' comprehension performance in sentences with more complex morpho-syntatic and passive structures would depend on their morphological analysis skills. Each question had only one correct response; at the scoring stage, each correct response was scored as 1 and the wrong response as 0.

Validity and Reliability

The validity and reliability of the paradigms were determined by content validity and Kuder Richardson (KR20) reliability coefficient calculations.

Content validity of paradigms was determined by expert opinion. To this end, we prepared a statement table containing the items and explanations (aim, instruction, developing procedure, suffix determination procedure etc.) for each paradigm. The tables were sent to three teachers who were teaching at the study's grade levels and four academics with a doctorate in the field of reading disorders and Turkish linguistics. These experts were asked to evaluate whether the contents, including all the words and morphological structures used to develop the paradigms, were compatible with the age level of the participants and to check both the base and derived versions of words in the sentence contexts in terms of their familiarity for the tested participants. The experts scored the procedure, content, and understandability of each item in the paradigms with a five-point rating, from 1 = not at all suitable to 5 = very suitable. If necessary, they suggested items that needed correction. In the next step, the means, standard deviations, and coefficients of variation were calculated for each item; only items with a mean greater than 4.25, standard deviation less than 1.00,

and coefficient of variation less than 25% were included in the paradigms. At the end of this process, the paradigms were finalized and prepared for application.

To determine the reliability of the paradigms, we calculated KR20 coefficients for each paradigm. All paradigms had high reliability scores (Morphological Compatibility Decision paradigm KR(20) = 0.84; Morphological Adjustment paradigm KR(20) = 0.92; Sentence Comprehension paradigm KR(20) = 0.80). Based on the findings, all paradigms were concluded to have high validity and reliability.

Procedure

Data collection began after permission and ethical approval were received from the Ministry of National Education. All data were collected in individual assessment sessions in appropriate locations (empty classrooms, libraries, counseling service rooms etc.) within participants' schools. Participants were interviewed individually, and the paradigms were applied only to those who volunteered to participate. During the interviews, participants were informed about the content, purpose, and implementation process of the study; all participants were informed that all collected data would be handled anonymously at all stages of processing. The sessions began after we received their readiness approval. Each session lasted 20–25 min.

All applications were conducted a specific procedure (modeling and testing phases). In the modeling stage, the experimenter explained the task/s to participants and carried out a sample application himself/herself for each paradigm as a model. Participants were asked whether anything was missing or they didn't understand something; if there was a problem, the necessary explanations were provided, and if not, the testing phase began. In the testing phase, the experimenter first gave the appropriate instructions and then started each paradigm for the participants to respond independently. This process was the same for all paradigms. In all sessions, the Morphological Compatibility Decision paradigm was first, followed by the Morphological Adjustment paradigm; the Sentence Comprehension paradigm was last. As mentioned above, in the implementation of the paradigms, participants were asked to read aloud; in this way, the experimenter determined that none had specific decoding problems. After participants answered all three paradigms independently, the testing session ended, and participants were thanked for their participation.

Results

Morphological Adjustment (MA) Paradigm

To compare the two groups' morphological adjustment performances, we conducted a MANOVA, computing the reader profile (poor and proficient comprehenders) and level of education (LoE) (second and third grades) as two between-subject factors and the suffix type (ST) (derivational and inflectional suffixes) as the within-subject factor. Results appear in Table 2.

The suffix type (ST) effect was statistically significant, $F(1,53) = 7.95,\ p < 0.05,\ \eta^2 = 0.13$, suggesting that overall, readers performed more accurately when applying derivational suffixes than inflectional ones. The main effect of level of education was statistically significant, $F(1,53) = 17.37,\ p < 0.01,\ \eta^2 = 0.24$, indicating that overall, third graders

Table 2 Descriptive statistics of morphological adjustment task with reference to reader profile and level of education

