COMPARISON OF READABILITY INDICES WITH GRADES 1-5 NARRATIVE AND EXPOSITORY TEXTS

by

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DEDICATION

This dissertation is dedicated to my family, the ones who have provided constant support of the time and energy I have put into this work. To my husband Eric W. Harden, who has not only supported me emotionally and intellectually, but also selflessly provided the financial support for this endeavor.

To my children, Faith, Lauren and Andrew, who have sacrificed much to allow me to spend the time and energy required to complete this work. I love you to Heaven and back for allowing me to reach this goal!

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And finally, to the memory of my father, Robert Rohde and my grandmother, Grace Baker. I miss you both terribly but still feel your love and support daily.

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CHAPTER 1

Reading is an act of recitation and a process that requires comprehension of the written word. Reading comprehension requires complex interactions with a text, i.e., engagement in a constant internal dialogue to make meaning from the written word (Zimmerman & Hutchins, 2003). Many factors contribute to reading comprehension, such as (a) ability to process and understand syntactic, semantic, and graphophonemic information (Hittleman, 1973) which include word difficulty and sentence length (Fry, 1975; Crossley, Allen, & McNamara, 2011), (b) motivation (Moley, Bandre, & George, 2011; Guthrie, et al., 2006; Logan, Medford, & Hughes, 2011) and (c) ability to decipher text elements such as pictures and diagrams (Gallagher, Fazio, & Gunning, 2012), as related to text complexity.

Hittleman (1973) stated "the reader, as a user of language and in response to the graphic display on the page, processes three kinds of information: syntactic, semantic, and graphophonemic" (p. 784). Reading becomes a selection of and partial use of, available language cues from a perceptual input based on expectations and tentative decisions which are confirmed, rejected, or revised as reading progresses (Zimmerman & Hutchins, 2003; Goodman, 1967). Phonemic awareness is introduced as early as preschool through an introduction of letter names and sounds. It is at this stage that processing and understanding of graphophonemic information, or the sound-symbol relationship, begins. Snow, Burns, and Griffith (1998) defined phonemic awareness as "the insight that every spoken word can be conceived as a sequence of phonemes which are the speech phonological units that make a difference to meaning" (p. 52). Knowledge of letters and phonemic awareness bear a strong and direct relationship to success and ease of reading acquisition (Adams, 1990).

Once phonemic awareness is grasped, decoding begins through phonics and vocabulary

instruction. Phonics refers to "instructional practices that emphasize how spellings are related to speech sounds" (Snow, Burns, & Griffin, 1998, p. 52). Vocabulary extends phonics instruction by moving from sound-symbol relationships to focusing on words and using phonological knowledge to figure out word meanings (Morrow, 2011). It is here that the processing and understanding of semantics, the meaning of words and vocabulary choices, occurs. *Put Reading First* (Armbruster, Lehr, & Osborn, 2001) a collaborative research group funded by the National Institute of Child Health and Human Development and the U.S. Department of Education, stated "readers cannot understand what they are reading without knowing what most of the words mean. As children learn to read more advanced texts, they must learn the meaning of new words that are not part of their oral vocabulary" (p. 36).

A strong foundation of phonemic awareness, phonics instruction, and vocabulary development leads to reading fluency. Fluency is the ability to read text quickly, accurately, and with proper expression (Kuhn & Stahl, 2013). Fluency can be the result of accurate word calling but lack comprehension. Syntax, the arrangement of words and phrases to create well-formed sentences, must be understood for proficiency to occur. Proficiency requires fluency and comprehension. Adams (1990) concluded that the research on fluency "indicates that the most critical factor beneath fluent word reading is the ability to recognize letters, spelling patterns, and whole words effortlessly, automatically, and visually. The central goal of all reading instruction—comprehension—depends critically on this ability" (p. 54). Fluency and comprehension contribute to learning in all areas and are contingent upon motivation and quality of the text (Gallagher, Fazio, & Gunning, 2012).

Assessment of reading skills determines the level of reading achievement, which is the proficiency in learning to read, as well as comprehend, text and requires conceptual integrations

of text-based content (Guthrie, Lutz-Klauda, & Ho, 2013). Reading engagement, however, consists of behavioral actions and intentions to interact with text for the purposes of understanding and learning. Therefore, engagement is the act of reading to meet internal and external expectations (Guthrie, Lutz-Klauda, & Ho, 2013). Motivation and interest are factors that affect reading engagement and are significantly associated with increased reading skill (Wang & Guthrie, 2004; McGeown, Norgate, & Warhurst, 2012).

Motivation and Interest

Motivation and interest are qualities that are subjective and complex, thus more difficult to measure. Edward Fry (1975) proposed a readability principle which stated "high motivation overcomes high readability level, but low motivation demands a low readability level" (p. 847). Reading motivation is significantly associated with reading skill (Baker & Wigfield, 1999; Wang & Guthrie, 2004; McGeown, Norgate, & Warhurst, 2012) and is highly correlated with important cognitive outcomes such as reading achievement and amount of reading (Guthrie, Hoa, Wigfield, Tonks, & Perencevich, 2006). Wang and Guthrie (2004) indicated "motivation is considered a multi-dimensional construct and within the field of reading research, a popular distinction is that of intrinsic and extrinsic reading motivation" (p. 175). Intrinsic motivations include, but are not limited to, interest and enjoyment in reading (Guthrie, Lutz-Klauda, & Ho, 2013; Moley, Bandre, & George, 2011), self-efficacy (McGeown, Norgate, & Warhurst, 2012; Guthrie, Lutz-Klauda, & Ho, 2013), valuing reading (Guthrie, Hoa, Wigfield, Tonks, & Perencevich, 2006; McGeown, Norgate, & Warhurst, 2012) and intentions to interact socially in reading, also known as prosocial goals (Guthrie, Lutz-Klauda, & Ho, 2013). Extrinsic motivation is driven by the possibility of receiving a separable outcome (McGeown, Norgate, & Warhurst, 2012), such as rewards, competition, grades, and praise (Guthrie, et al., 2006; McGeown, Norgate, & Warhurst, 2012).

Motivation can be influenced through classroom instruction practices (Gambrell, 2002).

Autonomy support consists of providing opportunities for choice of self-direction while minimizing external control (Guthrie, Lutz-Klauda, & Ho, 2013). Deci and Ryan (1985) noted autonomy support is "related to…intrinsic motivation, self-esteem, and beliefs about intellectual competence" (p. 255). Guthrie et al. (2013) pointed out "instructional emphases on autonomy support, relevance, collaborative learning, and self-efficacy support are each associated with appropriate motivation constructs in correlational and experimental research" (p. 11). Motivation plays an important role in literacy development. In a study examining the effects of motivation on the amount of reading completed it was concluded, "one of the major contributions of motivation to text comprehension is that motivation increases reading amount, which then increases text comprehension" (Guthrie, Wigfield, Metsala, & Cox, 1999, p. 245).

Text Complexity

Text complexity refers to numerous factors including vocabulary and sentence structure (Papola-Ellis, 2014), organization and general structure of the text (Shanahan, Fisher, & Fray, 2012), and background knowledge and interest level about the topic (Fisher, Fray, & Lapp, 2012). It was noted in the Common Core State Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers [NGA & CCSSO], 2010) more attention needs to be placed on text complexity and comprehension. Representatives of the NGA and CCSSO (2010) claimed that "sophisticated texts are ones that often contain novel language, new knowledge, and innovative modes of thought" (p. 4, Appendix A).

A problem exists when a narrow understanding and interpretation of text complexity dominates how this instructional shift is implemented (Papola-Ellis, 2014). Text complexity can refer to the text itself, or the tasks to be performed with the text. Texts should challenge readers

sufficiently to improve existing knowledge and skills for reading, comprehending, and learning from texts just beyond their current levels (Goldman & Lee, 2014). Matching readers to appropriately complex texts is a difficult process involving qualitative analyses of text features that contribute to comprehension difficulties (Pearson & Hiebert, 2014). Pearson & Hiebert (2014) pointed out "qualitative analyses in the form of rich descriptions of features of texts that contribute to comprehension difficulties…were sentence length, obscure vocabulary, and rare syntax" (p. 292-293). The practice of focusing on quantitative word- and sentence-level counts increased in popularity as readability indices developed throughout the 1900's and continue to be applied to texts across the board (Goldman & Lee, 2014).

In psycholinguistics, reading is regarded as a multicomponent skill operating at a number of different levels of processing: lexical, syntactic, semantic, and structural (Just & Carpenter, 1987; Koda, 2005). Crossley, Greenfield, & McNamara (2008) stated "it is a skill that enables the reader to make links between features of the text and stored representations in his or her mind. These representations are not only linguistic, but include world knowledge, knowledge of text genre, and the discourse model which the reader has built up of the text so far" (p. 477). Structurally, many expository texts contain tables, graphs, charts, pictures, and diagrams that must be interpreted as part of the learning. If it is not possible to access information from structural text features, then comprehension will be diminished. Awareness of how to identify and use structures in expository text is helpful for learning situations in which readers have low levels of knowledge about the content domain of the text (Goldman & Rakestraw, 2000; Meyer, 1984).

Another factor to consider when determining text complexity is schema. In the 1980's, schema theory was developed in cognitive psychology to explain how our previous experiences, knowledge, emotions, and understandings have a major effect on what and how to learn (Anderson

& Pearson, 1984). It is the prior knowledge and experiences used to construct meaning from a text. When there is an experience similar to a character in a story, understanding the character's motives, thoughts, and feelings is more likely; similarly, when there is an abundance of knowledge about a specific content area, the new information is woven with prior knowledge for enhanced comprehension (Harvey & Goudvis, 2000). Conversely, knowledge deficits result in fragmented and isolated understandings of the text, causing a failure in comprehension of the overall text content (Best, Rowe, Ozura, & McNamara, 2005). According to Fisher, Frey, and Lapp (2012), "text complexity is based, in part, on the skills of the reader" (p. 3). Lack of experiences or prior exposure to information regarding a certain topic can impact how challenging a text is to read (Papola-Ellis, 2014).

Readability

Readability was defined as the degree to which a class of people determine certain reading matter to be compelling and comprehensible (Plucinski, 2010; McLaughlin, 1969). It differs from "legibility" which refers to the ease of being read (Plucinski, 2010, p. 49). Text readability refers to factors that affect success in reading and understanding a text (Johnson, 1971; Plucinski, 2010). These factors can be qualitative such as levels of meaning and knowledge demands, quantitative as represented through text readability indices, and/or reader/task considerations such as motivation, interest, and schema (Papola-Ellis, 2014). The more each factor overlaps with the other factors, the greater the comprehension will be for the reader. Word difficulty and sentence length are quantitative measures that are highly determinate of text readability.

An interplay exists between text readability, motivation/interest, and reader schema in relationship to reading comprehension, as depicted in Figure 1.

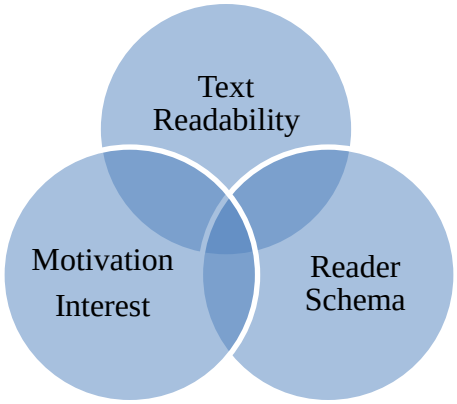


Figure 1: Venn Diagram of Reading Comprehension Factors

A large intersection of factors, ideally all three, is desirable and indicates an increased level of comprehension. Gallagher et al. (2012) pointed out "learning from text is imperative to learning in any discipline; it is foundational to build knowledge to explore concepts and essential skills" (p. 94). Fluent reading and comprehension are strong contributors to learning in content-based subjects such as science (Gallagher, Fazio, & Gunning, 2012). Expository texts, such as science texts, tend to have a higher readability level due to the descriptive, precise, and often technical vocabulary (Pearson, Hiebert, & Kamil, 2007; Gallagher, Fazio, & Gunning, 2012). Vocabulary knowledge is strongly correlated to reading comprehension (Thorndike, 1972). Stahl (2003) stated "correlations between measures of vocabulary and reading comprehension routinely are in the 0.90s. The correlations have been found to be robust almost regardless of the measures used or the populations tested" (p. 241). This mosaic of factors contributing to text complexity all coexist to create comprehension for the reader. Readability is a moment at which time the reader's emotional, cognitive, and linguistic backgrounds interact with each other, the topic, and with the proposed purposes for doing the reading (Hittleman, 1973).

When attempting to solve the text complexity issue, it is important and appropriate to determine readability levels through the use of quantitative readability index measures instead of presenting unachievable expectations based on grade level (Pearson, 2013; Papola-Ellis, 2014).

Reading comprehension is believed to increase when appropriate texts are utilized. Providing readers with texts that are accessible and well matched to ability has always presented a challenge (Crossley, Greenfield, & McNamara, 2008). Text readability indices are important means of determining which texts can be deemed appropriate (Hittleman, 1973). Readability indices, being quantitative in nature, are the only comparable factors of text readability.

Statement of the Problem

The problem that exists when using one or more readability indexes to ascertain a text grade level is the varied outcomes received on any given text from readability indexes that purport to measure the same construct. Since 1920, between 50 (Crossley, Allen, & McNamara, 2011) and 200 readability indices (DuBay, 2004) were produced in the hopes of providing tools to measure text difficulty more accurately and efficiently. The plethora of formulas indicated there were significant differences in the semantic variables making it incumbent to ask how the indices might compare, agree and whether they are valid measures of various narrative and expository texts. When selecting readability indexes to measure text grade levels, practitioners need to be able to confidently select multiple measures that will provide similar outcomes on each text. This study aims to provide data that will allow practitioners to use readability indexes interchangeably.

Currently, the research on readability indexes addresses the ability of the indexes to show correspondence between grade level and difficulty level, analyzes the disparate variables that contribute to each index, tests the accuracy of readability indexes, and evaluates how the indexes can be used to examine the role of quantitative dimensions of text complexity and the effects of these dimensions on comprehension. The current research is limited to comparisons of two or more readability indexes. No research was found analyzing any number of readability indexes for agreement.

The majority of the formulas were based on factors that represent comprehension difficulty: (a) lexical or semantic features and (b) sentence and syntactic complexity (Chall & Dale, 1995; Crossley, Greenfield, & McNamara, 2008). Readability was calculated as a combination of text features including one or more of the following: percentage of high frequency words (i.e. words on a predetermined list defined as familiar to most students at a particular grade level), average number of words per sentence, average number of syllables per word, number of single syllable words, or number of words with multiple syllables (Begeny & Greene, 2014). Due to the discrepancies of semantic and syntactic variables, the indexes were not known to yield the same reading level for a given text (Gallagher, Fazio, & Gunning, 2012). Hence, further investigation is warranted by the existing discrepancies among readability indexes to determine which readability indexes can be used interchangeably to provide the practitioner with information regarding text level. Begeny et al. (2014) indicated "the widespread use of readability estimates in education highlights the need to further investigate whether meaningful differences exist between the grade level text (defined by readability formulas) and a measure of the actual difficulty level of the text" (p. 199).

Purpose of the study

In order to determine which of several readability indexes provide agreement between treatments, eight readability indexes will be examined. The application will be limited to texts used from first grade through fifth grade (1-5) and will include narrative and expository styles. The readability indexes that will be used are the Flesch-Kincaid Grade Level index (Flesch, 1948), Flesch Reading Ease formula (Flesch, 1951), Fry Readability graph (Fry, 1968; Fry, 1975), Dale-Chall Readability Formula (Dale & Chall, 1948), Spache Readability formula (Spache, 1953), Gunning Fog index (Gunning, 1968), the SMOG Grading Plan (McLaughlin, 1969)and the Coh-

Metrix L2 index (Graesser, McNamara, Louwerse, & Zhiquiang, 2004). These formulas represent a cross-section of different computational variables including: number of sentences, syllables, number of characters, multi-syllabic words, and vocabulary complexity (Gallagher, Fazio, & Gunning, 2012).

The results from the readability indices will then be analyzed to make comparisons using the Bland-Altman method. This procedure provides a method of assessing agreement between two measurement systems, called the limits of agreement approach (Stevens, Steiner, & MacKay, 2015). The method of differences is designed to detect bias between measurements, not to calibrate one measurement against another (Ludbrook, 2010). The Bland-Altman method is most commonly used in medical research with application in clinical settings but is also used in other fields to analyze agreement between methods. Each readability index will be plotted against the other seven indexes to make comparisons regarding agreement, i.e. Flesch-Kincaid Grade Level and Fog index; Flesh-Kincaid Grade Level and Coh-Metrix L2 index.

Assumptions and Limitations

Several assumptions have been made regarding readability formulas and text complexity. Most conventional readability formulas were developed using general assumptions about reading difficulty and text complexity (Begeny & Greene, 2014). It has been assumed that shorter words, shorter sentences, words with fewer syllables, and words that are used more frequently are easier to read (Connatser & Peac, 1999). The use of readability indexes allows practitioners to provide a better text match for the reader. It is also assumed that assigned grade level difficulty is based on one or more indexes and represents meaningful differences in text complexity (Begeny & Greene, 2014). Differences exist among different reading indexes due to a variety of factors, quantitative and qualitative, included in each formula and it is assumed that such differences will be apparent

in the analyses.

Due to the quantitative nature of readability indices, limitations exist within the study. Some of the formulae are based on word lists containing high frequency words (e.g. Spache, Dale-Chall). Expository texts contain technical, and often scientific, vocabulary that would not be common on such lists. This qualification is known to underestimate readability levels (Gallagher, Fazio, & Gunning, 2012). Readability indices fail to address qualitative features that impact comprehension, such as: content, illustrations, format, curriculum, reader schema, language structure, length of the book, and overall text complexity in relation to the reader's ability. The formula for each index is unique and utilizes different factors for computation. Some indexes are recommended for use at particular grade levels (e.g., Spache for text at Grade 3 or lower; Dale-Chall for text higher than Grade 4), yet calculations were made with all indexes on all texts. This limits the generalizability of the findings and potentially compromises validity for grade levels outside of the specified restrictions (Gallagher, Fazio, & Gunning, 2012).

CHAPTER 2 Review of Literature

A review of literature was conducted focusing on the historical perspective of reading assessment and readability indices, the theories behind reading assessment and readability indices, and the policy, research and practice implications derived from the literature. ERIC (Education Resources Information Center) ProQuest was the main database used to conduct the literature search based on the broad collection of education-related journal articles and materials. Searches of this database were conducted utilizing keywords related to readability indices. Search terms included, but were not limited to, the following: readability indices, readability indexes, history, reading comprehension, text complexity, readability formulas, text matching, reading readiness, and assessment. These terms were searched in various combinations filtered for scholarly articles to create a pool of documents for review. Other materials, such as published books found in the author's collection, were also reviewed. Provided in Table 1 is a bibliography of the journal articles reviewed. An overview of each article is provided in Table 2.

Table 1.

