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Efficient Reading for Arab Students: Implications from Neurocognitive Research

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Biographical Information

Helen Abadzi is a Greek psychologist and a polyglot. She is a research faculty at the University of Texas at Arlington College of Education and Health Professions. While a Senior Education Specialist at the World Bank (1987-2013) she focused on improving learning outcomes for low-income populations. She regularly monitors the emerging research in cognitive science and synthesizes relevant findings to explain and predict likely outcomes from various interventions. She is interested in studying the building blocks that lead to automatic execution of complex skills, such as math, reading, and rapid comprehension of Arabic. Thanks to her work, early-grade reading fluency has become an international priority.

Marialuisa Martelli is an Italian psychologist and a tenured Research Scholar at La Sapienza in Rome. She studied psychology and psychophysiology of visual perception at the University of Rome La Sapienza with Prof. Pierluigi Zoccolotti, focuing on object recognition abilities after long-term visual deprivation in humans. Her work in the field of cognitive neuroscience focuses on reading, object recognition, developmental and acquired dyslexia, and the speed of processing in brain damaged patients.

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Acronyms

ALECSO	Arab League Educational, Cultural, and Social Organization
GCC	Gulf Cooperation Countries
MSA	Modern Standard Arabic
PIRLS	Progress in International Reading and Literacy Study
TIMSS	Trends in Mathematics and Science Study
USAID	United States Agency for International Development

Executive Summary

The countries that formally use the Arabic language and script for instruction range from the poorest to the wealthiest. But all experience a puzzling problem, that is low student performance in national and international tests. In fact, all Arabic-speaking countries score at the bottom of the relevant distributions in reading, math, and science in grade 4. In the critical "reading to learn" competency, most of the sampled Arab students are classified as performing at a low level against international benchmarks.

The research suggests that the inordinate difficulties of Arab students are due to interactions between visual as well as linguistic obstacles.

The voweled Arabic script adequately represents most sounds, and children in principle ought to learn its letters quickly, within 100 days or so. However, certain features of the letters and their arrangements challenge visual perception research findings. The shapes of the Arabic letters tend to be very similar, and the visual detection involves multiple components that may also have non-linear relations. The connectivity rules also affect identification speed. The most quickly identified words have fully connected letters, given the relative rarity of words that have only unconnected letters. Words with dots that alternate above and below seem to also be identified more slowly. As a result of various factors, even experienced readers take about three times longer to identify letters in Arabic than in the Roman script.

Textbooks typically delete vowels in grades 3-4. Paradoxically perhaps, the vowels clarify the pronunciation but create visual crowding and slow down detection. Removal of the vowels makes the meaning opaque and creates dependency on neighboring words and context. . Unlike other languages, even adult experienced readers must rely on context.

Readers must retain alternatives in working memory to make sense of text. The alternatives compete with the meaning of the passage. As texts become more complex, the working memory load gets an extra burden. Simultaneously the readers must decipher the meaning of standard Arabic expressions that may be unclear. All these decisions may be reducing the amount of time that students have to decide about the meaning of a text.

Morphological and phonological awareness are very important processes for beginners. Some studies, however, suggest that although students acquire phonological awareness, they are less likely to benefit from it than readers of other languages, due to the dependence on context.

Reading in the Arabic language presents linguistic difficulties due to the lexical and grammatical distance between modern standard Arabic and the various vernaculars. Research suggests that students treat standard Arabic as a different language. And the greater the linguistic distance from various Arabic variants, the harder it is for students to make sense of text. Students must learn the standard Arabic letter sounds that do not occur in their language. And paradoxically perhaps, they recognize the letter shapes more slowly for years.

Standard Arabic grammar is often not taught explicitly, and students are expected to learn its patterns through contact. This creates problems for students from poorer families who have limited education and ability to help students.

The interaction of the perceptual and linguistic complexities may magnify the effects, and it may turn Arabic reading into a complex multistage exercise. A reader of the Arabic script must (a) decipher the letters, (b) predict the short vowels and keep multiple alternative words in working memory to test and decide on meaning, and (c) make linguistic sense. This process requires faster identification of words than in other scripts in order to make sense of the text, but in fact they identify them more slowly and make more errors.

In principle practice would speed up word and meaning identification and would compensate for the working memory load. This is a recommendation for all languages, but in Arabic this must be qualified; students must know sufficient vocabulary and grammar to make sense of the text. However many countries give limited instruction in standard Arabic grammar or vocabulary, so weaker students may comprehend too little or too slowly. They may therefore be less likely to read for pleasure, so their linguistic and visual identification speed may stagnate. The result may be a vicious circle. Students need specific instruction to get over this burden.

Languages using the Arab script, notably Urdu, Pashto, or Farsi also face visual perception challenges. Students usually read in a language they understand, if they speak the relevant language at home or in the market. But in Indoeuropean languages, vowels are not predictable. Many words end up with the same configurations, so unvoweled Urdu or Pashto present comprehension ambiguities that require time to resolve. The milliseconds needed to resolve each ambiguity tend to add up, and readers may have limited working memory left to make sense of text.

A great deal has been written on the above issues, but remedies have been in short supply. Use of cognitive science, however, opens unexplored possibilities. In principle it may be possible to speed up Arab students' reading speed and comprehension, so that it can approximate that of students of other languages who have lower visual and linguistic challenges before they can read.

Methods for measuring perceptual and comprehension speed can identify low-level perceptual and linguistic issues and may help find solutions. Optimizing printing fonts for speed, removing certain vowel signs (harakat) but not others, or learning some linguistic features that are identified slowly would alleviate the working memory load. There is also a need to experiment with ways of teaching standard Arabic grammar early and efficiently, in order to improve comprehension and speed it up. The expectation is that targeted practice on low-level components that are processed more slowly could result in faster reading and comprehension, thus giving students more time to think about the contents of texts.

To do this, "translational' research is needed; options suggested by research must be applied in schools to study effects and monitor rates of change vis-à-vis benefits and costs. To do so,

there is a need to introduce measurement methods that are routinely used in psychology, such as:

- reaction time to letters and words, measured through computerized displays (often called rapid serial visual presentation)
- monitoring students' gaze on texts through eye tracking
- monitoring comprehension speed, measurable through audio software
- monitoring brain changes as a result of increasing literacy; these can be measured through functional magnetic resonance imaging, event-related potentials, and other methods
- assessing understanding of dialectical expressions at various ages.

Many Arab countries are financially well equipped to undertake such research. It is hoped that through better understanding and resolutions of low-level problems that higher level performance problems will be resolved.

A. Background

The countries that formally use the Arabic language and script for instruction stretch across the income range. At the low end are Sudan, Yemen, Mauritania, where significant portions of the population are illiterate and many children are out of school. At the higher end are the Gulf countries (GCC) that have attained universal primary education and endow their schools with state-of-the-art resources.

In low-income countries students countries often have trouble learning to read; 80-90 percent of second and third graders in some countries cannot even read a single word and may know few if any letters (RTI 2009, 2010, 2011a, 2011b). The reasons are usually linked to limited instructional time, textbooks or parental help, potentially poor nutrition, or complex teaching methods that originated in high-income countries (e.g. Abadzi 2006, RTI 2009b).

In high-income countries, teachers are well educated, and there is a surfeit of print and electronic media in classrooms. It is surprising, therefore, to see that the Gulf Cooperation Countries (GCC) score low among the countries that participate in international comparison tests. In fact, all Arabic-speaking countries score at the bottom of the relevant distributions in reading, math, and science in grade 4 (Mullis, Foy & Drucker, Mullis, Foy & Arora, Mullis, Foy & Stanco, 2012).[1] The International Evaluation Association specifies the 4th grade PIRLS test as an indicator of "reading to learn" competency.[2] In this critical competency, most of the sampled Arab students are classified as performing at a low level against international benchmarks. The performance gap has been consistent over time, and limited reading-to-learn ability reflects in 8th grade tests.

Table 1: PIRLS 2011, grade 4 (Mullis et al. 2012, p. 38-39)

PIRLS Scale Centerpoint	500
[1] Georgia	488 (3.1)
Malta	477 (1.4)
Trinidad and Tobago	471 (3.8)
[2] Azerbaijan	462 (3.3)
Iran, Islamic Rep. of	457 (2.8)
Colombia	448 (4.1)
United Arab Emirates	439 (2.2)
Saudi Arabia	430 (4.4)
Indonesia	428 (4.2)
[2] Qatar	425 (3.5)
Ψ Oman	391 (2.8)
Morocco	310 (3.9)

Benchmarking Participants◊	
[1 3] Florida, US	569 (2.9)
[2] Ontario, Canada	552 (2.6)
[2] Alberta, Canada	548 (2.9)
Quebec, Canada	538 (2.1)
Andalusia, Spain	515 (2.3)
Dubai, UAE	476 (2.0)
Maltese - Malta	457 (1.5)
Abu Dhabi, UAE	424 (4.7)
Ψ Eng/Afr (5) - RSA	421 (7.3)

In the 2011 administration of PIRLS (reading),[3] Arab countries scored as shown in Table 1. The TIMSS scores in math and science show similar trends in grades 4 (Mullis, Foy & Arora, Mullis, Foy & Stanco, 2012; Tables 2 and 3). As with reading, the performance of Arab students is considered intermediate to

[1] Some GCC countries have English medium curriculum available for students and also offer the tests in English. In TIMSS and PIRLS publications scores are not differentiated by language. (See Annex for details.) Thus the reported scores may represent student performance in Arabic only for some countries.

[2] http://timss.bc.edu/, Campbell et al. 2001

[3] TIMSS is "Trends in International Math and Science Study" by the International Evaluation Association; PIRLS is "Progress in International Reading and Literacy Study" (Mullis et al. 2012). PIRLS has only been given in grade 4, though some countries like Morocco also give it in grade 6. Tests have been administered in1995, 2006, and 2011. The next one is in 2016.

low. Only in grade 8 do some Arab countries surpass some non-Arab countries (Mullis, Foy & Arora, 2012, p. 42). It must be noted that **to solve math problems**, students must first read them, understand them, and keep related variables in working memory.

Table 2: 2011 TIMMS grade 4 math scores (Mullis et al. 2012, p. 40)

TIMSS Scale Centerpoint	500
Malta	496 (1.3)
‡ Norway	495 (2.8)
2 Croatia	490 (1.9)
New Zealand	486 (2.6)
Spain	482 (2.9)
Romania	482 (5.8)
Poland	481 (2.2)
Turkey	469 (4.7)
2 Azerbaijan	463 (5.8)
Chile	462 (2.3)
Thailand	458 (4.8)
Armenia	452 (3.5)
1 Georgia	450 (3.7)
Bahrain	436 (3.3)
United Arab Emirates	434 (2.0)
Iran, Islamic Rep. of	431 (3.5)
2 Qatar	413 (3.5)
Saudi Arabia	410 (5.3)
Ψ Oman	385 (2.9)
Ψ Tunisia	359 (3.9)
1 ✳ Kuwait	342 (3.4)
✳ Morocco	335 (4.8)
✳ Yemen	248 (6.0)

Benchmarking Participants	
1 2 North Carolina, US	554 (4.2)
1 3 Florida, US	545 (2.9)
Quebec, Canada	533 (2.4)
Ontario, Canada	518 (3.1)
2 Alberta, Canada	507 (2.5)
Dubai, UAE	468 (1.6)
Abu Dhabi, UAE	417 (4.6)

Table 3: TIMSS 2011 Science scores, grade 4 (Martin et al., 2012. P. 40)

TIMSS Scale Centerpoint	500
New Zealand	497 (2.3)
2 Kazakhstan	495 (5.1)
‡ Norway	494 (2.3)
Chile	480 (2.4)
Thailand	472 (5.6)
Turkey	463 (4.5)
1 Georgia	455 (3.8)
Iran, Islamic Rep. of	453 (3.7)
Bahrain	449 (3.5)
Malta	446 (1.9)
2 Azerbaijan	438 (5.6)
Saudi Arabia	429 (5.4)
United Arab Emirates	428 (2.5)
Armenia	416 (3.8)
2 Qatar	394 (4.3)
Oman	377 (4.3)
1 Ψ Kuwait	347 (4.7)
Ψ Tunisia	346 (5.3)
✳ Morocco	264 (4.5)
✳ Yemen	209 (7.3)

Benchmarking Participants	
1 3 Florida, US	545 (3.7)
2 Alberta, Canada	541 (2.4)
1 2 North Carolina, US	538 (4.6)
Ontario, Canada	528 (3.0)
Quebec, Canada	516 (2.7)
Dubai, UAE	461 (2.3)
Abu Dhabi, UAE	411 (4.9)

The differences between Arab and non-Arab countries at various levels are illustrated by achievement levels in Tunisia, which is a middle-income country (Table 4).

Table 4: Tunisia TIMSS 2011: **Classification of 4th Graders' Scores on the Four Levels of Achievement**

Level	National Percentage	International Percentage
Advanced – score 625	0	5
High – score 550	3	32
Intermediate – score 475	14	72
Low – score 400	35	92
Too low to be scored	65	8

Score differences do not just appear in large-scale measurements that include low-income children; they also appear among high-income groups. For example, schools in Qatar may administer the test in Arabic or in English. Curricula of international schools (teaching in English) had a 101-125 points of difference in grade 4 in PIRLS and TIMSS (Figure 1); in grade 8 TIMSS they similarly had a difference of 106-120 points (Figure 2). Qatari schools provide students with a great deal of resources, so these results cannot be easily attributed to socioeconomic status (Supreme Education Council, undated).

Figure 1: Score differences among the highest-scoring schools in Qatar, grade 4

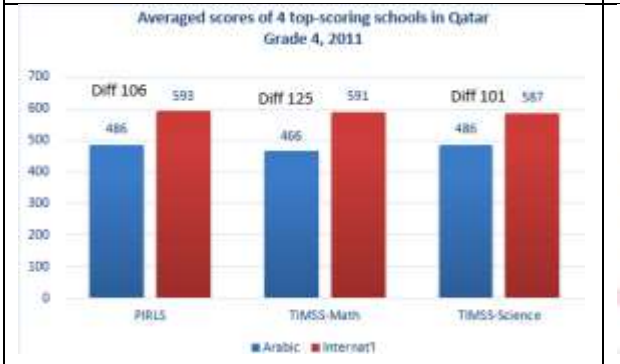
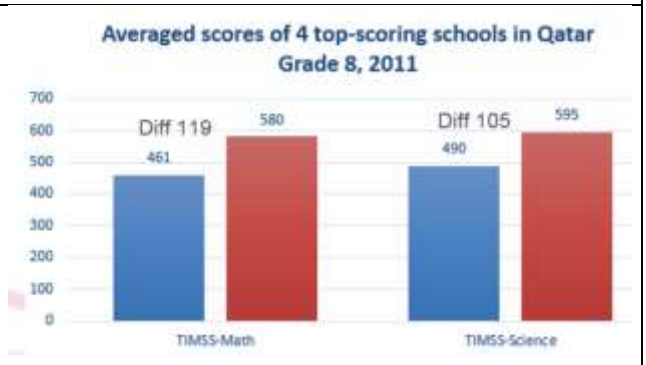


Figure 2: Score differences among the highest-scoring schools in Qatar, grade 8



Source: Supreme Education Council website; http://www.sec.gov.qa

The performance gap is complicated by **an equally mysterious gender gap**. Worldwide, girls of higher-income countries tend to perform better than boys in reading and language, early on. However, in scores of the Arab countries the difference is exaggerated. In fact, Saudi Arabia has the highest gender performance gap of all countries tested in grade 4 in PIRLS and Kuwait does so in TIMSS (Mullis, Foy & Arora, 2012, p. 68). In grade 8 math, Oman and Bahrain have differences of 43 and 63 points favoring

girls (Mullis, Foy & Arora, 2012, p. 68). Similar gender gaps favoring girls exist in 4th and 8th grade science (Mullis, Foy & Stanco, 2012, p. 63). Research has pointed out girls' superiority in Arabic lexical and orthographic processing (Taha, 2006). Nevertheless, in a study of Egyptian private schools, boys performed better (Mohammed, Elbert & Landerl, 2010). Few efforts have been made to understand the gender disparities better and take action. In principle, boys' performance could increase to approximate girls'.

Parents and governments in the Arab world are concerned that students are failing not only the international tests but internal examinations as well. Some newspaper articles also raise concerns about language modernization (Ghinwa, 2014). In Qatar, for example, informal estimates suggest that about 20% of the students are poor readers. Much interest therefore exists in finding solutions to improve reading fluency and comprehension at the higher and lower schooling levels.

Overall, attempts have been made to attribute the performance gap to planning, curricular, and instructional issues. These include the ability of teachers to convey complex material and keep students focused on task, given the distractions of the digital age. Sociocultural explanations have also been offered. For example, it has been argued that Arab countries may score lower because of oral cultural traditions that place little emphasis on reading for pleasure. Indeed, some middle-income Arab countries have relatively low parental levels of education, and the percentages of parents who reportedly like to read are rather low; TIMSS and PIRLS questionnaires show that parental trends correlate with student scores ((Mullis, Foy & Drucker, 2012, p. 114, 120), and research also suggests that literate mothers are critical in reading instruction (Levin et al. 2013).

Educational system issues are significant, but they can only be one part of the solution. The gap in test scores as well as the gender gap are suggestive of factors that have received limited attention thus far in education: (a) **visual complexity of the Arab script** and (b) **proficiency in standard Arabic grammar and vocabulary.** These issues can best be explored from an information-processing point of view. Perceptual learning and cognitive neuroscience have much to offer in explaining and potentially remedying student problems.

To do so, more knowledge has been necessary. A World Bank working paper on Arabic included terms of reference for a literature research and a set of research questions to answer (Abadzi, 2012). From these, two reviews were independently conducted: USAID (2013) and ALECSO (2013). Simultaneously a number of reading studies on Arabic were published in journals such as "Writing Systems Research". Finally, a large-scale review was published in a book form (Saiegh-Haddad & Joshi, 2014). Several studies have explanatory power and immediate applicability.

This document summarizes the research and focuses on instructional implications. It formulates hypotheses on the aspects that affect student achievement and offers potential solutions. It also points to the utility of neurocognitive research methods in exploring reading problems.

B. Historical Traits of the Arabic Script and Some Instructional Implications

To understand the challenges of the Arabic script, it is useful to study briefly its evolution through history.

Scripts arose about 5000 years ago in multiple countries. Commerce spread the use those that worked well. Successful scripts conform to the information processing capacities of humans, so they have substantial underlying similarities; they often consist of angles and shapes that are found in nature, so they may be easier to perceive (Changizi and Shimojo, 2005).

The human brain seems to focus on consonant-vowel combinations more easily than single phonemes (Pellerino et al. 2011); therefore many ancient characters represented consonant-vowel combinations. Writing series of consonants, such as s-t-r presented challenges that various scripts dealt in various ways. Phonological awareness has arisen gradually in history, so the early scripts did not always render letter sounds precisely.

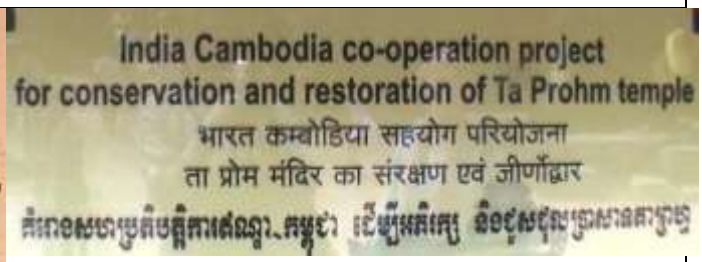
People learning to read start seeing multiple letters simultaneously after some hours of practice. (See research review in Abadzi, 2013.) Effortless, fluent, and automatic reading creates an advantage for scripts that people already read fluently. It is not so strange, therefore, that most of the world reads using letters that evolved from one or two scripts around 2000-2500 years ago. The Phoenician script spread through commerce and gradually replaced the complex syllabic scripts of Greece. It gave rise to the Arabic, Hebrew, Greek, and Latin alphabets (Daniels and Bright, 1996, p. 559). The other similarly influential script is Brahmi, which apparently adopted about half its letters from the Phoenician alphabet. It gave rise to the syllabic scripts of South and East Asia.