LoE	Reader profile	n	$\bar{x}$	SD
Inflectional suffixes				
Grade 2	Proficient Comprehenders	13	7.69	1.60
	Poor Comprehenders	13	1.07	1.65
	Total	26	4.38	3.73
Grade 3	Proficient Comprehenders	15	7.73	1.16
	Poor Comprehenders	15	5.93	2.28
	Total	30	6.83	2.00
Total	Proficient Comprehenders	28	7.71	1.35
	Poor Comprehenders	28	3.67	3.16
	Total	56	5.69	3.15
Derivational suffixes				
Grade 2	Proficient Comprehenders	13	8.00	.70
	Poor Comprehenders	13	3.07	3.12
	Total	26	5.53	3.34
Grade 3	Proficient Comprehenders	15	7.93	1.03
	Poor Comprehenders	15	6.73	2.49
	Total	30	7.33	1.97
Total	Proficient Comprehenders	15	7.96	.88
	Poor Comprehenders	15	5.03	3.31
	Total	56	6.50	2.82

Maximum score per inflectional suffix or derivational suffix category: 9

had higher scores than second graders in all categories. The non-significant interactions between ST and LoE (ST*LoE) and between ST and reader profile (ST*Reader Profile), and between ST and reader profile and LoE (ST*Reader Profile*LoE) ($F(1,53)=1.24$, $p>0.05$, and $F(1,53)=3.58$, $p>0.05$, and $F(1,53)=0.86$, $p>0.05$ respectively), showed the performance differences between derivational and inflectional suffixes were the same for both reader groups and both educational levels (Table 2). Another finding that should be emphasized at this point was that there seemed to be a ceiling effect on the scores of proficient ones and the differences such as the between grade 2 and grade 3 proficient comprehenders were very small. A significant interaction effect between LoE and Reader profile confirmed that the LoE seems to matter for the poor comprehenders as there is hardly any difference in the mean scores of proficient ones in grade 2 and grade 3.

To clarify the significant effect of the overall morphological adjustment scores we found between the reader groups at both education levels (LoE*Reader profile, $F(1,53)=25.82$, $p<0.05$, $\eta^2=0.33$), we conducted a series of ANOVAs, each computing derivational and inflectional suffixes as two dependent variables and reader profile as a between-subject factor, running these separately at each educational level. Evidence obtained from this analysis showed statistically significant differences between the groups in the second grade for both derivational and inflectional suffixes, $F(1,26)=107.18$, $p<0.01$, $\eta^2=0.81$, and $F(1,26)=30.75$, $p<0.01$, $\eta^2=0.56$, respectively. In the third grade, there was a statistically significant difference between the groups for the derivational suffix category, $F(1,26)=7.40$, $p<0.05$, $\eta^2=0.20$.

Table 3 Descriptive statistics of morphological compatibility decision task with reference to reader profile and level of education

LoE	Reader profile	n	$\bar{x}$	SD
Grade 2	Proficient Comprehenders	13	7.92	2.28
	Poor Comprehenders	13	3.00	1.77
	Total	26	5.46	3.21
Grade 3	Proficient Comprehenders	15	9.13	1.12
	Poor Comprehenders	15	7.00	1.77
	Total	30	8.06	1.81
Total	Proficient Comprehenders	28	8.57	1.83
	Poor Comprehenders	28	5.14	2.67
	Total	56	6.85	2.85

Maximum score: 10

Morphological Compatibility Decision (MCD) Paradigm

To compare the performance of the reader groups in the Morphological Compatibility Decision paradigm, we conducted a GLM ANOVA, computing the reader profile (poor and proficient comprehenders) and level of education (LoE) (second and third grade) as two between-subject factors. Results appear in Table 3.

The between-group effect was statistically highly significant, $F(1,53)=55.43,\ p<0.01,\ \eta^2=0.51$, suggesting proficient comprehenders determined the words with the appropriate morphological structure more accurately than poor ones. The main effect of level of education was statistically significant, $F(1,53)=30.22,\ p<0.01,\ \eta^2=0.36$, indicating that overall, third graders had higher scores than second graders. The significant interaction between LoE and reader profile, $F(1,53)=8.66,\ p<0.01,\ \eta^2=0.14$, suggested the differences between poor and proficient comprehenders were not similar for second and third graders (Table 3).