Articles Included in Review of Literature

1. Heibert, Elfrieda & Pearson, P. David. (2014). Understanding Text Complexity: Introduction to the Special Issue. *The Elementary School Journal,* 115 (2), 153-160. **(History and Policy)**
2. Gamson, David A., Lu, Xiaofel, & Eckert, Sarah A. (2013). Challenging the Research Base of the Common Core State Standards: A Historical Reanalysis of Text Complexity. *Educational Researcher,* 42 (7), 381-391. **(History and Policy)**
3. Wray, David & Janan, Dahlia. (2013). Readability revisited? The implications of text complexity. *The Curriculum Journal,* 24 (4), 553-562. **(History, Theory, Policy and Practice, Global Implications)**
4. Begeny, John C. & Greene, Diana J. (2014). Can readability formulas be used to successfully gauge difficulty of reading materials? *Psychology in the Schools,* 51 (2), 198-215. **(Theory and Practice)**
5. Crossley, Scott A., Allen, David B., & McNamara, Danielle S. (2011). Text readability and intuitive simplification: A comparison of readability formulas. *Reading in a Foreign Language,* 23 (1), 84-101. **(Theory)**
6. Mikk, Jaan (2001). Prior knowledge of text content and values of text characteristics. *Journal of Quantitative Linguistics,* 8 (1), 67-80. **(Practice and Theory)**

7. Crossley, Scott A., Greenfield, Jerry, & McNamara, Danielle S. (2008). Assessing text readability using cognitively based indices. *TESOL Quarterly*, 42 (3), 475-493. **(Theory and Practice, possible Global Implications)**
8. Gallagher, Tiffany L., Fazio, Xavier, & Gunning, Thomas G. (2012). Varying readability of science-based text in elementary readers: Challenges for teachers. *Reading Improvement*, 93-112. **(Theory, Practice, and Policy)**
9. Shymansky, James A. & Yore, Larry D. (1979). Assessing and using readability of elementary science texts. *School Science and Mathematics*, 670-676. **(Practice)**
10. Hauptli, Megan V. & Cohen-Vogel, L. (2013). The federal role in adolescent literacy from Johnson through Obama: A policy regimes analysis. *American Journal of Education*, 119 (3), 373-404. **(History, Policy, and Theory)**
11. Reed, Deborah K. & Kershaw-Herrara, Sarah. (2016). An examination of text complexity as characterized by readability and cohesion. *The Journal of Experimental Education*, 84 (1), 75-97. **(Practice)**

Table 2

Critical Analysis of Literature Review Articles

Study	Need for the Study	Theoretical Framework	Goal, Aim, Objectives, Questions	Significance of the Study	Methodology	Interpretations	Implications
1	CCSS identified quantitatively indexed goals; evidence is growing against claims of decelerated complexity in past 50 years	Complexity historically began with qualitative analysis (late 1800s), moved to quantitative analysis (early to mid-1900s) with nearly 200 readability formulas developed and increased technology;	Provide an overview of the three components of the model of text complexity identified in Appendix A of the CCSS: (1) qualitative, (2) quantitative, and (3) reader-task considerations	Text complexity is grounded currently in policy within the CCSS, however the evidence is growing against claims that text complexity is decreasing in recent years.	No methodology provided. Articles provides an historical overview of the systematic study of text complexity.	Text complexity is an educational topic in need of much more research so that policies and practices can be based on sound research and complete information	Widespread mandates in policy and change in practice without stronger theory and research is likely to have serious repercussions on the reading experiences of students
2	CCSS claims to be grounded in research indicating declining text complexity. CCSS only uses Lexile Framework to measure complexity. Authors believe there is evidence proving otherwise	Text historically changed for different reasons. Pre-WWI the McGuffey Readers were the standard. These were used for elocution, not comprehension. Chall noted a reverse bell curve in her research indicating an increase in complexity	To locate a sample of third- to sixth-grade reading textbooks that accurately represent the market from 1890s to 2008. To analyze using several measures to determine whether there indeed has been a decline in complexity over the course of those years	Because current policy is grounded in research that claims declining complexity of text, it is important to explore the assumptions embedded within the CCSS. It is important that further examination of the statements are examined in depth	Four measures: (lexical difficulty)-LEX and WBF [word frequency band] Readability Formulas-Dale-Chall Readability Index and Mean Length of Sentence. ANOVA was used to determine	Findings show a distinctly different pattern of historical shifts in complexity than the simple declines reported by the CCSS. The findings show a steady increase over the past 70 years. The reported downward trend (CCSS) is inaccurate. CCSS effort to quickly ratchet up complexity is	Raises implication for policy, research, and practice. There is a need for a broader view of complexity that incorporates text, instruction, and a wider variety of materials, as well as and for an assessment approach

		post-WWII			significant differences in mean between decades	unnecessary and could cause a larger discrepancy in the achievement gap. Text complexity is only one dimension of a robust reading program	using measures that are less restrictive.
3	CCSS in the USA has had a global effect on text complexity and the teaching of reading throughout K-12 education. Secondary teachers need to focus more on reading instruction in all content areas	Readability has had declining visibility in education research in the past 20 years (historical). Theoretically, the process of reading has moved from describing a process of getting meaning from a text to one of creating meaning through interaction with a text.	To make educators more aware of the need for reading instruction at the secondary level in all content areas. Reading instruction is not left to elementary teachers only.	ACT reported that success of students did not lie in their ability to comprehend text but rather in the ability to successfully read and respond to harder, more complex texts. Performance on complex texts was the clearest differentiator in reading	Examination of CCSS and current curriculum in UK	The problems most students have with reading are related to engagement rather than their potential to learn requisite skills. Reading needs to be extended for students to gain insight into why it is important, or useful, to read. Globally, expository texts still provide the most difficulty for students.	More attention to the teaching and development of reading in secondary schools is necessary. Deliberate policies and strategies are needed if students are expected to achieve mastery over increasingly complex texts.
4	Past research does not address the use of R.I. as an accurate gauge of text difficulty between closely leveled text.	Theoretically, a text at a second grade level should be easier than a third grade level text, and a fifth grade level text should be more difficult than a fourth grade level text.	To identify which readability formulas (if any) show an actual correspondence between grade level and difficulty level, when difficulty level is determined by students' actual reading performance.	Unlike most previous research examining readability formulas, this study does not examine whether estimates can be used to create "equally difficult" passages or define the precise difficulty of passages; presents practical uses for research.	N = 360; 2nd, 3rd, 4th, and 5th graders Used DIBELS passages (12 passages-2 @ each grade 1-6) Eight readability estimates were used to analyze data Fishers Exact tests were used to analyze high vs. low ability and expected vs. unexpected results	Only Dale-Chall formula was significant for the total comparisons. FOG, Lexile and Spache showed promise as valid indicators for one specific grade level comparison; most common readability formulas are inappropriate to use across a range of grade levels when trying to discriminate general difficulty level. Formulas seem to be more accurate for higher level readers.	Most readability formulas may not assist teachers well with selecting text that is of greater or lesser difficulty; nearly all formulas do not appear to be valid indicators of text of varying difficulty. There is little evidence that the use of formulas is a valid or consistent way of differentiatin g text difficulty.
5	Previous studies on L2 learners have agreed that simplification of text is necessary however, there has not been a means of measuring text	Psycholinguisti c theory and Cognitive theory; both necessitate a readability measure that considers comprehension	Analyzing differences between traditional readability formulas and readability formulas based on	This study could provide findings that support the use of cognitively inspired readability formulas over traditional	N = 300 (texts) Analyzed using Flesch-Kincaid; Flesch Reading Ease, and Coh-	Demonstrated that a readability formula based on psycholinguistic and cognitive models of reading and traditional readability	Due to the moderate degrees of success of the Coh-Metrix at classifying news texts, as well as its accuracy, in

	simplification. Traditional readability formulas don't factor in linguistic and cognitive factors.	factors such as coherence and meaning construction, as well as cognitive processes such as lexical decoding and syntactic parsing.	psycholinguistic and cognitive accounts of text processing. Examine the potential for readability formulas to distinguish among levels of simplified texts that have been modified using intuitive approaches.	readability formulas when simplifying texts. This would allow greater access to a variety of texts for L2 learners. Determine which index best classifies the text level.	Metrix L2 indexes Conducted a series of ANOVA to examine if all the readability formulas demonstrated significant differences between the levels of the reading texts. Also, DFA (discriminant function analysis) Did use Cohen's Kappa to determine agreement	formulas can significantly classify texts based on their levels of intuitive text simplification. Accuracy scores are significantly higher with Coh-Metrix L2 (better able to discriminate between different text levels). Traditional readability formulas classified texts into appropriate categories at a level above chance.	comparison to traditional readability formulas, the findings may be extendible to genres outside of strictly academic texts. This would lead to greater accessibility for L2 learners.
6	Readability formulas have been used and criticized for their narrow ability to predict comprehension levels and text complexity. The authors believe that there is a possible relationship between text content familiarity and the average word length of a text.	A constructivist theory approach to deconstructing complex text. Familiar content is expressed in shorter words than unfamiliar content and scientific terms are longer than nouns which are not terms.	The hypothesis was that there should be some text characteristics that correlate with the level of knowledge of the text content that people have before reading a text (prior knowledge, schema). The aim of the research was to discover text characteristics, the values of which are related to the level of prior knowledge of the text content.	The level of prior knowledge was correlated with the text characteristics and 33 statistically significant coefficients were found. The authors were able to create two readability formulas to measure prior knowledge of text content.	N = 30 texts All texts were of a scientific nature (physics, chemistry, astronomy, and biology). Average length of the text was 166 words Prior knowledge was established before subjects read the materials 350 students (9^{th} and 10^{th} grade)	The level of prior knowledge was correlated with the text characteristics and 33 statistically significant coefficients of correlation were found. Word length = 25% of prior knowledge Sentence length = 24% of prior knowledge Text abstractness = 20% of prior knowledge Word familiarity = 25% of prior knowledge A formula was calculated using regression analysis in Excel to determine prior knowledge. Formula predicted 35% of the level of prior knowledge	Data confirmed the hypothesis; many characteristics are related to the level of prior knowledge. Readability formulas have some ability to predict prior knowledge and characterize the level of familiarity and complexity of the text content and are not simply measures of linguistic characteristics.
7	In order to help match readers to texts, a psycholinguistic based assessment of comprehensibility must go deeper than surface readability	Psycholinguistic theory frames the idea that a readability measure needs to be framed to take appropriate account of the role of working memory and the	To construct a new model incorporating at least some variables that reflect the cognitive demands of the reading process to yield a new,	The findings of this study have immediate transfer potential in that it provides a readability formula that is based on freely accessible	Corpus of 32 academic reading texts Mean length of the texts 269.28 words; mean number of sentences per hundred	Significant correlations were obtained for all indices when comparing the 3 selected variables to the EFL mean cloze scores.	Using the Coh-Metrix L2 formula can help to accurately predict readability for readers of English as a second or

	features to explain how the reader interacts with a text. Must include measures of text cohesion and meaning construction.	constraints it imposes in terms of propositional density and complexity. The theoretical goal of English readability research is to devise a measure that has strong construct validity as well as predictive validity.	more universally applicable measure of readability. Purpose of the study was to examine if certain Coh-Metrix variables can improve the prediction of text readability.	computational indices. This could provide materials developers and selecting appropriate text for L2 learners.	words 7.10 Three independent variables (lexical recognition, syntactic parsing, and meaning construction) Used R^2, Stein's unbiased risk estimate, and *n*-fold cross-validation	Multiple regression analysis using these three variables indicate the model can predict 86% of the difficulty for the passages. The Coh-Metrix formula has a clear superiority in accuracy to all of the other indices.	foreign language. The study draws attention to the impact on reading difficulty not of individual structures but of syntactic variety. Need to consider reader, not text.
8	Readability formulas have disparate variables that contribute to the measures. It is important to compare the indices and determine whether they are valid measures of various genres of science-based texts. Appropriate readability impacts comprehension and learning.	Theorists focus on behaviorism and multidisciplinary conceptual views of reading as a means of learning. Recently, the constructivist perspective has brought the focus on to the active role of the learner in using experiences to build an understanding of information through constructive processes to operate, form, elaborate, and test mental structures.	The goal was to determine how several indices would compare and whether they are valid measures of various genres of science-based text.	The authors utilize the CCSS policy to focus on text complexity and the increased vocabulary demands of science-based texts. They also acknowledge the importance of gaining knowledge from the text and not just surface learning. By testing a variety of indices, they are able to make comparisons that are useful to practitioners. Also, they feel it is timely to reconsider the role that text readability plays in reading instruction and student achievement.	Texts were science-based and selected from two Canadian publishers. Readability levels were reported by the publisher. They tested the texts using 9 indices that were chosen for their use by publishers and classroom teacher. N = 178 passages All nine formulas were used on all 178 passages. Descriptive statistics, rank ordering, correlations, and t-tests were performed on all data.	The Power-Sumner-Kearls had the highest correlated measure with the other measures for Publisher B's texts. Fry readability was the least correlated. All formulas tended to inflate readability calculations for nonfiction texts yet were more closely aligned with the publishers leveling for fiction texts. There is considerable variance among the nine formulas and also in comparison to the publisher-designated grade level for the passages, suggesting that these commonly used measures are not perfect predictors of readability. Readability formulae offer probability statements and estimates of text difficulty.	Since science vocabulary is complex and discipline specific, and prior knowledge is required to comprehend science texts it is important that publishers use valid formulas to determine grade levels. Practitioners need to be critically aware of the impact of readability on instructional decision making and appropriate strategy instruction.
9	Reading materials are used in most science classrooms and it is important to	Many researchers and practitioners utilize the Cloze method because it	The questions raised by the researchers are: What are the readability	Reading requirements of all written materials used in a classroom should be	The researchers used the Fry Readability index and a 10% random	The average reading level was observed to progress generally throughout the	Practitioners need to create an environment in which a student's

	determine the readability limitations and how readability data can be used effectively in practice.	appears to be a valid indicator of readability since it gives a measure of the reader's interaction with the printed materials. This is not always feasible to use with science and mathematics texts due to their unique vocabulary, diagrams, graphs, formulas, and symbols.	limitations of science reading materials? How can readability data and reading material be used effectively?	considered for comprehensibility for particular readers. Reading skills are no less important in science than they are in reading any other materials. In fact, the vocabulary unique to science, content loading, sentence structure, the use of symbols, graphics, directions, and if-then statements make science reading skills more difficult and more critical to overall student success.	sample of all reading materials from each grade level within a program, readability data were collected on six popular elementary science textbook series.	graded texts in each series, but each series was marked by gaps and regressions in the reading levels. The commonly reported average masks extreme variation in reading level within texts supposedly specified for a given grade.	interest in science is complemented by his reading skills-not dependent on or limited by them. Due to the variations in reading levels present in individual textbooks, it may be necessary to split a school's selection between two or more series.
10	Historically, adolescent literacy has received little attention from the federal government. Adolescent literacy policy received only slight modifications over the course of almost 50 years. Recent attention to the adolescent literacy issue has created change in the federal approach to policy	The policy regimes (PR) framework, adapted from political science, offers a testable explanation for the prolonged policy stability and recent changes that characterize the federal government's role in adolescent literacy. The PR framework is one of the newest, synthetic theory models grown out of international relations literature.	Analysis of historical documents to assess the federal government's role in developing and implementing adolescent literacy policy. This analysis suggests a gradual change in both the way the problem has been defined and how it should be solved. A shift over time from an equity paradigm to a paradigm of accountability and results.	Evidence of prolonged policy stability characteristic of policy regimes was evident. In 2002, the federal government began to recognize the importance of adolescent literacy marked by the No Child Left Behind (NCLB) adoption. New accountability for schools and introduction of scientifically-based instructional modalities.	Database search (ERIC, Hein Online, US Supreme Court Library, Federal Register Library, and the Treaties and Agreements Library) to analyze 49 historical documents on educational policy. Three domains were analyzed: (1) problems federal policy was intended to address, (2) goals and assumptions embedded in adolescent literacy policy, and (3) policy instruments developed to deliver the goals.	Analysis of federal initiatives revealed evidence of prolonged policy stability characteristic of policy regimes. The federal government's inaction regarding adolescent literacy policy provided only slight modifications to static federal initiatives over the course of 40 years. NCLB was the first policy adoption that included significant changes to adolescent literacy policy.	This shift in policy has created a new focus on the importance of adolescent literacy and the instruments necessary for reducing high school dropout rates, as well as identify middle school students with specific deficiencies in reading.
11	This study expands on existing research that has clearly identified readability and cohesion as separate and	The construction-integration model and landscape model were used to consider elements of	The research question was: "What are the effects of manipulating the readability level and cohesion of	Current practices for text matching and comprehension generally utilize either readability indices or cohesion	High school seniors (n = 103) were randomly assigned to 4 groups. Each group read versions of	The findings suggest that the practice of matching readers to texts may be counterproductive if based on a single	Both indexes used in the study appear to be important in determining the true instructional

	important elements of text complexity. The focus was on quantitative dimensions, which are replicable across research, because no objective standards exist for defining the qualitative or reader-task dimensions of text complexity	cohesion as indicators of text complexity. Both models conceptualize reading comprehension as a strategic and cyclical process of activating and connecting information within the text and the reader's existing knowledge framework.	informational text on high school students' comprehension of causal content in informational texts?" The hypothesis was comprehension performance will be influenced by both readability and cohesion such that significant differences would be apparent between a passage at a challenging readability level with low cohesion and a passage at an easier readability level with high cohesion.	measures. This study looks at both measures of text complexity to measure students' processing capacity and strategic formation of a coherent representation of the text.	the same two informational passages and answered comprehension test items targeting factual recall and inferences of causal content. Group A passages had a challenging readability level and high cohesion; Group B passages had an easier readability and low cohesion; Group C passages had a challenging readability level and low cohesion; and Group D passages had an easier readability and high cohesion. A 2 x 2 between-subjects factorial design with both readability and cohesion as independent variables was utilized.	quantitative dimension. Gauging the complexity of a text by readability alone is problematic. Indexes are based on the notion that words of higher frequency occurring in shorter, simpler sentences should speed processing and facilitate fluent reading, leaving more cognitive resources available for comprehending the text.	level of text because students need to be exposed to more challenging vocabulary and sentence structures to grow as readers and be exposed to precise content in the subject area domain. The causal ratio index was found to be one of the strongest indicators of text complexity in a previous study comparing Coh-Metrix and readability statistics on a larger set of passages.

Note. The study number in the first column refers to the corresponding number in Table 1.

A study was included if it addressed one or more of the focus questions (see Table 3), was published in a peer-reviewed journal or book written by a leader in the literacy field, and was a comparison of reading indices, it presented historical background, or addressed text complexity/text matching issues related to readability indices.

Table 3

Key Questions for Literature Review

1. **Why were readability indices developed?**
2. **What research methods have been used in the past to compare readability indexed?**

3. **From the previous research, what is the treatment effect (indices comparison) on the outcomes?**
4. **What effect do readability indexed have on text complexity issues?**
5. **What is the relationship between readability indices and text-reader matching?**

History

Historically, reading assessments, and the actions that derived from such assessments, were rooted in a political vision for eliminating poverty. Lyndon B. Johnson's Great Society initiative in the mid-1960s led to the Elementary and Secondary Education Act (ESEA) providing children of low income families with provisions for education and created an unprecedented evaluation and reporting mandate (McLaughlin, 1975). Hauptli and Cohen-Vogel (2013) examined the role of the federal government from the Johnson-era through former President Obama and the policy shifts around reading assessment. The following initiatives were analyzed by Hauptli and Cohen-Vogel (2013): Economic Opportunity Act (1964), Elementary and Secondary Education Act (ESEA, 1965), Right to Read (1969), National Reading Improvement Program (education amendments to ESEA of 1974), ESEA Education Amendments (1978), Student Literacy Corp (1988), Augustus F. Hawkins-Robert T. Stafford Elementary and Secondary School Improvement Amendments (1988), National Literacy Act (1991), America Reads Challenge (1996), Reading Excellence Act (1998), National Reading Panel Report (2000), No Child Left Behind (2001), Striving Readers Grants (2005), and Reading for Understanding (2010).

Each of these initiatives were "analyzed around adolescent literacy based on the problems they were intended to solve, the goals they were expected to achieve and the instruments of reform, in order to find evidence of the prolonged policy stability characteristic of policy regimes" (p. 398). Hauptli and Cohen-Vogel (2013) found federal policy rarely, if ever, focused on adolescent (grade 4-8) literacy and "policy stasis was the overarching characterization of the federal government's role in adolescent literacy until a shift occurred just over a decade ago with President

George W. Bush extending the Clinton administration's goal from all students reading by the end of third grade to all students in grades 3-8 reading on grade level and establishing consequences for schools that failed to demonstrate improvement" (p. 399). They isolated two major changes to the regime leading up to No Child Left Behind. The first was the shift from an equity perspective to one of accountability for schools and educators. The second, was the emergence of a power shift in the late 1980s and 1990s from professional educators, toward state agencies and researchers. Hauptli and Cohen-Vogel (2013) focused on the historical policies created for literacy improvement but lacked information on assessment instruments useful for attaining positive results.

Roller, Eller and Chapman (1980) focused on the assessment instrument utilized in the late 1960s around the time of the first federal policies for literacy improvement. The National Assessment of Educational Progress (NAEP) was introduced to study achievement trends in American education. The focus was solely on assessment without regard to theory or use of data to improve outcomes.

As early as the late nineteenth century, the systematic study of text complexity in an exclusively qualitative manner began, focusing on text features that would impact comprehension or text readability (Pearson & Hiebert, 2014). In the early twentieth century, scientific methods were more prevalent in solving educational problems, leading to quantitative methods for describing text comprehensibility. Lively and Pressey (1923) proposed the first formula for readability based on word frequency and sentence length, leading to the introduction of many other formulas. Hiebert and Pearson (2014) found quantitative measures were disputed in research and policy by psychologists (Gardner, 1987) whose attention focused on "understanding the roles of particular text features in cognitive processing of information" (p. 155), and linguists (Davison &

Kantor, 1982) who examined consequences of lexical and syntactic changes on comprehension and processing. However, quantitative measures were being disputed, and the digital age was underway. Hiebert and Pearson (2014) determined "with large databanks, rankings of frequency of words in texts could be gotten in nanoseconds" (p. 156) setting the stage for more sophisticated analyses.