Automaticity also creates a certain resistance to change. People find it easier to continue with an imperfect script that they can read easily. Scripts are meant to be read widely, so radical changes without the knowledge of faraway readers would not work. So scripts tended to be adapted, and known letters may change sound or get diacritics. There are several examples of script substitution in history, such as the adoption of the Phoenician script around the 7th century in Greece, or new scripts for the Maldives, Korea, and Turkey. Typically, literacy rates were low, so few people were affected. When literacy rates are higher, countries have undertaken reforms of more limited nature. For example, the Soviet Union and Laos in the 20th century simplified Cyrillic and Lao, but they mainly deleted superfluous letters and simplified spelling. Automatic readers could still read.

Ancient scripts were not standardized. The archeological record shows that letters within countries and areas showed variability and change over short periods of time (Daniels and Bright, 1996). This phenomenon can probably be attributed to limited communications with other areas. It is also probably a function of limited reading practice. Before the discovery of inexpensive paper, opportunities to write were few. People wrote on clay, stone, papyrus paper, and sometimes leather or leaves. (Daniels and Bright, 1996). Some societies, such as Egypt, Babylon, and Bactria had better means for writing and their scribes developed calligraphy. But in countries such as Greece, inscriptions show variability that suggests limited practice, and possibly the fluency of a modern first grader. It was easy to render letter shapes imprecisely.

Variants of letters often included shape and orientation. Sometimes letters were written from left to right, other times the opposite, and early inscriptions showed one line to the right and the next to the left (boustrophedon). Also, ancient scripts had no space between words, possibly due to limited phonological awareness or perhaps space. Final versions of letters may have evolved to demarcate words. Though there was a tendency to create lines of letters (horizontal or vertical), linearity was approximate. Also due to the scarcity of writing materials, scribes had little space to use. Therefore, a tendency arose to link letters through ligatures. In some scripts such ligatures are occasional or decorative, whereas in others they continued through time and became obligatory (see Figures 3 and 4). The ancient Brahmi script of India evolved into scripts that had extensive ligatures for the precise rendering of vowels. (see Figure 4 for its descendants, Devanagari and Khmer).

Scholars decoding ancient scripts often find multiple possible ways to read them. So how well could the ancients decode other people's writings given variability and imprecision? One hypothesis is that the vocabulary was rather limited, and uses were specific such as keeping accounts. It is likely that the inscriptions were read more easily by their contemporaries than by later readers.

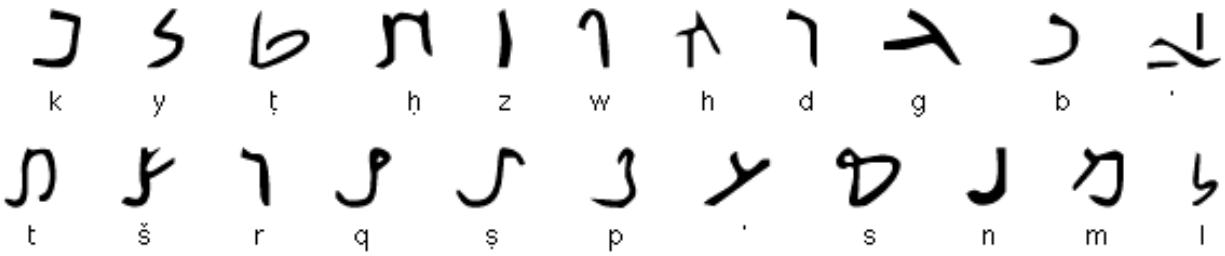
Figure 3: Byzantine decorative religious text	Figure 4: A modern trilingual inscription in Angkor Wat
	
Greek letters in ligatures and top to bottom combinations. In Greek this style has been only used occasionally	Compared to Devanagari in the middle and Latin on top, Khmer seems dense. Many words are also written without spaces, as in ancient years.

The modern Arabic script arose from the Nabatean Aramaic script around the first century BCE (Daniels and Bright 1996; Figure 5). As with other Middle Eastern scripts, Nabatean was an offshoot of the Phoenician script. Pre-Islamic and early Islamic texts, called Old Arabic, offer a glimpse of its development and the challenges it faced on its road to large-scale use. [4]

The Semitic alphabets did not include many vowels, which in principle are predictable from the grammar. This means that many words are spelled exactly the same, and the reader must decide the word from the context. At any rate, script had fewer letters than what Arabic needed, so one or two centuries after its introduction, inscriptions show the insertion of distinguishing dots (diacritics) to differentiate consonants.

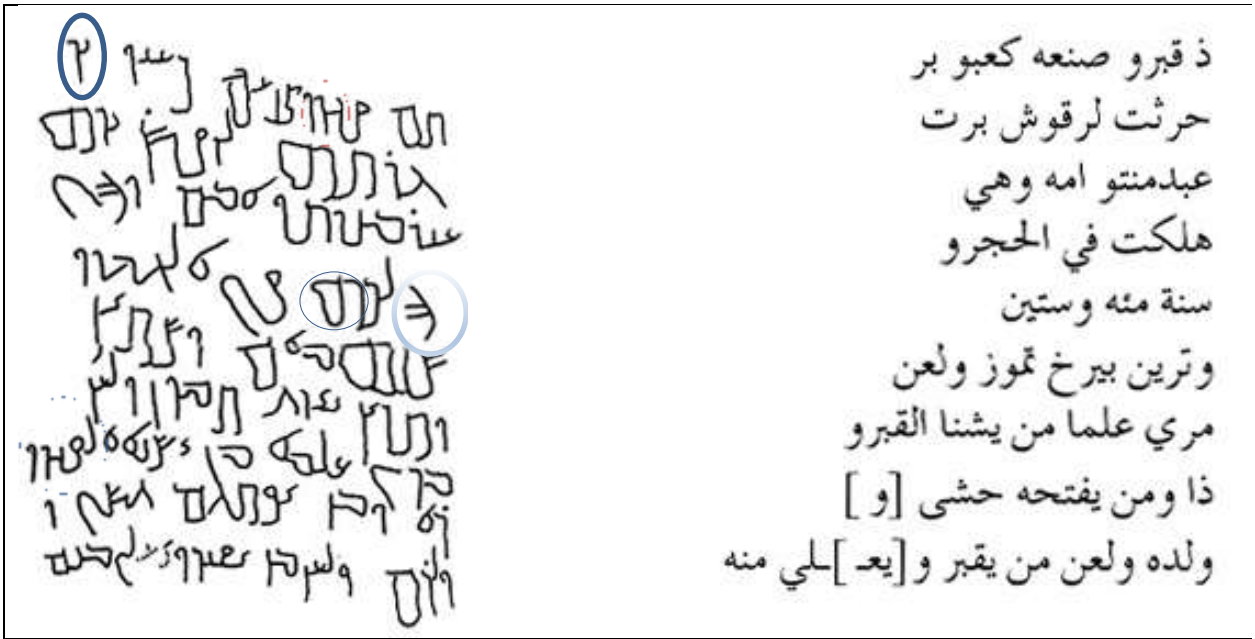
[4] For relevant bibliography and ancient text samples see www.islamicawareness.org; also Daniels, 2013

Figure 5: The Nabatean alphabet (from www.omniglot.com)



In addition, linguistic evolution and shape variations over time raised the needs for adjustments. When letters shapes or sounds became too similar, ways had to be devised to distinguish them. Diacritics appeared as dots above or below certain consonants as early as the 3rd century CE. The earliest known Arabic inscription (Figure 4) shows many letters that cannot be easily identified from contemporary shapes. However, it has the features that make Arabic distinct today: Some diacritics are used, though inconsistently. The letters are large and spaced, as the human visual system prefers them (see next section). But some letters touch others or are written at different levels (see for example br at the end of the first line).

Figure 6: **Earliest Dated Pre-Islamic Arabic Inscription (Raqush) in 267 CE**



The inscription shows some diacritic, early and non-linear letter ligatures, and early final letters. See br on top left, b in mid-word (compare to figure 1), h is disconnected; the final ha looks like a loop, possibly from the Nabatean th or t prototype. (www.islamicawareness.org)

The number of dots and diacritics accumulated over time suggest that overall the Nabatean version of the Phoenician script did not fit the needs of Arabic very well. The habit of creating ligatures eventually made the letters b, n, y, th, t too similar. However, there was no radical change of script. Since the 5th and 6th centuries inscriptions show diacritic dots with values used today. Figure 7, for example, is a one-word inscription remnant:

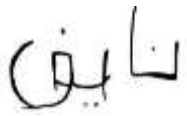


Figure 7: naif = exalted, naiq = quick-witten

In another example, a 7th century Quranic manuscript in the kufic style uses forms for k and T that are quite confusable. Similarly, the b and the n are very similar. In other languages as in Greek and Latin, these letter shapes became more distinct and designated specific consonants. In Arabic, however, they all eventually morphed into one basic shape that needed diacritics to be distinguished. Similarly, the Q and F evolved into one shape with consonant diacritics. These conventions of diacritics were relatively stabilized around the 7th century.

Figure 8: 7th-century Kufic manuscript, Q 7:86–87 (Daniels, 2013). Letters are broad and linear

As Islam spread, the Arabic script had to adjust for clarity and precision. Guessing vowels from context was no longer sufficient, because many converts were not Arabs. Initially dots appeared in manuscripts, written with red ink (potentially after the manuscripts had been written.) However, dots could create confusion with consonant diacritics, so around 786 the known vowel signs started replacing the red dots (e.g. lines fatha, dhamma, qasra, attributed to Al-Khalīl Ibn Ahmad, dated 786 CE). To avoid confusion with the consonant diacritics, the vowel signs are written further above and below the letters. This trait creates letter configurations that are long and columnar. Readers may tend to read in a straight line, due to the "good continuation" principle of Gestalt perception. But letters that are connected often

have implicit or explicitly written vowels in between and force the readers to process the signs above and below the connected linear forms.

The early Islamic centuries also brought to Arabic orthographic distinctions that served to distinguish certain words better. Hamza, obligatory لا la and marking an article as al آل regardless of the consonant pronunciation, silent aleph in verb conjugations (e. g. كتبوا). These help distinguish forms that lack short vowel sounds, so orthography is an important learning prerequisite in Arabic (Elbeheri et al., 2011).

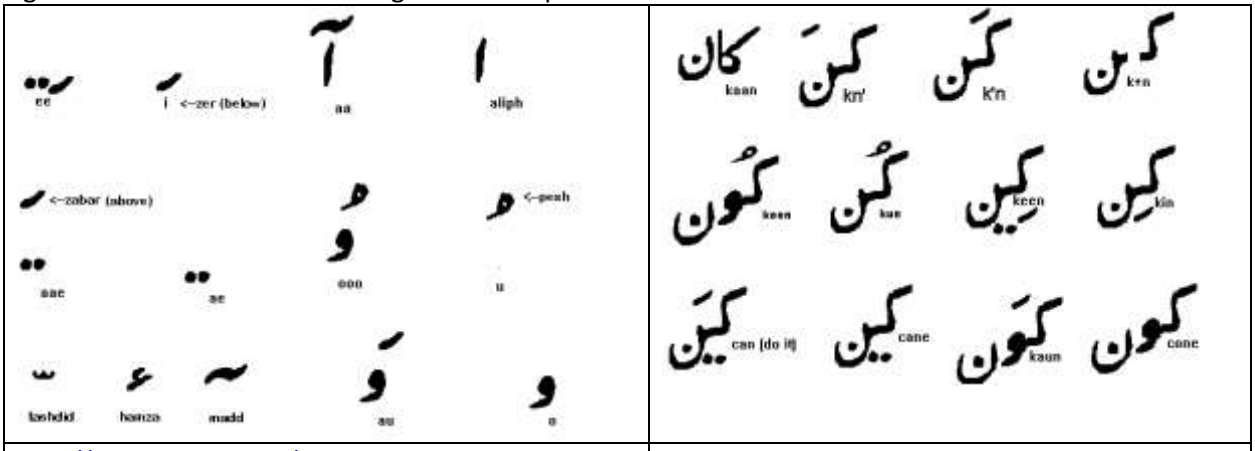
Overall, with time the script recognition traits and spelling rules of Arabic have changed. From the Nabatean spaced characters written more or less on a single line and denoting syllables arose a script that can designate letter sounds fairly precisely. The tradition of connecting and stacking letters nonlinearly created in the Arab world the artful and complex letter designs that are the hallmark of the script. But many forms involve two or three parts. Some letters are small and have multiple tiny dots above and below them. In handwriting, two dots are often written as a line and three as a circumflex, but this convention is not standard, and it creates further confusion to beginners. A script that relies on such configurations may take longer to read than the shorter, one-piece configurations used by most other languages.

The difficulties in rendering the short vowel signs conveniently are one reason why Arabic dialects cannot be conveniently written. In addition, a lack of e and o hampers comprehension for those that rely on these letters. Decoding is also difficult in languages outside the Semitic family. The continuity needed among most letters makes it hard to use vowel marks habitually in languages that need them. Perhaps nonlinear combinations of letters served to distinguish patterns and word spellings that would otherwise be confusable. This may be one reason why the artful nastaliq style and its variations have been traditionally used in Iran, Pakistan, and Afghanistan. Some letters are larger than others, and their arrangement in space creates shapes that may function a bit like ideograms. There are unique combinations, such as a small dod on top of r. Long and short vowels create different words. There are also aspirated letters (bh, dh, etc) which in principle can be taught as diphthongs with ha, but they cannot be easily chunked within a word due to letter connection rules; they merge with the rest. To read efficiently, students of Urdu and other Indoiranian languages must learn these conventions in detail, one by one. This may be laborious, and in many textbooks it is not sufficiently detailed.

Diacritics are not unique to Arabic. The Roman alphabet has developed many diacritics to distinguish letters for languages that use it, including tones for Vietnamese and various sounds for Czech. However, the Arabic script started with a smaller letter set that lacked vowels, and due to the sacredness of the script, new shapes are not introduced. Combinations to serve other languages are only made reusing existing letters and signs, which may be confused in students' minds. Resolving the confusion, even among adults may require time.

There are potential instructional consequences. Iranian students score only a bit above Arab students in PIRLS and TIMSS, although the language used is contemporary Farsi rather than an ancient form. And the Urdu script compared to the Hindi (Devanagari) script generates slower reaction times and higher error rates, despite the sizeable number of signs involved in the Devanagari script (Rao et al. 2011).

Figure 9: Urdu vowels and arrangements to spell out certain words

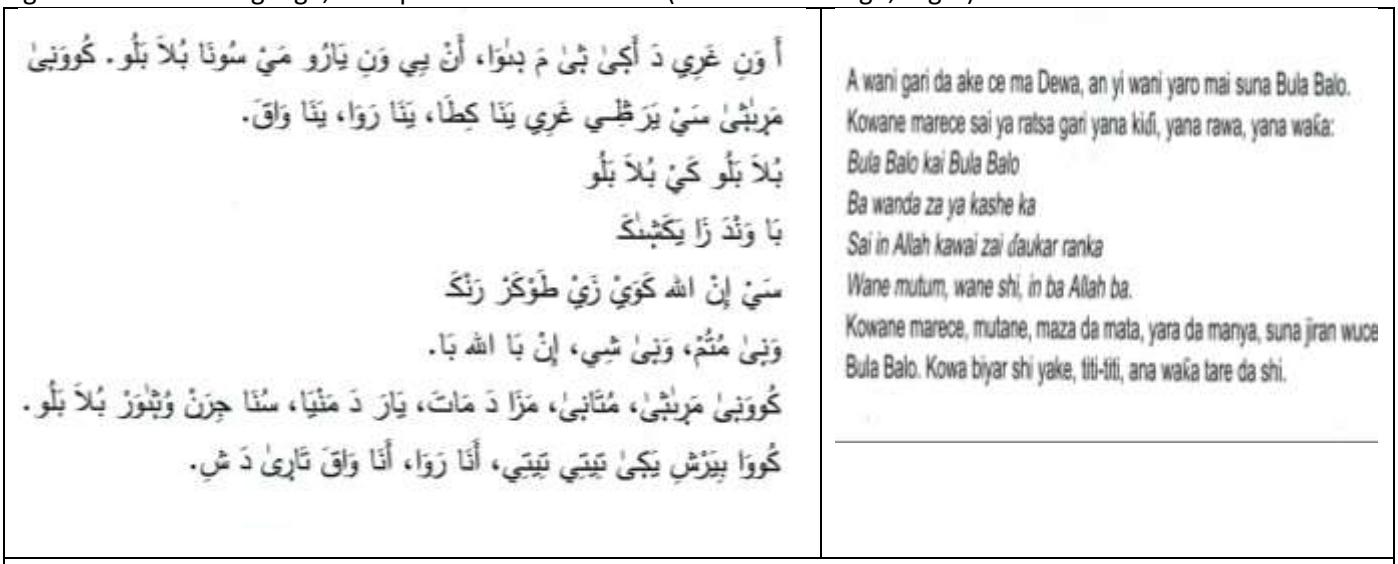


http://www.ukindia.com/zurdu1.htm

Many African languages have also been written traditionally in the Arabic script, such as Wolof, Hausa, Malinke, and Swahili. Consonants and some vowel conventions have been formulated to serve them, sometimes in laborious configurations (Figure 10). West and East African governments have adopted the Roman alphabet, so these Arabic script adaptations are taught in madrasas and are not a prerequisite for acquiring knowledge in school.

Overall, with time the script recognition traits of Arabic have changed. From spaced syllabic characters more or less on a single line, there arose a script that describes sounds exactly but can be written in intricate patterns that may take time to decipher.

Figure 10 : Hausa language, biscriptural children's book (editions Gashingo, Niger)


أ وَنِ غَرِي دَ أَكِىٰ بْىٰ مَ بِىٰوَا، أَنْ بِي وَنِ يَارُو مَيْ سُونَا بُلاَ بَلُو. كُووَنِىٰ
مَرِبْتِىٰ سَيْ يَرَطْيِ غَرِي يَنَا كِطَا، يَنَا رَوَا، يَنَا وَاقَ.
بُلاَ بَلُو كَيْ بُلاَ بَلُو
بَا وَنْدَ زَا يِكَبْتِكَ
سَيْ إِنْ الله كَوَيْ زَيْ طَوْكَرْ رَبْكَ
وَنِىٰ مُتُمْ، وَنِىٰ شِي، إِنْ بَا الله بَا.
كُووَنِىٰ مَرِبْتِىٰ، مُتَانِىٰ، مَزَا دَ مَاتَ، يَارَ دَ مَنْيَا، سُنَا جِرَنْ وُبْتُورْ بُلاَ بَلُو.
كُووَا بِيَرْشِ يِكِىٰ تِيتِي تِيتِي، أَنَا رَوَا، أَنَا وَاقَ تَارِىٰ دَ شِ.

A wani gari da ake ce ma Dewa, an yi wani yaro mai suna Bula Balo.
Kowane marece sai ya ratsa gari yana kidi, yana rawa, yana waka:
Bula Balo kai Bula Balo
Ba wanda za ya kashe ka
Sai in Allah kawai zai daukar ranka
Wane mutum, wane shi, in ba Allah ba.
Kowane marece, mutane, maza da mata, yara da manya, suna jiran wuce
Bula Balo. Kowa biyar shi yake, titi-titi, ana waka tare da shi.

A overhanging aleph marks e; dhamma and subsequent u mark an o; three dots below a b create a ch

Education for All has created new challenges for Arabic, as well as for some other visually complex scripts (like Khmer). A skill that was the domain of a few scribes or learned people

earlier must now be learned by everyone. And the vocabulary to be written has expanded, often including foreign words and names. These create more deciphering challenges, particularly since o and e are not designated in standard Arabic. Also, volumes of texts must be read and rapidly understood. It is important to understand better what the neurocognitive research shows about Arabic reading and adapt instruction accordingly.