Sentence comprehension (SC) paradigm

To check the two research groups' sentence comprehension, we ran a MANOVA, computing the reader profile (poor and proficient comprehenders) and level of education (LoE) (second and third grade) as two between-subject factors and the sentence complexity (SoC) (sentences with simple and more complex morphological structures) as the within-subject factor. Results are shown in Table 4.

The SoC effect was statistically not significant, $F(1,53)=0.81,\ p>0.05,\ \eta^2=0.01$, suggesting that overall, readers understood the sentences with simple and more complex structures with similar accuracy. The main effect of reader profile and level of education was statistically significant, $F(1,53)=36.77,\ p<0.01,\ \eta^2=0.41$ and $F(1,53)=4.71,\ p<0.05,\ \eta^2=0.08$, respectively, implying that overall, proficient comprehenders had higher sentence comprehension scores than poor ones, and when grade level increased, this situation did not change. The non-significant interactions between SoC and LoE (SoC*LoE) and between SoC and reader profile (SoC*Reader Profile) and between SoC, LoE and reader profile (SoC*LoE*Reader Profile), $F(1,53)=0.27,\ p>0.05$ and $F(1,53)=0.49,\ p>0.05$ and $F(1,53)=2.25,\ p>0.05$ respectively, indicated the comprehension differences between sentences with simple and more complex structures were similar for both proficient and poor comprehenders at each educational level (Table 4).

Table 4 Descriptive statistics of reading comprehension with reference to reader profile and level of education

LoE	Reader Profile	n	$\bar{x}$	SD
Morphological simple				
Grade 2	Proficient Comprehenders	13	5.53	1.12
	Poor Comprehenders	13	2.76	1.78
	Total	26	4.15	2.03
Grade 3	Proficient Comprehenders	15	5.26	1.33
	Poor Comprehenders	15	4.66	1.71
	Total	30	4.96	1.54
Total	Proficient Comprehenders	28	5.39	1.22
	Poor Comprehenders	28	3.78	1.96
	Total	56	4.58	1.81
Morphological more complex				
Grade 2	Proficient Comprehenders	13	5.15	1.14
	Poor Comprehenders	13	2.92	1.93
	Total	26	4.03	1.92
Grade 3	Proficient Comprehenders	15	5.46	1.06
	Poor Comprehenders	15	3.60	2.02
	Total	30	4.53	1.85
Total	Proficient reader	15	5.32	1.09
	Poor reader	15	3.28	1.97
	Total	56	4.30	1.88

Maximum score per morphological simple or more complex category: 6

A significant interaction effect between LoE and Reader profile (LoE* Reader profile) confirmed that the LoE seems to matter for the poor comprehenders as there is hardly any difference in the mean scores of proficient ones in grade 2 and grade 3. To clarify the significant effect of the overall sentence comprehension scores we found between the reader groups at both education levels (LoE*Reader profile, $F(1,53)=4.75,\ p<0.05,\ \eta^2=0.08$), we ran a series of ANOVAs, each computing simple and more complex structure comprehension scores as two dependent variables and reader profile (poor and proficient comprehenders) as a between-subject factor, running these separately at each educational level. In the second grade, we discovered statistically significant differences between poor and proficient comprehenders in comprehending sentences with both simple and more complex structures, $F(1,26)=22.34,\ p<0.01,\ \eta^2=0.48,$ and $F(1,26)=12.80,\ p<0.01,\ \eta^2=0.34,$ respectively. However, in the third grade, there was a statistically significant comprehension difference between the groups only for sentences with more complex structures, $F(1,26)=9.97,\ p<0.05,\ \eta^2=0.26$.

Relations Between Morphological Knowledge and Sentence Comprehension

To determine the relations between morphological knowledge and sentence comprehension, we ran Spearman's rank-order correlation procedure. Results are given in Table 5.

As Table 5 shows, there were statistically significant correlations between suffix type (inflectional and derivational suffixes), morphological compatibility decision task, and comprehending simple and more complex sentences; i.e., for simple sentences, $r_s=0.610,\ p<0.01,\ r_s=0.290,\ p<0.01$ and $r_s=0.628,\ p<0.01$, respectively, and for more complex sentences, $r_s=0.465,\ p<0.01,\ r_s=0.495,\ p<0.01$ and $r_s=0.427,\ p<0.01$ (n: 56), respectively, suggesting readers with greater morphological knowledge were more successful in sentence comprehension.