Policy

The introduction of the Common Core State Standards (2010) marked the first time a standards document addressed the issue of text complexity. An entire standard is devoted to increasing capacity with complex texts through a combination of qualitative, quantitative, and reader-task analyses (Hiebert & Mesmer, 2013).

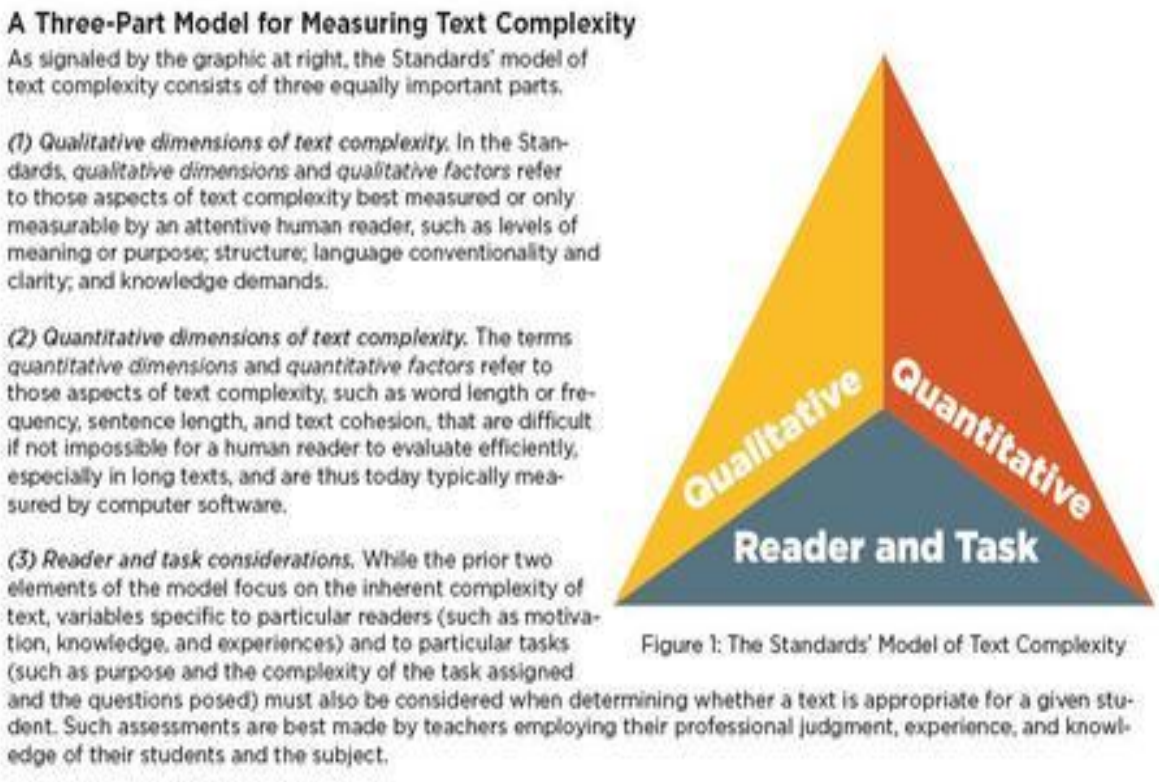


Figure 2: Common Core State Standards Model of Text Complexity

Note. From National Governors Association Center for Best Practices & Council of Chief State

School Officers [NGA & CCSSO]. (2010). *Common Core State Standards: English Language Arts*. Washington DC: National Governors Association for Best Practices & Council of Chief State School Officers.

CCSS claimed to be grounded in research indicating declining text complexity since the 1940s, as noted in Appendix A of the standards:

> In 2006, ACT, Inc., released a report called Reading Between the Lines that showed which skills differentiated those students who equaled or exceeded the benchmark score (21 out of 36) in the reading section of the ACT college admissions test from those who did not. Prior ACT research had shown that students achieving the benchmark score or better in reading—which only about half (51 percent) of the roughly half million test takers in the 2004–2005 academic year had done—had a high probability (75 percent chance) of earning a C or better in an introductory, credit-bearing course in U.S. history or psychology (two common reading-intensive courses taken by first-year college students) and a 50 percent chance of earning a B or better in such a course.
>
> Surprisingly, what chiefly distinguished the performance of those students who had earned the benchmark score or better from those who had not was not their relative ability in making inferences while reading or answering questions related to particular cognitive processes, such as determining main ideas or determining the meaning of words and phrases in context. Instead, the clearest differentiator was students' ability to answer questions associated with complex texts. Students scoring below benchmark performed no better than chance (25 percent correct) on four-option multiple-choice questions pertaining to passages rated as "complex" on a three-point qualitative rubric described in the report. These findings held for male and female students, students from all racial/ethnic groups, and students from families with widely varying incomes. The most important implication of this study was that a pedagogy focused only on "higher-order" or "critical" thinking was insufficient to ensure that students were ready for college and careers: what students could read, in terms of its complexity, was at least as important as what they could do with what they read.
>
> The ACT report is one part of an extensive body of research attesting to the importance of text complexity in reading achievement. The clear, alarming picture that emerges from the evidence, briefly summarized below, is that while the reading demands of college, workforce training programs, and citizenship have held steady or risen over the past fifty years or so, K–12 texts have, if anything, become less demanding. This finding is the impetus behind the Standards' strong emphasis on increasing text complexity as a key requirement in reading (National Governors Association Center for Best Practices & Council of Chief State School Officers [NGA & CCSSO], 2010).

Current research, however, indicates a distinctly different pattern of historical shifts in complexity rather than the simple declines reported by the CCSS (Gamson, Lu, & Eckert, 2013). Gamson, Lu, and Eckert (2013) used four different measures to understand changes in text over

the past century; two of the measures focus on lexical difficulty (LEX and word frequency band [WFB]) and two measures to calculate readability (Dale-Chall readability index) and Mean Length of Sentence. Elementary textbooks published between 1905 and 2004 were analyzed, 187 third grade texts and 71 sixth grade texts. ANOVA was used to determine significant differences in mean between decades. The findings showed a distinctly different pattern of historical shifts in complexity than the simple declines reported by the CCSS. The findings show a steady increase over the past 70 years, disputing the downward trend reported by the CCSS. Text complexity is only one dimension of a robust reading program and any efforts to unnecessarily ratchet up complexity could cause a larger discrepancy in the achievement gap (Gamson, Lu, & Eckert, 2013). Motivation decreases when tasks become too challenging. The findings have implications on policy, research and practice. A broader view of complexity that incorporates text, instruction, and a wide variety of materials is needed, as well as an assessment approach using measures that are less restrictive. Widespread mandates in policy and change in practice without stronger theory and research is likely to have serious implications (Pearson & Hiebert, 2014). According to Hiebert and Mesmer (2013) "when quantitative ranges are connected to a standards document adopted by the legislatures of the vast majority of American states and the accompanying standard indicates that students need to read from the top of a text complexity range, potential for misinterpretation exists" (p. 46).

Readability

Begeny and Greene (2014) characterized readability as "an attribute of written text, commonly defined by factors that theoretically make text more or less difficult to read (e.g., vocabulary, sentence complexity)" (p. 198). To quantify readability, mathematical formulas using semantic and syntactic factors have been derived over the last century (Harrison, 1980).

Readability formulas are unique in construction; each formula consists of a combination of factors and mathematical constants. The combination of factors and the mathematical constants used in the different formulas can vary significantly, even when theoretically consistent (Connatser & Peac, 1999; Harrison, 1980). Factors that are often applied to readability formulas include total words, total sentences, total syllables, number of polysyllabic words, and words from unique vocabulary lists. Readability formulas were originally used to determine text difficulty but have also become a means of modifying materials to a predetermined level (Begeny & Greene, 2014). This practice, which occurs in technical communication, research, and textbook development, can be questionable; yet, is used commonly for text modification to obtain desired readability scores (Connatser & Peac, 1999). Begeny and Greene (2014) stated "the widespread use of readability estimates in education highlights the need to further investigate whether meaningful differences exist between the grade level of the text (defined by readability formulas) and a measure of the actual difficulty level of the text" (p. 199).

Begeny and Greene (2014) investigated readability formulas to determine which (if any) showed an actual correspondence between grade level and difficulty level, when difficulty level is determined by reading performance. Differing grade levels, as determined by eight commonly used readability formulas, were examined to see whether grade levels predicted text difficulty, as determined by oral reading fluency (ORF) scores. In the study, 360 students in second (n = 87), third (n = 83), fourth (n = 96), and fifth (n = 94) grades in 21 different classrooms in an elementary school located in the Southeastern United States participated. Each participant read a set of six DIBELS (Dynamic Indicators of Basic Early Literacy) benchmark passages: two passages below grade level, two passages at grade level, and two passages above grade level. Eight readability estimates for each of the twelve passages were calculated using the computer software program

Readability Studio.

The formulas used to calculate estimates included Dale-Chall, Flesch-Kincaid, FOG, Forcast, Fry, PSK, SMOG, and Spache. Begeny and Greene (2014) demonstrated only one (Dale-Chall formula) of the readability formulas examined in the study was a valid measure of text difficulty for each of its comparisons. The Dale-Chall formula successfully discriminated between the grade level comparisons that were evaluated with the formula (i.e. third vs. fourth grade materials and fourth vs. fifth grade materials). As one of the most commonly used formulas, the Dale-Chall appears to be a relatively reliable formula for gauging general text difficulty across grades 3-5 and findings are consistent with the intended purpose of the formula, to gauge text difficulty around the fourth-grade level and above. The findings reported by Begeny and Greene (2014) suggested most readability formulas may not assist in the selecting of text that is of greater or lesser difficulty, whether the purpose of text selection is for instructional or assessment purposes. Further, although findings showed that several readability formulas seem to be better at differentiating text that is read with higher vs. lower reading abilities, nearly all formulas do not appear to be valid indicators of text difficulty. Only reading fluency was assessed to determine reading difficulty. The elements of comprehension and vocabulary were not considered, therefore limiting the study outcomes. Begeny and Greene (2014) acknowledged readability formulas may vary in appropriateness for certain grade levels due to the unique calculations of each readability formula and the many variables that influence text difficulty.

Gallagher, Fazio, and Gunning (2012) analyzed the disparate variables that contribute to the measures of nine readability formulas, as well as the lack of attention paid to vocabulary, schema, and task considerations. The goal of the study was to determine how several indices compared and whether the indices were a valid measure of various genres of science-based text.

The texts analyzed were science-based and selected from two Canadian publishers. Readability levels were reported by the publishers. A total of 178 passages were chosen and tested using all nine readability indices: (a) Gunning-Fog; (b) Flesch-Kincaid; (c) Fry; (d) Coleman-Liau; (e) Automated Reading Index (ARI); (f) SMOG; (g) Spache; (h) Dale-Chall; and (j) Powers-Sumner-Kearl (PSK). These indices were chosen as recognized measures used by many publishers, as well as being a cross-section of different computational variables.

Mikk (2001) hypothesized that there should be some text characteristics that correlate with the level of knowledge of the text content that a reader has prior to reading a text (e.g., prior knowledge, schema). The goal was to discover text characteristics, the values of which are related to the level of prior knowledge of the text content. Mikk (2001) analyzed 30 texts, all of a scientific nature (e.g., physics, chemistry, astronomy, and biology). The average length of the texts was 166 words. Prior knowledge was established before subjects (n = 350) read the materials. The level of prior knowledge was correlated with the text characteristics and 33 statistically significant coefficients of correlation were found. A formula was calculated using regression analysis in Excel to determine prior knowledge. The formula predicted 35% of the level of prior knowledge. Data confirmed the hypothesis that many characteristics are related to the level of prior knowledge. Readability formulas have some ability to predict prior knowledge and characterize the level of familiarity and complexity of the text content and are not simply measures of linguistic characteristics (Mikk, 2001). Although Mikk (2001) developed a formula to predict the level of prior knowledge, the formula cannot be generalized to other populations or recommended for practical use because the research used only popular scientific texts with a small sample of students.

The readability of science-based texts is inextricably connected to vocabulary and

vocabulary is a strong predictor of text difficulty (Chall & Dale, 1995). Gallagher et al. (2012) point out the focus on behaviorism and multidisciplinary conceptual views of reading as a means of learning by learning theorists. The constructivist perspective has brought focus on the active role of using experiences to build understanding of information through constructive processes to operate, form, elaborate, and test mental structures (Driscoll, 2000).

Gallagher et al. (2012) utilized CCSS policy to focus on text complexity and increased vocabulary demands of science-based texts. The findings of Gallagher et al. (2012) suggested due to the complexity of discipline-specific science vocabulary, prior knowledge is required to comprehend science texts; therefore, readability impacts instructional decision making and appropriate strategy instruction. Curriculum and instruction have not focused on the demands of independently reading informational text, according to the CCSS. Reading expository or nonfiction text requires engaging prior knowledge and an understanding of specific scientific vocabulary. According to Gallagher et al. (2012), "the linguistic features of scientific vocabulary and the need to engage prior knowledge present challenges to the comprehension of science-based text, therefore reading comprehension strategies (e.g., word study) should be offered to enhance fluency" (p. 108). Reading proficiency can also be positively impacted through explicit instruction in morphological analysis (e.g., word study). Considerable variance among the nine formulas suggest the commonly used measures are not perfect predictors of readability. Several of the formulas are based on high frequency word lists (e.g., Dale-Chall, Spache) which do not include scientific words, causing an underestimation of readability levels, therefore limiting the study outcomes. Another limitation of the Gallagher et al. (2012) study was the narrow genre of literature. Including texts from a variety of genres and levels may produce a more accurate outcome.

Shymansky and Yore (1979) noted “reading skills are no less critical in reading science topics than they are in reading any other materials. In fact, the vocabulary peculiar to science, content loading, sentence structure, the use of symbols, graphics, directions, and if-then statements, make science reading skills more difficult and more critical” (p. 670). Using the Fry Readability approach and a 10% random sample of all reading materials from each grade level within a program and collecting readability data on six popular elementary science textbook series, Shymansky and Yore (1979) found the average reading level was observed to progress generally throughout the graded texts within each series, but each series was marked by gaps or regressions in the reading levels.

The second interesting feature revealed by the analyses was that “the commonly reported average masks extreme variation in reading levels with texts supposedly specified for a given grade” (p. 672). Shymansky and Yore (1979) believed interest in science is complemented by reading skills, not dependent on or limited by such skills. Science texts require strong background knowledge to enhance understanding and one series may not fit the needs of every classroom. The authors stated “books and reading are part of the search and organization of science knowledge and need to be included in the science environment” (p. 676) however, science is a subject of exploration, experimentation, and creative action and should be approached in a dynamic manner, not as a passive activity.

Text Readability Formulas and Text Simplification

Traditional readability formulas such as Flesh Reading Ease (Flesch, 1948) have been accepted by the educational community because they are easily associated with text simplification (Chall & Dale, 1995). However, traditional formulas have been criticized by both first language (L1) and second language (L2) researchers for the inability to take account of deeper levels of text

processing (McNamara, Kintsch, Butler-Song, & Kintsch, 1996). Several L1 validation studies (Crossley, Greenfield, & McNamara, 2008; Crossley, Allen, & McNamara, 2011; Graesser, McNamara, Louwerse, & & Cai, 2004; McNamara, Kintsch, Butler-Song, & Kintsch, 1996) have found the predictive validity of traditional readability formulas to be high, correlating with observed difficulty in the $r = 0.8$ range and above (Chall & Dale, 1995). Traditional readability formulas are generally not based on theories of reading or comprehension building, but on tracing statistical correlations (Crossley, Greenfield, & McNamara, 2008), "therefore, the credibility accorded to them is strictly based on their demonstrated predictive power" (p. 477). The attraction of simple, mechanical assessments has led more commonly to the use of traditional formulas for assessing all sorts of text designed for a wider variety of reading situations, rather than for the situations the formulas were created (Crossley, Greenfield, & McNamara, 2008).

In psycholinguistics, reading is considered a multicomponent skill operating at different levels of processing: lexical, syntactic, semantic, and discoursal (Just & Carpenter, 1987; Koda, 2005). Reading is a skill that enables the reader to make links between features of the text and stored representations, not only linguistic, but world knowledge, knowledge of text genre, and the discourse model which the reader has built up of the text (Crossley, Greenfield, & McNamara, 2008). When there is more concern with comprehension, assessment must go deeper than surface readability features to explain interactions with the text, including measures of text cohesion and meaning construction (Gernsbacher, 1997; McNamara, Kintsch, Butler-Song, & Kintsch, 1996) and encoding comprehension as a multilevel process (Koda, 2005). Based on the findings of several L2 studies (Carrell, 1987; Brown, 1998) researchers determined the formulas used generally depended on surface-level sentence difficulty indices, such as the number of words per sentence and surface-level word difficulty indices such as syllables per words (Brown, 1998;

Crossley, Greenfield, & McNamara, 2008). Carrell (1987) was critical of traditional readability formulas for not accounting for reader characteristics or for text-based factors such as syntactic complexity, rhetorical organization, and propositional density. Brown (1998) was also concerned that traditional readability formulas failed to account for L2 reader-based variables. In addition, it was argued readability formulas for L2 readers needed to be sensitive to the type, function, and frequency of words and to word redundancy within the text (Crossley, Greenfield, & McNamara, 2008).

Crossley et al. (2008) questioned whether constructing a new model incorporating at least some variables that reflect the cognitive demands of the reading process would yield a new, more universally applicable measure of readability. Psycholinguistic theory frames the idea that a readability measure needs to take appropriate account of the role of working memory and the constraints it imposes in terms of propositional density and complexity. The theoretical goal of English readability research is to devise a measure that has strong construct validity as well as predictive validity. Graesser, McNamara, Louwerse, and Cai (2004) reported recent advances in numerous disciplines have made it possible to computationally investigate various measures of text and language comprehension that supersede surface components of language and instead explore deeper, more global attributes of language. A synthesis of the advances in these areas has been achieved in Coh-Metrix, a computational tool that measures cohesion and text difficulty at various levels of language, discourse, and conceptual analysis (Crossley, Greenfield, & McNamara, 2008). The purpose of the study was to examine if certain Coh-Metrix variables can improve the prediction of text readability, specifically the examination of variables that more accurately reflect the cognitive processes involved in skilled L2 reading. Crossley et al. (2008) analyzed a corpus of 32 academic reading texts to test the hypothesis that linguistic variables

related to cognitive processing and cohesion could better predict text readability. Mean length of the texts was 269.28 words and mean number of sentences per hundred words was 7.10. Three independent variables were selected to correspond to three general levels into which many psycholinguistic accounts divide reading. These variables were lexical recognition, syntactic parsing, and meaning construction (Just & Carpenter, 1987; Perfetti, 1985; Crossley, Greenfield, & McNamara, 2008).

A statistical analysis of the data was conducted using R^2, Stein's unbiased risk estimate (SURE), and *n*-fold cross validation. Crossley et al. (2008) believed the three models were important to analyze for the purposes of generalization. If the models were significant, by extension, it could be argued that the readability formula would be successful in textual genres other than academic texts. Based on the findings of the study, Crossley et al. (2008) stated the Coh-Metrix formula has a clear superiority in accuracy to all other indices and has an "impact on reading difficulty not of individual structures but of syntactic variety" (p. 489). The Coh-Metrix formula allows for "a shift in perspective from considering the text to considering the reader" (p. 489). Although Crossley et al. (2008) provided a practical perspective for the L2 learner, the texts analyzed were all from secondary textbooks and did not provide a separate or comparable set of primary texts or genre variety. Also, the passage set was relatively small. A larger set may provide more opportunity for generalization of findings.

As a follow-up study to Crossley et al. (2008), Crossley, Allen, and McNamara (2011) conducted a study to examine readability formulas' potential for evaluating a corpus of intuitively simplified news texts (Allen, 2009). An analysis of the differences between traditional readability formulas and readability formulas based on psycholinguistic and cognitive accounts of text processing, i.e., the Coh-Metrix L2 Reading Index, (Crossley, Greenfield, & McNamara, 2008)

were analyzed to examine the potential for readability formulas to distinguish among levels of simplified texts that have been modified using intuitive approaches in order to evaluate the readability formulas' construct validity and to better understand intuitive text simplification. Crossley et al. (2011) hypothesized "the Coh-Metrix L2 Reading Index will better reflect the intuitive text simplification processes…because such processes account for comprehension factors, meaning construction, decoding, and syntactic parsing" (p. 85). A corpus of 300 non-academic news texts were analyzed using Flesch-Kincaid Grade Level, Flesch Reading Ease, and Coh-Metrix L2 indexes. Crossley et al. (2011) conducted a series of ANOVA to examine if each readability formula demonstrated a significant difference between the levels of reading texts.