The following sections discuss the memory and perceptual issues related to the phenomena, the relevant research, and potential methods for measuring reaction times and reducing them.

C. Memory, Perceptual Learning, and the Arabic Script

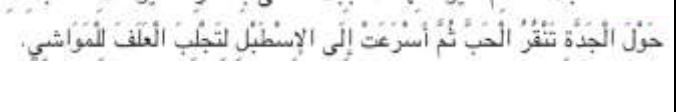
Reading can be considered a race to write fast sufficient content on a blackboard that a mysterious hand keeps erasing. We all read by instantly decoding text and keeping its contents in our working memory (sometimes understood as short-term memory). Working memory is very limited; traditionally it has been considered able to hold about 7 items for about 12 seconds (Abadzi, 2006). Consequently, chunks of words and phrases must be decoded and interpreted within milliseconds. Text must be read at least at 45-60 words per minute for students to make sense of it. If people read too slowly, by the end of a sentence the reader may have forgotten the beginning. The higher the reading speed, accuracy, and automaticity, the more time students have to think about the content. Critical thinking becomes possible when people have time to bring various concepts in working memory, link them, and make decisions.

To understand text therefore, students must be able to decode it instantly and maintain it in their working memory long enough to make sense of it. In this space-time, they must decode the letters, recall word meanings, and still have enough time to think critically about the message. If reading time is taken up with decoding and comprehension takes effort, little working memory is left to think about the text or enjoy it. Reading may become a tedious task, and inefficient readers may avoid it.

Visual identification speed

Our visual system optimally discriminates when letters have certain space between them. Small and dense letters slow down identification (Pelli et al. 2006, 2007, 2003; review in Martelli et al. 2012). Visual complexity matters a lot to early readers (Figure 11). Research on orthographic decoding shows that crowding limits the optimal size for reading.

Figure 11: illustration of crowding effects

	
When looking at the cross in the middle, the A is quickly readable on the right but not on the left. Complexity impairs perceptual identification and may slow down or stop weak readers.	Compared to the Latin script, the Arabic features may appear dense and complex to beginning readers. In most fonts, the shorter letters are half the size of Latin letters. Vowels may create visual crowding and slow down reading.

When reading in a specific language, we acquire experience with frequent letter constellations and learn that certain letter go well together, while others do not. (Hansen 2014, p. 65). Compared to the Roman alphabet, Arabic letter forms are more similar. Many are only distinguishable by the number and placement of the dots. Semitic words do not look as diverse as European words. When it comes to letter constellations, the question of whether or not a letter is connected to the following one is an important means for distinguishing between similar letters. The graphic similarity demands more visuospatial awareness and visual attention than decoding English (Abu Rabia, 2001, Hansen 2014).

One study in Arabic illustrated this phenomenon (Alotaibi, 2007). The reading speed of the normally sighted subjects increased as the print size increased, e.g. from 8 point to 12 point). Larger print sizes resulted in dramatic increases in the reading speed and rate, particularly with Times New Roman font compared to Courier (Figure 12). In particular, people with visual challenges benefitted. As discussed later, this phenomenon clearly impacts Arabic reading.

Figure 12: Meaningful sentences in Arabic in different fonts

A. Reading speed

Times New Roman	Courier
تعد القراءة من الهوايات المحببة للنفس والتي يحرص الكثير من الناس علي ممارستها في أي وقت	تعد القراءة من الهوايات المحببة للنفس والتي يحرص الكثير من الناس علي ممارستها في أي وقت

B. Reading rate

Times New Roman	Courier
حاول الإنسان منذ القدم اختراع العديد من الأجهزة التي تعينه علي القيام بكل أعماله بيسر وسهولة	حاول الإنسان منذ القدم اختراع العديد من الأجهزة التي تعينه علي القيام بكل أعماله بيسر وسهولة

People exposed to letters quickly adapt to crowding, and exposure to print has increased in recent years, enabling the use of small fonts. The difference can be readily seen when comparing older and contemporary textbooks. Ottoman texts from 1925, for example, were formulated at a time when few Turks were literate; the expected size and spacing contrast with contemporary Urdu grade 1 texts, given the rise of a literate middle class in Pakistan[5] (Figures 13 and 14).

[5]Certain syllabic scripts (e.g., Thai, Khmer, Kannada) also entail visual crowding and high error rates up to advanced grades. However, their users are fewer than the Arabic script users. Only Thailand has participated in TIMSS.

The number of dots above and below the letter shapes induce visual crowding. Letters that have three additional consonantal competitors have been found to incur more processing cost relative to letters which have only a single consonantal competitor (Dai et al., 2013). Position, too, may also be a factor given that most diacritics appear above the letters rather than below which might make subscript dots a greater challenge. (Dai, Ibrahim, Share 2013; Figure 15). Perhaps due to visual crowding, readers tend to read faster known words without vowel diacritics. Finally, the breaks in letter connection may introduce ambiguity on where words start and end, so fully connected words are read faster than partly connected or not connected words (Khateb et al., 2013).

Figures 13 and 14: Larger and spacier letters of 1925 vis-à-vis contemporary text

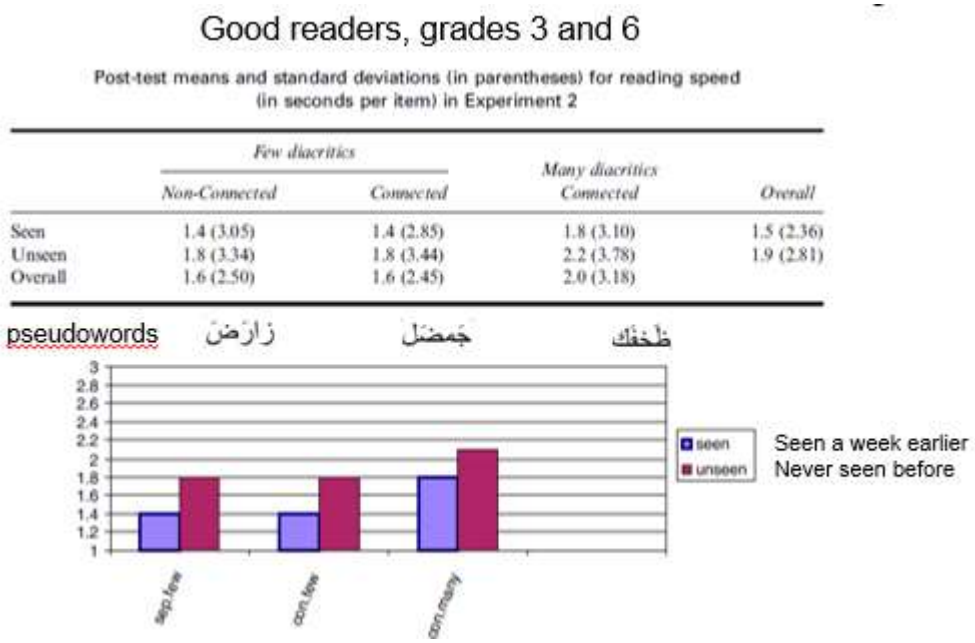
Grade 1 Urdu textbook (author unknown), around 2000.

Ottoman Textbook 1925 (author Ali Heydar)

The visual load affects speed and accuracy, so those who are better at serial searches, read better. Among 12-year olds, a relationship was found between identification of nonwords and visual search for digits, and also between word identification and visual discrimination tasks (Taha, 2013). Furthermore, the orthographic structure of Arabic words creates a significant cognitive burden and requires visual resources for the task that are perhaps higher than in other languages (Ibrahim, Eviatar, & Aharon-Peretz, 2002; Taha & Haddad-Saiegh, submitted). Visual and phonological processing must be closely synchronized for accurate reading in Arabic (Taha, 2013).

Nonlinearity also poses perceptual challenges. In keeping with ancient traditions, Arabic letters are not always written on a single line. This may have been an adjustment to permit quick writing of obligatorily connected and obligatorily separate letters. Ability to follow changing relations among objects that maintain a constancy of sequence is a little-studied phenomenon of humans. (This phenomenon can be called “topological imprinting” (Goldstone, 1998; Figures 16 and 17). As mentioned earlier, non-linearity may create new shapes in people’s minds and thus help distinguish syllables and words; it could be quite useful in languages other than Arabic. However, these non-linear forms often appear in grade 1 textbooks, typically without explanations. This creates an additional layer of complexity in decoding. Students in grade 6 are still improving in speed and accuracy, and still no show a word superiority effect (that is, faster recognition of letters within words; Abdelhadi et al. 2011).

Figure 15: Words with many consonant diacritics are read more slowly



Source: Dai, Ibrahim & Share, 2013

The **obligatory connections and separations** often create situations where space between words is about as long as space between the disconnected letters within a word. A student has to make decisions. Research shows that the outside letters of a word mark them, and people are sensitive to them, though they are not as sensitive to permutations within words (Paterson, Read, McGowan, et al., 2014). To make decisions, readers must look at the very center of words. By contrast, readers of English focus between the beginning and the middle of a word (Almabruk, 2011).

Figures 16 and 17: Stacked letters in traditional uses

Stacked letters in grade 1 books (Last line is Urdu)	Mosque lamp, nonlinear writing (Museum of Islamic Art, Qatar)
مَريم ولي صَباحُ الخَيْر. الهُدوء انور بیمار ہوگیا	

The above issues unconsciously influence readers' decisions. When students must deal with these visual variables simultaneously, the learning process may slow down. Efficient reading is characterized by automatic decoding, based on instant orthographic recognition. This phase seems to have a longer time course for the Arabic script (Taouka & Colheart, 2004). In fact, brain-imaging research suggests that the

low definition and connectivity of some letters may not activate the right side of the brain that recognizes gross patterns, so readers must overly rely on the left side (Eviatar et al., 2004). And as age or level of fluency increases, readers rely more on sentence context and less on word-final vowels to identify the meaning, grammatical function and pronunciation of words (Taouka and Colheart, 2004, p. 51).

Figure 18: Reaction times to Arabic and to Roman letters

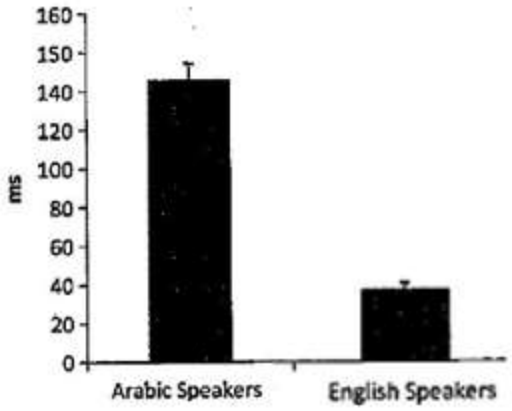


Figure 18: Processing in adult skilled Arabic readers; mean exposure duration to achieve a 50% error rate in letter identification of nonsense trigrams in native readers of Arabic and English (Source: Eviatar & Ibrahim, 2014, p. 84).

So the linear features of European languages, such as trigrams, neighbor frequency effects and splitting of words into syllables do not make much sense in Arabic. The tight morphological structure in Semitic languages provides resources such as prefixes, infixes, suffixes and word length. Arabic words are more dense in information.

In Semitic languages the difference between pseudo-words and nonwords does not depend on letter constellations but on valid and invalid patters. Thus, Arab children may have higher phonological awareness, they benefit from it less (Ibrahim et al., 2007; 2014 p. 80)

Not surprisingly, various studies have found that Arabic students may make more mistakes and read more slowly than similarly trained students of scripts such as Roman. Even adults seem affected to some extent (Eviatar et al. 2004; Azzam, 1993; Bourisly, 2013).

Voweled text may result in perceptual overload, making simple detection of letters and vowels more difficult. (Abdulhadi et al., 2011; Eviatar & Ibrahim, 2014; p. 83). However, reading is much more demanding when vowels are removed. Unlike reading in other languages, Arabic continues to be

dependent on context, even among expert readers. This means among other issues that highly proficient readers must be highly proficient in the language (Hansen, 2014, p. 65).

Therefore correct reading aloud and reading comprehension do not correlate highly in Arabic (Abu Rabia 2001). When spoken and written Arabic are so far apart, the possibilities of phonological association processes are reduced. Word recognition relies to a large extent on other resources besides phonology (Saiegh-Haddad 2005; Saiegh-Haddad and Geva, 2008; Hansen 2014, p.67). One finding is that children do not show a word superiority effect, either in response latency or sensitivity. The word superiority effect is the consistent finding that among literate participants letters are detected faster and more accurately in the context of real words than in pseudowords (Cattell, 1886 in Eviatar & Ibrahim, 2014, p. 85).

Readers of voweled Arabic first need to read at a threshold level and only then does their fluent reading develop. Spelling in Arabic accelerates both the alphabetic and the orthographic phase, and reading develops only later (Mohammed et al. 2014; p. 113). The fastest and most accurate responses were obtained on the connected stimuli (Eviatar and Ibrahim, 2014; p 85). At least by grade 3, students in middle class environments show that they are using a holistic strategy.

Not surprisingly, Arab students are vulnerable to reading difficulties. For example, a sample of 3rd graders in Egypt shows a considerable proportion developing serious deficits. Dyslexia (e.g. 16th %ile, has been reported in less affluent families; disabled readers are comparatively rare among the highest social classes (Jorm 1983, Finucci et al. 1985, Mohammed et al., 2014; p. 112).

Students' Linguistic Needs and Proficiency in standard Arabic

The Arabic world writes almost exclusively in the modern standard Arabic (fusha) which no one really speaks at home.[6] The Arabic spoken in various countries is often referred to as dialectal, but in other contexts these dialects are considered languages (Mejri, Said & Sfar, 2009). Vocabulary varies,[7] verbs are conjugated differently than standard Arabic, with future tenses; negatives in particular are quite different. Cases are marked, and students are taught to read them, although even from standard Arabic they tend to disappear.

Children entering school process standard Arabic as a foreign language. They behave linguistically and metalinguistically like bilinguals (Eviatar & Ibrahim, 2014; p. 79). There is a direct effect of the linguistic distance between written and spoken Arabic on basic reading skills development (Saiegh-Haddad 2003b, 2004, 2007; Hansen, 2014, p. 71).

Also certain letters are pronounced differently. Most Arabic dialects pronounce "t" instead of "th" and use the vowels "e" and "o" that cannot be written in Arabic. The widespread Egyptian dialect changes

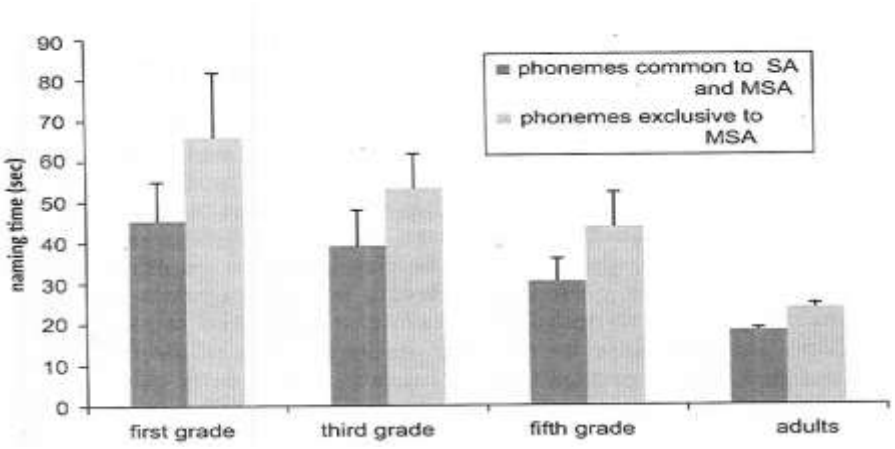
[6] Until 1976, Greek in Greece was also taught in its koine or Byzantine form and represented also a case of frozen dyglossia (Myhll, 2014, p. 21]

[7] In a study of 5 year old Palestinian Arabic speakers it was found that 40% of the words in their lexicon have a completely different form in standard Arabic, 40% of the words are partial cognates (paired lexical items) and only 20% are have the same form in both varieties (Darmon and Polak 2012).

the pronunciation of Q into a glottal stop (‘a) or changes the j into a “g”. The Maghreb countries shorten certain vowel sounds. These variations require specific training and may result in comprehension delays and errors. Phonological awareness is affected by the standard Arabic (Taha and Haddad-Saiegh, submitted).

Also, letters that occurred only in standard Arabic are identified more slowly. Children reading in Arabic read more slowly and make more errors than children reading in some other languages (Saiegh-Haddad et al., 2011; p. 81).

Figure 19: Reaction times to letters exclusive to modern standard Arabic vs. others



Source: Ibrahim et al., 2007 (Eviatar & Ibrahim, 2014, p. 80)

One reason for the slower performance is that grammar increases working memory load, particularly when expressions are different, as in the formation of Arabic negative statements. The effect was studied in Japanese students learning English (Hasegawa et al., 2002). A study of Turkish students in the Netherlands also found that reaction times and accuracy were influenced by both whole-word and constituent information in both the first and second languages in all grades. The non-native learners were typically less efficient in processing this information (de Zeeuw, Schreuder & Verhoeven (2014).

Unfortunately, standard Arabic conjugations and specific vocabulary are often not explicitly taught, and students are expected to acquire them intuitively. Also linguistic distance is not taken into account in international comparison tests. Arab students are classified as speaking the language of the TIMSS test (Mullis et al., 2012 p. 118).

After the perceptual obstacles are overcome, readers ought to understand text. Literal comprehension is a normal human function if the vocabulary is known.[8] In consistently spelled languages and known vocabulary, students ought to make sense of simple text and render its meaning without further instruction (Georgiou et al. 2008, 2009). Exceptions may be students who have unusually limited working memory (Gathercole and Alloway 2008).

Speed of comprehension matters a great deal. Working memory has serial position effects, and this means that the beginning and the end of a text are recalled more easily (Gupta et al. 2005). When students read relatively slowly and close to working memory limits, they tend to remember the beginning and the end of a text, thus missing the point. Therefore when slow readers retell content, the results may be inaccurate (Cohen et al. 2009). Weak students benefit from re-reading text slowly and carefully in order to understand it better (Taha, 2013b).

The interaction of the perceptual and linguistic complexities may magnify the effects, and it may turn Arabic reading into a complex multistage exercise. A reader of the Arabic script must (a) decipher the text, (b) predict the short vowels and keep multiple alternative words in working memory to test and decide on meaning, and (c) make linguistic sense in the case of Arabic. This process means that readers need to identify words faster than in other scripts in order to make sense of the text, but in fact they identify them more slowly and make more errors.

Some Policy Implications

These issues have policy implications, but they have been hard to deal with for political, cultural, and religious reasons.

One reason why these memory and perceptual explanations are not discussed more widely is limited knowledge about them. Education colleges rarely teach memory functions in sufficient depth, so these variables have remained the domain of cognitive psychologists and neuroscientists. To understand the causes of efficiency loss in Arabic and to mitigate them, it is important to measure variables critical in reading and math performance and get precise information on how to optimize them. Then interventions can be introduced for speeding up reading and comprehension. Rapid and accurate execution of fundamental visual and linguistic units may lead to faster execution of larger units. Then students may acquire more information to answer the more advanced parts of tests (e.g., TIMSS science in grades 4 and 8).

The standard Arabic vocabulary and grammar could be taught to first graders in the various Arab countries in detail through scripted lessons and direct instruction methods. Depending on dialectal differences, different countries may explicitly teach the grammatical constructions that are dissimilar to local script and also teach the needed vocabulary. To choose vocabulary, specialists could use word

[8]In reading, the term “comprehension” often includes predictions and inferences. But strictly speaking these are higher-order functions that do not stand in the way of literal comprehension. Literal comprehension of a known language requires no teaching, but higher order functions can and should be taught.

maturity, print frequency, adult rated rate of acquisition (Biemiller, Rosenstein, Sparks, Landauer, & Foltz, 2014).

