

Universally Designed Text on the Web: Towards Readability Criteria Based on Anti-Patterns

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Abstract. The readability of web texts affects accessibility. The Web Content Accessibility guidelines (WCAG) state that the recommended reading level should match that of someone who has completed basic schooling. However, WCAG does not give advice on what constitutes an appropriate reading level. Web authors need tools to help composing WCAG compliant texts, and specific criteria are needed. Classic readability metrics are generally based on lengths of words and sentences and have been criticized for being over-simplistic. Automatic measures and classifications of texts' reading levels employing more advanced constructs remain an unresolved problem. If such measures were feasible, what should these be? This work examines three language constructs not captured by current readability indices but believed to significantly affect actual readability, namely, relative clauses, garden path sentences, and left-branching structures. The goal is to see whether quantifications of these stylistic features reflect readability and how they correspond to common readability measures. Manual assessments of a set of authentic web texts for such uses were conducted. The results reveal that texts related to narratives such as children's stories, which are given the highest readability value, do not contain these constructs. The structures in question occur more frequently in expository texts that aim at educating or disseminating information such as strategy and journal articles. The results suggest that language anti-patterns hold potential for establishing a set of deeper readability criteria.

Keywords. Reading comprehension, reading ability, readability, text, dyslexics, Universal Design

1. Introduction

This study examines text patterns that may contribute to reduced readability. Reading comprehension and fluency can affect individuals' accessibility to vital information. Compared to non-dyslexic readers, dyslexic readers tend to read more slowly and strenuously. The World Wide Web Consortium's Web Content Accessibility Guidelines (WCAG2.0) offer useful practice for developers to ensure inclusive designs for users, especially those with disabilities [1]. Web users' ability to comprehend written text directly affects their accessibility to any information they require. Language-related issues are thus among the concerns WCAG2.0 addressed.

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Common readability measures draw on lengths of word and sentence. Often they are straightforward to implement even manually. However, these measures are viewed as superficial [2, 3]. Available readability formulae (e.g., the Flesch-Kincaid reading easy index [4], Gunning Fog index, Coleman-Liau [5], SMOG index [6], the Fry-chart [7]) adopt the view that the longer a word, the more difficult to process or understand. Many longer words are a result of morphological changes of their root words (including prefixes, suffixes, and verb inflections), hence in effect assisting readers' comprehension by their predictability or inference [2]. Further, comprehension of morphological formation (such as forming nouns by adding -er to verbs) is said to be unrelated to word length or frequency of use [8]. Also, there exist a great deal of monosyllabic or disyllabic words that are less familiar to people than those exceeding two syllables [2].

Sentence length is often regarded as syntactic complexity in most readability measure [9]. The determination of an average sentence length may differ in various indexes but all seem to assume that the greater length an average sentence in a text, the more difficult to read. However, adding words that indicate clear sequence of events or relationship between clauses (e.g., *or*, *because*, *and then*, *and after that*) may assist understanding due to explicit logical connection. Such use may increase sentence length but also its readability. Shorter sentences that lack clear communicational objectives between them may in fact affect readers' comprehension and thus reduce its readability. Hence, sentence length does not equal sentence complexity and a different measure more closely reflecting text quality should be introduced.

Other factors have not been incorporated, such as properties of text and reader characteristics, except eye movement [10, 11]. Further, grammatically correct text does not guarantee its readability. Different stylistic features may make one text more readable than others. This study thus aims to investigate features of text that are not included in current readability measure but there may be effect in actual readability. An additional goal is to help contribute to universally designed web by helping writers write better texts and providing frameworks for web owners to check for accessibility compliance. Having more objective and accurate metrics will also assist web owners to improve their documentation. Three structures are examined: relative clause, garden path sentence, and left-branching structure [2]. Each of these is explained in the following sections.

1.1. Relative Clauses

A sentence is easier to process when having its relative clauses openly stated in series, compared to a sentence having its several relative clauses nested inside the main relative clause, as illustrated in the examples [2]: "The mouse ate the cheese, and then the rat ate the mouse, and after that, the cat ate the rat and died" as opposed to "The cat that ate the rat that ate the mouse that ate the cheese died". The first construction would be more straightforward to process than that in the second and thus has greater readability. Comprehension experiments also showed that readers gain more processing ease when relative pronouns are openly stated than when omitted in sentences containing relative clauses ([12], also mentioned in [13]). Compare the following sentences where relative pronouns *which* and *whom* are present in one but not the other: "The pen which the author whom the editor liked used was new" as opposed to "The pen the author the editor liked used was new."