Discussion

The study examined the importance of morphological knowledge in the reading comprehension difficulties of poor comprehenders in Turkish, a highly agglutinative language. It tested participants' morphological knowledge using three two-step hierarchical paradigms at lexical and supralexical levels. The two lexical paradigms (MA and MCD) focused on a wide range of suffixes and their usage forms in literacy; the supralexical paradigm (SC)

Table 5 Spearman's rank order correlations between morphological knowledge and sentence comprehension

Variables	IS	DS	MCD	MSC	MMCS
IS	–				
DS	.523**				
MCD	.626**	.484**	–		
MSC	.610**	.290*	.628**	–	
MMCS	.465**	.495**	.427**	.215	–

IS inflectional suffixes, *DS* derivational suffixes, *MCD* morphological compatibility decision, *MSC* morphological simple sentences, *MMCS* morphological more complex sentences

**Correlation is significant at the 0.01 level (2-tailed)

focused on the transformation of morphological and morpho-syntactic knowledge into the reading comprehension process.

In general, the study contributes to the literature in two areas. First, much of the previous literature has explained reading comprehension difficulties in the context of limitations in word decoding (e.g., Lonigan et al., 2018; Snow, 2018; Steensel et al., 2016; Torgesen & Hudson, 2006; Tunmer, 2008; Tunmer & Hoover, 2019; Ziegler & Goswami, 2005) and vocabulary (e.g., Adlof et al., 2006; Biancarosa et al, 2020; Capin, 2020; Cromley & Azevedo, 2007; Perfetti & Stafura, 2014; Perfetti et al., 2008). This study extended these findings to include morphological knowledge in agglutinative languages. Second, the study suggests morphological knowledge can be an important indicator of proficient reading comprehension skills in Turkish, a fully transparent orthography representing a morphologically highly complex agglutinative language.

At the lexical level (the first step), the most noticeable finding was that the participants' morphological knowledge was in direct proportion to their reading comprehension levels (poor and proficient comprehenders) at each grade level. This finding fully confirmed our first hypothesis and suggested that at the lexical level, proficient comprehenders have more morphological knowledge than poor ones. To make this conclusion more visual, we calculated the rates of correct responses of the groups for the lexical paradigms. Results showed the proficient comprehenders achieved an average success rate of 85% and 89% for MCD and MA, respectively, while the poor ones had 50% and 22% success, respectively. When we examined the mistakes made by the poor comprehenders, we discovered they made the most in morphological manipulation (more than 90% of their errors fell into this category). The most common errors in the MA task were the use of incorrect suffixes and/or the use of more suffixes than necessary, while in MCD, they made more mistakes in words containing two or more suffixes. This suggests that participants' limited morphological knowledge was in direct proportion to their reading profile / reading comprehension. According to the SVR model (Tunmer & Chapman, 2012a, b), being successful in reading comprehension is generally in direct proportion to readers' language-based literacy skills including the level of vocabulary, syntactic knowledge, and morpho-syntactic skills under the efficient decoding prerequisite (Brimo et al., 2018; Chik et al., 2012; Siu et al., 2016; Tong et al., 2014; Yeung et al., 2011, 2013). From this point of view, considering that vocabulary and decoding performances were controlled during the participant selection and the paradigm development phases of the study, at first glance it can be said that the findings that occurred in morphological awareness tasks at the lexical level were consistent with the SVR model.

Turkish orthography—a shallow orthography with respect to grapheme-to-phoneme consistency– defines as an agglutinated language in which root words rarely place alone, but are suffixed by inflectional and derivational morphemes that change their core meaning (Miller et al., 2019). Rationally, Turkish orthography reflects the characteristics of the language in the form of lengthy polymorphemic letter sequences. Particularly for poor readers, the decomposition of morphologically highly complex letter sequences into meaningful subunits may become a rather difficult process (Guldenoglu, 2016; Miller, et al., 2019). Given this to be true, a limitation that arises in morphological awareness of poor readers may have caused them to have problems at the lexical level. Provided this scenario is valid, the finding that poor readers were also limited in morphological awareness paradigms makes sense.