D. Instructional Complexities and Whole Word Methodology

Perceptual and language problems are exacerbated by the whole-word reading methods that have been imported from English-speaking countries (see textbook examples, Figures 20-23). In educated households and higher-income countries, the apparent results in Arabic seem satisfactory; young students tend to recognize word patters instantly and read easy material fluently. So instruction of whole words without short vowels (harakat, tashkeel) has become prevalent in the Arab world. The grade 1 textbooks of most Arab countries (e.g., Egyptian, Yemeni, Moroccan, and Tunisian) introduce whole words and standard Arabic from the first day, without making explicit efforts to teach the knowledge students lack.

Figure 20: Page 1 of grade 1 book of Tunisia	Figure 21: Grade 3 science textbook in Yemen
	
This song introduces standard Arabic with noun conjugations; it seems designed for students who already know reading and language (Kitab al Qira'a, National Center of Pedagogy, 2002)	Book has no harakat and uses fonts that keep the low letters very small. The letters barely rise above the baseline. Weaker students may learn little science from this text.

But the method works poorly for students whose parents cannot help them at home or for those having difficulties in reading. The students who cannot do this complex work on day 1 may fall behind and be unable to catch up. Thus one often hears that students need 3-4 years to learn how to read in Arabic, whereas voweled Arabic letter by letter ought to be learnable in about four months, like most other scripts and languages.

Even for the better off who may learn through whole-word methods, texts become increasingly complex and require instant and accurate letter-level decoding. Students with limited practice in breaking down words and predicting morphological patterns may decode more slowly and less accurately (Dai et al, 2013; Saiegh-Haddad, 2013). If all the attention is spent on deciphering texts, there is little working

memory left to actually attend to information. Thus the early-grade obstacles constitute a serious reason why Arab students score low in the higher grades.

Since vowels are predictable in Semitic languages, [9] they can be deleted. The prerequisite is rapid and automatic comprehension of standard Arabic vocabulary and comprehension, which is uncertain. In many countries the harakat are almost entirely removed from textbooks in grade 3 or 4. They are removed just at the time that many students begin to read automatically. Then reading speed may drop and further delay comprehension.

Figures 22-23: Book pages showing whole-word methodology

Figure 22: Egypt: Grade 1 textbook circa 2006; requires instant reading in whole words and small fonts	Figure 23: The first instance where letters are shown in a grade 1 book is an exercise; and most are shown sideways
	

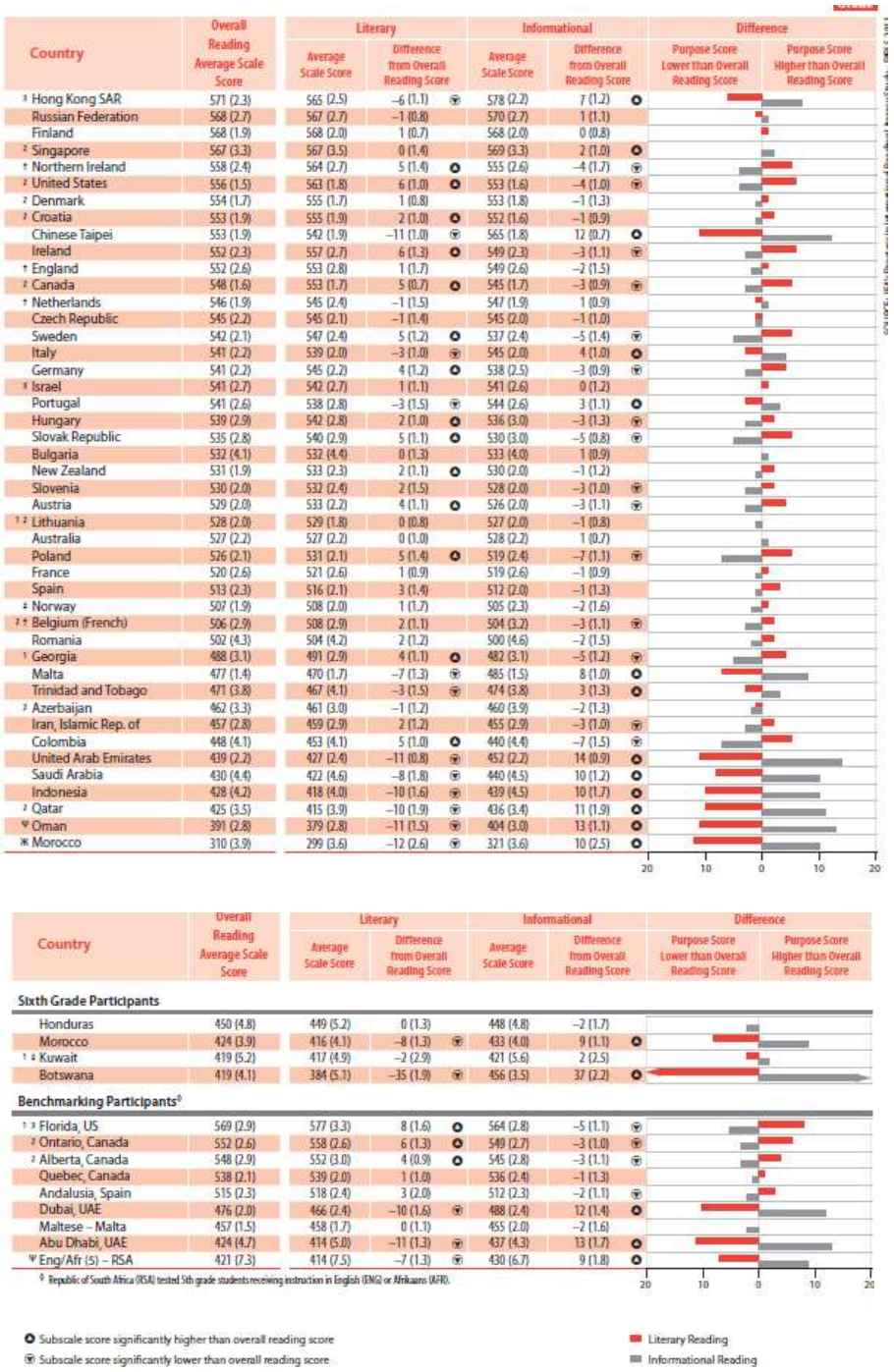
The absence of vowels interacts with the above challenges and constitutes an additional challenge in decoding and comprehension. (See Figure 21, Yemeni textbook.) Students must search for appropriate words, identify likely alternatives for the unvoweled word shapes, hold them in working memory, and then make sense of sentences written with a grammar and vocabulary that may be partly understood. The multiple millisecond-delays may add up, and students' working memory may be overwhelmed. Thus they may be unable to answer some test items correctly. The features of the script may also interact with the visual system of the children that is still developing. Prima facie one would expect an information-processing penalty when a volume of text must be studied and answered.

Not surprisingly, the PIRLS questionnaires suggest that some students do not read comfortably. In Qatar, for example, only 17% declared that they liked reading; this is a much lower figure compared to

[9] Hebrew also deletes vowels and has several letters that are similar, but its characters are separate and linear, thus avoiding much of the Arabic visual complexity.

countries with other scripts and languages. Also students from countries participating in PIRLS score much higher in the informational parts than in literary reading (Table 5; Mullis et al, 2012, p. 90). This suggests ability to extract necessary information from texts when needed, but limited understanding of literary material. Lower accuracy in the extraction of meaning may also be associated with slower processing, as students search their memories for likely interpretations.

Table 5: PIRLS grade 4. 2011, reading scores for various purposes (Mullis et al, 2012, p. 90)



Country	Overall Reading Average Scale Score	Literary		Informational		Difference	
		Average Scale Score	Difference from Overall Reading Score	Average Scale Score	Difference from Overall Reading Score	Purpose Score Lower than Overall Reading Score	Purpose Score Higher than Overall Reading Score
¹ Hong Kong SAR	571 (2.3)	565 (2.5)	–6 (1.1) ▼	578 (2.2)	7 (1.2) ▲		
Russian Federation	568 (2.7)	567 (2.7)	–1 (0.8)	570 (2.7)	1 (1.1)		
Finland	568 (1.9)	568 (2.0)	1 (0.7)	568 (2.0)	0 (0.8)		
² Singapore	567 (3.3)	567 (3.5)	0 (1.4)	569 (3.3)	2 (1.0) ▲		
† Northern Ireland	558 (2.4)	564 (2.7)	5 (1.4) ▲	555 (2.6)	–4 (1.7) ▼		
² United States	556 (1.5)	563 (1.8)	6 (1.0) ▲	553 (1.6)	–4 (1.0) ▼		
² Denmark	554 (1.7)	555 (1.7)	1 (0.8)	553 (1.8)	–1 (1.3)		
² Croatia	553 (1.9)	555 (1.9)	2 (1.0) ▲	552 (1.6)	–1 (0.9)		
Chinese Taipei	553 (1.9)	542 (1.9)	–11 (1.0) ▼	565 (1.8)	12 (0.7) ▲		
Ireland	552 (2.3)	557 (2.7)	6 (1.3) ▲	549 (2.3)	–3 (1.1) ▼		
† England	552 (2.6)	553 (2.8)	1 (1.7)	549 (2.6)	–2 (1.5)		
² Canada	548 (1.6)	553 (1.7)	5 (0.7) ▲	545 (1.7)	–3 (0.9) ▼		
† Netherlands	546 (1.9)	545 (2.4)	–1 (1.5)	547 (1.9)	1 (0.9)		
Czech Republic	545 (2.2)	545 (2.1)	–1 (1.4)	545 (2.0)	–1 (1.0)		
Sweden	542 (2.1)	547 (2.4)	5 (1.2) ▲	537 (2.4)	–5 (1.4) ▼		
Italy	541 (2.2)	539 (2.0)	–3 (1.0) ▼	545 (2.0)	4 (1.0) ▲		
Germany	541 (2.2)	545 (2.2)	4 (1.2) ▲	538 (2.5)	–3 (0.9) ▼		
¹ Israel	541 (2.7)	542 (2.7)	1 (1.1)	541 (2.6)	0 (1.2)		
Portugal	541 (2.6)	538 (2.8)	–3 (1.5) ▼	544 (2.6)	3 (1.1) ▲		
Hungary	539 (2.9)	542 (2.8)	2 (1.0) ▲	536 (3.0)	–3 (1.3) ▼		
Slovak Republic	535 (2.8)	540 (2.9)	5 (1.1) ▲	530 (3.0)	–5 (0.8) ▼		
Bulgaria	532 (4.1)	532 (4.4)	0 (1.3)	533 (4.0)	1 (0.9)		
New Zealand	531 (1.9)	533 (2.3)	2 (1.1) ▲	530 (2.0)	–1 (1.2)		
Slovenia	530 (2.0)	532 (2.4)	2 (1.5)	528 (2.0)	–3 (1.0) ▼		
Austria	529 (2.0)	533 (2.2)	4 (1.1) ▲	526 (2.0)	–3 (1.1) ▼		
†² Lithuania	528 (2.0)	529 (1.8)	0 (0.8)	527 (2.0)	–1 (0.8)		
Australia	527 (2.2)	527 (2.2)	0 (1.0)	528 (2.2)	1 (0.7)		
Poland	526 (2.1)	531 (2.1)	5 (1.4) ▲	519 (2.4)	–7 (1.1) ▼		
France	520 (2.6)	521 (2.6)	1 (0.9)	519 (2.6)	–1 (0.9)		
Spain	513 (2.3)	516 (2.1)	3 (1.4)	512 (2.0)	–1 (1.3)		
¹ Norway	507 (1.9)	508 (2.0)	1 (1.7)	505 (2.3)	–2 (1.6)		
²† Belgium (French)	506 (2.9)	508 (2.9)	2 (1.1)	504 (3.2)	–3 (1.1) ▼		
Romania	502 (4.3)	504 (4.2)	2 (1.2)	500 (4.6)	–2 (1.5)		
¹ Georgia	488 (3.1)	491 (2.9)	4 (1.1) ▲	482 (3.1)	–5 (1.2) ▼		
Malta	477 (1.4)	470 (1.7)	–7 (1.3) ▼	485 (1.5)	8 (1.0) ▲		
Trinidad and Tobago	471 (3.8)	467 (4.1)	–3 (1.5) ▼	474 (3.8)	3 (1.3) ▲		
² Azerbaijan	462 (3.3)	461 (3.0)	–1 (1.2)	460 (3.9)	–2 (1.3)		
Iran, Islamic Rep. of	457 (2.8)	459 (2.9)	2 (1.2)	455 (2.9)	–3 (1.0) ▼		
Colombia	448 (4.1)	453 (4.1)	5 (1.0) ▲	440 (4.4)	–7 (1.5) ▼		
United Arab Emirates	439 (2.2)	427 (2.4)	–11 (0.8) ▼	452 (2.2)	14 (0.9) ▲		
Saudi Arabia	430 (4.4)	422 (4.6)	–8 (1.8) ▼	440 (4.5)	10 (1.2) ▲		
Indonesia	428 (4.2)	418 (4.0)	–10 (1.6) ▼	439 (4.5)	10 (1.7) ▲		
² Qatar	425 (3.5)	415 (3.9)	–10 (1.9) ▼	436 (3.4)	11 (1.9) ▲		
▼ Oman	391 (2.8)	379 (2.8)	–11 (1.5) ▼	404 (3.0)	13 (1.1) ▲		
✱ Morocco	310 (3.9)	299 (3.6)	–12 (2.6) ▼	321 (3.6)	10 (2.5) ▲		
Sixth Grade Participants							
Honduras	450 (4.8)	449 (5.2)	0 (1.3)	448 (4.8)	–2 (1.7)		
Morocco	424 (3.9)	416 (4.1)	–8 (1.3) ▼	433 (4.0)	9 (1.1) ▲		
¹ ‡ Kuwait	419 (5.2)	417 (4.9)	–2 (2.9)	421 (5.6)	2 (2.5)		
Botswana	419 (4.1)	384 (5.1)	–35 (1.9) ▼	456 (3.5)	37 (2.2) ▲		
Benchmarking Participants◊							
¹ ² Florida, US	569 (2.9)	577 (3.3)	8 (1.6) ▲	564 (2.8)	–5 (1.1) ▼		
² Ontario, Canada	552 (2.6)	558 (2.6)	6 (1.3) ▲	549 (2.7)	–3 (1.0) ▼		
² Alberta, Canada	548 (2.9)	552 (3.0)	4 (0.9) ▲	545 (2.8)	–3 (1.1) ▼		
Quebec, Canada	538 (2.1)	539 (2.0)	1 (1.0)	536 (2.4)	–1 (1.3)		
Andalusia, Spain	515 (2.3)	518 (2.4)	3 (2.0)	512 (2.3)	–2 (1.1) ▼		
Dubai, UAE	476 (2.0)	466 (2.4)	–10 (1.6) ▼	488 (2.4)	12 (1.4) ▲		
Maltese – Malta	457 (1.5)	458 (1.7)	0 (1.1)	455 (2.0)	–2 (1.6)		
Abu Dhabi, UAE	424 (4.7)	414 (5.0)	–11 (1.3) ▼	437 (4.3)	13 (1.7) ▲		
▼ Eng/Afr (5) – RSA	421 (7.3)	414 (7.5)	–7 (1.3) ▼	430 (6.7)	9 (1.8) ▲		

◊ Republic of South Africa (RSA) tested 5th grade students receiving instruction in English (ENG) or Afrikaans (AFR).

▲ Subscale score significantly higher than overall reading score
▼ Subscale score significantly lower than overall reading score

Literary Reading
Informational Reading

The Arab countries value the development of **critical thinking**, but rapid and highly accurate reading is a prerequisite. Decisions on content, particularly counterintuitive decisions as would be expected from critical thinking, require depth of knowledge and rapid access to it. Information therefore must be processed well with the limits of working memory, so that students have time to think about it. Critical thinking training has had ambivalent results in many parts of the world. However, reading and calculation proficiency are often not taken into account as prerequisites. Some critical thinking training may help.[10] But if the lower-level processing prerequisites are speeded up, students may be more likely to engage in critical thinking without extra training in it.

Overall, Arabic reading has some unique characteristics:

- It is consistent to read when vowels are marked.
- Individual letters are relatively simple shapes, using little "ink"; in principle they should be easy to memorize and faster to write.
- The basic shapes (رسم) are few and most letters consist of two parts (e.g. cups and dots above or below).
- Letters have obligatory connection rules, and boundaries between connected letters may be unclear;
- When words contain unconnected letters, it may become unclear where the next word starts;
- Prefixes change the word shapes;
- Arabic is not always written on a straight line. Letters are often stacked to create unique word or syllable shapes;
- About 4 letters are taller than the others, forcing the rest often into very small fonts.
- About 4 letters of the standard Arabic are pronounced differently in dialects.
- When short vowels are not marked, students must predict words from morphology;

In languages other than Arabic, there may be additional visual complexity and confusability.

- Consonants such as ch, p, v, are written with dots above or below existing shapes.
- Vowels é and ó cannot be written, so the languages that need them use approximations; (e.g. Urdu, Farsi, Pashto)
- In languages requiring novel combinations, such as aspirated sounds of Urdu, connection rules of letters may inhibit clarity.

Despite many debates and publications, actions have been limited. Some of these issues have been rarely studied in detail and are poorly understood. One reason is that curricular designers tend to be middle-class native readers; they have been programmed and become habituated to the exigencies of their script and may be unaware of difficulties faced by weaker students, and by those who get no help at home.

[10] Critical thinking is a way of deciding whether a claim is true, partially true, or false. It includes observation, interpretation, analysis, inference, evaluation, explanation, and metacognition (Reynolds, 2011). Components include observation, context skills, relevant criteria for making the judgment well, applicable methods or techniques for forming the judgment, applicable theoretical constructs for understanding the problem and the question at hand. Research on effective approaches to improvement is still evolving, even with populations proficient in reading; e.g. see http://www.criticalthinking.org

Some governments are considering reading campaigns. For example the Office of the Vice-Chair in the Supreme Education Council of Qatar has launched a National Reading Campaign. Its mission is to create a culture of reading by raising awareness, empowering, providing access and encouraging collaboration between entities in Qatar. For the year of 2013-2014, the campaign focused on preprimary and primary school children and included a library enrichment program, book fairs, children's play events, as well as a Bookstart initiative. A high-level reading committee would analyze proposed programs and events, identify gaps and strategically plan necessary initiatives. The reading committee may also lead studies related to reading and reading programs in Qatar as well as provide educational information for its website. For such activities to succeed, fast standard Arabic comprehension is crucial.

E. Data Regarding Arabic Reading Fluency and Comprehension

The relationship between fluency and comprehension and the use of words per minute as an achievement benchmark was first promoted by the World Bank through senior education specialist Helen Abadzi. Starting in 2004, USAID financed the development of early-grade reading assessments (EGRA). These have been carried out in most countries, largely financed by USAID (see www.eddataglobal.org).

EGRA studies have been undertaken in five Arab countries: Jordan, Iraq, Yemen, Morocco, and Egypt. Each one has its own linguistic and sociological particularities, which differ from those of the GCC countries.

The data support the hypothesis that students read slowly and have limited comprehension of standard Arabic. Second graders in these countries read on average only 5-15 words per minute correctly. Due to working memory limitations (see background section) people must read at least 45-60 words per minute to make sense of text. The average numbers in these countries are too low to facilitate comprehension with the limits of working memory. However, these numbers are averages; they include sizeable numbers of students who could not read at all and score 0 words per minute (Table 6).