As a starting point, the present study focuses on the occurrence of relative clauses, regardless of whether relative pronouns are present or omitted. Future studies could further examine the difference of use or frequency between the two types in web text.

1.2. Garden Path Sentences

The construction of garden path sentences poses processing difficulty when readers try to parse them the first time. Often readers need to reread and reanalyse in order to assign plausible meaning or resolve ambiguity. Although grammatically correct, reparsing is required and hence causing reduced readability. Commonly cited examples include the following: “The old man the boat”. “The complex houses married and single soldiers and their families”. “The horse raced past the barn fell”.

1.3. Left-branching Structures

Left-branching sentences may cause comprehension difficulty. The following examples show the clauses connected by subordinating conjunction *because* in two forms. The sentence beginning with *because* has the left-branching structure: “Bob called a locksmith because he left his key in the car” as opposed to “Because he left his key in the car, Bob called a locksmith” [14].

Experimental data revealed that young readers (third and fifth graders) comprehended the former better than the latter, compared to older participants who showed no difference [14]. It was reasoned that the information provided by the *because* clause had to be stored in memory while the reader searches for the main clause (*Bob called a locksmith*), which is on the right branch of the sentence.

2. Method

To examine the three structures, several text types are chosen to represent at least some commonly seen texts. The source texts consist of three children’s stories of different levels, one disclaimer, one strategy document, and one full scientific journal article as well as its separate parts (abstract, introduction, method, findings, discussion, and conclusion). Children’s text tends to be accounts of life experience, easier for children to draw reference and closer to speech. Disclaimer is a form of denying responsibility, commonly used in work environment. Strategy consists of points displaying plans or actions for achieving specific goals, more formal but widely used in official websites. The journal article is a longer text aimed at disseminating specific information for interested or advanced readers.

As this is a preliminary study to look into text patterns that may reduce readability, it is necessary first to conduct visual inspections or visual reading to identify the occurrence and frequency of the three linguistic uses. All documents are thus read and inspected in detail by the researcher based on the principles as described above for each category. Any occurrences are manually labelled and recorded into the excel sheet. Future steps could then attempt to classify these structures by means of automated grammar checkers. To achieve coherent understandings, cross references with results employing available readability measures are also made.

3. Results

3.1. Relative Clauses

The use of the three structures are summarised in Table 1. The children's stories of all three levels used no relative clauses. The disclaimer has two instances, while strategy has 41. The full journal has 90 uses, the highest of all. The journal's findings (results) section has the greatest use of relative clauses among all other sections, which is possibly a result of its specific topic (online video propaganda) that deals with issues related to politics, media technology use, language and culture. Different journals may have different specifications regarding whether results and discussions be clearly separated; the journal article selected herein does not appear to clearly separate the two and thus contribute to the findings' having more use of elaborative statements. The introduction and discussion parts have similar amount of instances (15 and 17, respectively). The method section and conclusion have a smaller number of relative clauses (6 and 7, respectively). The abstract has the lowest use (4).

Table 1. The three linguistic devices used in texts.

Text	Relative clause	Garden path sentences	Left-branching structures
Child level 1	0	0	0
Child level 2	0	0	0
Child level 3	0	0	0
Disclaimer	2	0	1
Strategy	41	1	1
Journal	90	1	10
J. abstract	4	1	0
J. introduction	15	0	3
J. discussion	17	0	4
J. conclusion	7	0	0
J. method	6	0	0
J. findings	41	0	3

Apparently, the content or focus of text has an effect on the use of relative clauses. As relative clauses are used to inform readers about people or things, the more complex content may benefit from such linguistic device to help explication. Comparatively, the strategy has a much higher percentage of relative clauses than all other types, given its length. A reference to the Flesch-Kincaid measure (22.5) (see Table 2, from [15]) shows that the strategy has the lowest readability amongst all, corresponding to its highest percentage of relative clause as found here. Children's stories of three levels gain the highest readability scores (Flesch-Kincaid 87.6, 82.7, and 81.1 respectively), also matching the non-existence of relative clauses reported herein. Compared to the measure of word difficulty, the strategy is also the one having the highest level (2.0). Close inspection indicates that the word difficulty might not be as robust. Most words in the strategy text are common words despite many are more than two syllables, whereas some words in the journal article (word difficulty 1.7) are less known (due to its cultural references) but are within two or three syllables. What the readability formulae extracted for the two types thus did not seem accurate, or useful. Typical readers may find the journal article easier to comprehend, while dyslexic readers may