To test the accuracy of the readability formulas to distinguish between the levels of L2 reading texts, a discriminant function analysis was conducted. Cohen's Kappa was used to measure agreement between the actual text type and that assigned by the discriminant function analysis model. Crossley et al. (2011) demonstrated that a readability formula based on psycholinguistic and cognitive models of reading, and traditional readability formulas can significantly classify texts based on levels of intuitive text simplification. However, accuracy scores were significantly higher for the Coh-Metrix L2 Reading Index, indicating this index was better able to discriminate between the different levels of texts. The variables used in the Coh-Metrix L2 Reading Index were more closely aligned to the intuitive text processing for simplifying reading texts than those provided by traditional readability formulas.

Traditional readability formulas did classify texts into appropriate categories at a level above chance. Due to the moderate degrees of successful classifying of the Coh-Metrix, as well as its accuracy in comparison to traditional formulas, the findings of Crossley et al. (2011) may be extendible to genres outside academic texts. This could lead to greater accessibility for L2 learners.

Crossley et al. (2008) pointed out larger reading studies need to be conducted to improve the Coh-Metrix L2 Reading Index and allow for the inclusion of additional variables and "the criteria in such studies should include both authentic and simplified texts" (Crossley, Allen, & McNamara, 2011, p. 98). This would allow for further assessment of validity of advanced readability formulas for predicting text comprehensibility.

Text Complexity

Text complexity remains a factor to be analyzed regarding reading comprehension and text matching. Mesmer, Cunningham, and Hiebert (2012) defined text complexity as the elements within the text that can be manipulated and studied. Features of complexity include the number of unfamiliar words and sentences of greater writing sophistication (Reed & Kershaw-Herrara, 2016). The three-part model (see Figure 2) to evaluating text complexity involves qualitative dimensions (e.g., levels of meaning, schema), reader and task considerations (e.g., motivation, knowledge, experiences, and purpose of the assignment) and quantitative dimensions (e.g., readability and cohesion).

The first two dimensions are described as requiring informed decisions regarding the reader (Hiebert & Mesmer, 2013), however, both lack extant research on the reliability or validity of such decision-making processes or the resulting designations of text (Reed & Kershaw-Herrara, 2016). Quantitative measures such as readability have had declining visibility in education research in the past 20 years (Wray & Janan, 2013). Wray and Janan (2013) recognized the CCSS has had a global effect on text complexity. Reading instruction needs to take place at all levels and in all content areas. It was determined that the process of reading has moved from describing a process of gaining meaning from a text to one of creating meaning through interaction with a text. The implications of the study indicated deliberate policies and strategies are needed to highlight the importance of

increasingly complex texts. Wray and Janan (2013) focused on all three dimensions of readability as they relate to text complexity yet failed to provide a solution to the problem most prevalent in relation to reading, namely comprehension and motivation.

Reed and Kershaw-Herrara (2016) conducted a study to examine the role of quantitative dimensions of text complexity and the effects of these dimensions on comprehension. High school seniors (n = 103) were randomly assigned to 4 groups. Each group read versions of the same two informational passages and answered comprehension test items targeting factual recall and inferences of causal content. Group A passages had a challenging readability level and high cohesion; Group B passages had an easier readability and low cohesion; Group C passages had a challenging readability level and low cohesion; and Group D passages had an easier readability and high cohesion. A 2 x 2 between-subjects factorial design with both readability and cohesion as independent variables was utilized.

The hypothesis of the study was "comprehension performance would be influenced by both readability and cohesion such that significant differences would be apparent between a passage at a challenging level with low cohesion and a passage at an easier readability level with high cohesion" (p. 79). No significant differences in prior comprehension abilities or prior knowledge of passage content were found based on a one-way analysis of variance (ANOVA). Readability level had a moderate effect on comprehension when passages had low cohesion. This was consistent with research that analyzed the dynamic elements of reader, text, and activity (Snow & Sweet, 2003). The findings of Reed and Kershaw-Herrara (2016) lend further support to the idea that text matching may be counterproductive if based on a single quantitative dimension (Hiebert & Mesmer, 2013; National Governors Association Center for Best Practices & Council of Chief State School Officers [NGA & CCSSO], 2010). Although current recommendations are to use a

multifaceted approach to evaluating text complexity, available concrete guidance is limited to suggesting how readability be interpreted, used and incorporated into the instructional decision-making process (Begeny & Greene, 2014; Mesmer, Cunningham, & Hiebert, 2012; National Governors Association Center for Best Practices & Council of Chief State School Officers [NGA & CCSSO], 2010; Reed & Kershaw-Herrara, 2016). Deep comprehension requires an integration of new information with prior knowledge (Guthrie, et al., 2006; Just & Carpenter, 1987; Shanahan, Fisher, & Fray, 2012). This study was limited to informational passages with similar organizational structures, thus it could not be generalized to other types of reading passages. However, the findings did suggest that gauging the complexity of a passage by readability alone is problematic, thus suggesting a need for analysis of cohesion.

CHAPTER 3 Methodology

Design and Sample

An analysis of narrative and expository texts deemed appropriate for grades 1-5 by the publisher, as well as a leveling system created by Fountas and Pinnell (2001), will be compared using readability indices. The target population will be all narrative and expository texts at a grade 1-5 reading level and the accessible population will be those texts that are available within local schools, libraries, and private collections. Non-probability sampling will be used to identify a convenience sample of 30 narrative and 30 expository texts at each grade level, taken from a local elementary guided reading collection, local libraries, and personal collection of texts.

The total sample size will be N = 300. A 100-word passage from each text will be arbitrarily selected. Each passage will be analyzed using the following eight readability indexes: Flesch-Kincaid Grade Level index (Flesch, 1948), Flesch Reading Ease formula (Flesch, 1951), Fry Readability graph (Fry, 1968; Fry, 1975), Dale-Chall Readability formula (Dale & Chall, 1948), Spache Readability formula (Spache, 1953), Gunning Fog index (Gunning, 1968), the SMOG Grading Plan (McLaughlin, 1969) and the Coh-Metrix L2 index (Graesser, McNamara, Louwerse, & Zhiquiang, 2004). These formulas represent a cross-section of different computational variables including: number of sentences, syllables, number of characters, multi-syllabic words, and vocabulary complexity (Gallagher, Fazio, & Gunning, 2012). Table 4 provides the formulas used to calculate each of the readability indices used in this study.

Table 4

Computational Formulas for Reading Indexed

Formulas	Mathematical Computation	Notes
Flesch-Kincaid	0.39 x (W/S) + 11.8 x (SY/W) – 15.59	S-total sentences SY-total syllables W-total words

Flesch Reading Ease	206.835 – (1.015 x W/S) – (84.600 x SY/W)	S-total sentences SY-total syllables W-total words
Fry	Count the number of sentences and the number of syllables in a 100-word passage. Plot a dot on the Fry Readability Graph where the two variables intersect. The area where the dot is plotted signifies the approximate reading grade level.	
Dale-Chall	(W/S x 0.0496) + (DW/W x 100 x 0.1579) + 3.6365	DW-total difficult words (based on the 3000 Dale-Chall word list) S-total sentences W-total words
Spache	(0.141 x (W/S)) + (0.086 x (UDW/W) x 100) + 0.839	S-total sentences UDW-total unique difficult words not in the Spache Word List W-total words
Gunning-Fog	0.4 x ((W/S) + (PSY/W x 100))	PSY-total polysyllabic words (words with 3 or more syllables) S-total sentences W-total words
SMOG	$3.1291 + (1.043 \text{ x } \sqrt{(\frac{PSY}{S} * 30)}\ )$	PSY-total polysyllabic words (words with 3 or more syllables) S-total sentences
Coh-Metrix L2	-45.032 + (52.230 x CWO) + (61.306 x SSS) + (22.205 x CELEX)	CWO-content word overlap SSS-sentence syntax similarities CELEX-word frequency index

Note. Adapted from "Varying Readability of Science-Based Text in Elementary Readers: Challenges for Teachers," by T. L. Gallagher, X. Fazio, and T. G. Gunning, 2012, *Reading Improvement*, pg. 112.

The Bland-Altman method will use the data gathered from each of the readability indices to determine agreement between each of the indices.

Agreement and Bland-Altman Method

Correlation and hypothesis testing are often used methods for determining agreement between two measures (e.g., Pearson Product-Moment coefficient, linear regression, multiple regression, discriminant function analysis, and *t* – tests). An established method to quantify agreement between two quantitative measurements by constructing limits of agreement was developed by Altman and Bland (1983; see also Giavarina, 2015).

The original goal was to detect bias, either fixed or proportional, between methods. Ludbrook (2010) stated "fixed bias means that one set of measurements gives values that are consistently higher (or lower) than the other, across the whole range of measurement (p. 144). The parameters α and β quantify the bias of the measurement system relative to the reference system. The fixed bias is referred to as α since it increases or decreases the average measurement of the second system by a fixed amount, and β refers to the proportional bias because it biases the second system's measurements by an amount that is proportional to the true values (Stevens, Steiner, & MacKay, 2015). This method was not meant to calibrate one method against another therefore, it does not indicate an advantage of applying one method over another. The two methods do not need to be identical to be used interchangeably if they provide similar measurements, in other words, the systems agree. Moen (2016) stated the population from which the two measures are drawn should not be an issue for determining agreement unless there is a problem (bias or instrument imprecision) with the measurement devices. This method has most commonly been used in the fields of medicine and science.

The limits of agreement approach characterizes the agreement between two measurement systems by evaluating the difference between measurements made on the same subject (Stevens, Steiner, & MacKay, 2015). The limits of agreement are calculated using the mean and the standard

deviation (s) of the difference between two measurements. To check the assumption of normality of differences and other characteristics, a graphical representation is used (Giavarina, 2015). The resulting graph is a scatterplot XY, in which the Y-axis expresses the difference between the two paired measurements (A – B) and the X-axis shows the average of the measures ((A + B) / 2).

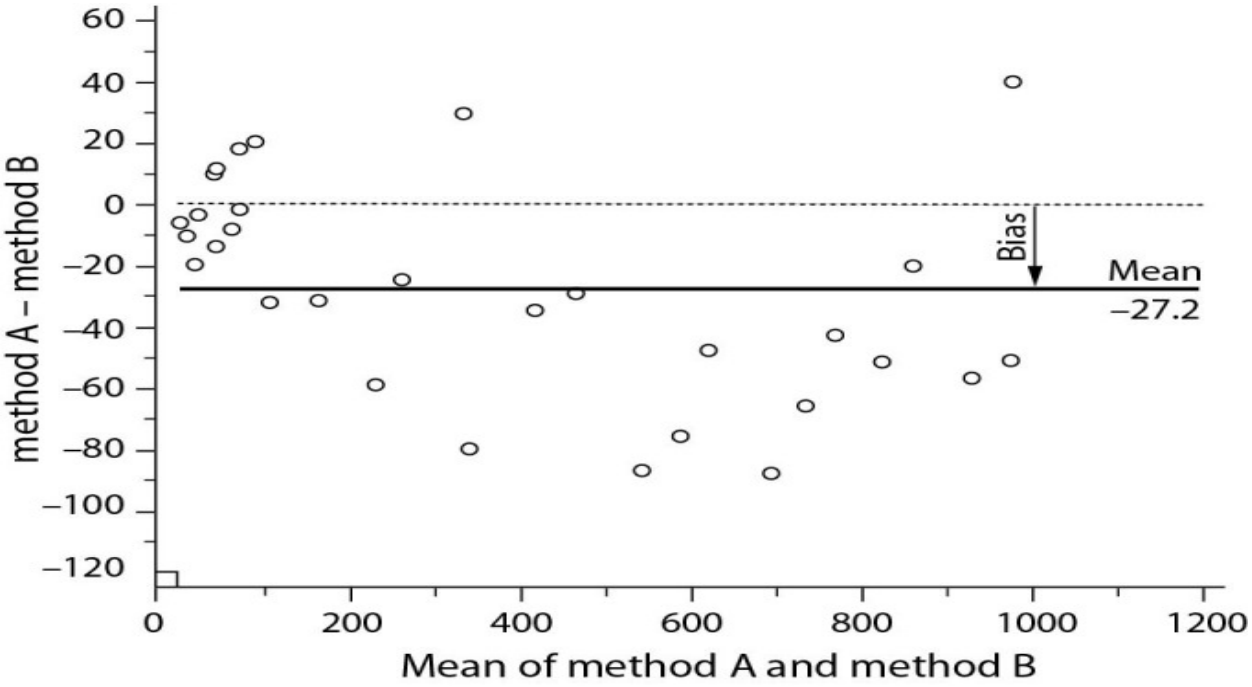


Figure 3: Sample Bland-Altman Plot

Note. Adapted from PubMed Central. Retrieved October 9, 2017 from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4470095/bin/bm-25-141-f2.jpg

Bland and Altman (1983) recommended that 95% of the data points should lie within ±2*s* of the mean difference, if the differences are normally distributed (Gaussian).

The Bland-Altman plot represents every difference between two paired methods against the average of the measurement and plotting difference against mean allows for investigating any possible relationship between measurement error and the true value (Giavarina, 2015). The limits of agreement will shift with each new sample added to the analysis (Altman & Bland, 1983), therefore, implications derived from a Bland-Altman plot are subjective, which could lead to error

in the conclusion that interchangeability exists where a statistical test may demonstrate that it does not (Moen, 2016). It is suggested by Stevens et al. (2015) to check the assumptions of normal distribution and that the repeatability is constant across the range of true values by using a QQ-plot and a repeatability plot. Non-parametric tests of distribution, such as Shapiro-Wilks or Kolmogorov-Smirnov test, can also be used to determine normal distribution of the sample (Giavarina, 2015). It is also suggested by Giavarina (2015) that the best way to use the Bland-Altman plot would be "to define *a priori* the limits of maximum acceptable differences, or the limits of agreement expected based on analytically relevant criteria, and then to obtain the statistics to see if these limits are exceeded, or not" (p. 146).

Reliability of Readability Indices

Reliability has been widely examined throughout the history of readability indices. Readability measurement is a research tradition that dates back to the beginning of the 20th century when the formulas produced purported to estimate the relative difficulty of a passage by a combination of factors (Stahl, 2003). Readability formulae are rough guides of text difficulty, with most having large standard errors of measurement of a full grade level or more (Chall & Dale, 1995; Zakaluk & Samuels, 1988).

Hintze and Christ (2004) reported that readability estimates could be used to control for passage readability which resulted in significantly smaller measurement of errors (i.e., lower standard error and standard error of estimates). The attraction of simple, mechanical assessments has led to the common use of readability indexes for assessing a wide variety of texts, readers, and reading situations beyond those for which the formulas were created (Crossley, Allen, & McNamara, 2011). Traditional readability formulas are simple algorithms that measure text readability based on sentence length and word length and have been found to successfully predict

first language (L1) text readability (Crossley, Allen, & McNamara, 2011). However, discourse analysts (Davison & Kantor, 1982) have widely criticized readability indices as being weak indicators of comprehensibility and for not closely aligning with the cognitive processes involved in text comprehension (Crossley, Allen, & McNamara, 2011). A lack of reliability has been noted by others, such as Crossley et al. (2008) who contend that formula variables relating to cognitive reading processes (e.g. decoding, syntax, meaning) contribute significantly to better readability measures than the surface variables used in traditional formulas. Similarly, Bailin and Grafstein (2001) stated traditional readability indices fall short on considering elements such as grammar, style, background knowledge, and textual characteristics. The variances among different indices indicates that they are not perfect predictors of readability estimates; however, they offer probability statements and estimates of text difficulty (Gallagher, Fazio, & Gunning, 2012). The notion that no formula yields an exact readability level has been supported by Fitzgerald (1980) who reported great variation in formula scores due to sampling methods. Formulas may yield unreliable estimates from small numbers of samples and generally are reliable only when the samples include the entire text using continuous 100-word passages from the beginning to the end of the text (Rush, 1985).

Reliability lies within the consistency of the readability index to measure the constructs it purports to measure. As such, a readability index that demonstrates adequate reliability with one sample (i.e. text passage) may not demonstrate the same reliability with a different sample due to the variable text features. Reliability also varies from one readability index to all other indexes. For example, Ricker (1978) reported the Fry index and the SMOG formula produced readability levels that appear to be almost two grade levels apart; the SMOG formula yielded scores two grade levels higher than the Fry index. Therefore, caution needs to be used in accepting average

readability scores for a text as a reliable indicator of readability (Shymansky & Yore, 1979). Although each index uses a specific combination of weighted factors, Klare's (1974-1975) exhaustive review of readability, along with the more recent Chall and Dale (1995) review, clearly established that the formulas using word length or difficulty and sentence length are sufficient to make relatively good predictions about readability. Klare (1963, 1984) pointed to the Dale-Chall readability formula as the most reliable and valid of the formulas (Meyer, 2003). The findings of Crossley et al. (2008) suggested that the incorporation of variables more closely aligned to psycholinguistic and cognitive reading processes improves the predictive ability of readability formulas and better assesses L2 text comprehensibility. Traditional formulas have also been faulted for use with L2 texts because they do not account for reader characteristics or text-based features such as syntactic complexity, rhetorical organization, and propositional density (Carrell, 1987). The inclusion of the Coh-Metrix formula in this study incorporates variables such as syntax, content and comprehension.

Convenience notwithstanding, all methods of readability analysis must be used knowledgeably and interpreted cautiously (Rush, 1985). Klare (1984, p. 730) stated to increase reliability and validity of readability indices, users of readability formulas should:

- Realize that different formulas produce variant scores for the same passage
- Consider formulas to be screening devices
- Take large random samples of text to be evaluated, and for research purposes, analyze the entire text
- Recognize that for materials intended for higher levels where content is important, formulas are poorer predictors
- Recognize that materials intended for training purposes are naturally more difficult than

other kinds of texts

- Consider the effects of motivation and prior knowledge on comprehension
- Not rely on formulas alone but include expert judges
- Not use formulas as part of writing

Data Analysis

All reading passages will be manually typed or scanned into Microsoft Word for analysis. Passages that are manually typed will be proofread by a third party. Scanned passages will be proofread by the author. The texts will be entered into two websites capable of computing the eight readability indexes. The Readability Formulas website (www.readabilityformulas.com) calculates seven measures of readability including the following indices: Flesch-Kincaid Grade Level, Flesch Reading Ease, Fry Readability graph, Dale-Chall, Spache, Gunning-Fog, and SMOG. The Coh-Metrix website (www.cohmetrix.com) calculates three measures of readability including the following indices: Flesch-Kincaid Grade Level, Flesh Reading Ease, and Coh-Metrix L2. These websites were vetted by comparing sample results from each site, particularly Flesch-Kincaid Grade Level and Flesh Reading Ease because both sites compute these indexes. Also, the formulas used to compute each readability index on the Readability Formulas site and Coh-Metrix site were compared to the formulas listed in Table 4 and found to be identical. Each passage will be analyzed with all eight readability indices to produce a score; or reading level. It is important to qualify that indexes recommended for use with text at a Grade 3 level or lower (i.e. Spache) and indexes recommended for use with text at a Grade 4 level or higher (i.e. Dale-Chall, SMOG) will be used with all levels of text.

Descriptive statistics (i.e. mean, standard deviation) on all data will be calculated using Microsoft Excel. These statistics will be used to determine agreement between each comparison

set (see Table 5) as required by the Bland-Altman method. A Bland-Altman plot will be created for each pair of quantitative measures to assess interchangeability of readability indices. A maximum acceptable difference for each readability index comparison will be one and one-half (1.5) grade levels, as determined through the calculated limits of agreement. Microsoft Excel will be used to calculate individual plot points and to create a Bland-Altman plot for each comparison set. A total of 28 plots will be created and analyzed.