One of the study's strengths was its use of two different lexical paradigms to interpret the morphological knowledge of the participants. In the MA paradigm, our aim was to test participants' awareness of the diversity of the individual derivational and inflectional suffixes, whereas, in the MCD paradigm, we focused on their familiarity with words, including

various forms (root words + one inflectional or derivational suffix, root words + inflectional + derivational suffixes, root words + multiple inflectional or derivational suffixes etc.) of suffixes in a specific semantic condition. In this way, we were able to evaluate the usage of various forms and functions of suffixes rather than an isolated written word in a specific semantic condition.

Findings at the lexical level suggested have more experience in reading had an impact on participants' morphological knowledge. Results implied morphological knowledge was shaped in accordance with participants' grade levels. As evidence, although both groups showed difficulties in reading comprehension at their own grade level, poor third-grade comprehenders had higher morphological knowledge than their second-grade counterparts. In addition, because of the Turkish national curriculum, no participants had received any formal reading instruction about the types of suffixes or their functions (MoNE, 2019). Therefore, differences between the second and third-grade poor comprehenders likely did not reflect the one-year difference in formal education. As factors that could affect the lexical paradigms, such as word decoding and vocabulary, were controlled in the phase of the selection of participants and the development of paradigms, one potential explanation for the difference between the two groups could be their experience in reading. When we examined the findings more closely, we found that although no participants (second and third grades) had problems decoding and no one received instruction on morphology, the morphological knowledge of the poor comprehenders was limited compared to that of the proficient ones (see Tables 2, 3). At the same time, when the poor comprehenders in the second and third grade were comparatively examined, we found the poor comprehenders in the third grade had an advantage; this could be explained by their greater experience in reading, not just their decoding. On the other hand, the ceiling level of performance of the 2nd and 3rd grades proficient comprehenders at the lexical level also confirmed this comment and suggested that their experience in reading may have supported their proper morphological decoding ability. More experience in reading means they will have encountered more suffixes in written materials, thus increasing their morphological awareness and familiarity with their use in written forms.

Another indicator of the contribution of experience in reading to morphological knowledge was that the performance difference between groups favored the MCD paradigm. Unlike MA, in the MCD paradigm, participants were presented with a group of target words with ideal morphemic structures and were asked to complete the sentences by selecting the correct words based on semantic conditions. A remarkable finding was that, despite the lack of formal reading instruction on morphology, the performance difference between poor and proficient comprehenders was less pronounced in the third grade than in the second. However, the fact that third-grade comprehenders used the reading task more frequently in all lessons within a school year may have increased their familiarity to the use and functions of suffixes used in words. This outcome may be seen as another indicator of the positive effects of the experience in reading on morphology.

Our second hypothesis was that the gains from morphological knowledge would contribute to sentence comprehension. In other words, in a language with complex morphological structures, better morphological knowledge should positively support the processes underlying reading comprehension because it facilitates the comprehension of words and sentence structures in the written material. Our findings confirmed this hypothesis and suggested participants' reading comprehension was indeed affected by such a positive transfer. Results showed that in direct proportion to the level of morphological knowledge, the proficient comprehenders had higher scores, especially in comprehending sentences with more complex morphological structures, than the poor comprehenders at each grade level.