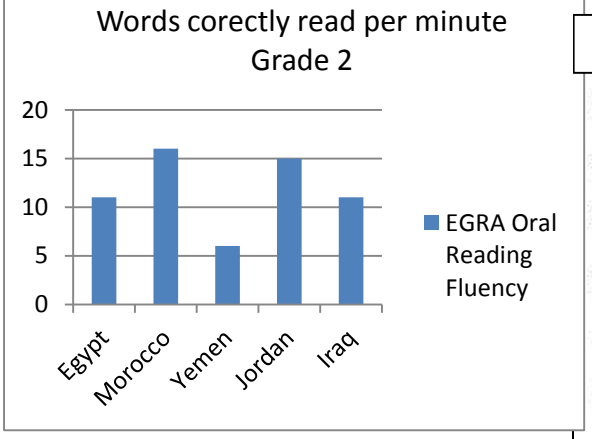
Table 6. Reading comprehension and corresponding fluency in grade 3 of five Arab countries

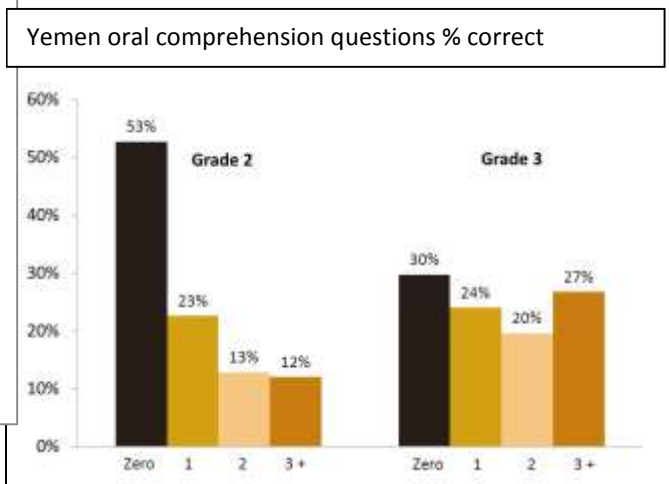
Country	**% of students tested who read with at least 80% comprehension**	**Corresponding average oral reading fluency (correct words per minute)**
Egypt	9%	47 + words
Iraq	9%	60+
Jordan	27%	43+
Morocco	2%	55+
Yemen	3%	48+

Source: USAID, 2013 (Creative associates; data presented at a USAID conference, August 6, 2013.) At least 4000 students were tested per country.

For example, in Yemen, over half the second graders could not answer any oral questions correctly after listening to a story (out of 6 total); 30% percent of third graders similarly could not do this task. The percentages of third graders who read well enough to answer 80% of questions correctly ranged from 2% in Yemen to 27% in Jordan. Clearly these students cannot learn much from texts, and they would be unlikely to make sense of the science textbook of Figure 21.

Figure 24. **Reading and oral fluency vs. comprehension in Arabic**





Source: Creative Associates; data presented at a USAID conference, August 6, 2013

Inability to read fluently is linked to writing and spelling difficulties. In Yemen, for example, students were tested in dictation. The examiner read three words to the children and asked them to write them down:

الطالب يكتب الدرس

65% of grade 2 students could not spell any of these words correctly

42% of grade 3 students could not spell any of them correctly

When listening comprehension was plotted against reading comprehension, linear patterns emerged that are similarly worrisome. There is improvement between grade 2 and 3, but overall third graders comprehended around 50% of the text. Human memory classifies knowledge in hierarchical networks. Unless students can access a fair amount of background knowledge, they may be unable to process messages into long-term memory and retain them for the long run.

Table 6 further demonstrates the potential penalty of Arab students. Only 3-27% in the five countries where reading fluency was measured could comprehend 80% of the reading test. One year later some of these students could be taking TIMSS and PIRLS.

From the above five countries, Morocco took the PIRLS in 2011 in grade 4 and finished last, while Yemen took the 2001 TIMSS test and finished last (Morocco was penultimate; Tables 1 and 2). It is reasonable to hypothesize that students had limited instruction in math, as they apparently did in Arabic. However, accurate and fast reading of math is a prerequisite to carrying out relevant calculations. It is impossible to evaluate math performance without adequate reading achievement.

Reading fluency has not been tested in GCC countries, and PIRLS scores indicate that GCC students overall would perform better than Yemen or Morocco. However, a segment of the students (informal estimates put it around 20%) might benefit from detailed letter-by-letter instruction along with standard Arabic instruction. Furthermore, these countries receive migrant workers from lower-income Arab countries, and their children may benefit from more detailed instruction.

F. **How to increase the efficiency of reading instruction in the Arabic script?**

The importance of phonics. It may seem retrograde to some parents and teachers, but instruction of individual letters has given better results worldwide compared to whole-word methods (see Abadzi, 2008 for a review). This partly happens because people learn larger chunks of material by automatizing small chunks first. Those who fail to learn the sound-letter combinations or small letter units cannot go on to texts of greater complexity. They can neither catch up on their own nor learn more advanced material by skipping the elementary gaps. Well to do children exposed to reading early may do well with whole-word methods, but countries have children of all socioeconomic levels, and it is important to use methods that work for all. Advanced students may cover these elementary steps more quickly.

Phonics have been used in Arabic for centuries, (method called tariqa Bagdadia or tariqa hija'ia (طريقة بغدادية , طريقة هجائيّة).[11] The old phonics principles were used and improved. The important instructional tasks to implement would include:

- Teaching each letter explicitly
- writing large and broadly spaced characters on the blackboard and books
- Using pattern recognition to identify letter positions and vowel combinations
- Teaching the sounds of letters unknown in specific dialects
- Specific practice to increase the speed and accuracy of small combinations
- Maintaining essential harakat through primary school in textbooks and class use
- Using in each country words that children already know from their dialect
- Explicitly teaching orthography, which helps differentiate words quickly
- Teaching morphological awareness, the constituents of words
- Learning standard Arabic conjugations, and practicing fast insertion in text
- Reading standard Arabic stories to children, using the conjugations since preschool
- Providing students with corrective feedback

Scope, Sequence, and Curricular Time

USAID contractors (USAID 2013) recommend devoting instructional time to 2-3 reading periods per day for Grade 1 (total 70 minutes); and 18 periods/week for Grade 1 and 12 periods per week for grade 2. Letters ought to be introduced in patterns; in the beginning, middle, final and independent positions, along with the short vowel signs (fatha, dhamma, qasra, also shidda for doubled consonants). Hand motions could help retain the shapes and functions of the vowel marks.

Letters ought to be introduced gradually, probably no more than one letter or sign per day. The more frequent letters could be taught first, so that meaningful combinations can be made soon.[12] There should be review, consolidation and enrichment exercises after every four lessons. Ideally, the instruction should initially focus on letter instruction and minimize language issues in order to ensure that students learn the

[11] As a result of these methods some Arab students are taught to say "d+fatha = da". This is useful and teaches them the basic technique. But they should soon be taught to say "d+a = da" rather than 'fatha'

[12] To focus children on letters being taught and clarify their sound, they should be presented using as few words as possible to focus attention on the sound-shape linkage. Such techniques may increase opportunities for long-term potentiation, the neural-level process which enables stimuli to be linked permanently in memory (e.g. Arai et al. 2009). Emotional expressions may help retain letter shapes (Nielson et al. 2006, Wagner Cook et al. 2009).

letters and acquire automaticity. This could be accomplished by using vocabulary and the dialect that students already know and that can be conveniently written in Arabic.

Sufficiently detailed instruction of phonics and language would require extensive teacher training and support. USAID contractors recommend, for example, 17 days of integrated practicums ("sandwich approach"), intensive hands-on coaching. Potentially observational training videoclips could be used.

As discussed earlier, the visual issues in early-grade textbooks are important. The letters should conform to the critical space and critical size expectations. The fonts used in school books are often small and connected. It would be worth piloting the readability of monospace fonts that have become very common in the Arab world.

Further research may inform on the spacing of the dots from the shapes or from each other. The circumflex that is often used in handwriting could be potentially tried for readability in printed text.

Figure 25: Arial mono-space, stretched	Usual naskh font, 14 point, Times New Roman
" ! شبّيك لبّيك ، عبدك بين يديك . في حكاية علاء الدين ، الفانوس السحريّ يحقّق كلّ أمانيكم	فَقَالَ بَعْضُهُمْ لِبَعْضٍ: «هَيَّا نَصْنَعُ طُوباً مَشْوِيّاً أَحْسَنَ شَيٍّ». فَاسْتَبْدَلُوا الْحِجَارَةَ بِالطُّوبِ، وَالطِّينَ بِالزِّفْتِ

Phonological and Morphological Awareness. Much research has linked phonological awareness to reading achievement in various languages so that students can learn how to map letters onto sounds. Exercises are oral and ought to be taught even before actual reading, at least during the first two weeks of instruction. These would include marking the beginning sound, breaking words down into phonemes, identifying syllables (e.g, Durgunoglou and Oney 1999). Teachers often find it hard to do these exercises, so some planning is needed.

Also students must become aware and learn to pronounce the standard Arabic letters that some dialects do not use. Where there is variation, the standard pronunciation must be taught. Examples would be th, q, Dh instead of z.

Morphological awareness is beneficial in all languages (Deacon et al. 2010), but it is crucial in Arabic given the eventual deletion of short vowels. For example, students must learn predict which words start with a ma, mu or end with pronouns (Haddad-Saiegh, 2013).

Results from Arabic phonics instruction. One notable experiment has been the three-year Girls Improved Learning Outcomes project in Egypt (USAID, 2011). It was carried out in 144 lower-income schools. It focused on teaching the sounds explicitly letter by letter and also teaching vocabulary and grammar. Teachers were trained and supervised extensively, and the program was subsequently adopted by the Egyptian government. Testing showed rapid increases in speed and comprehension over control schools across time as well as in the course of six months.

Figure 26: Explicit instruction in each letter resulted in fast improvements

EGRA Test Component	Change in Mean Score: # of Units Read Correctly in 1 minute 2009 – 2011		% of Grade 2 Students Reading at Desired Level * 2011	
	GILO Schools	Control Schools	GILO Schools	Control Schools
Letter Names	+ 34%	+ 6%	78% (+15%)	55% (+1.5%)
Letter Sounds	+ 192%	+ 18%	51% (+39%)	14% (+1.5%)
Words	+ 111%	+ 34%	24% (+15%)	11% (+3.5%)
Non-Words	+ 61%	+ 27%	12% (+6%)	7% (+3%)
Passage Reading	+ 91%	+ 23%	20% (+15%)	8% (+3.5%)

USAID, 2011 (Research Triangle Institute)

Pattern Analogies of Arabic

To learn fluent reading and rapid recognition of patterns, students may benefit a lot from learning a table of orderly combinations. Students are excellent pattern detectors, and these need to be shown. Analogies have been discussed as above. They include the use of vowel signs and the patterns in beginning, medial and final shapes of various letters.

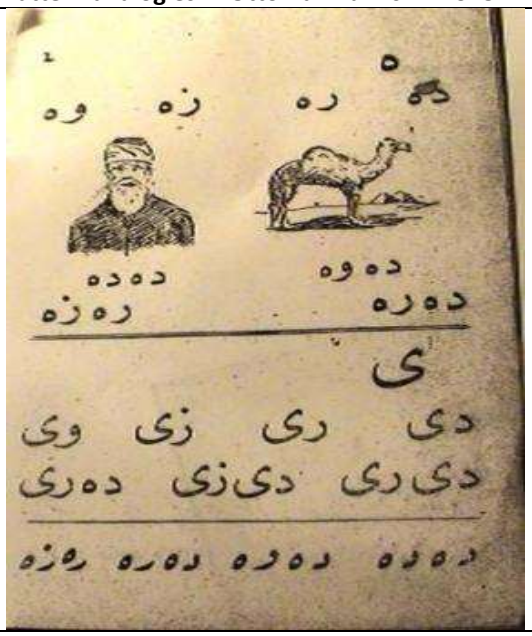
Figures 27-28: Pattern recognition

Vowel consonant analogies can be used in Arabic

	a	e	i	o	u
B	ba	be	bi	bo	bu
C	ca	ce	ci	co	cu
D	da	de	de	do	du
F	fa	fe	fi	fo	fu
G	ga	ge	gi	go	gu
H	ha	he	hi	ho	hu
Etc					

Letter	Fatha	Qasra	Dhamma
ص	صَ	صِ	صُ
ص	صَ	صِ	صُ
ت	تَ	تِ	تُ
ق	قَ	قِ	قُ
د	دَ	دِ	دُ
ف	فَ	فِ	فُ
س	سَ	سِ	سُ
etc			

Pattern analogies in Ottoman Turkish – 1925



Consonants can also be taught through analogies. It is typically said that each Arabic letter has four shapes. However, the Old Arabic inscriptions show that this is due to creation of ligatures. Letter shapes really remain constant, and inside or at the end of words and they follow predictable patterns, with flourishes as a final line. The ayn closes a loop in the middle and end of a word but its basic form is really identifiable (Daniels, 2013). Only the h ھ changes shape into the ۃ or ة, but this may have historically represented t that became silent or h at the end of a word (see inscription in Figure 10).

So instead of dealing with shapes in the four shapes as distinct, it may be more efficient to train students to link patterns initially without dots. For first graders this could be accomplished through writing exercises. For adults (including foreign learners) the explanation of the patterns and rationale for the various diacritics and conventions may be useful.

Table 7. Relating Arabic letters to their prototypic forms (Daniels, 2013)

Basic letter shapes (رسم	Connections formed by basic letter shapes	Patterns of connections; Final forms are really a flourish at the end			Letter shapes with dots
ا	ا	Ia.	ف	ڤ	ا
ر	ر	Ib.	ب ت ث	ب ت ڤ ز ي	ب ت ڤ ز ي
ح	ح	IIa.	ق ن	ق ز	ج ح خ
د	د	IIb.	ي	ي	د ذ
ر	ر	IIIa.	س ص	س ص	ر ز
س	س	IIIb.	ح ع	ح ع	س ش
ص	ص	IV.	ل م	ل م	ص ض
ط	ط	V.	ك	ك	ط ظ
ع		VI.	ه	ھ	ع غ
(ف)	(ڤ)	VII.	ط (ا د ر و)		ف ق
ك	ك				ك
ل	ل				ل
م	م				م
ھ					ھ
و	و				و

Teaching Standard Arabic To Students

Ideally, students should learn to read in a language they know well and later progress to other languages. Despite difficulties in rendering the sounds of Arabic dialects, probably all dialects have been written in

the Arabic script. (Maltese Arabic is written in the Roman script.) However, due to cultural and political reasons, students do not get any formal instruction in local dialects.

It is important, therefore, to maximize in textbooks the words that children already know from their dialect. These can be multiplied by teaching morphological awareness early. It seems that even in kindergarten children can understand and produce morphology (Haddad-Saiegh, 2013). Reading standard Arabic stories to children, using the standard forms since preschool seems to prepare students (Iraqi, 1990; Feitelson, Goldstein, Iraqi, and Share, 1993; Haddad-Saiegh, 2013). Children may recognize the standard letter names and show increased phonological awareness (Levin et al., 2008). It was earlier thought that the standard language is too hard for the young students, but apparently this is not the case.

Schools do teach verb and noun conjugations extensively but do so in advanced grades and along with much grammatical terminology. However, to memorize verb conjugations, terminology is not necessary. The students can learn to conjugate, pick the right person, form, and gender, and insert it in a sentence. Also dialectal forms would be contrasted with standard forms.

Research from the US suggests **a great need for additional vocabulary**. In English, at least, more than 10 vocabulary words should be taught every week – not just in reading class but across all subject areas including math, science and social studies (Wright & Neuman, 2013). Teachers could focus not only on presenting words, but also on reviewing them, offering them in different contexts, asking about dialectal uses, and monitoring whether the students truly grasped their standard Arabic meanings. Instructional videos may be developed showing these tasks. Thus vocabulary development could include comprehension of expressions and also contrasts of standard Arabic meanings with the meanings in various dialects. The assessments would point to the needs for specific words and areas of systematic confusion.

Reliance on distinct word spellings. Orthography is particularly important in Arabic, because words are often distinguished by small differences, such as the addition of a hamza or silent final aleph. Research shows that poor readers have difficulties remembering the spelling of words, so exercises in spelling and automatizing orthographic forms are important in Arabic (Elbeheri, Everatt, Mahfoudhi, Abu al Diar, and Taibah, 2011). These ought to start as soon as students can decode the letters.

Writing would reinforce phonemic awareness and vocabulary. It should progress from penmanship to composition. Potentially students should receive practice not just in reciting and using the standard Arabic conjugations but also in writing them.

Practice to speed up reaction time to identification and comprehension

Arabic instruction should focus on increasing the speed and accuracy of recognizing the small components of reading within the linguistic contexts, so that recognition takes milliseconds: If the individual skills are practiced sufficiently, then “low-level” skills improve quickly, within a few weeks. Given the chunking process with which the brain creates chains of automatized skills, it is hypothesized that global skills, such dealing successfully with the PIRLS test, will improve faster than is usually expected. Studies indeed suggest that improvement from targeted practice should increase speed,

accuracy, and spelling proficiency (Dai et al, 2013, Khateb et al., 2013, Saiegh-Haddad, 2013). Thus it is possible to structure programs that specifically help students speed up reading. If students are taught reading letter by letter (phonics), the script and reading strategy can be learned in about four months.

Students should read aloud or silently until they read fluently and effortlessly. They can read texts all together, alone, in small pairs, reread the same text after some time, take books home to read to parents. Because they easily learn sequences of words by heart, they should get a lot of different reading exercises, not just a few sentences as is commonly done. Individual practice should be a part of the daily routine.

Specific problem combinations ought to be practiced in Arabic. This can be done through computerized devices. Some software already exists to teach language; [13] for example the Aladdin project of Qatar University uses computerized tables that permit students to choose from various options and to write. Also more cost effective software can be developed to practice students on specific patterns starting in the first year. Software is particularly useful in providing many trials of practice as well as personalized feedback on various language items.

Thus software could be built to provide feedback as well as data on reaction times. It would include among other tasks:

- Letter shapes and combinations that must be speeded up
- Conjugations of standard Arabic forms and practice in inserting them in various sentences
- Vocabulary practice in depth and breadth of meaning, speed tests in the identification of various words.
- Morphological awareness exercises to facilitate prediction of unvoweled word forms (Saiegh-Haddad, 2013).
- Frequent words without harakat in preparation for this stage (e.g. Oweini and Hazoury list; 2012, see below)

Some experiments in the US offer guidelines for the time and duration of practice. For example, practice for 30 minutes a day, 3-4 days a week, over 4 weeks in a summer session resulted in considerable comprehension gain in English.[14] Also innovative research suggests a significant advantage in optimizing the timing of reviews for language instruction (Lindsay et al., 2014). Initial trials in various countries could assess the amount of improvement possible in speed and accuracy of decoding and

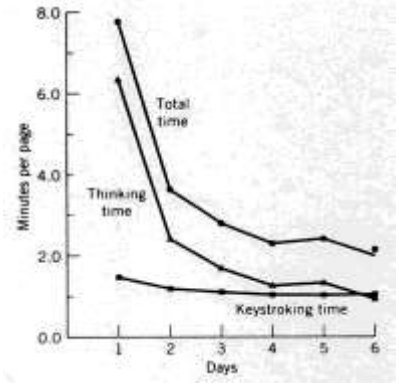
[13] Arabic software already exists and could be adapted or used as examples. E.g. https://www.youtube.com/watch?v=eSc_oBHPw7U&feature=player_embedded. Words pronounced in Arabic could be used in software http://swac-collections.org/index.php

[14] With more data gathering it may be possible to determine lexile scores for comprehension by Arab students. A Lexile is a standard score that matches a student's reading ability with difficulty of text material. A Lexile can be interpreted as the level of book that a student can read with 75% comprehension. A 75% comprehension level has been identified in English as offering the reader a certain amount of comfort and yet still offering a challenge. The Lexile Framework Map shows Lexiles ranging between approximately 200 and 1700 (Stenner & Burdick, 1997; Scientific Learning, customerservice@scilearn.com. scilearn.com/resultsreports, 888-3580212.) Students usually gain 120 lexile points after a full year of instruction, but in one month of summer school such gains are possible.

comprehension in one-month intervals. Of course teachers would have to supervise the computer practice and potentially assign homework for it.