Table 5

Paired Readability Indices to Determine Agreement Using Bland-Altman Plots

Readability Index Groupings
1. **Flesch-Kincaid Grade Level and Flesch Reading Ease**
2. **Flesch-Kincaid Grade Level and Dale-Chall**
3. **Flesch-Kincaid Grade Level and Gunning Fog**
4. **Flesch-Kincaid Grade Level and SMOG**
5. **Flesch-Kincaid Grade Level and Fry Readability Graph**
6. **Flesch-Kincaid Grade Level and Spache**
7. **Flesch-Kincaid Grade Level and Coh-Metrix L2**
8. **Flesch Reading Ease and Dale-Chall**
9. **Flesch Reading Ease and Gunning Fog**
10. **Flesch Reading Ease and SMOG**
11. **Flesch Reading Ease and Fry Readability Graph**
12. **Flesch Reading Ease and Spache**
13. **Flesch Reading Ease and Coh-Metrix L2**
14. **Dale-Chall and Gunning Fog**
15. **Dale-Chall and SMOG**

16. **Dale-Chall and Fry Readability Graph**
17. **Dale-Chall and Spache**
18. **Dale-Chall and Coh-Metrix L2**
19. **Gunning Fog and SMOG**
20. **Gunning Fog and Fry Readability Graph**
21. **Gunning Fog and Spache**
22. **Gunning Fog and Coh-Metrix L2**
23. **SMOG and Fry Readability Graph**
24. **SMOG and Spache**
25. **SMOG and Coh-Metrix L2**
26. **Fry Readability Graph and Spache**
27. **Fry Readability Graph and Coh-Metrix L2**
28. **Spache and Coh-Metrix L2**

CHAPTER 4 Results

Unintended Findings

A total of 300 reading passages were typed into Microsoft Word for analysis using eight readability indexes. Each reading passage was proofread by two readers. The first proofreading was completed by the researcher and the second proofreading was completed by an independent reader. The passages were then analyzed using www.readabilityformulas.com and www.cohmetrix.com. Each passage received eight individual scores; one for each readability index. Bland-Altman plots were created in Microsoft Excel for each of the twenty-eight (28) comparison sets found in Table 5. During the course of the analyses, it was determined that two of the readability indexes did not measure the same constructs as the other six. Therefore, it was necessary to eliminate Flesch Reading Ease and Coh-Metrix for this study resulting in fifteen (15) comparison sets instead of twenty-eight (28). Also, it was determined that several of the reading passages created outliers that skewed the data. Those reading passages were eliminated from the analyses for accuracy. The remaining readability indexes included Flesch-Kincaid Grade Level, Fry Readability Graph, Dale-Chall, Spache, Gunning Fog, and Smog. Table 6 shows the sample sizes for each grade level and genre that were used in the data analyses after removing the outliers that did not fit into the Grade 1-5 sampling. A total of 244 reading passages were used in the final analyses.

Analysis

Fifteen comparisons were analyzed using Bland-Altman plots, percentage error and correlation. The comparisons were: Flesch-Kincaid Grade Level-Fry Graph, Flesch-Kincaid Grade Level-Dale-Chall, Flesch-Kincaid Grade Level-Spache, Flesch-Kincaid Grade Level-Gunning Fog, Flesch-Kincaid Grade Level-Smog, Fry Graph-Dale-Chall, Fry Graph-Spache, Fry Graph-

Gunning Fog, Fry Graph-Smog, Dale-Chall-Spache, Dale-Chall-Gunning Fog, Dale-Chall-Smog, Spache-Gunning Fog, Spache-Smog, and Gunning Fog-Smog. The difference was calculated for each pair and analyzed for normality in IBM SPSS Statistics 25 using the Shapiro-Wilk test and QQ plots. Raw data found to be normal were utilized to calculate mean and difference for each of the data points in the analysis. When the raw data were found to be heteroscedastic, instead of computing the difference between the data points, the ratio of the data sets were computed and used for the Bland-Altman plot, as noted in Bland and Altman (1999, pg. 145).

Table 6

Reading Passage Sample Sizes

Grade	Fiction (*n*)	Non-Fiction (*n*)
1	29	18
2	30	30
3	26	34
4	18	29
5	13	17
Total (*n*)	116	128

Bias and standard deviation were calculated from the mean and difference, or ratio. These statistics were then used to calculate the limits of agreement (LoA), both upper and lower. The spread of the LoA was calculated by finding the difference between the upper and lower limits of agreement. When proportional error was evident in the Bland-Altman plot, the percentage error was calculated. The percentage error is the proportion between the magnitude of measurement and the error in measurement (Hanneman, 2008). Hanneman (2008) indicated the Bland-Altman plot allows for visualization of proportional error but due to bias and repeatability estimates

being computed across all data points, the proportional error may not be visible in the estimate, however calculating the percentage error remedies the issue. The percentage error was calculated by dividing the spread of the limits of agreement by the average for the measurements obtained by the established method.

The correlation coefficient was calculated in Microsoft Excel to determine if a predictable relationship exists between two instruments that purport to measure estimated grade level. The readability comparison sets that were found to have high correlation were:

- Flesch-Kincaid Grade Level vs. Fry Graph (Fiction, r = .902; Non-Fiction, r = .885)
- Flesch-Kincaid Grade Level vs. Spache (Fiction, r = .740; Non-Fiction, r = .600)
- Flesch-Kincaid Grade Level vs. Gunning Fog (Fiction, r = .857; Non-Fiction, r = .823)
- Flesch-Kincaid Grade Level vs. Smog (Fiction, r = .712; Non-Fiction, r = .776)
- Fry Graph vs. Gunning Fog (Fiction, r = .860; Non-Fiction, r = .783)
- Fry Graph vs. Smog (Fiction, r = .659, Non-Fiction, r = .727)
- Gunning Fog vs. Smog (Fiction, r = .708; Non-Fiction, r = .905)

For each comparison of data sets, it was determined that a sampling of grade level and genre would be used to evaluate interchangeability with Bland-Altman plots. Not all grade levels of fiction and non-fiction were analyzed. Three grade levels/genres were randomly selected for each comparison. Each of the Bland-Altman plots broken out by grade and genre are included in Appendix A. Although agreement was ultimately determined based on the preceding sampling, an analysis of each comparison set by genre including all grades 1-5 was also conducted and Bland-Altman plots were constructed. These plots are included in Appendix B.

Spache vs. Gunning Fog

The first data set comparison assessed the agreement between Spache and Gunning Fog.

Five data sets were analyzed for this comparison: Fiction-all five (5) grade levels, Non-Fiction-all five (5) grade levels, Fiction-Grade 3, Non-Fiction-Grade 2, and Non-Fiction Grade 4. Table 7 includes a breakdown of each comparison.

All comparison sets were found to have a normally-distributed set of differences based on the Shapiro-Wilk test, allowing for analysis of the raw data. No ratio transformations were performed.

The bias also represents the average difference between the two measures. The maximum difference set *a priori* was one and one-half grade levels (1.5). The comparisons that fall within this measure and appear to have agreement are Fiction Grade 1-5 and Non-Fiction Grade 2. Non-Fiction Grade 2 has a relatively small correlation coefficient of r = .147 and a large percentage error of 0.97. Although the larger sample size of the Fiction Grade 1-5 (n = 116) appears to effect agreement, it is not validated by the Non-Fiction Grade 1-5 comparison which has an even larger sample size (n = 128). There appears to be agreement between Spache and Gunning Fog readability indexes when the sample size is large, and the text genre is fiction.

Table 7

Spache vs. Gunning Fog

	Fiction Grade 1-5	**Non-Fiction Grade 1-5**	**Fiction Grade 3**	**Non-Fiction Grade 2**	**Non-Fiction Grade 4**
Mean (Bias)	-1.36293	-1.91172	-1.56154	-1.14	-2.8069
SD	1.13846	1.396769	0.936836	0.85242	1.322857
Upper LOA	0.868451	0.825949	0.27466	0.530744	-0.2141
Lower LOA	-3.59341	-4.64939	-3.39774	-2.81074	-5.3997
Spread LOA	4.4628	5.4753	3.672	3.3415	5.1856

Percentage error	n/a*	n/a*	0.934	0.97	n/a*
Correlation	0.63	0.38	-0.127	0.147	-0.34

**Note: percentage error not appropriate possibly due to extreme outliers*

Figures 4-8 contain the Bland-Altman plots for each of the Spache-Gunning Fog comparisons.

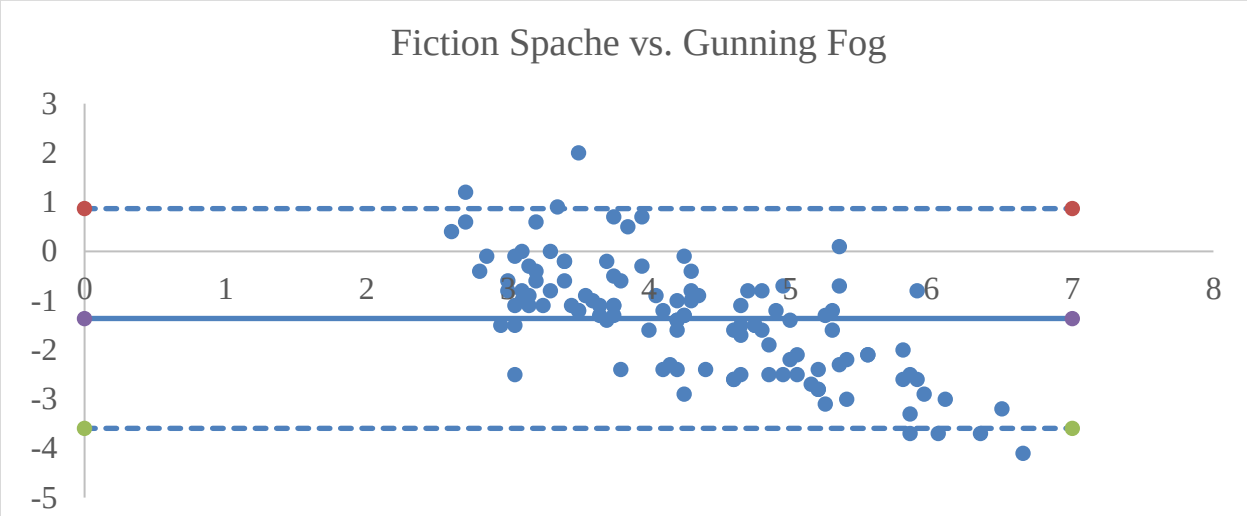


Figure 4. Fiction Grade 1-5 Spache-Gunning Fog Bland-Altman Plot

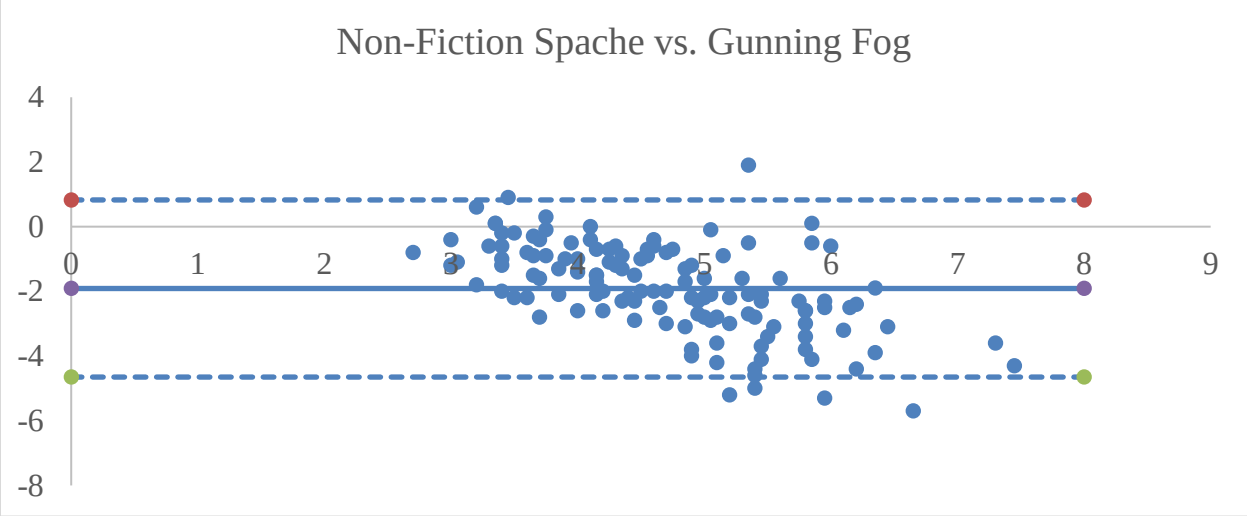


Figure 5. Non-Fiction Grade 1-5 Spache-Gunning Fog Bland-Altman Plot

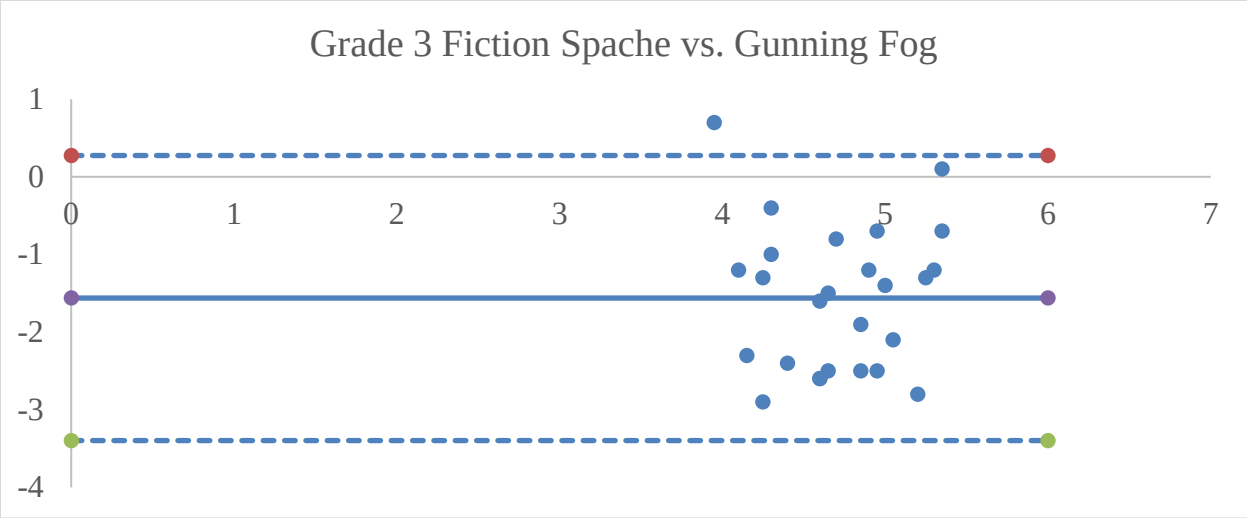


Figure 6. Fiction Grade 3 Spache-Gunning Fog Bland-Altman Plot

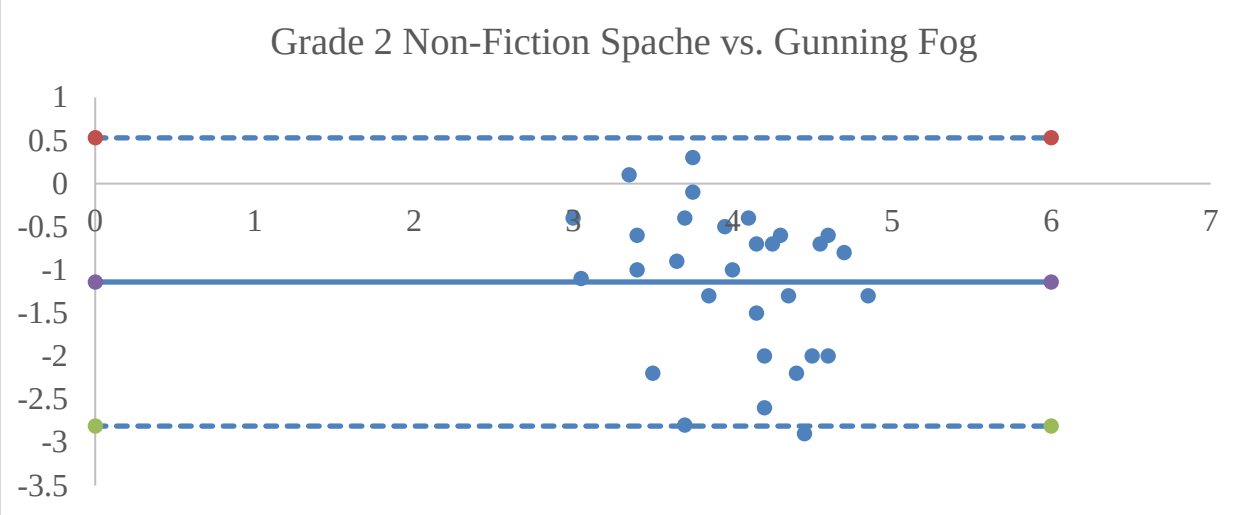


Figure 7. Non-Fiction Grade 2 Spache-Gunning Fog Bland-Altman Plot

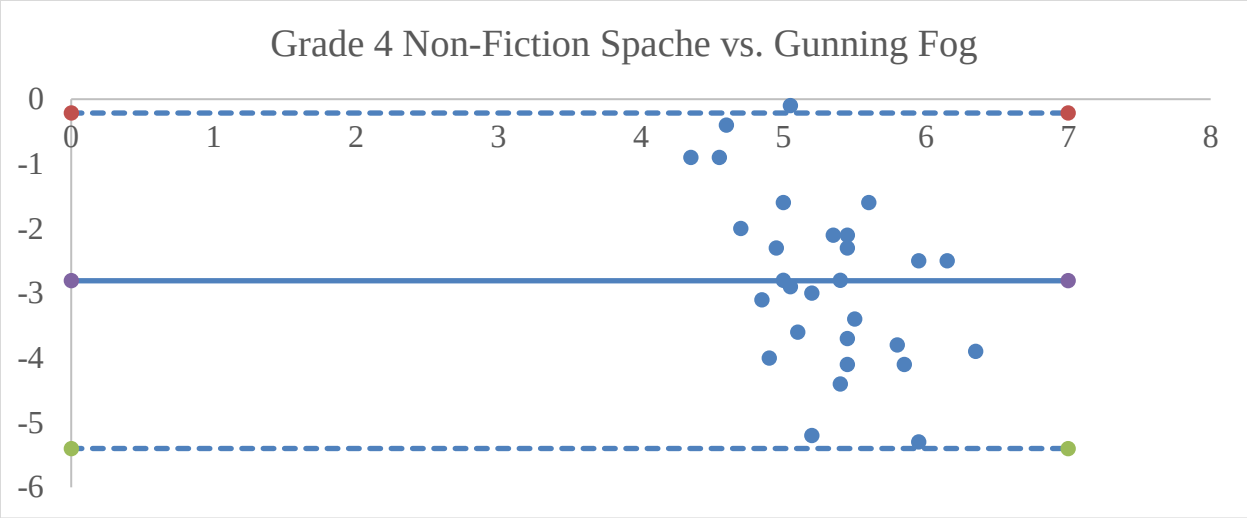


Figure 8. Non-Fiction Grade 4 Spache-Gunning Fog Bland-Altman Plot

Each of the five (5) Bland-Altman plots have been included for the first comparison. The following comparisons will utilize the breakouts of grade level/genre and include only those plots that are significant to the analysis. The plots including Grades 1-5 Fiction and Non-Fiction for each comparison are included in Appendix B.

Flesch-Kincaid Grade Level vs. Fry Graph

The three (3) breakout data sets used to assess agreement for Flesch-Kincaid Grade Level and Fry Graph were Fiction Grade 1, Fiction Grade 2, and Non-Fiction Grade 3. The data for Fiction Grade 2 and Non-Fiction Grade 3 were normally distributed. Therefore, the raw data were used to create Bland-Altman plots. Fiction Grade 1 data, however, were non-normal. A ratio transformation was performed on this set of data. The ratio data were used to create the Bland-Altman plot. Table 8 includes a breakdown of each of the three (3) comparisons.

The difference of each set falls within the allowed 1.5 grade levels, suggesting possible agreement. Each Bland-Altman plot reveals an interesting pattern. As the average increases in each set, the difference decreases in a linear fashion. The linear sets of data do not suggest a relationship between differences and averages, as would be expected when two measures agree. When two

measures agree the scatter of data points will fall near the bias line. There appears to be proportional bias between these two measures. A large measure of proportional error was detected in the Non-Fiction Grade 4 data set. The spread of each LoA also appears to be wider than desired when evaluating for agreement.

Table 8

Flesch-Kincaid Grade Level vs. Fry Graph

	Fiction Grade 1 (ratio)	**Fiction Grade 2**	**Non-Fiction Grade 4**
Mean (Bias)	0.906897	-0.016667	-1.23235
SD	0.351288	0.806475	0.780344
Upper LOA	1.595421	1.564025	0.297102
Lower LOA	0.218372	-1.597358	-2.76181
Spread LOA	1.377048	3.161383	3.05891
Percentage error	n/a*	n/a*	0.88
Correlation	0.47859	0.462697	0.47134

**Note: percentage error not appropriate possibly due to extreme outliers*

The Bland-Altman plots for these comparisons are included in Figures 9-11. The linear patterns are apparent among all data sets when Fry Graph is analyzed. There does not appear to be agreement between Flesch-Kincaid Grade Level and Fry Graph readability indexes based on the data and the plots.