find both difficult, each with its specific difficulty – one being longer, the other being incomprehensible. What is more, dyslexic readers may be able to combat longer words by re-decoding and re-retrieving in their verbal memory despite taking longer time but not for unseen words. This particular result is in line with the argument put forward by [2] that using word length as difficulty measure is not entirely feasible. Further research is needed regarding what readability measure is the most suitable or accurate for dyslexic readers and whether readability formulae should be re-defined to determine difficulty levels for different readers. Possibly, less known words, foreign words, loan words, and words of several senses all add to reading difficulty, more so than word length for all readers.

Table 2. Text test suite with text length (number of words), mean sentence length (number of words), mean word difficulty (mean number of syllables per word) and the Flesch-Kincaid reading index. Taken from [15].

Text	Length	Sentence length	Word difficulty	Flesch-Kincaid
Child level 1	79	8.8	1.3	87.6
Child level 2	76	12.7	1.3	82.7
Child level 3	74	12.3	1.3	81.1
Disclaimer	109	21.8	1.6	45.8
Strategy	2,235	18.2	2.0	22.5
Journal	8,231	13.4	1.7	48.1
J. abstract	178	13.7	1.7	46.6
J. introduction	437	24.3	1.7	35.8
J. discussion	887	19.3	1.7	43.9

Note that relative clauses do not necessarily lengthen the sentence. Grammatically one may choose to omit a relative pronoun (who, whom, which, and that) that functions as object of its clause. This may also explain why the strategy is not the text that has the greatest sentence length although it has the highest occurrence of relative clauses. The measure of sentence length shows that the strategy text in fact is ranked the fourth (18.2), following journal introduction (24.3), journal discussion (19.3), and disclaimer (21.8) (see Table 2).

3.2. Garden Path Sentences

There are very few cases of this type. Garden path sentences typically do not match readers' expectation of left-to-right parsing and often readers are required to reparse and reinterpret. There may be one or two sentences that match this definition. One is from the strategy text: "HiOA's strategic plan is founded on the strategy documents that formed the basis for the merger between Akershus University College and Oslo University College in 2011, national guidelines issued by the Ministry of Education and Research, and analyses of regional, national and global conditions".

When a reader begins to process, the sentence up to *in 2011* is understandable. After that, when a reader encounters *national guidelines issued by the Ministry of Education and Research*, the lack of clarity occurs. One wonders if this part refers to the merger or the strategy documents or is the object of *on*. One has to reparse perhaps from the beginning to be certain. The same could be said regarding the last part *and analyses of regional, national and global conditions*. Again, a reader may feel the need of having to reparse from its preceding part or from the beginning to assign what the *analyses* are referring to. Is the part *and analyses of regional, national and global*

conditions referred to *the merger*, or *the strategy documents*, or the object of preposition *on*?

A second example is from the journal abstract: “We evaluate that claim through a comparative multimodal content analysis of the ISIS video *Flames of War* and the videos posted in response on the U.S. Department of State’s (USDS) *Think Again Turn Away YouTube channel*”.

This sentence is ambiguous in a different way. At a first glance, this sentence seems to pose no problem for understanding. However, when a reader comes across the second word related to video *the videos posted*, he or she is likely to feel the need to reparse the sentence again to ensure if the part *the videos posted in response on the U.S. Department of State’s (USDS) Think Again Turn Away YouTube channel* is also the object of evaluation (the first object is *that claim*) or is actually part of their methodological content analysis.

If the two examples cited above pose challenges for non-dyslexic readers, one would expect that dyslexic readers could take even longer time to reprocess and reinterpret to extract the meaning as intended. Fortunately, statements could be rephrased in various ways to increase readability for all readers.