Figure 29

Learning curves illustrate the power of practice (shown here is typing speed increase)



If interventions are designed and implemented intensely, students would show rapid improvements in the fundamental skills related to speed and comprehension. In principle, 4th graders of low-scoring schools may register significant improvements in the 4th grade PIRLS. Students may be tested with a sample instrument in order to assess differences.

Removing Short Vowels in the Arabic Script

After reading is automatized, a visual dictionary is made of words, and their meaning becomes evident without resorting to sound (Glezer, Jiang, and Riesenhuber 2011). Eventually Arab students must learn to read without vowels. When this happens, new visual patterns result and must be automatized all over again. Unvoweled patterns have fewer features and could potentially be more efficient to read. One brain imaging study of adult readers found that reading words without diacritics yielded shorter response times than words with diacritics (Burisly et al. 2013).

When vowels are deleted, however, identification speed temporarily decreases (Shany, Bar-on, and Katzir, 2012). Pattern recognition is one issue, but language is another; students must retain too many alternatives in working memory. The alternatives in working memory compete with the meaning of the passage. So as texts become more complex, the working memory load gets an extra burden. Simultaneously the readers must decipher the meaning of standard Arabic expressions that may be unclear. All these decisions may be reducing the amount of content that students retain.15 In principle faster reading and faster word identification would compensate; but limited instruction of standard Arabic may make students also less likely to engage in reading, so neither the linguistic nor the visual identification speed may increase. Therefore a vicious circle may be created. Students may be decoding and understanding too slowly to continue reading and thus get over this burden.

For unvoweled Arabic, sight words could be of considerable help. One example is a Lebanese list of frequent words (Oweini and Hazoury 2012; Table 8). Other countries can adapt it as needed. For Urdu, Farsi, Pashto similar words lists should be developed if they do not already exist.

To get students to decipher text, retain its meaning, and perform in exams, it makes more sense to keep certain vowels through the primary grades. Harakat create visual complexity by themselves, so there is a good reason to remove them when students can reliably predict words. Until then, they could become

[15] Bourisly et al. (2013) found stronger activation in the hippocampus and middle temporal gyrus, possibly reflecting a search among multiple lexical entries that may be associated with these words. In contrast, real words with vowel signs yielded longer response times and activated the insula and inferior frontal areas, suggesting an engagement of phonological and semantic processes in recognizing words with diacritics.

printed in gray. In particular the first haraka may be retained throughout primary and secondary grades to "prime" students' word recognition. Also foreign and unusual words should continue to be voweled. Research is needed to study when the weaker students can reliably understand text without harakat.

As mentioned elsewhere, due to working memory limitations, speed is required for comprehension. Perhaps a threshold speed is needed to hold alternatives in mind and thus safely remove the vowels, but we have no sense at this point what it is. Data may exist in various studies of the Arab world, and a literature review may find them and obtain insights.

Table 8: Oweini and Hazoury frequent unvoweled word list, 2012

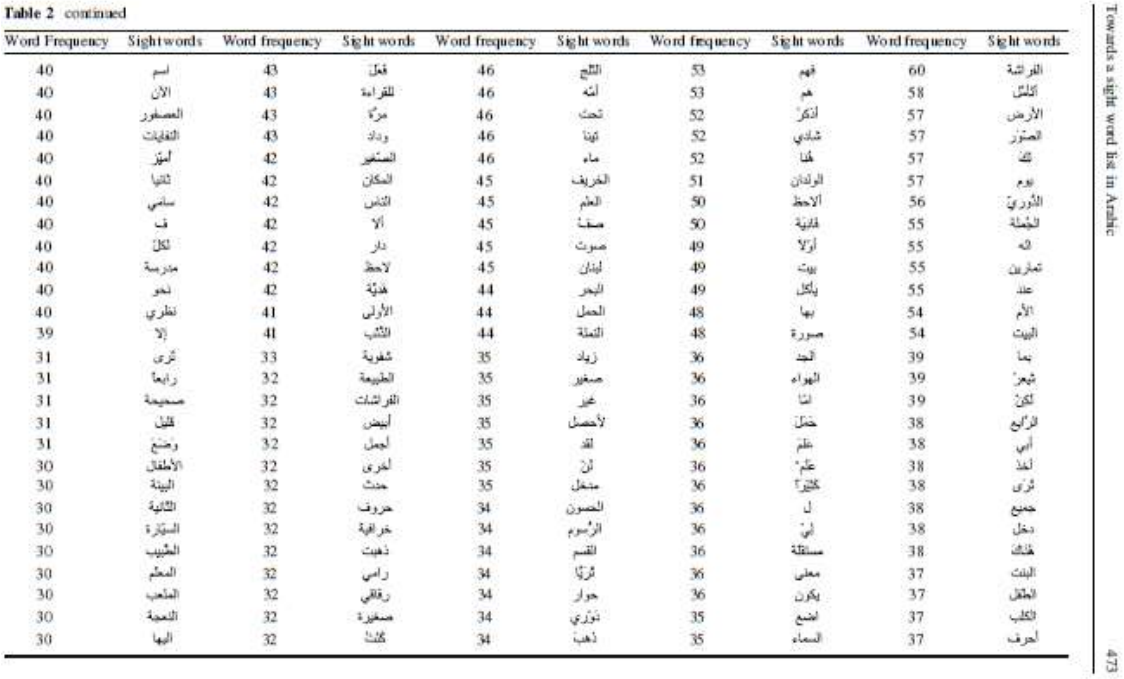


Table 2 continued

Word Frequency	Sight words	Word frequency	Sight words	Word frequency	Sight words	Word frequency	Sight words	Word frequency	Sight words
40	اسم	43	فعل	46	الثلج	53	فهم	60	القرائة
40	الان	43	للقراءة	46	أمّه	53	هم	58	أكلّمُ
40	العصفور	43	مرّة	46	تحت	52	أذكرُ	57	الأرض
40	الثقافيات	43	وداد	46	ثوبا	52	شادي	57	الصّوَر
40	أمّهُ	42	الصّغير	46	ماء	52	هُنا	57	تلك
40	ثانيا	42	المكان	45	الخريف	51	الولدان	57	يوم
40	سامي	42	الناس	45	العلم	50	الاحظ	56	الأوربيّ
40	ف	42	ألا	45	صفّ	50	فاطمة	55	الجُملة
40	لكلّ	42	دار	45	صوت	49	أوّلاً	55	الله
40	مدرسة	42	لاحظ	45	لبنان	49	بيت	55	تمارين
40	نحو	42	هديّة	44	البحر	49	يأكل	55	عند
40	نظري	41	الأولى	44	الحمل	48	بها	54	الأم
39	إلا	41	الثّلج	44	النملة	48	صورة	54	البيت
31	ترى	33	شفوية	35	زياد	36	الجد	39	بما
31	رابعاً	32	الطبيعة	35	صغير	36	الهواء	39	شهرٌ
31	صحيحة	32	القرائات	35	غير	36	امّا	39	لكنّ
31	قليل	32	أبيض	35	لأحصل	36	حَمَلَ	38	الرّابع
31	وضع	32	أجمل	35	لقد	36	علّم	38	أبي
30	الأطفال	32	أخرى	35	لن	36	علّمَ	38	أخذ
30	البيئة	32	حدث	35	منخل	36	كثيرًا	38	ترى
30	الثانية	32	حروف	34	الحصون	36	ل	38	جميع
30	السيّارة	32	خرافية	34	الرّسوم	36	ليّ	38	دخل
30	الطّيب	32	ذهبت	34	القسم	36	مستقلة	38	هناك
30	المعلّم	32	رامي	34	ثرثا	36	معلى	37	البنت
30	الملعب	32	رفاقي	34	حوار	36	يكون	37	الطّفل
30	النعجة	32	صغيرة	34	نوّري	35	اشبع	37	الكلب
30	اليها	32	كلتا	34	ذهبَ	35	السماء	37	أحرف

Towards sight word list in Arabic

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Activities Needed for Arabic Students of Lower Income Countries

In many African countries there are Arabic-language schools (e.g., écoles Francoarabes) or populations that speak Arabic dialects. In countries such as rural Sudan or Mauritania, the poor may have limited exposure. Some may not have seen a book by the time they enter grade 1.

To ensure everyone knows, students should be shown during the first week of school that books contain symbols written in certain directions. Students can be asked to point to the beginning and end of a page, show the direction of reading, and understand that they must go from one line to the next. Most important, students may have no experience with two-dimensional figures and may fail to see the shapes pointed to them, let along assign them a letter value.

Maintaining Student Attention in Lower-Income Countries. Visitors in lower-grades of poorer countries often observe students repeating in a chorus text written on the blackboard without actually reading.

Text may be undecipherable from the back seats, or they may be looking away. Their voices may assuage teachers, but most students may be in fact illiterate.

To prevent mindless repetition of sounds, techniques must be used to attract and maintain attention to a letter being taught. Children may be asked to put their thumbs up if they understood and down if they did not. They may be asked to point to a flash card while voicing the sound and to put their fingers on the letter on the book. (So the presentation letters should be big.) They could also be asked to come to the front of the class to see new letters from close up.

Figures 30-31: Spatial attention and practice with systematic feedback in class

Some children repeat what is written on the blackboard without focusing at the specific letters	Students in the Gambia practicing independent reading
	

Spatial attention may be a developmental feature, and poorer children may perform it less well. This is a crucial problem, and some experimentation may be needed to resolve it.

Corrective Feedback to All Students Daily. Teachers in high-income countries are expected to give individual attention to students' learning needs. But this is usually impossible in countries with a long tradition of selectively attending to the best. Classroom observations in low-income countries often show that few students are involved in instruction at any given time (e.g. IEG 2008, 2009a, 2009b, 2009c, Schuh More et al. 2009). Teachers in low-income environments often stand by the blackboard, broadcast to students, call for volunteers, and interact mainly with the few who know the answers. The rest are left to their own devices.

Corrective feedback is crucial because the nervous system must determine whether an action is correct (Salamone and Correa 2002, Galvan et al. 2006). The better students may gradually concentrate at the front, while weaker students may sit silently in the back. Children that escape teachers' attention may never learn to read (Lockheed and Harris 2005, Llambiri 2005).

Some experiences, notably from the Bangladeshi NGO Gono Shahajjo Shangstha16 suggest that it may be possible to systematize the checking of all students' knowledge and offering of brief corrective feedback. The teacher could hear each child read three or four lines for a few seconds per day during a time others are practicing. Teachers could be taught to do this systematically row by row starting from the back. The three or four best students could also be identified and set to work with the weaker kids at the same time.

[16] www.gssbangladesh.org

Teachers need to be trained specifically for these activities, and they need to understand why they matter. One important aspect is to discuss the "for all" aspect of teaching to read. Often the weakest children are the ones most likely to give up, stopping work after reading a few words. There is a need for monitoring that teachers are not used to giving to the weakest. In fact, consultations with them and videos may be important in increasing attention to this critical issue.

Figure 32: Teacher listening to a child read for one minute per day (Gono Shahaja Shangstha NGO in Bangladesh)

Observational Learning for Teachers of Limited Education. It seems that teachers teach Arabic through traditions set for decades. Training teachers in teach phonological awareness, concepts of print, phonics so that they can teach these skills takes some effort.

Teachers in higher-income countries have university-level education and undertake much training. However, those in low-income countries may get little or no training on how to teach reading. At any rate in low-income countries, pre-service and in-service teacher training efforts have produced limited results and limited behavioral changes (e.g. UNESCO 1998). Poor outcomes are partly due to brief training duration, limited prior education, lack of textbooks for student teachers, poor time use in training classrooms, and curricula that offer little actual guidance on how to teach.

Trainees may receive instructions to execute various procedures when they return to their class, but observations suggest that they may not do so. Perhaps the need to recall and carry out multiple tasks at the same time fills their working memory beyond capacity and result in "cognitive overload" (Feldon 2007). Those teachers with more limited education and fewer automatized skills may be more vulnerable to this phenomenon. They must become able to carry out the requested procedures automatically. One mechanism is observational learning.

People are biologically set up to model actions of people who have the same goal, so instructional behaviors may be more effectively taught through audiovisual role modeling and visualization (forward self-review; Dowrick 2010). These methods have rarely been used in low-resource environments, and they are more complex to create than mere lectures. However, the cost of technology has dropped significantly in the past years. Camcorders are prevalent everywhere through cell phones, and editing software is in every computer. Palm-top projectors running on batteries can be taken to areas that have no electricity.

Initial trials with brief instructional video clips were conducted informally in Liberia and the Gambia in 2011, and more detailed plans were underway to pilot this methodology in subsequent years.

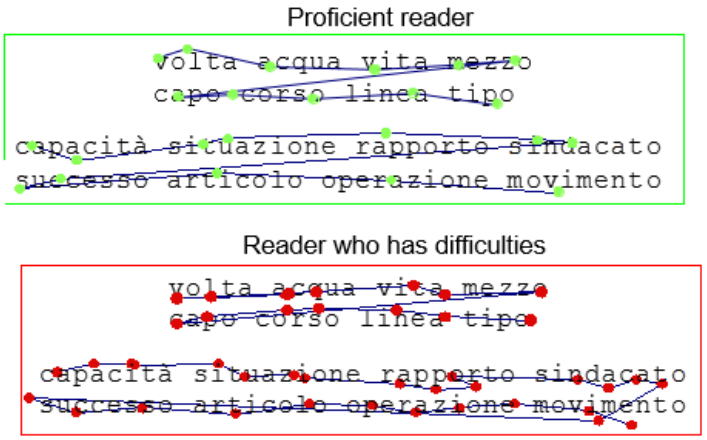
Neurocognitive Measurement of Various Variables Related to Reading Fluency

Research on assessing reading performance in Arabic, given the perceptual and linguistic features discussed above, has been limited. To assess the learning trajectory of students in various countries, grades 1-6 ought to be assessed. Suggested measures are shown below.

Determining a satisfactory reading rate for PIRLS. PIRLS mainly consists of a 3.5 page text and approximately 16 multiple choice and open-ended questions that range from direct facts recall to inferences. The Arabic translation of one PIRLS text could be obtained, and a random sample of 4th graders in lower- and higher-performing groups could be asked to read. Words per minute read correctly and percentage correct of answered questions could be estimated, in order to understand what reading speed and comprehension percentage corresponds to a score of 500 in Arabic in a country such as Qatar.

For example, 4th graders getting a scaled score of 500+ may read at 120 words correct per minute and understand correctly 90% of the vocabulary. By contrast, 4th graders scoring at 300 may read 60 words per minute and understand correctly 65% of the vocabulary. The findings will be further refined by using eye-tracking equipment to find out where students' eyes focus longer and therefore may have difficulties. Students may be observed and asked about difficulties and linguistic ambiguities that they experience. From these and other data points, instructional "treatments" will be derived for precise pratice and remediation.[17] Experiments could be conducted to find out in what timeframe and with how many hours of practice various percentages of students can attain this standard.

Figure 33: Use of eye-tracking equipment to determine reading rate and specific difficulties (P. Zoccolotti, U. Rome)



Eye-tracking goggles constitute state-of-the art equipment that will greatly facilitate this task in comparison to equipment available earlier.[18]

[17] Similar principles determine math performance. Research shows that rapid and automatized mental math as well as estimation exercises in the early grades lead to high-level math performance in the upper grades. This proposal will limit itself to reading in order to avoid excessive complexity and costs larger than QNRF normally awards. But if time and resources permit, some neuroscientific assessments and remediation can be undertaken on numeracy as well. Experiments could be designed to speed up numeracy acquisition through estimations and mental math.

[18] Data to be obtained are hit maps of the eye, movement distribution, fixation number and fixation duration. These will be recorded along with accuracy, speed and reading comprehension of the text.

Figure 34: PIRLS 2011 4th grade reading tasks in English (Foy et al., 2012)

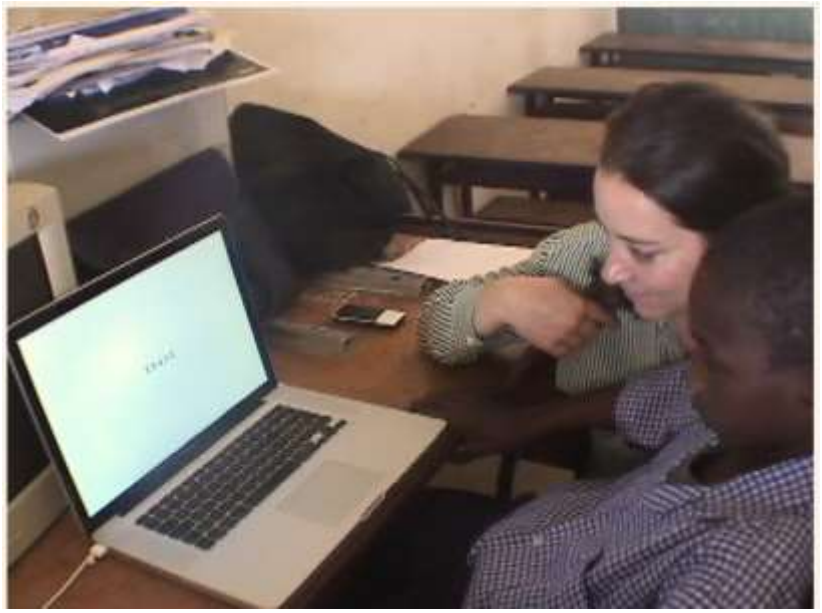
In English text is often presented in columns, as above. However, research in Arabic showed that comprehension scores may be better for single-column text than for the multicolumn setting. (Interline spacing did not improve reading; Ganayim & Ibrahim, 2013).

General assessment. Children may vary in their reading acquisition ability for several factors. These include exposure to print and teaching style, others to more general cognitive functions or to specific skills related to reading. Certain general measures are needed in order to interpret the reading improvement tested in the proposed experiments. These would be:

- Phonological awareness exercises
- *Reasoning*. Usually the progressive matrices of Raven are administered, this test is particularly useful because it doesn't penalize illiterate and assesses reasoning with visuo-spatial material.
- *Working memory span*. Usually a digit span is measured asking the children to repeat series of number that increase by one digit. Potentially 10% of students have unusually short working memory spans.

Estimating students' functional reading rate. Short and simple texts would be administered to measure syllables and words read correctly per minute as well as error rates (e.g., one-minute tests). A comprehension task will be given to the subjects. Normative data will be collected with this tool that will help evaluate reading acquisition difficulties as well as difficulties in other subjects. These will also help chart a trajectory to the grade and achievement level students would need to perform satisfactorily on the PIRLS test. The researchers hypothesize that math performance in Arabic speaking children may be partly a consequence of the orthographic script compexity rather than a specific difficulty in teaching and learning arithmetic. Thus, math problems will be among the tests to be read, and these will help estimate fluency in reading math problems in order to solve them. The memory span will help estimate the likelihood of solving the problems while reading the data.

Figure 35: Measuring reaction time to letters and words through psychophysics principles



Prof. M. Martelli experimenting with rapid visual serial presentation in the Gambia, May 2012

Assessing automaticity in word recognition. Lists of voweled and unvoweled words will be given to children to read aloud. Reading time in syllables per second and error rate will be estimated.[19] Measures on word and text reading as a function of age will provide normative data for Arabic reading acquisition in various countries. Moreover the assessment of the effects of word frequency, lexicality,[20] and length will provide estimates of the reading style adopted by the children as well as the degree of word recognition that characterizes efficient adult word decoding (Casles and Coltheart, 1983). A joint measure of speed and comprehension on equivalent vowelled and unvowelled text will estimate the cost of harakat removal in various grades. This may facilitate policy decisions. An item-based analysis on these data will enable the development of a database that defines the lexicality effects for Arab words. The database will then be available for interested governments.