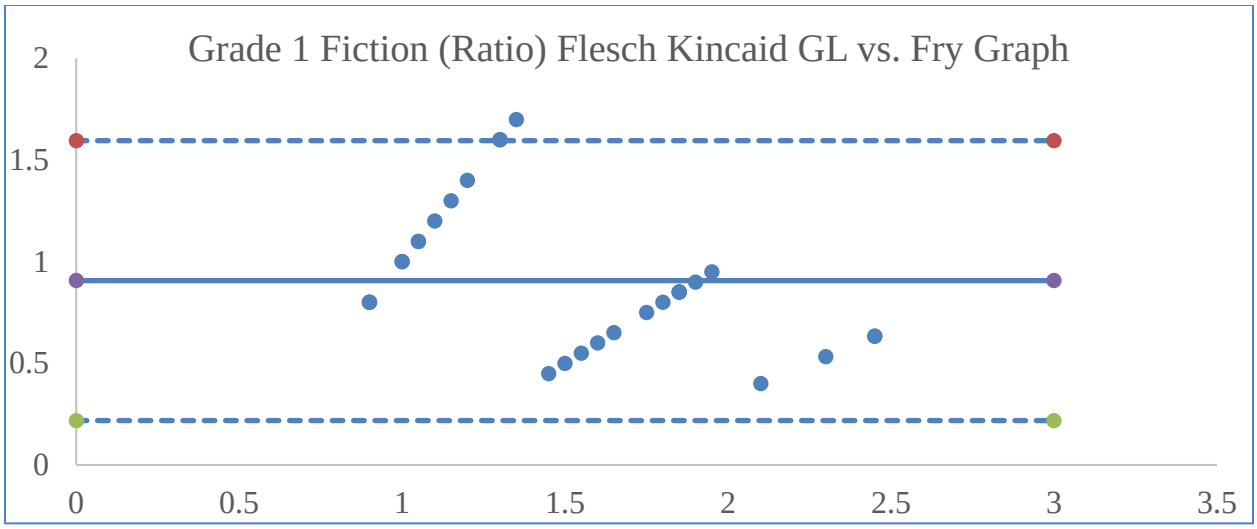


Figure 9. Fiction Grade 1 Flesch-Kincaid Grade Level-Fry Graph Bland-Altman Plot

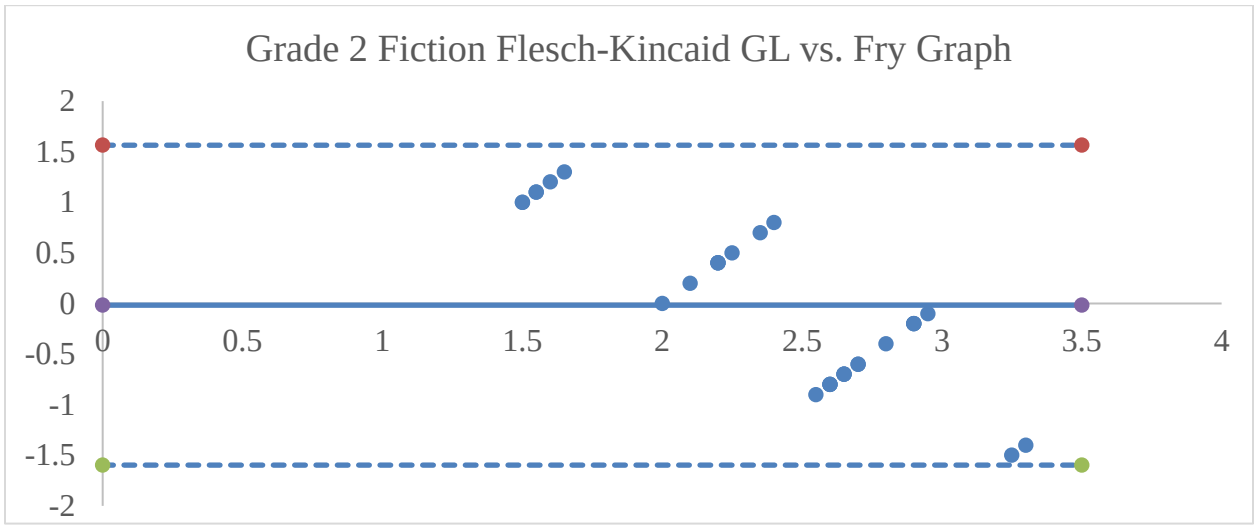


Figure 10. Fiction Grade 2 Flesch-Kincaid Grade Level-Fry Graph Bland-Altman Plot

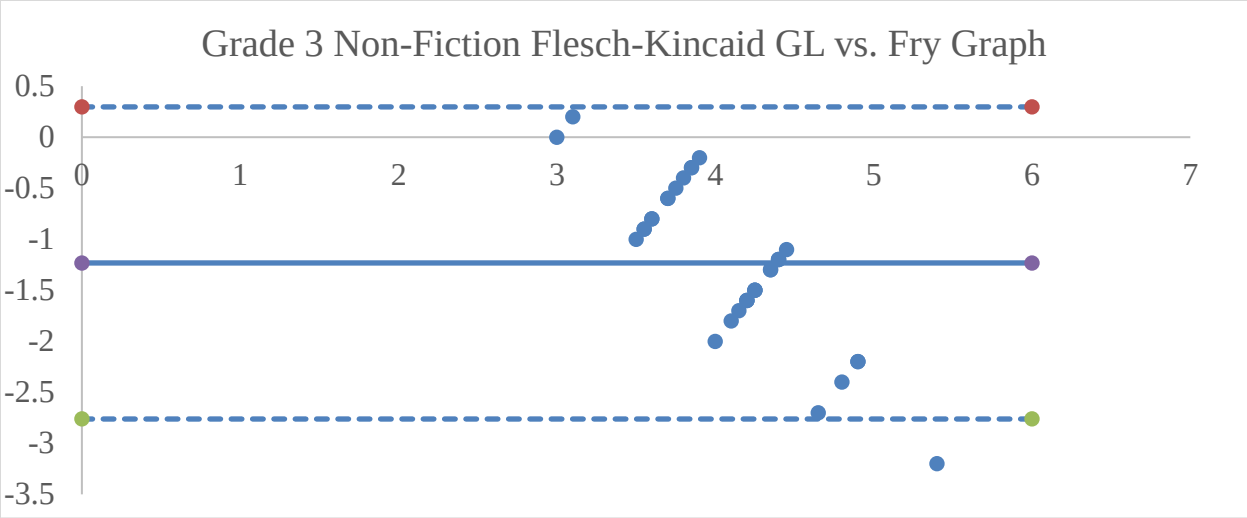


Figure 11. Non-Fiction Grade 3 Flesch-Kincaid Grade Level-Fry Graph Bland-Altman Plot

Flesch-Kincaid Grade Level vs. Dale-Chall

The three (3) breakout data sets used to assess agreement for Flesch-Kincaid Grade Level and Dale-Chall were Fiction Grade 3, Non-Fiction Grade 4, and Non-Fiction Grade 5. The Non-Fiction Grade 4 and Non-Fiction Grade 5 sets provided normally distributed data, therefore, the raw data were used to construct these Bland-Altman plots. Fiction Grade 3 however provided non-normal distribution of data. Ratio transformations were performed on this set of data. The ratio data were used to create the Bland-Altman plot. Table 9 includes a breakdown of each of the three (3) comparisons.

Table 9

Flesch-Kincaid Grade Level vs. Dale-Chall

	Fiction Grade 3 (Ratio)	**Non-Fiction Grade 4**	**Non-Fiction Grade 5**
Mean (Bias)	0.697883	-1.267857	-1.07647
SD	0.626022	0.697643	0.559609
Upper LOA	1.924887	0.099524	0.020362
Lower LOA	-0.52912	-2.635238	-2.1733

Spread LOA	2.454007	2.734762	2.19366
Percentage error	0.71210	0.60967	0.41116
Correlation	0.29046	-0.10940	0.33099

The difference of each set falls within the allowed 1.5 grade levels suggesting possible agreement. Fiction Grade 3 provides a Bland-Altman plot that also suggests agreement based on the cluster of data around the bias line. Figure 12 provides the Bland-Altman plot of Fiction Grade 3. Although there appears to be a large percentage error for this data set, one extreme outlier apparently skews the findings. Although other factors may be influencing the outcome of this data, the comparison set suggests agreement between Flesch-Kincaid Grade Level and Dale-Chall readability indexes, especially when analyzing Fiction Grade 3 material.

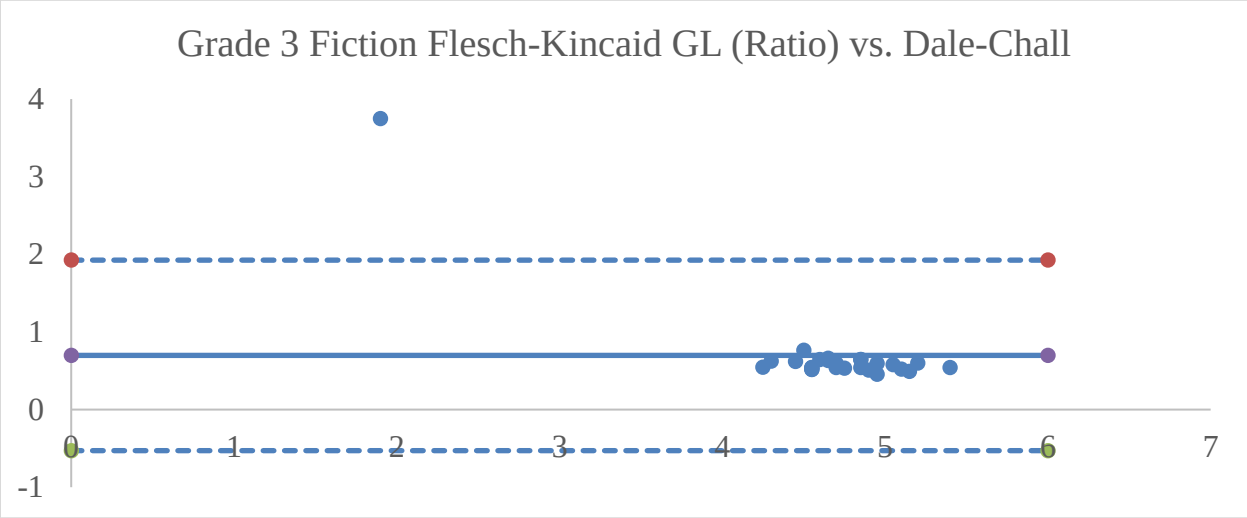


Figure 12. Fiction Grade 3 Flesch-Kincaid Grade Level-Dale-Chall Bland-Altman Plot

Non-Fiction Grade 4 and Non-Fiction Grade 5 produce Bland-Altman plots similar in shape and distribution. These plots are provided in Figure 13 and Figure 14.

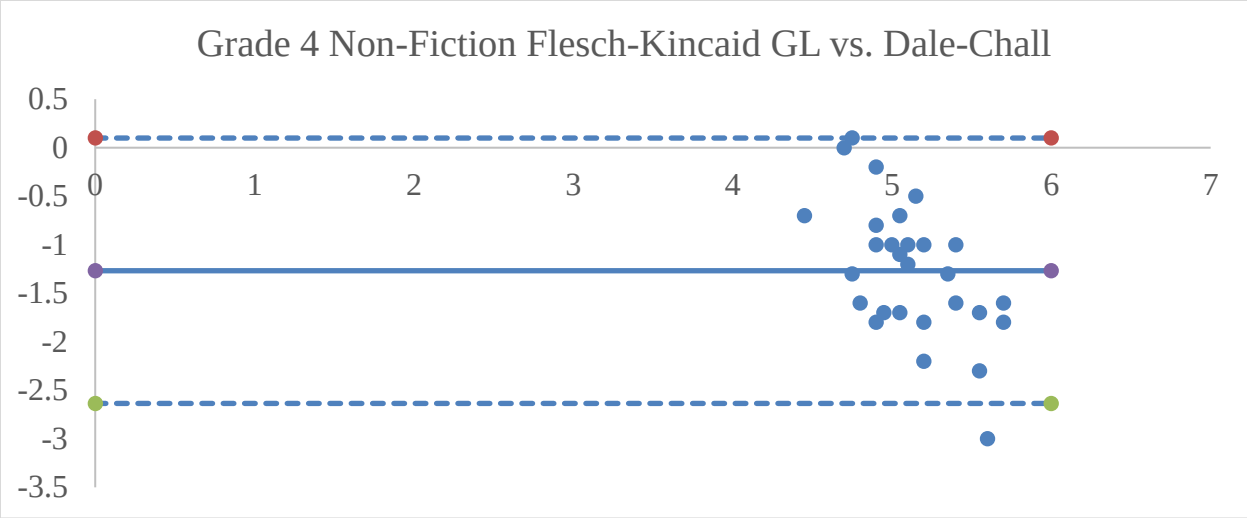


Figure 13. Non-Fiction Grade 4 Flesch-Kincaid Grade Level-Dale-Chall Bland-Altman Plot

Sample size (n = 17) for Grade 5 Non-Fiction Flesch-Kincaid Grade Level vs. Dale-Chall limits the outcome of the data. However, the majority of the data points fall within the limits of agreement. The full Non-Fiction Grades 1-5 plot supports the suggestion of agreement between these two measures. Although there appear to be several outliers, the majority of the data points cluster around the bias line and provide a larger sample size (n = 129). See Appendix B for the Bland-Altman plot.

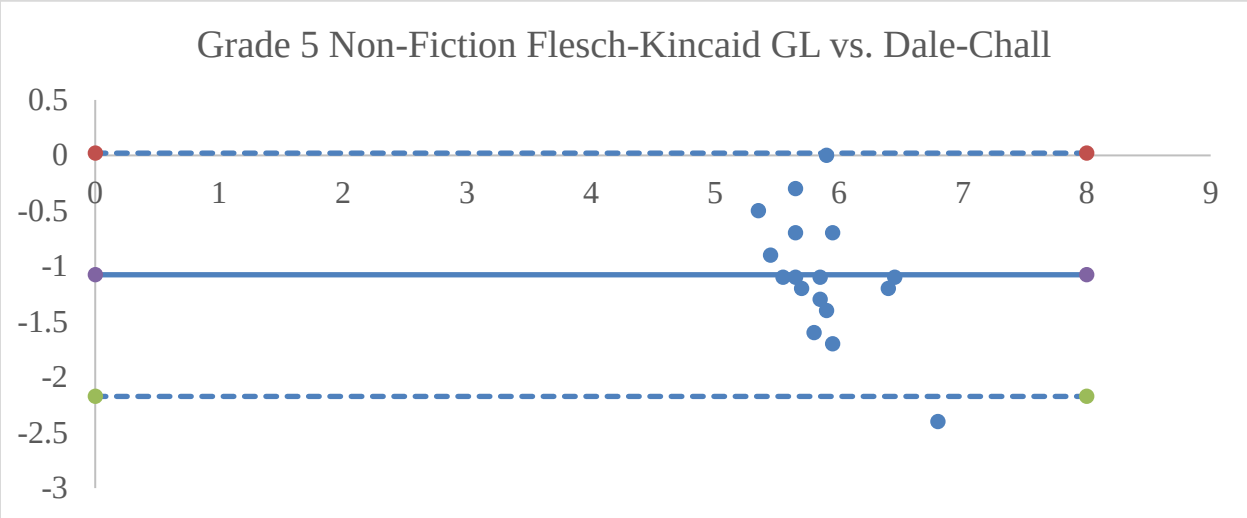


Figure 14. Non-Fiction Grade 5 Flesch-Kincaid Grade Level-Dale-Chall Bland-Altman Plot

Flesch-Kincaid Grade Level vs. Spache

The three (3) breakout data sets used to assess agreement for Flesch-Kincaid Grade Level and Spache were Fiction Grade 1, Fiction Grade 5, and Non-Fiction Grade 4. The Non-Fiction Grade 4 set provided normally distributed data, therefore, the raw data were used to construct the Bland-Altman plot. Fiction Grade 1 and the Fiction Grade 5, however, provided non-normal distribution of data. Ratio transformations were performed on these sets of data. The ratio data were used to create the Bland-Altman plots. Table 10 includes a breakdown of each of the three (3) comparisons.

The difference of each set falls within the allowed 1.5 grade levels suggesting possible agreement. Each of the fiction data sets has little proportional error and the data points fall within the limits of agreement, clustered loosely around the bias line. Fiction Grade 1 and Fiction Grade 5 also have a small spread of limits of agreement further suggesting agreement may be possible. Figures 15-16 provide the Bland-Altman plots for Fiction Grade 1 and Fiction Grade 5.

Table 10

Flesch-Kincaid Grade Level vs. Spache

	Fiction Grade 1 (Ratio)	**Fiction Grade 5 (Ratio)**	**Non-Fiction Grade 4**
M**ean (Bias)**	0.471245	1.240932	0.586207
SD	0.105412	0.119818	0.631169
U**pper** LOA	0.677853	1.475774	1.823298
L**ower** LOA	0.264637	1.006089	-0.65088
S**pread** LOA	0.413216	0.469685	2.474183
P**ercentage error**	0.1946	0.086	0.4070
Correlation	0.5388	0.0827	0.108

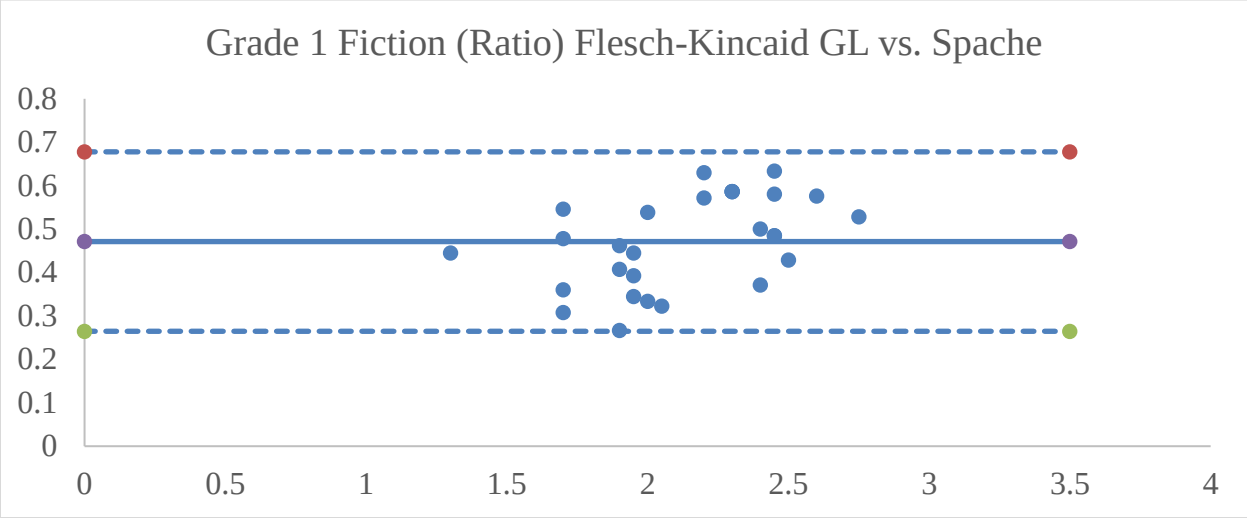


Figure 15. Fiction Grade 1 Flesch-Kincaid Grade Level-Spache Bland-Altman Plot

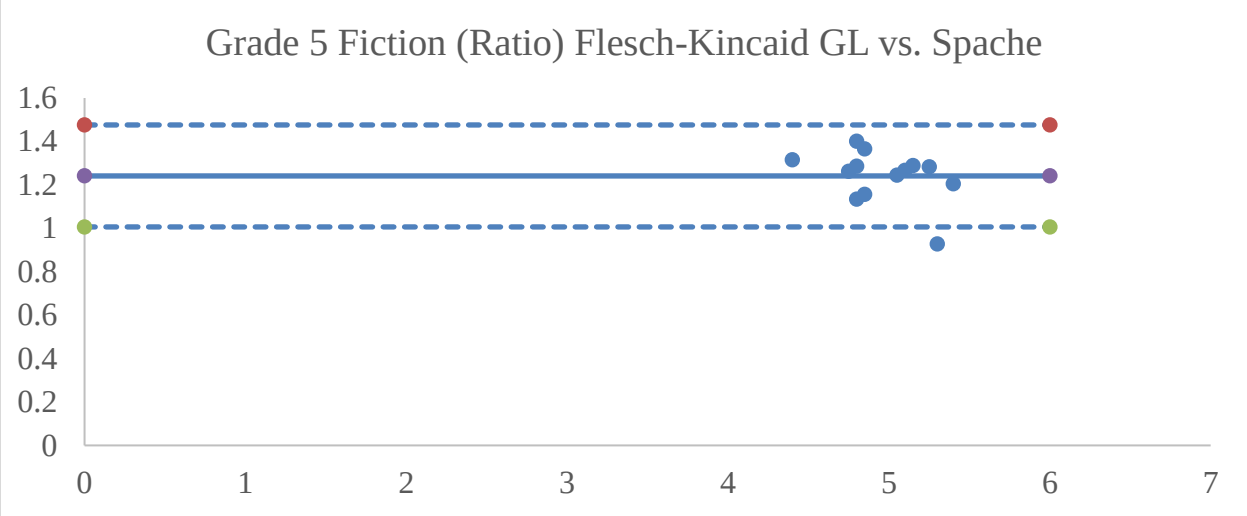


Figure 16. Fiction Grade 5 Flesch-Kincaid Grade Level-Spache Bland-Altman Plot

The data are less strong when analyzing Non-Fiction Grade 4. There appears to still be agreement based on the difference, however, the spread of the limits of agreement is much larger and the proportional error that exists is greater. Sample size (n = 29) is the same as Fiction Grade 1 (n = 29) but greater than Fiction Grade 5 (n = 13). Figure 17 provides the Bland-Altman plot for Non-Fiction Grade 4. The Bland-Altman plot for Fiction Grades 1-5 also suggests agreement based on the difference and a narrow spread of limits of agreement. See Appendix B for the plot.