At the lexical level, morphology is concerned with the meaning of a word, whereas at the supralexical level, it is combined with syntax. In other words, it focuses on how words create a meaningful structure in the context of sentence and prose (Bowers et al., 2010; Carlisle, 2003, 2007; Deacon & Kirby, 2004). In languages with complex morphological structures, such as Turkish, syntax, defined as grammatical harmony and word order, should be analyzed together with morphology to make sense of written sentences (Aksan, 2005; Durgunoglu, 2003; Guldenoglu et al., 2015; Kargin et al., 2019; Martin et al., 2004; Miller et al., 2013). This association, referred to as the analysis of morpho-syntax or morpho-syntactic codes, is considered an important element of the reading comprehension process (Bowers et al., 2010; Deacon & Kirby, 2004). Previous research has emphasized that readers must analyze the morpho-syntactic structures appropriately to get the correct message in the written material (e.g. Brimo et al., 2018; Deacon & Kirby, 2004; Lopez-Higes et al., 2015; Miller et al., 2013; Perfetti et al., 2005; Shimron, 2006). The bottom-up model, defined as the construction of meaning from the smallest to the largest elements of written material, provides the most detailed explanation of the relationship between morpho-syntax and reading comprehension (e.g., Andrews & Bond, 2009; Ahmadi & Pourhosein, 2012; Miller, 2000, 2010; Miller et al., 2013; Woolley, 2011). In this model, for readers to correctly comprehend sentences, they need to decipher the linguistic units (vocabulary, syntax, morpho-syntax etc.) of sentences (Andrews & Bond, 2009; Woolley, 2011). The process starts with effective word decoding and continues with the analysis of the order and the morpho-semantic connections of the words in sentences. To be successful, readers need sufficient linguistic knowledge (e.g., morphology and morpho-syntactic knowledge) of the written language (Miller, 2010; Miller et al., 2013; Woolley, 2011).

The use of the bottom-up model in a highly agglutinative language, such as Turkish, requires an adequate level of morphological knowledge, in this case, the analysis of complex morphological structures equipped with suffixes. The proficient comprehenders in our study had more morphological knowledge; this may have contributed to their use of a bottom-up model, as they may have figured out the morpho-syntactic codes of sentences. However, if we assume morphology facilitates the semantic integration of words into complex morphological sentence structures, our finding that variance in sentence comprehension was paralleled by variance in the participants' morphological knowledge makes sense. In other words, better comprehenders could have a more effective morphological base that might enhance the acquisition of morpho-syntactic codes and their integration into semantic structures. This conclusion supports our final hypothesis and straight-forwardly shows the linear relationship between participants' morphological knowledge and their ability to comprehend the sentences.

In sum, the findings suggest that reading comprehension difficulties in a language with highly complex morphological structures such as Turkish is related to the inability to use morphological knowledge effectively. Considering the present findings as a whole leads to several note-worthy conclusions on the nature of the reading comprehension process in Turkish orthography and the factors that seem to underlie reading comprehension failure in this language. First and foremost morphology that in other orthographies has not been emphasized as one of the critical markers of reading disorders seems rather unique to the reading of Turkish orthography. Our results suggest that Turkish readers can benefit from their morphological awareness already at a very early stage of reading and rely on this for their reading comprehension. Based on the findings, we reach the following practical conclusions. First and foremost, active morphological knowledge is one of the important indicators of proficient reading comprehension in Turkish. Second, reading comprehension

difficulties in Turkish may originate in overstated phonologically based reading instructions that skip the processing of morphological knowledge as a vital source of information. Therefore, considering the complex structure of Turkish, to improve reading comprehension skills, Turkish classroom teachers should make substantial efforts to develop students' linguistic-based reading skills, such as morphology, syntax, morpho-syntax, etc. Third, introducing a reading comprehension curriculum, including morphological knowledge, in the early grades will enhance reading comprehension and positively affect reading-based performance in all courses.

Admittedly, the study had certain limitations. First, as this was a vanguard study focusing on the importance of morphological knowledge in the reading comprehension process in Turkey, the sample was limited to 56 elementary students. Future studies should increase the sample size and take a longitudinal perspective to validate the generalizability of our findings. Second, the study was limited to the role of morphological knowledge in sentence comprehension; other possible factors (vocabulary, the mean length of utterance and other cognitive skills like working memory, attention etc.) were not addressed. Future work should test the effects of these factors at different reading levels (word decoding, paragraph or text comprehension) to better understand reading comprehension difficulties and develop suitable interventions.

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Declarations

Conflict of interest We have no conflict of interest to disclose.

Ethical Approval Participants were collected in accordance with the code of conduct of research with human material in the Turkish Academy of Science. This study was approved by the ethical educational committee of the responsible university where the study was conducted.

Informed Consent Informed consent was obtained from both all individual participants involved in the study and their teachers.

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