3.3. *Left-branching Structures*

The children’s stories show no such use, while the disclaimer and strategy text each has one instance. The journal introduction and findings each has three examples. The journal discussion has four instances, possibly illustrating the more complicated situations when dealing with religious political-cultural conflicts. Note that left-branching usually causes some parsing delay, since English is mainly a right-branching language. The main constituent of a phrasal unit is usually on the right part. Until the main constituent of a phrasal unit is processed, the preceded left-side material has to be put on hold in one’s memory. A cross comparison with Flesch-Kincaid measure reveals a slightly different trend on non-children text. Children’s text is consistent in that it has the highest Flesch-Kincaid readability and also uses non left-branching structures. The strategy has the lowest Flesch-Kincaid readability yet it has only one use of left-branching structure. The disclaimer has a lower Flesch-Kincaid score than that of the full journal and that of abstract but it has also only one use of left-branching structure. While the journal discussion has a lower Flesch-Kincaid measure than the disclaimer, it employs more left-branching structure. Thus, the connection between the current readability index and left-branching construct is not obvious. Nevertheless, with such a small number of instances found, one may argue that the overall readability is not affected by this specific linguistic use. It is logical to reason that the proportion of such linguistic device to the length of a given text should then be adequately calculated to determine a threshold that predicts its effect on readability. What seems to be clear is that children’s text uses common left-to-right ordering while all other more expository-based texts have more left-branching structure. More specifically, the longer a text, the more such use. This may be a reflection of what long texts often are required in that variation is employed to avoid repeating the same sentence structure. This raises another issue of variation versus readability. Variation in text may increase novelty and more interesting to read and thus enhance “readability” in a different way. One tends to argue that readability is more vital than variation for dyslexic readers.

4. Discussion

The three linguistic devices are realised differently in the different types of documents investigated. Children's stories of all three levels show no such constructs, thus also consistent with the measure of sentence length being the shortest of all types. However, a closer inspection shows that it is only the lowest level 1 that is much shorter (8.8) than other types; level 2 and level 3 (12.7 and 12.3 respectively) are quite close to journal abstract in sentence length (13.7). Children's text has also the highest readability based on Flesch-Kincaid's score, which is as expected considering factors of content, word, and sentence. The disclaimer employs two relative clauses and one left-branching structure, with the second highest sentence length of all types (only lower than that of the journal introduction). The strategy uses 41 relative clauses, one garden path sentence, and one left-branching structure. Cross comparisons to the previous study (see [15]) reveal that the strategy has in effect the lowest Flesch-Kincaid readability and the greatest word difficulty. As mentioned, there exist possibly more difficult words in the journal article than in the strategy but the strategy contains more words of more than two syllables. Further, it is the researcher's overall impression that the strategy text is perhaps the most challenging to read amongst all documents examined herein. If confirmed so, then the readability measure is accurate for this strategy text but the word difficulty index is inaccurate. Reading perception tests involving more readers could be measured to verify this observation. The correlation between and among use of relative clauses, garden path sentences, left-branching structure, readability, and word difficulty requires further work.

As expected, the journal article employs the highest number of all three linguistic constructs: 90 relative clauses, one garden path sentence, and 10 left-branching structures. Flesch-Kincaid score suggests that the journal overall is the second most readable of all types (48.1), with its abstract more readable (46.6) than the discussion (43.9) and introduction (35.8). A closer look indicates that the introduction has the greatest sentence length than other sections, though its section length is about half the size of the discussion. Of these, nearly half (41) of the relative clauses are deployed in the findings, 17 in the discussion and 15 in the introduction. About half (4) of the left-branching construct is in the discussion, three in the findings and three in the introduction. These results suggest that the more use of relative clauses does not necessarily add to reading burden, given that the journal article has the second highest readability measure and also highest use of relative clauses. It could even be that the uses of relative clause assist readability. However, the strategy text, having the second highest number of relative clause but also the greatest word difficulty (note that the author has questioned the validity of the word difficulty measure) as well as the lowest readability, poses a strong contrast. It is noted that the ratio of relative clauses to overall document length in the strategy is twice as much as the journal article. Understandably, having more than two relative clauses in one sentence may require more parsing efforts, hence possibly reducing readability. It thus appears that other device than relative clause could also contribute to reduced readability. Indeed, visual observations reveal that the strategy has other linguistic issues that may affect its overall readability, such as pronoun reference, parallelism, heavy noun phrases as subject and heavy phrasal object. Impressionistically, the journal article is overall quite readable although it is the longest document and contains high percentage of relative clauses as well as incorporating left-branching structure.

An impressionistic correlation of the three linguistic structures and the current readability measure show a certain match as well as discrepancy. It appears that children's text is quite accurate for both dimensions since it is given the highest (good) readability value and it makes no use of these language constructs. The journal text is also quite adequate, ranked the second highest index based on abstractions of separate sections but they vary among themselves within a certain range, possibly because of varied section lengths. All three linguistic structures are used in the journal article and with the highest frequency. The disclaimer and strategy text are less accurate in readability measure possibly due to their specific type and less explored by readability research. Their uses of the three linguistic structures are also in between those of children's text and the journal article.