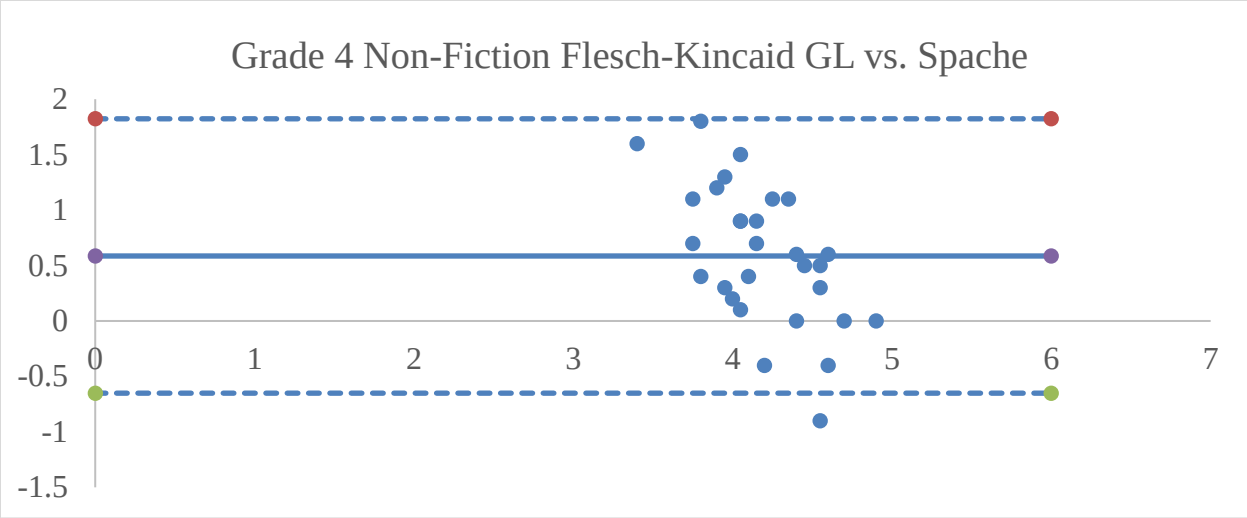


Figure 17. Non-Fiction Grade 4 Flesch-Kincaid Grade Level-Spache Bland-Altman Plot

Flesch-Kincaid Grade Level vs. Gunning Fog

The three (3) breakout data sets used to assess agreement for Flesch-Kincaid Grade Level and Gunning Fog were Fiction Grade 3, Fiction Grade 5, and Non-Fiction Grade 3. The Fiction Grade 3 and Non-Fiction Grade 3 sets provided normally distributed data, therefore, the raw data were used to construct the Bland-Altman plots. The Fiction Grade 5, however, provided non-normal distribution of data. Ratio transformations were performed on this set of data. The ratio data were used to create the Bland-Altman plot. Table 11 includes a breakdown of each of the three (3) comparisons.

Table 11

Flesch-Kincaid Grade Level vs. Gunning Fog

	Fiction Grade 3	**Fiction Grade 5 (Ratio)**	**Non-Fiction Grade 3**
Mean (Bias)	-2.04615	0.811341	-2.2558
SD	0.513988	0.23226	0.90225
Upper LOA	-1.03874	1.266571	-0.48747
Lower LOA	-3.05357	0.356112	-4.02429

Spread LOA	2.014837	0.91046	3.53682
Percentage error	0.5847	0.1662	n/a*
Correlation	0.59	0.33	0.408

**Note: percentage error not appropriate possibly due to extreme outliers*

The difference of each set exceeds the allowed 1.5 grade levels suggesting the two indexes lack agreement. Grade 5 Fiction data provide a difference of -1.58 which is only slightly above the limit and other factors that point to possible agreement. The spread of the limits of agreement remains narrow and the proportional error is low. Also, based on the Bland-Altman plot in Figure 18, the cluster of data is close to the bias line. Based on all of these findings it would appear that Fiction Grade 5 for these two indexes would suggest agreement. The Fiction Grades 1-5 Bland-Altman plot supports agreement with an acceptable difference and narrow limits of agreement.

Fiction Grade 3 and Non-Fiction Grade 3 each have a greater difference in the data sets, as well as a larger spread of the limits of agreement. Also, the data points are more loosely dispersed throughout the limits of agreement with several outliers. This is also evident in the Non-Fiction Grades 1-5 plot. Figures 19-20 provide the Bland-Altman plots for Fiction Grade 3 and Non-Fiction Grade 3.

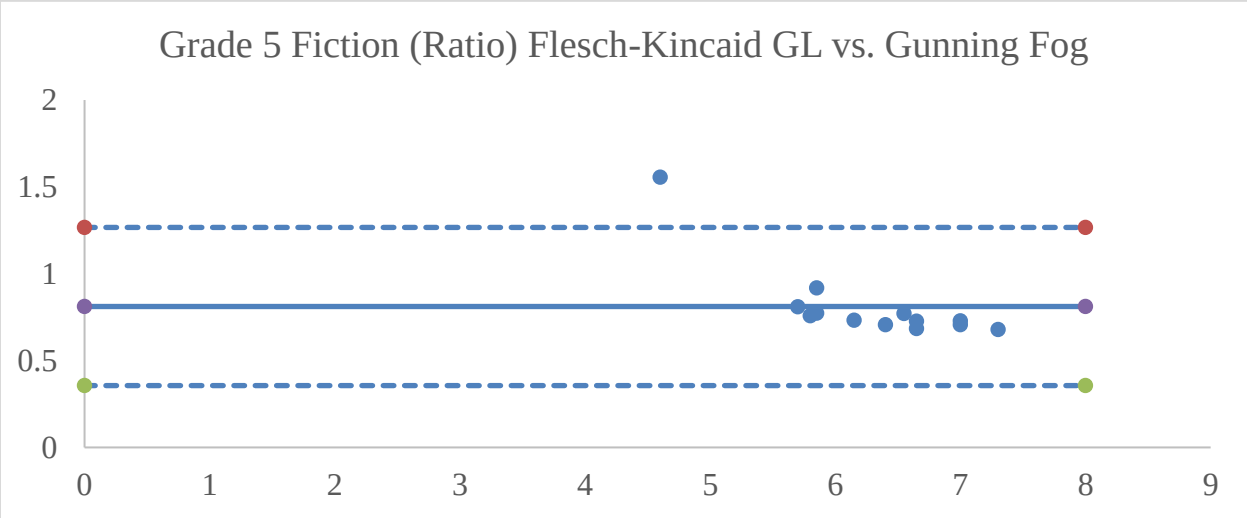


Figure 18. Fiction Grade 5 Flesch-Kincaid Grade Level-Gunning Fog Bland-Altman Plot

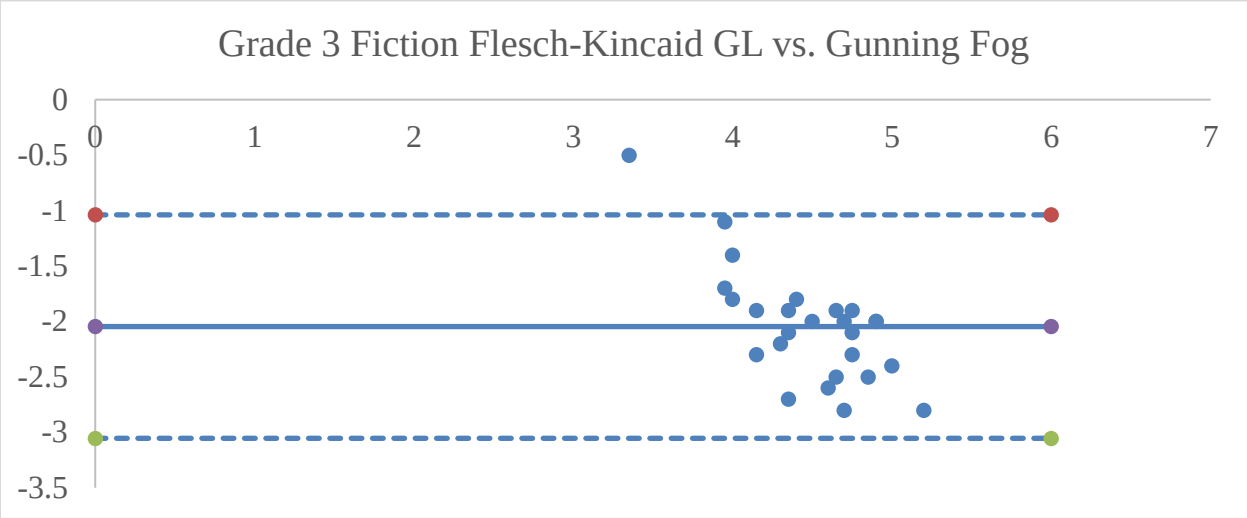


Figure 19. Fiction Grade 3 Flesch-Kincaid Grade Level-Gunning Fog Bland-Altman Plot

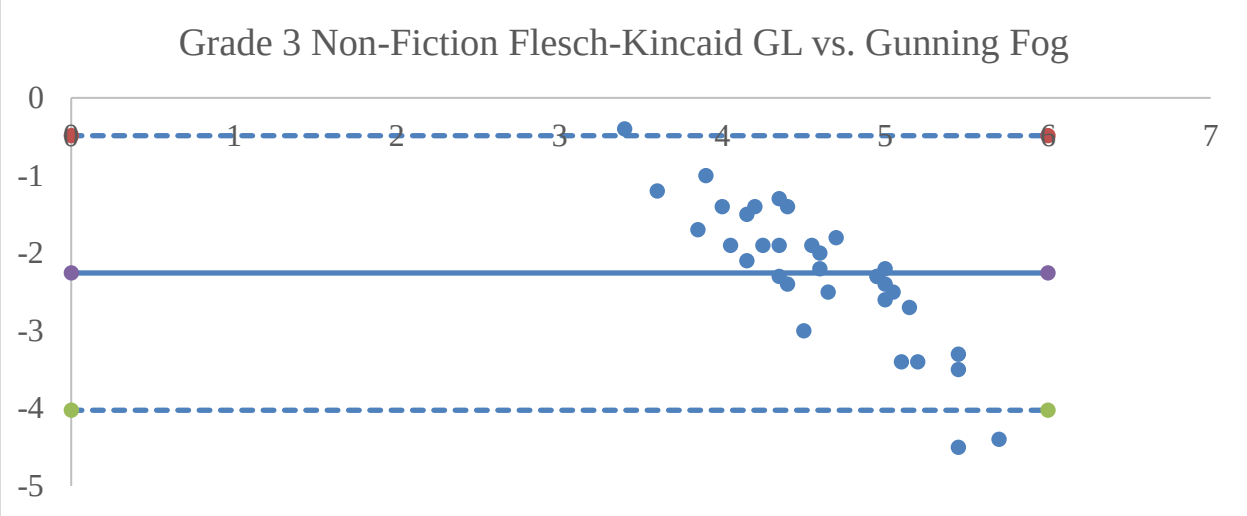


Figure 20. Non-Fiction Grade 3 Flesch-Kincaid Grade Level-Gunning Fog Bland-Altman Plot

Flesch-Kincaid Grade Level vs. Smog

The three (3) breakout data sets used to assess agreement for Flesch-Kincaid Grade Level and Smog were Fiction Grade 1, Non-Fiction Grade 3, and Non-Fiction Grade 4. All sets provided normally distributed data, therefore, the raw data were used to construct the Bland-Altman plots. Table 12 includes a breakdown of each of the three (3) comparisons.

Table 12

Flesch-Kincaid Grade Level vs. Smog

	Fiction Grade 1	**Non-Fiction Grade 3**	**Non-Fiction Grade 4**
Mean (Bias)	-1.72759	-0.65	-0.544828
SD	0.721059	0.888052	0.795337
Upper LOA	-0.31431	1.090582	1.014034
Lower LOA	-3.14086	-2.390582	-2.103689
Spread LOA	2.826551	3.481164	3.117723
Percentage error	n/a*	n/a*	0.696
Correlation	-0.197	0.265	0.162

**Note: percentage error not appropriate possibly due to extreme outliers*

The difference for both Non-Fiction Grade 3 and Non-Fiction Grade 4 were within the *a priori* defined 1.5 grade levels suggesting possible agreement. The Fiction Grade 1 set exceeds the allowed 1.5 grade levels suggesting the two indexes lack agreement. The two Non-Fiction sets appear to have proportional error based on the Bland-Altman plots. Figures 21-22 include the Bland-Altman plots for both Non-Fiction sets. In both cases, as the average increases the difference decreases. Although data points for both plots fall within the limits of agreement, the proportional error suggests that the two measures do not agree. The Non-Fiction Grades 1-5 Bland-Altman plot does suggest agreement with an acceptable difference between the two measures and a narrow limit of agreement. See Appendix B for the Bland-Altman plot.

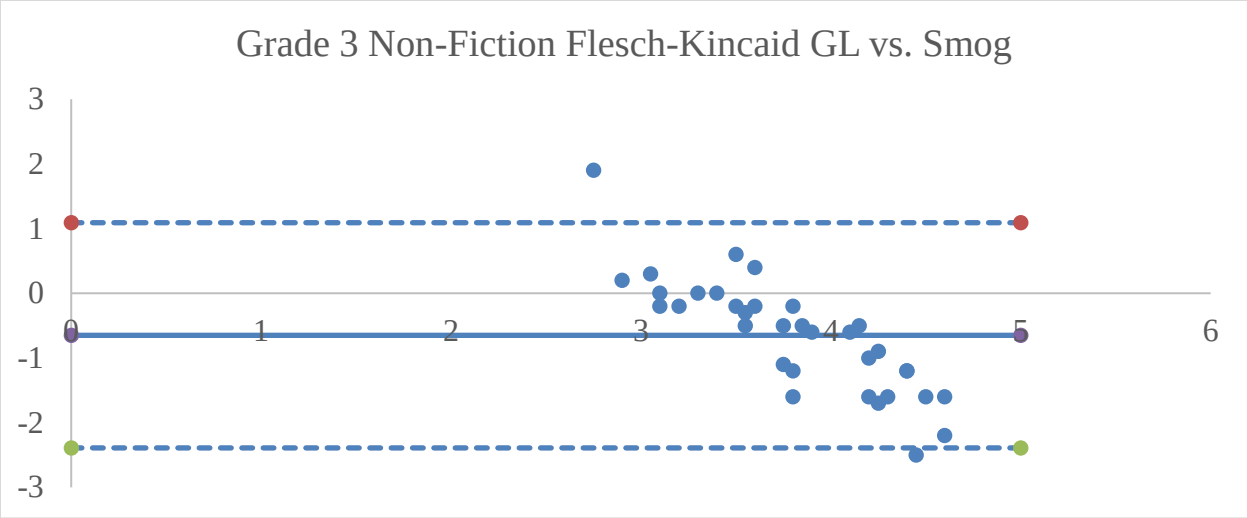


Figure 21. Non-Fiction Grade 3 Flesch-Kincaid Grade Level-Smog Bland-Altman Plot

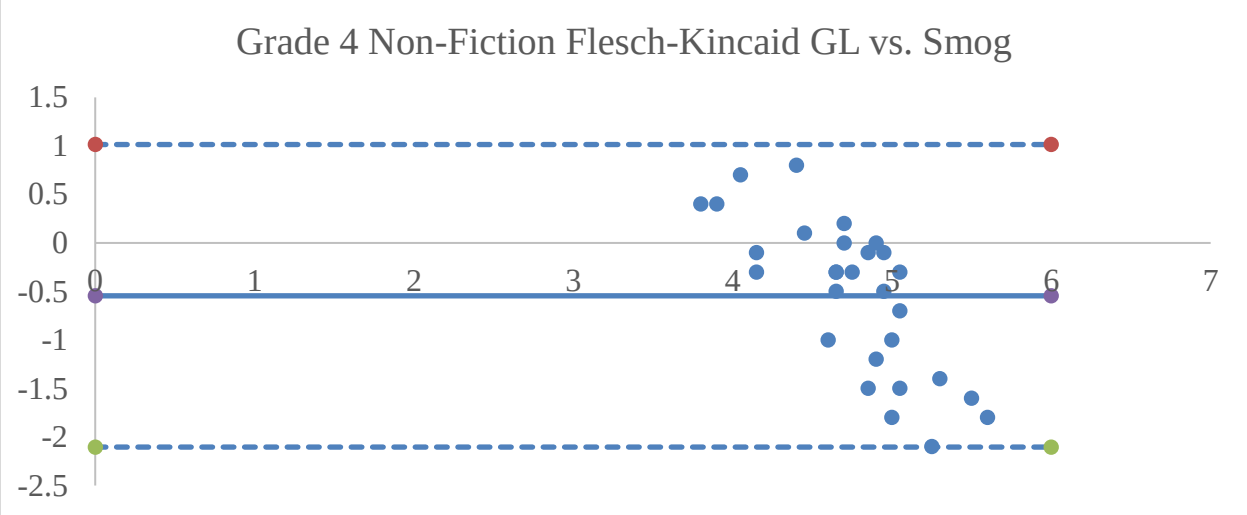


Figure 22. Non-Fiction Grade 4 Flesch-Kincaid Grade Level-Smog Bland Altman Plot

Fry Graph vs. Dale-Chall

The three (3) breakout data sets used to assess agreement for Fry Graph and Dale-Chall were Fiction Grade 4, Non-Fiction Grade 3, and Non-Fiction Grade 5. The Fiction Grade 4 and Non-Fiction Grade 5 sets provided normally distributed data, therefore, the raw data were used to construct the Bland-Altman plots. The Fiction Grade 3, however, provided non-normal distribution of data. Ratio transformations were performed on this set of data. The ratio data were used to create the Bland-Altman plot. Table 13 includes a breakdown of each of the three (3) comparisons.

Table 13

Fry Graph vs. Dale-Chall

	Fiction Grade 4	**Non-Fiction Grade 3 (ratio)**	**Non-Fiction Grade 5**
Mean (Bias)	-0.65556	0.855907	-0.841935
SD	1.380206	0.154879	0.919701
Upper LOA	2.049647	1.159468	0.960678
Lower LOA	-3.36076	0.552345	-2.644549
Spread LOA	5.410406	0.607124	3.605227
Percentage error	n/a*	0.1263	0.7501
Correlation	-0.334	0.155	0.155

**Note: percentage error not appropriate possibly due to extreme outliers*

The difference of each set falls within the allowed 1.5 grade levels suggesting possible agreement. Each Bland-Altman plot however reveals an interesting pattern. As the average increases in each set, the difference decreases in a linear fashion. The linear sets of data do not suggest a relationship between differences and averages, as would be expected when two measures agree. When two measures agree, the scatter of data points falls near the bias line. There appears to be both fixed and proportional bias between these two measures. A large measure of proportional error was detected in the Non-Fiction Grade 5 data set. The spread of the LoA also appears to be wider than desired when evaluating for agreement, especially for Fiction Grade 4 and Non-Fiction Grade 5. While data points for both plots fall within the limits of agreement, the proportional error suggests that the two measures do not agree. The Bland-Altman plots for Fry Graph vs. Dale-Chall are in Figures 23-25.