Assessing and subsequently optimizing readability. Vowels and consonant diacritics above and below the letters may cause clutter and crowding, slowing down reading, even in proficient readers. This effect can be minimized by increasing size or spacing. To determine what that is, rapid serial visual presentations will be used (RSVP).[21] This series of tests will help determine the optimal font density and

[19] The list type to be administered could be as follows: 1 list of short high frequency words (15-20 items)); 1 list of short low frequency words (15-20 items)); 1 list of long high frequency words (15-20 items)); 1 list of long low frequency words (15-20 items). The Oweiny and Hazoury list of high frequency words would be used (2012). In each session a new list for each condition should be administered in order to avoid list-learning effects. As a consequence the number of words per list and the number of session administered (frequency of testing) may depend on Arabic vocabulary needed to match the stimuli for length and frequency.

[20] Lexicality refers to all variables which asses the use of words stored in the brain, such as the effect of word frequency, age of acquisition, imaginability, orthographic neighborhood etc. Orthographic material refers to the written form of words as opposed to oral word presentation. Orthographic decoding refers to the mechanism used to process written words that can be holistic or letter based depending on reading acquisition stage.

[21] Reading rate for lists of words as a function of complexity, spacing and size will be measured as a function of age. In the RSVP generally four words are presented in quick succession in the same location and the observer is asked to read. The exposure duration is varied according to the observer performance; the rate increases if the reading is correct and decreases for

size needed to achieve maximum reading rate as a function of age. This will improve print for textbooks in different grades. Guidance may even be provided in the fonts used for the TIMSS and PIRLS tests.

Speed of comprehending standard Arabic. Working memory capacity requires rapid as well as correct comprehension. Reaction time to comprehension may be recorded through the time needed by a child to click on alternatives on the screen via a mouse.[22] One possibility is to measure latencies, the seconds that pass before a person responds to a stimulus (23). We propose to present short sentences with right or false content. Children will have to decide whether the sentence is right or wrong by clicking on a response screen (left for right and right for wrong). Raction times, accuracy as well as response trajectories will be recorded. Motor response trajectories expose the decision uncertainty providing a relevant index for comprehension (Hodzik, 2011). The sentence presentation could be oral and visual. It could compare response times to the student's dialect vs. standard Arabic. As students' proficiency increases, the response time to standard Arabic should decrease.

Testing could include timed reading of letters and a simple 60-word passage along with five "shallow", fact-based comprehension questions (Research Triangle Institute 2009, 2010). The learning outcomes would be measured in terms of letters per minute and words per minute read correctly. To In the first few weeks, reading speeds may be lower than those needed to understand passages well, but the most important early goal would be to leave no child unable to decode. In reality, 100% of students are unlikely to become fluent; some may be severely dyslexic or learning-disabled. In low-income countries using the Arabic script it may be wiser to set an initial goal of 83% of students decoding (down to -1 standard deviation of a theoretical normal curve of ability), extending to 96% (-2 SD below the mean). Thus there should be practically *no students reading at 0 words per minute*.

How to count words for maximal comparability with other countries? Arabic attaches the article to the nouns and also attaches the personal pronouns. An analysis must be done, but Arabic words per minute may count fewer words and is thus lower than the scores obtained in other countries. Some consideration is needed on how to count Arabic words. The articles could be counted separately, since most of the languages do so. However, agreements must be made regarding other languages.

Conclusions and Implications for Further Research

The voweled Arabic script adequately represents most sounds, and children in principle ought to learn its letters quickly, within 100 days or so. However, certain features of the letters and their arrangements challenge visual perception. Simultaneously, reading in the Arabic language presents linguistic difficulties

each error made. This estimates the reading abilities minimizing the role of eye movements at a fixed criterion of task performance (say 80% correct). The eyes do not move, so RSVP reading produces rates about three times faster than functional reading, probably prompting the observer to use a holistic strategy in word decoding.

[22] Mousetracker (http://www.dartmouth.edu/~freemanlab/mousetracker/) is a free software that enables to easily measure time and response trajectories, and it is useful to assess decisions over time. It is thus possible to obtain information on response time, accuracy but also the reader uncertainty. The program provides an index of the deviation of the trajectory from the optimal as an attraction factor of the alternative response. This attraction seems to be related to high-level uncertainty. The program also offers data on velocity, acceleration and angle of the trajectories. It would make it possible to design stimuli that manipulate low-level visual and high level grammatical and psycholinguistic factors. A voice recording program to use would be DMDX (http://www.u.arizona.edu/~kforster/dmdx/dmdx.htm) Latency would expected to be significantly shorter where linguistic cues, i.e. constraining context and high transitional probability), to anticipation are available, i.e. reaction time to grammatical statements (Hodzik, 2011; Wright & Neuman, 2013, Freeman, Dale & Farmer, 2011).

due to the lexical and grammatical distance between modern standard Arabic and the various vernaculars. These two sets of factors seem to interact, particularly when vowels are omitted. The result may be slower and perhaps less efficient processing of text.

Scientific research implies that some fundamental prerequisites must be satisfied before students enter the world of meaning, reading for fun, and "reading to learn." Students must first be able to distinguish letters, detect their salient features, associate specific shapes to sounds. Then they should decode letter groups fast enough to fit messages into working memory. And they must have in their cognitive networks the needed prior knowledge to understand the vocabulary, grammar, and context of the messages. This knowledge needs to be available fast, in milliseconds. For all this, they need independent practice and corrective feedback. In low-income countries such as Sudan, Mauritania, Chad, space in class must be made for this.

Performance data from the Arab world suggest that varying income levels face different issues. In countries such as Yemen or Sudan, illiteracy is high, and many students fail to learn reading in school. Higher-income countries put more resources in reading instruction, and most students learn fluent reading early on. However, the limited vocabulary and grammatical knowledge of standard Arabic may inhibit text processing. Many students may continue to struggle in translating their stored knowledge into standard Arabic, and may even have trouble converting the mathematical codes. All these factors may result in low TIMSS or PIRLS scores.

The Arabic perceptual and linguistic difficulties may translate into a preference for English. This is paradoxical given the complexities of English spelling, but in well-to-do schools and families, students may get sufficient early-grade reading practice. And the English language may prove easier to teach than standard Arabic. Students may also develop an affective preference for the English language in comparison to standard Arabic. In comparison to English that is a spoken language with many interesting books, Arabic school texts may appear artificial and unappealing.[23]

A great deal has been written on the above issues, but remedies are in short supply. Use of cognitive science, however, opens unexplored possibilities. This document, an update to a 2012 version, presents research that may lead to improved automaticity in the lower-level skills, so that students can have more time in working memory to process text. It also presents neuropsychological methods for measuring perceptual and comprehension speed to identify low-level perceptual and linguistic issues. The expectation is that targeted practice on components that are processed more slowly could result in faster reading and comprehension, thus giving students more time to think about the contents of texts.

Overall, there is much potential for substantial improvement in reading achievements if attention is given to the low-level visual and linguistic issues. What is already known points to a need for iterative piloting and research. Technology interventions for reading are possible in the Arab world, and these would need to be piloted specifically. Brain imaging is providing insights about the parts of the brain activated for various tasks. This information can then put to use in likely methods that can be piloted. Results of course must be monitored, and further iterations would be made.

[23] Prof. Eva Kosma, personal communication, January 20, 2014

Annex

PIRLS and TIMSS analyses by Home Language, Test Language, Reading Difficulty

To disentangle the effects of language and script, efforts were made to use the TIMSS and PIRLS questionnaires that offered relevant information. The 4th grade PIRLS test included a parents' questionnaire about language use. However, interpreting the data proved difficult.

Specification of "Arabic". Standard Arabic is typically not spoken in daily life, but all Arab countries teach and test in it. The PIRLS parents questionnaire asks about language spoken at home vs. language of the test. When the parental response is "Arabic", this is probably not the language spoken at home. But when parents respond otherwise, it is unknown if the language is an Arabic dialect or something else.

Degree of language command. Parents in the 2011 PIRLS questionnaire were asked to state whether the student speaks at home the language always, some of the time, or never. The 'some of the time' designation was hard to interpret. Are some students code-switching at home or are they talking different languages to different family members or servants? It was unclear.

Arabic vowel use. The use of vowels is significant in Arabic and Farsi. In grade 4 (and of course grade 8) most Arab countries give unvoweled tests that may be unreadable by weaker readers. On occasion, however, text is voweled, such as grade 4 TIMSS math in Tunisia.

Some coding changes and clarifications for the 2015 administration would facilitate the work of various Ministries of Education. For example, it would be useful to offer parents "standard Arabic" as an option along with the main dialects, e.g. Egyptian, Tunisian, Moroccan, Syro-Palestinian, Hasaniya, etc. It may be useful or the governments to get breakdowns by the Arabic version spoken at home. Gulf countries have students from many Arab countries, and they may have different linguistic challenges.

On language spoken at home, it would be more informative to ask about the student's command of the language used in the test (and specify that language). Native-level? Good command but still a second language? Knowledge of related dialect? Limited or poor command? The latter could help also in other countries, such as Thailand.

Better language designation could clarify results. For example, Annex Table 3 (Exhibit 4.5 of TIMSS math grade 4; Mullis, Martin & Foy, 2012b) lists scores by whether students spoke the language of the test. For such tables, a note could be inserted that the language of the test is standard Arabic.

Thus far, IEA has merely accepted the texts that governments submit, and staff have limited knowledge about the contents and formats of tests given. It may be useful to note with an asterisk the voweled and unvoweled texts.

Annex Table 1: Home language, socioeconomic status, and PIRLS scores in grade 4

PIRLS Grade 4	Arabic- students - all socioeconomic status				Arabic test takers of average SES only			
Language at home:	Almost always	Sometimes	Never	Average	Almost always	Sometimes	Never	Average
Kuwait	433	432	447	436	442	446	454	445
Morocco	314	339	312	322	335	358	341	346
Oman	388	390	366	385	405	403	392	403
Qatar	397	390	371	393	407	401	383	404
Saudi Arabia	430	448	421	433	436	449	436	438
United Arab Emirates	407	413	388	407	413	417	393	413
Morocco (Grade 6)	432	459	435	444	448	476	458	464
UAE (Dubai)	391	401	401	394	397	412	400	401
UAE (Abu Dhabi)	402	418	386	404	411	416	387	411
Average	399	407	378	398	413	420	409	414
	English - students - all socioeconomic status				English test takers of average SES only			
Language at home:	Almost always	Sometimes	Never	Average	Almost always	Sometimes	Never	Average
Oman	434	441	405	436	420	448	420	442
Qatar	498	471	421	472	477	457	415	455
Saudi Arabia	350	400	391	391	356	387	422	386
United Arab Emirates	513	465	422	472	486	457	419	458
UAE (Dubai)	529	475	429	488	503	461	416	467
UAE (Abu Dhabi)	482	456	425	456	462	450	442	451
average	511	465	422	472	484	456	421	457

Source: PIRLS data, analyses by Pierre Varly and Yussef El Haji

Annex Table 2: Home language, tested language, and PIRLS scores in grade 4

PIRLS Grade 4			**Speaking Arabic at home**			Speaking English at home		
Country	% pupils tested in Arabic	% pupils tested in English	**ALWAYS, ALMOST ALWAYS**	**SOMETIMES**	**NEVER**	**ALWAYS, ALMOST ALWAYS**	**SOMETIMES**	**NEVER**
Kuwait	100%	0%	430	431	447	0	0	0
Morocco	100%	0%	316	340	313	0	0	0
Oman	87%	13%	388	391	365	433	443	407
Qatar	65%	35%	396	390	367	497	470	425
Saudi Arabia	98%	2%	430	446	422	341	394	395
United Arab Emirates	45%	55%	406	414	386	512	466	423
UAE (Dubai)	23%	77%	390	400	399	528	476	430
UAE (Abu Dhabi)	63%	37%	402	421	384	482	456	425

Source: PIRLS data, analyses by Pierre Varly and Yussef El Haji

Annex Table 3: (TIMSS Exhibit 4.5) 4th graders who spoke the language of the test before starting school

Reported by Parents

Country		Spoke the Language		Did Not Speak the Language	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement
Australia	s	95 (0.6)	531 (3.2)	5 (0.6)	535 (14.7)
Austria		93 (0.6)	512 (2.7)	7 (0.6)	471 (4.7)
Azerbaijan		96 (0.9)	465 (5.7)	4 (0.9)	454 (14.5)
Chinese Taipei		97 (0.3)	593 (1.9)	3 (0.3)	558 (7.0)
Croatia		100 (0.1)	490 (1.9)	0 (0.1)	~ ~
Czech Republic		99 (0.3)	513 (2.3)	1 (0.3)	~ ~
Finland		99 (0.2)	547 (2.3)	1 (0.2)	~ ~
Georgia		98 (0.7)	453 (3.4)	2 (0.7)	~ ~
Germany	r	97 (0.3)	534 (2.2)	3 (0.3)	494 (6.0)
Hong Kong SAR		97 (0.4)	607 (2.7)	3 (0.4)	600 (6.8)
Hungary		99 (0.2)	519 (3.4)	1 (0.2)	~ ~
Iran, Islamic Rep. of		80 (1.5)	443 (3.4)	20 (1.5)	383 (5.5)
Ireland		93 (0.6)	533 (2.8)	7 (0.6)	504 (6.6)
Italy		94 (0.5)	512 (2.5)	6 (0.5)	488 (6.8)
Lithuania		98 (0.6)	535 (2.6)	2 (0.6)	~ ~
Malta		44 (0.8)	514 (1.9)	56 (0.8)	490 (2.0)
Morocco		83 (1.9)	337 (4.7)	17 (1.9)	328 (6.6)
Northern Ireland	s	98 (0.4)	579 (3.4)	2 (0.4)	~ ~
Norway		97 (0.4)	497 (2.8)	3 (0.4)	468 (7.9)
Oman		94 (0.3)	385 (3.2)	6 (0.3)	407 (4.8)
Poland		99 (0.1)	482 (2.2)	1 (0.1)	~ ~
Portugal		98 (0.3)	535 (3.2)	2 (0.3)	~ ~
Qatar	r	73 (1.7)	414 (4.6)	27 (1.7)	460 (6.0)
Romania		97 (1.1)	483 (5.9)	3 (1.1)	456 (17.1)
Russian Federation		96 (1.0)	543 (3.6)	4 (1.0)	536 (13.3)
Saudi Arabia		74 (1.4)	415 (5.9)	26 (1.4)	400 (6.9)
Singapore		82 (0.5)	611 (3.2)	18 (0.5)	587 (4.4)
Slovak Republic		98 (0.6)	510 (3.4)	2 (0.6)	~ ~
Slovenia		97 (0.3)	516 (2.1)	3 (0.3)	462 (6.9)
Spain		87 (1.1)	488 (2.7)	13 (1.1)	472 (4.6)
Sweden	r	95 (0.4)	509 (2.0)	5 (0.4)	474 (5.8)
United Arab Emirates		77 (0.8)	431 (2.1)	23 (0.8)	456 (3.2)
International Avg.		91 (0.1)	501 (0.6)	9 (0.1)	477 (1.8)
Sixth Grade Participants					
Botswana		26 (1.3)	450 (6.5)	74 (1.3)	414 (3.3)
Honduras		97 (0.5)	396 (5.6)	3 (0.5)	393 (15.3)
Benchmarking Participants					
Quebec, Canada		94 (0.8)	535 (2.6)	6 (0.8)	525 (5.1)
Abu Dhabi, UAE		81 (1.4)	412 (4.5)	19 (1.4)	448 (7.1)
Dubai, UAE		69 (0.7)	473 (2.3)	31 (0.7)	473 (2.4)

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

* Available only for countries that administered both TIMSS and PIRLS to the same fourth grade students because this item was included in the PIRLS Home Questionnaire completed by parents.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent. A tilde (~) indicates insufficient data to report achievement. An "r" indicates data are available for at least 70% but less than 85% of the students. An "s" indicates data are available for at least 50% but less than 70% of the students.

http://timssandpirls.bc.edu/timss2011/downloads/T11_IR_M_Chapter4.pdf

Comparisons with Iran and Malta

Annex Table 4: Performance of Iran and Malta

PIRLS grade 4	% taking the test	**Test language spoken at home**		
Country and test language		Almost always	Sometimes	Never
Iran (Farsi)	100	57%	25%	18%
	PIRLS Score	**484**	461	**402**
Malta (English)	49	17%	58%	25%
	PIRLS Score	501	491	435
Malta(Maltese)	51	61%	34%	5%
	PIRLS Score	458	469	390

Source: PIRLS data, analyses by Pierre Varly and Yussef El Haji

Certain countries could function as comparator points and could give some insights regarding the language and script problems of Arabic. The population of Malta speaks Moroccan or Tunisian Arabic written in the Roman script. Maltese speakers tested in Maltese scored in PIRLS around 461. By comparison, the Arab countries tested in standard Arabic scored around 398 (Annex Table 1). In some respects, the Maltese results suggest that an Arabic darija written in a transparent orthography requires about the same amount of learning time and resources as other transparently written European or Asian languages that have participated in PIRLS.

Another country of research interest has been Iran. All students were tested in Farsi, although only 58% of Iranian students speak Farsi at home. (Others speak Arabic, Kurdish, Turkish, and Urdu; various languages constitute 42% of the country's population.) Those who speak the language at home scored 484 at PIRLS, whereas those who never speak it at home scored 402, near the Arabic mean (Annex Table 1). These findings may suggest the costs of language and script, or perhaps the interaction of these. As with Arab students, Iranian students also take the 4th grade test without harakat.

Annex Tables 5: TIMSS Scores According to Reading Difficulty

The 2011 4th grade TIMSS scores in math and science have been analyzed on the basis of PIRLS item reading difficulty. The graphs below show the average percent correct for students at three levels of PIRLS reading ability grouped by three levels of reading demands. A sample of countries is presented below (from Exhibit 2.10-2.12 of 2011 TIMSS manual; Mullis, Martin & Foy, 2012b).

To some extent, the results demonstrate the effects of reading complexity vis-a-vis students' achievement in math and science. Countries that use a transparent orthography, such as Finland and Malta, show no reading effects on math and science responses. In fact, Finland and other countries that score high in PIRLS may perform even better in math items that have high reading demands. The Arab countries as well as Iran, show considerable effects of complexity. Math seems to be more affected than science, perhaps due to computational needs that compete with reading demands in working memory.

However, the scores in each country reflect not only the orthography of the national language, but also other languages in which the test was given. In some countries, as in Oman, the students taking TIMSS in English are few or none; but in the Gulf, the effects are confounded. Qatar, Kuwait, and UAE have substantial numbers of students or taking the test in English. By grade 4, middle-class students have learned to read in English fluently. This may be one reason why their score patterns show less effect from reading. Therefore the magnitude of the effect is modified in unknown ways.