The results reported therein suggest that one cannot assume that text readability is high or low based on one measure. This measure could well be part of the truth but its truth may not reflect all factors that contribute to readability. As experienced, readability calculated based on available formulae may not be accurate in all aspects of the strategy text and the journal article but is quite accurate in children's text. Further, word length as difficulty measure is not accurate across text types, factors such as less known and culturally-oriented concepts or words should be taken into consideration. It thus appears that readability index generally corresponds well with text related to narratives such as children's text, which is less expository in nature, but less so with texts aiming at explicating or disseminating as in disclaimer, strategy, and the journal article.

Future work may experiment using various text versions with and without these linguistic constructs to help verify their effect on readability. Reading speed and comprehension may be tested to quantify their significance in text processing. If deemed significant in assisting readers' text comprehension, future measure could include these structures as factors for improved readability. Readers and writers would also benefit from increased awareness of potential impact of such linguistic devices in text composition.

5. Implications

Several implications may be drawn based on the observations herein. First, longer texts or sentences do not necessarily reduce readability, as shown in cases of longer journal article versus shorter strategy text. For dyslexic readers, more research is necessary to pinpoint to what degree adequate length could increase or reduce readability, given that subtle structure change may increase sentence length but may also increase comprehensibility. Since reading challenges among dyslexics vary, systematic research into text-decoding and perception load is needed. The two examples mentioned show two different effects – one long journal text is easy to read and one shorter strategy text is harder to read. Very likely, other devices also need to be included as part of readability measure such as text type or genre. Text could at least be broadly divided into two types such as narrative (e.g., most children stories) and expository (e.g., most processes, informative, or scientific writing) to increase readability adequacy. Longer text such as journal clearly could also be measured differently given its distinct section categories. It does appear that readability metrics encourage or reward shortening of sentences, while this may actually not help the quality.

Second, the three linguistic structures examined are more used in explanations of details, multiple representations, and relationships in complex issues, as particularly found in the journal article. None of these is used in the children's text. The uses of such structures are also found in disclaimer and strategy documents, but less than that of the journal article. Possible generalizations of these findings are that other linguistics constructs may also help vary sentence structures in expository texts whose goals are to instruct and inform readers of specific matter. Varied sentences help break up monotonic patterns and thus enrich content and readability with a possibility of increased length of words or sentences; however, the issue of length may not occur as sentence variations do not necessarily lengthen sentences significantly. Conversely, one may argue that a smaller palette of simple constructs that everyone understands may be easier for web owners to implement. One would also raise the concern of whether varying the language could result in unreadable constructs being introduced. Further research may help specify the threshold of comprehensibility in various sentence patterns for both common readers and dyslexic readers.

Lastly, for both research purpose and practical web site cases, it is useful to conduct reading experiments to verify comprehension with various texts, linking comprehension and reading speed with readability, hence making readability measure more accurate and meaningful and hence practical and usable, not merely hypothetically useful. The current readability formulae could further include other language constructs, in addition to the three constructs examined herein, to improve accuracy, including subject phrases, verb phrases, object phrases, adverbial phrases, sentence structure, etc. Knowledge from natural language processing including parsing and part-of-speech tags may contribute to classification of text structure and text complexity measure. Further development for more objective metrics may help writers and website owners achieve improved text accessibility.

6. Conclusions

This study examines three linguistic structures that are up-to-now not part of the classic readability formulae, namely, relative clause, garden path sentence, and left-branching structure. The goal is to see whether these stylistic features reflect readability and how they correspond to common readability measure. The results reveal some degree of match and dissimilarity, as well as new observations. These constructs occur more in expository texts that aim at instructing or disseminating information but none in narratives such as children's stories. The trend is that the longer a text, the more these constructs. Current readability formulae may suffice for lower level texts such as those meant for children, young learners or dyslexic readers but more complex text requires more accurate measure for all readers. Further research is needed to ascertain their effect in comprehensibility. An additional aim is to help contribute to universally designed web by helping writers create better texts and help owners check their web sites for accessibility compliance. The observations reported herein also have implications for academic writing pedagogy [16] and learning language skills [17].

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