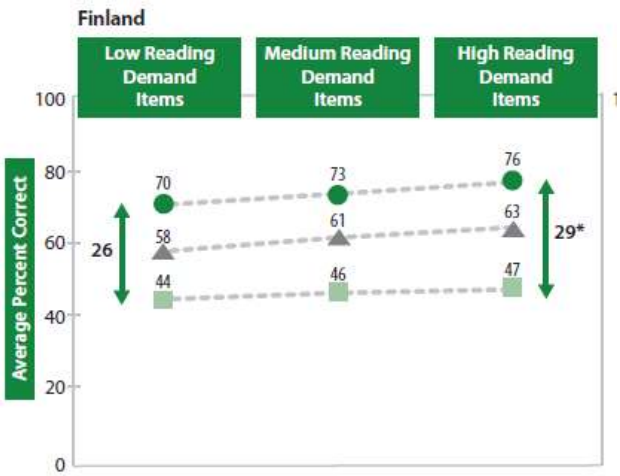
Exhibit 2.10: Mathematics Achievement Averaged Across Countries—Fourth Grade

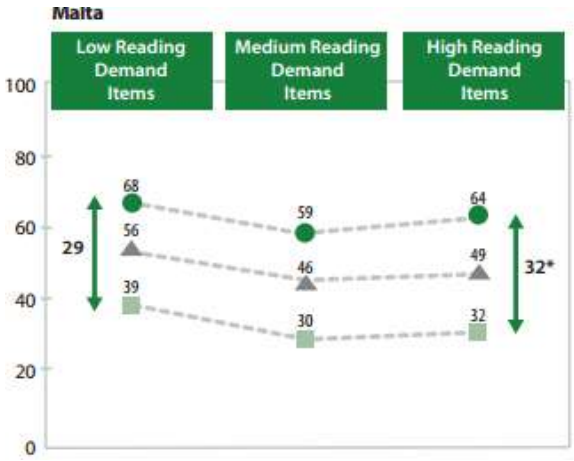
Average Percent Correct for Students at Three Levels of PIRLS Reading Ability on Mathematics Items Grouped by Three Levels of Reading Demands

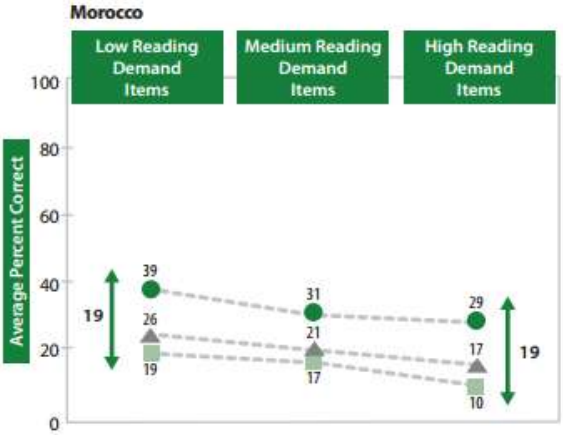
Results for each tercile averaged accross countries.

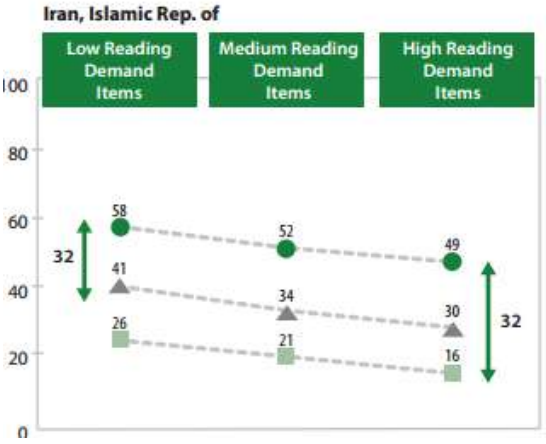
* The inter-tercile difference for High Reading Demands is significantly different from the inter-tercile difference for Low Reading Demands.

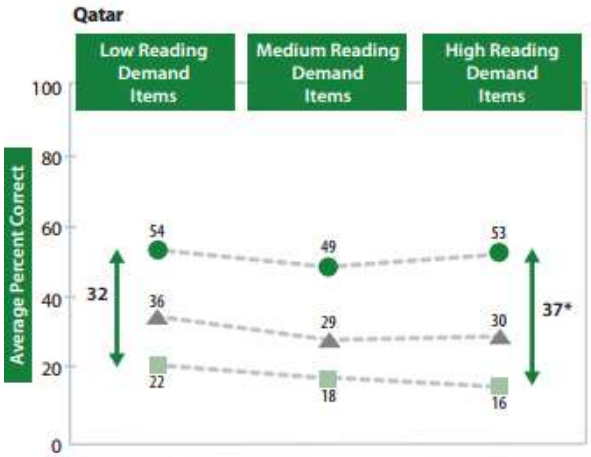
Because of rounding, some results may appear inconsistent.

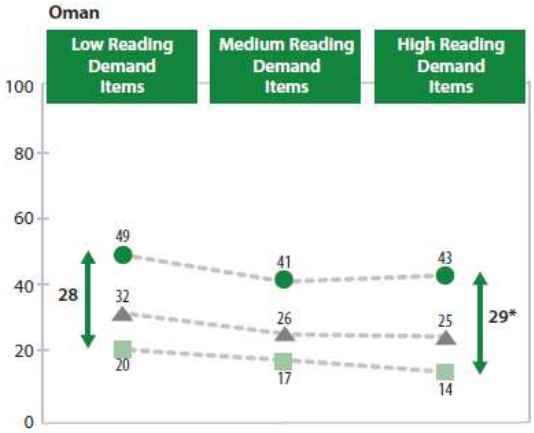

Finland
Low Reading Demand Items
Medium Reading Demand Items
High Reading Demand Items
Average Percent Correct
100
80
60
40
20
0
70
73
76
58
61
63
44
46
47
26
29*

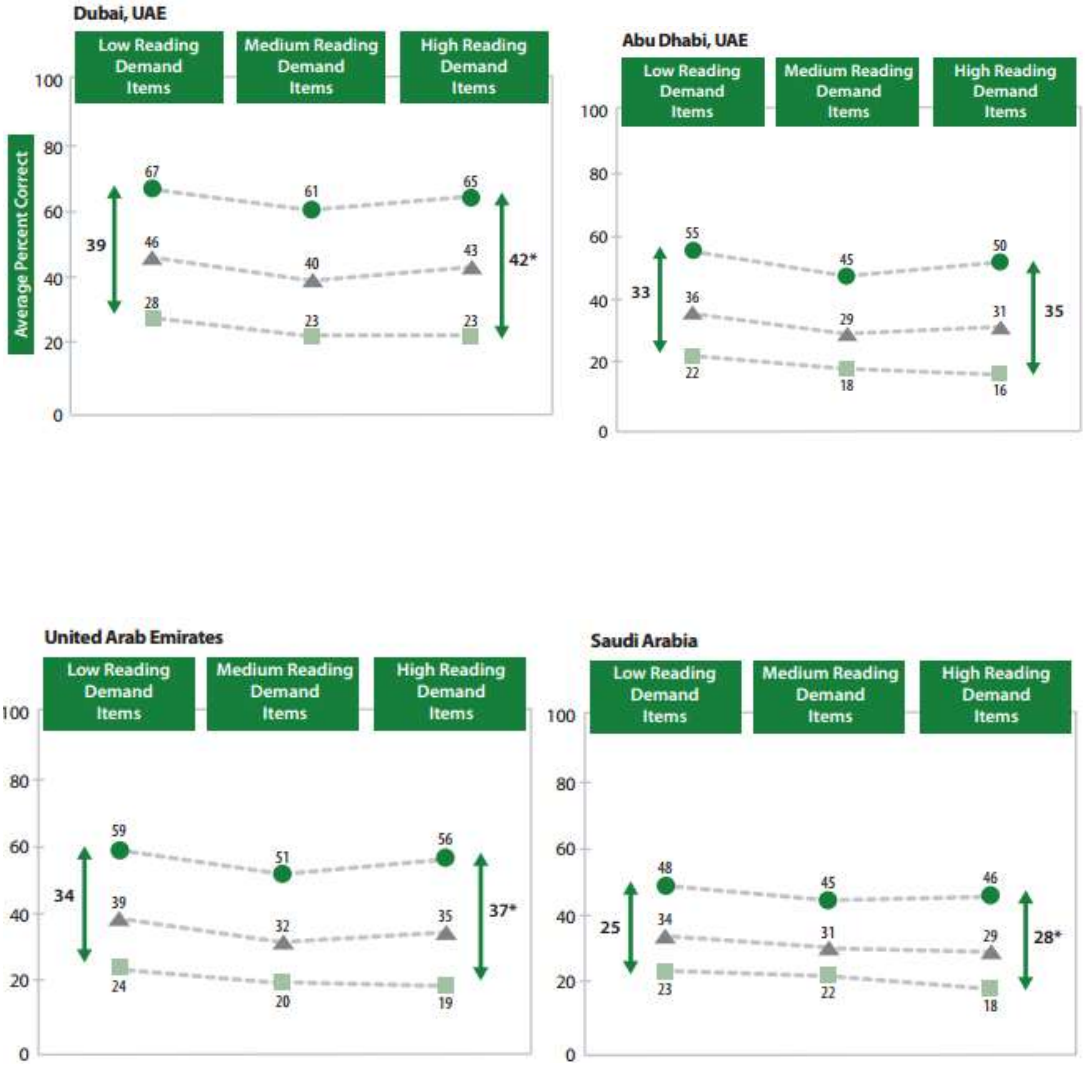

Malta
Low Reading Demand Items
Medium Reading Demand Items
High Reading Demand Items
100
80
60
40
20
0
68
59
64
56
46
49
39
30
32
29
32*


Morocco
Low Reading Demand Items
Medium Reading Demand Items
High Reading Demand Items
Average Percent Correct
100
80
60
40
20
0
39
31
29
26
21
17
19
17
10
19
19


Iran, Islamic Rep. of
Low Reading Demand Items
Medium Reading Demand Items
High Reading Demand Items
100
80
60
40
20
0
58
52
49
41
34
30
26
21
16
32
32

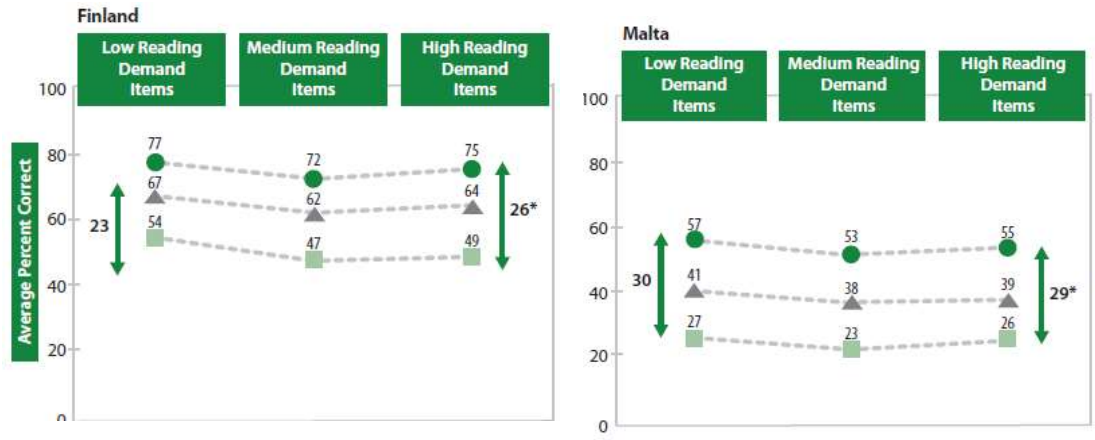

Qatar
Low Reading Demand Items
Medium Reading Demand Items
High Reading Demand Items
Average Percent Correct
100
80
60
40
20
0
54
49
53
36
29
30
22
18
16
32
37*

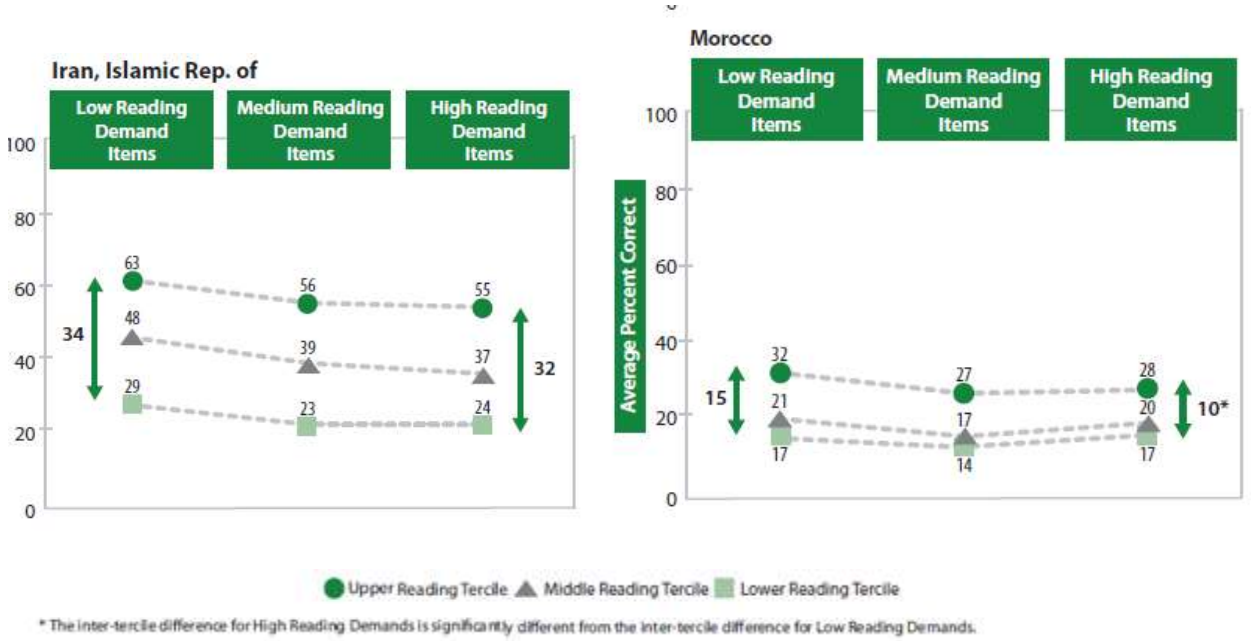

Oman
Low Reading Demand Items
Medium Reading Demand Items
High Reading Demand Items
100
80
60
40
20
0
49
41
43
32
26
25
20
17
14
28
29*



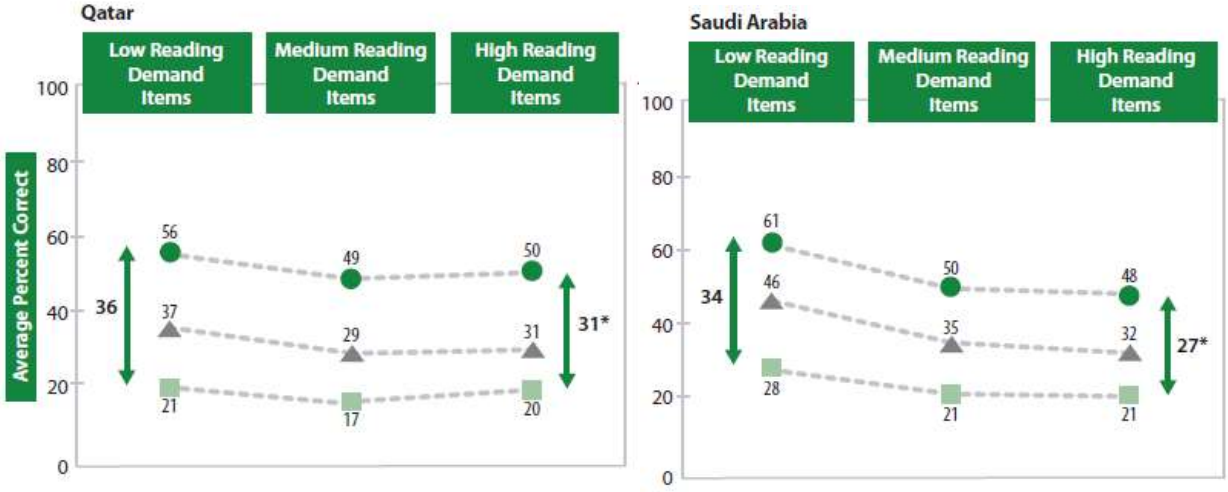
Science Achievement as a Function of Reading, Grade 4 (TIMSS Exhibit 2.13)

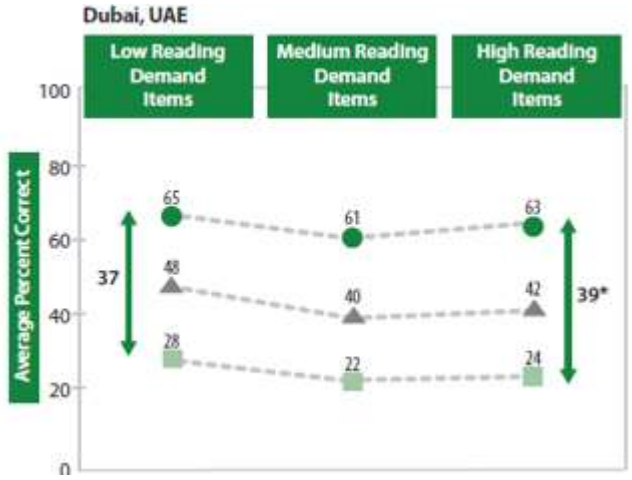
Average Percent Correct for Students at Three Levels of PIRLS Reading Ability on Science Items, Grouped by Three Levels of Reading Demands

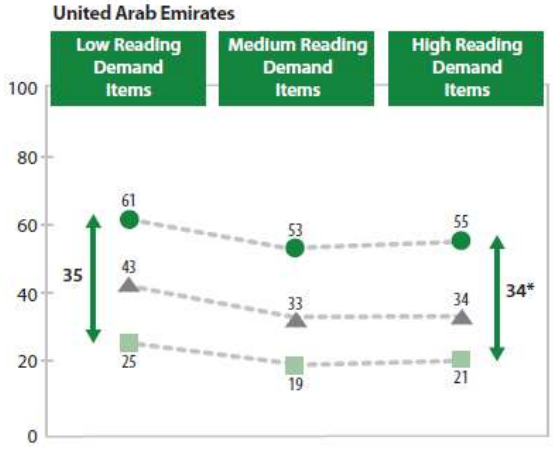


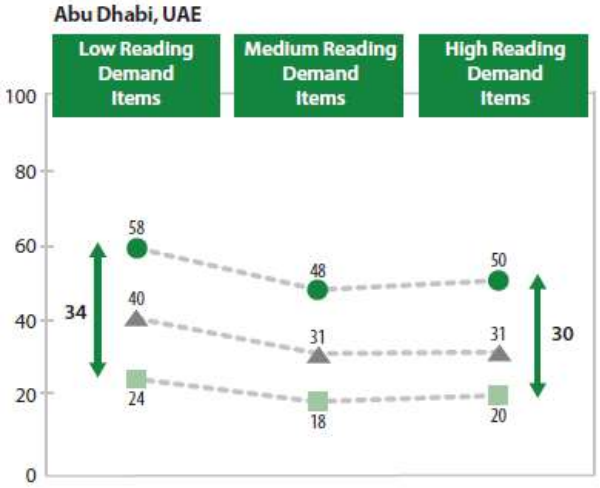


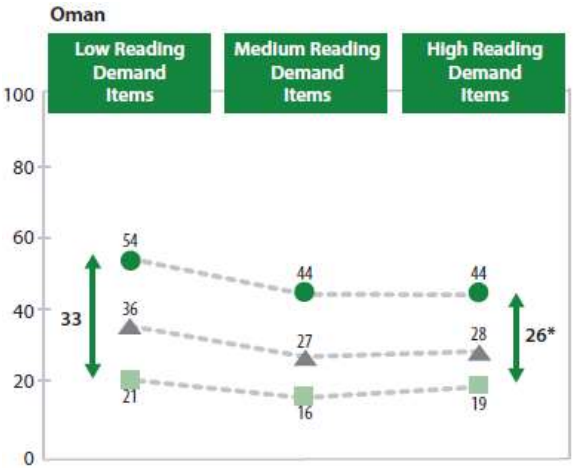
* The inter-tercile difference for High Reading Demands is significantly different from the inter-tercile difference for Low Reading Demands.




Dubai, UAE
Low Reading Demand Items
Medium Reading Demand Items
High Reading Demand Items
Average Percent Correct
100
80
60
40
20
0
65
61
63
48
40
42
28
22
24
37
39*


United Arab Emirates
Low Reading Demand Items
Medium Reading Demand Items
High Reading Demand Items
100
80
60
40
20
0
61
53
55
43
33
34
25
19
21
35
34*


Abu Dhabi, UAE
Low Reading Demand Items
Medium Reading Demand Items
High Reading Demand Items
100
80
60
40
20
0
58
48
50
40
31
31
24
18
20
34
30


Oman
Low Reading Demand Items
Medium Reading Demand Items
High Reading Demand Items
100
80
60
40
20
0
54
44
44
36
27
28
21
16
19
33
26*

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