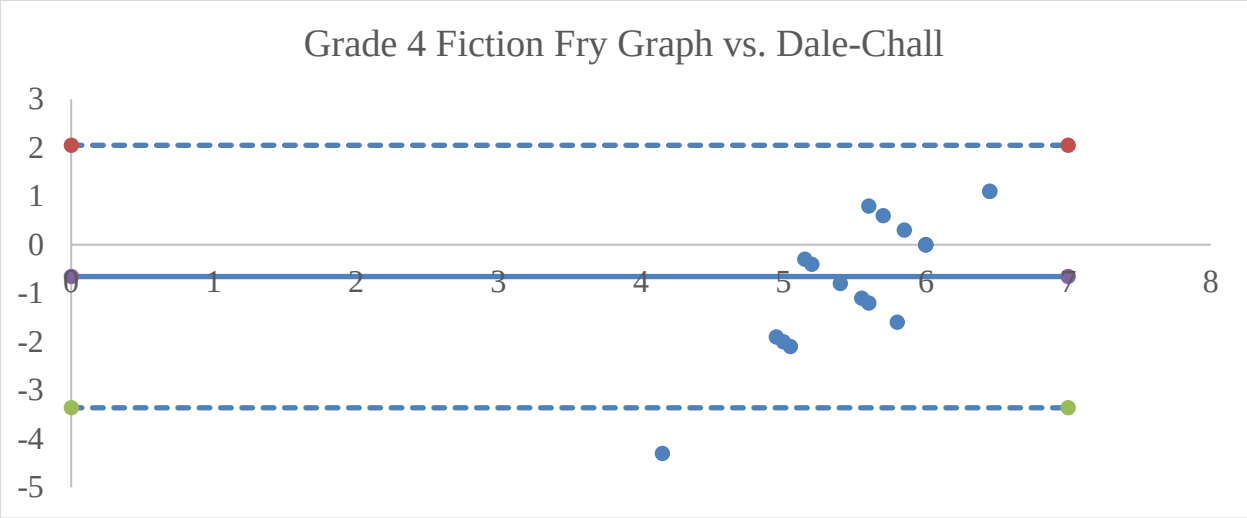


Figure 23. Fiction Grade 4 Fry Graph-Dale-Chall Bland-Altman Plot

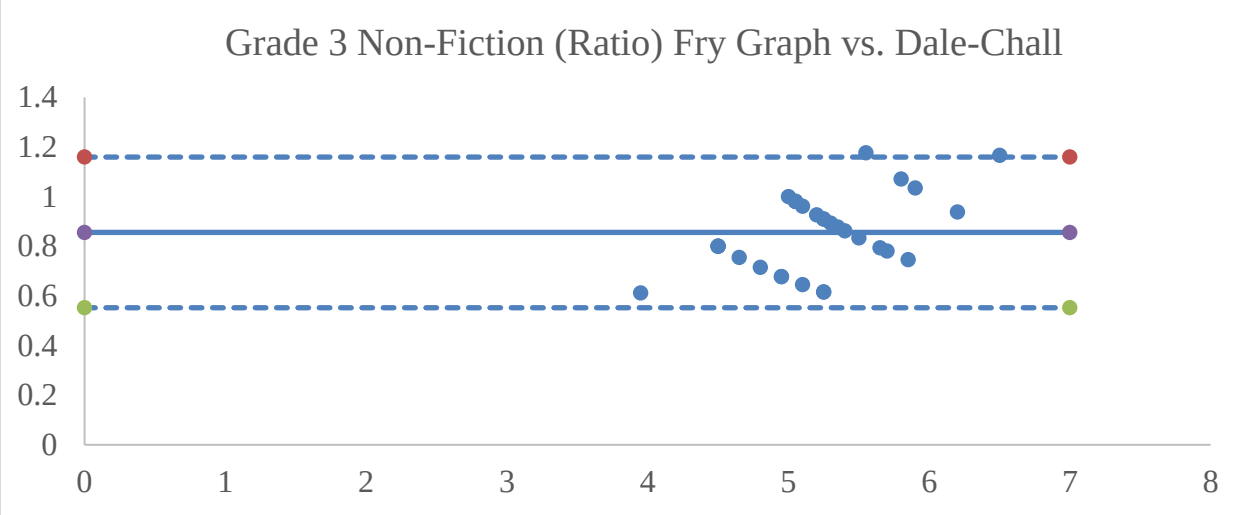


Figure 24. Non-Fiction Grade 3 Fry Graph-Dale-Chall Bland-Altman Plot

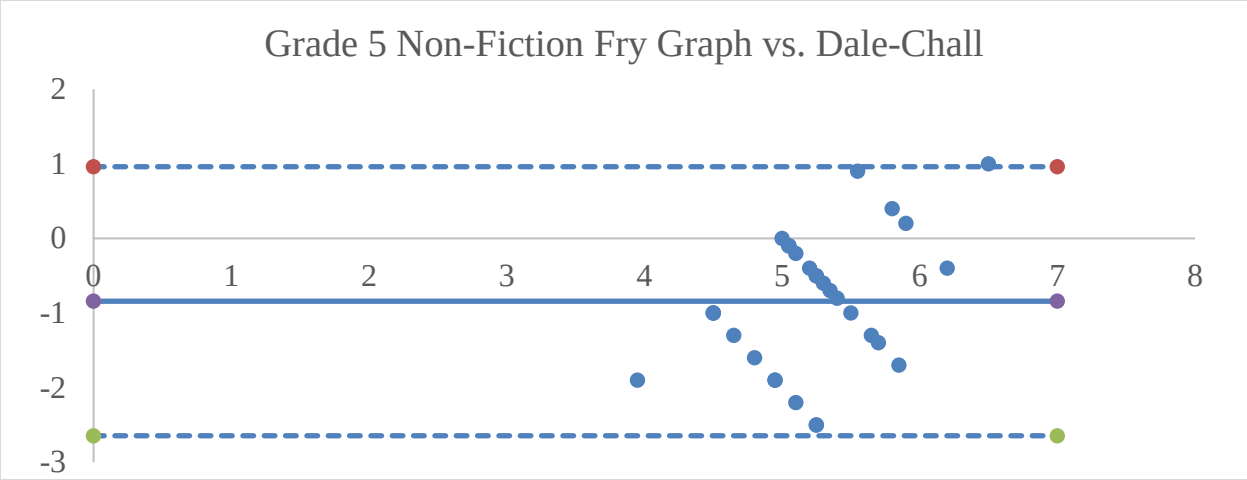


Figure 25. Non-Fiction Grade 5 Fry Graph-Dale-Chall Bland-Altman Plot

Fry Graph vs. Spache

The three (3) breakout data sets used to assess agreement for Fry Graph and Spache were Fiction Grade 1, Non-Fiction Grade 1, and Non-Fiction Grade 2. All sets provided normally distributed data, therefore, the raw data were used to construct the Bland-Altman plots. Table 14 includes a breakdown of each of the three (3) comparisons.

Table 14

Fry Graph vs. Spache

	Fiction Grade 1	**Non-Fiction Grade 1**	**Non-Fiction Grade 2**
Mean (Bias)	-1.24138	-0.7111	-0.27667
SD	0.770676	0.998757	1.032467
Upper LOA	0.269145	1.246453	1.746969
Lower LOA	-2.7519	-2.668676	-2.3003
Spread LOA	3.0210	3.915129	4.047271
Percentage error	n/a*	n/a*	n/a*
Correlation	0.20	0.24	-0.08

**Note: percentage error not appropriate possibly due to extreme outliers*

The difference of each set falls within the allowed 1.5 grade levels suggesting possible agreement. Each Bland-Altman plot, however, reveals an interesting pattern. As the average increases in each set, the difference decreases in a linear fashion. The linear sets of data do not suggest a relationship between differences and averages, as would be expected when two measures agree. When two measures agree the scatter of data points will fall near the bias line. There appears to be strong proportional bias between these two measures, as well as fixed bias. The spread of the LoA also appears to be wider than desired when evaluating for agreement for all data sets. While the majority of data points for both plots fall within the limits of agreement, the proportional error suggests that the two measures do not agree.

The Bland-Altman plots for each Fry Graph-Spache data set are in Figures 26-28.

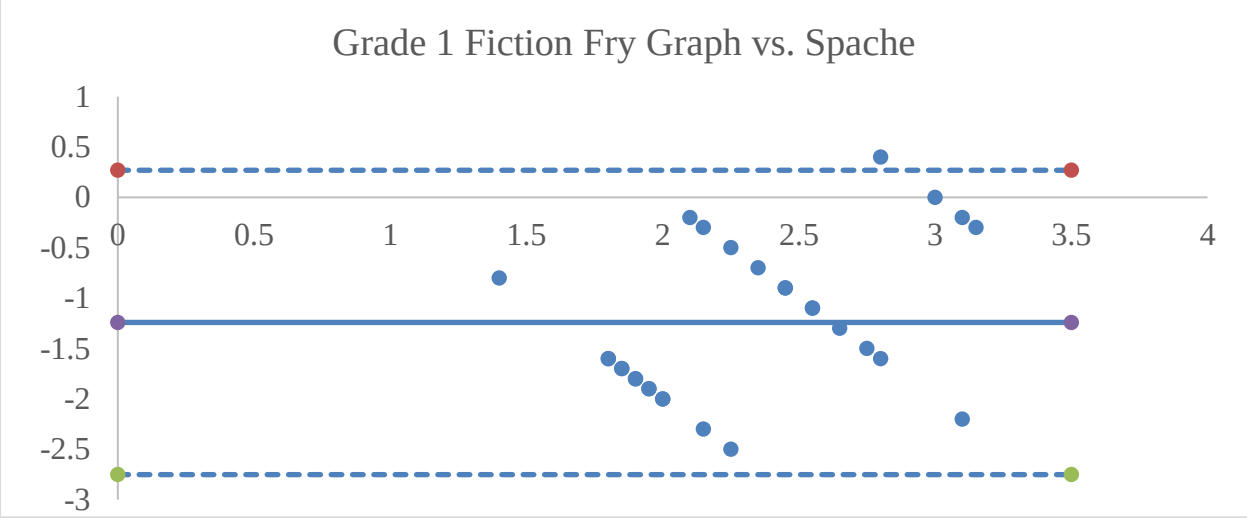


Figure 26. Fiction Grade 1 Fry Graph-Spache Bland-Altman Plot

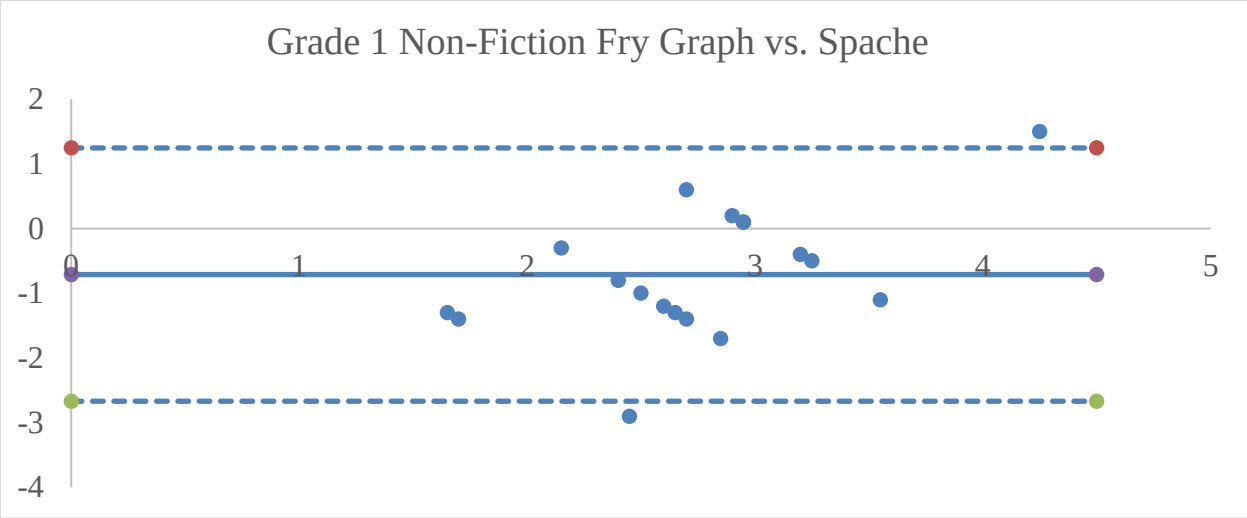


Figure 27. Non-Fiction Grade 1 Fry Graph-Spache Bland-Altman Plot

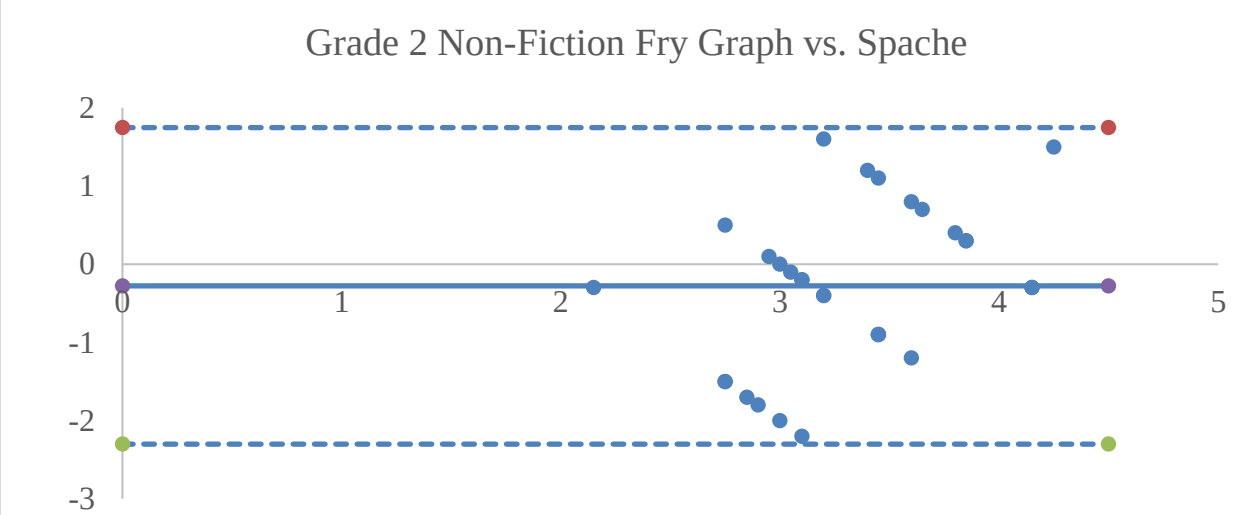


Figure 28. Non-Fiction Grade 2 Fry Graph-Spache Bland-Altman Plot

Fry Graph vs. Gunning Fog

The three (3) breakout data sets used to assess agreement for Fry Graph and Gunning Fog were Fiction Grade 5, Non-Fiction Grade 2, and Non-Fiction Grade 3. The Non-Fiction Grade 2 and Non-Fiction Grade 3 sets provided normally distributed data, therefore, the raw data were used to construct the Bland-Altman plots. The Fiction Grade 5, however, provided non-normal distribution of data. Ratio transformations were performed on this set of data. The ratio data were used to create the Bland-Altman plot. Table 15 includes a breakdown of each of the three (3)

comparisons.

The difference of each set falls within the allowed 1.5 grade levels suggesting possible agreement. Again, each Bland-Altman plot reveals an interesting pattern. As the average increases in each set, the difference decreases in a linear fashion. This appears to be a pattern when evaluating data with the Fry Graph readability index. The linear sets of data do not suggest a relationship between differences and averages, as would be expected when two measures agree. When two measures agree the scatter of data points will fall near the bias line. The data being analyzed do not fall consistently near the bias line.

Table 15

Fry Graph vs. Gunning Fog

	Fiction Grade 5	**Non-Fiction Grade 2**	**Non-Fiction Grade 3**
Mean (Bias)	0.887186	-1.41667	-1.02353
SD	0.175769	1.007244	1.192161
Upper LOA	1.231694	0.557531	1.313106
Lower LOA	0.542678	-3.39086	-3.36016
Spread LOA	0.689015	3.948396	4.673271
Percentage error	0.113	n/a*	0.99
Correlation	0.613	0.184	0.174

**Note: percentage error not appropriate possibly due to extreme outliers*

There appears to be strong proportional bias between these two measures, as well as fixed bias. The spread of the LoA also appears to be wider than desired when evaluating for agreement for all data sets. Although the majority of data points for both plots fall within the limits of agreement, there appear to be several outliers. The proportional error suggests that the two measures do not agree. The Bland-Altman plots for each Fry Graph-Gunning Fog data set are in

Figures 29-31.

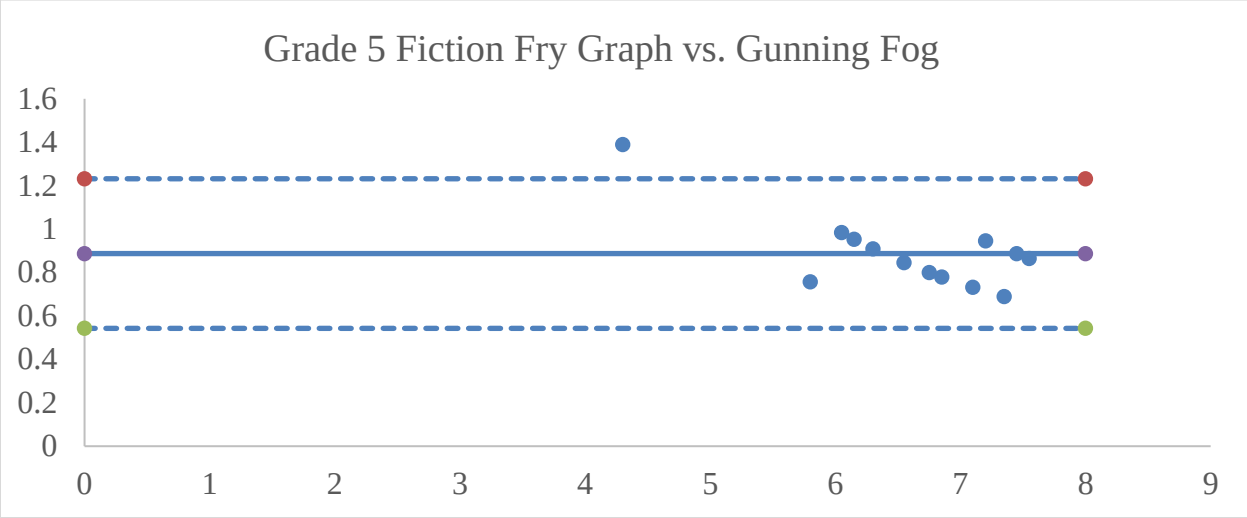


Figure 29. Fiction Grade 5 Fry Graph-Gunning Fog Bland-Altman Plot

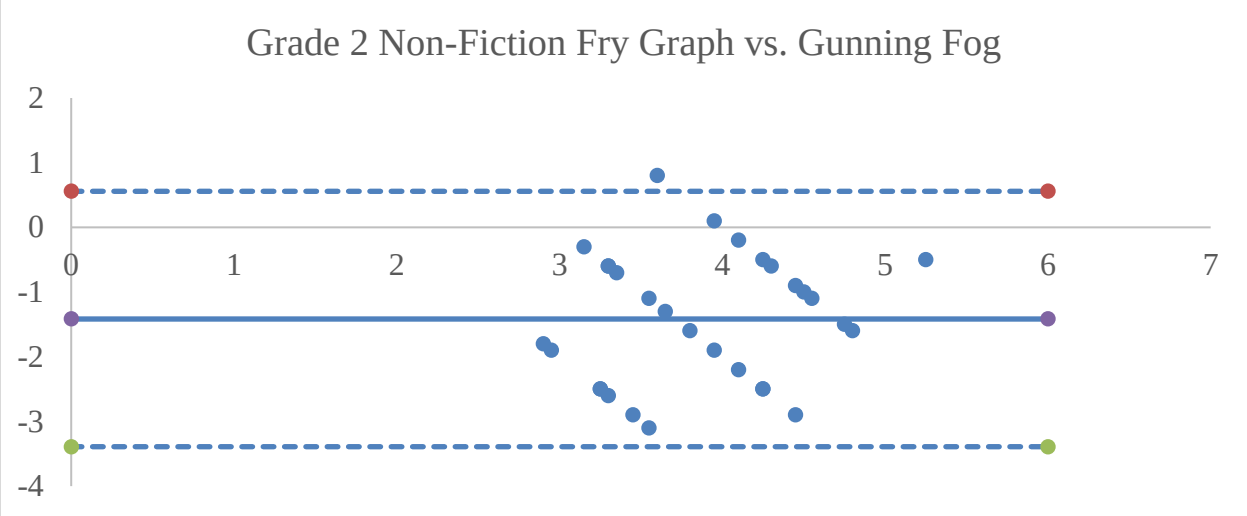


Figure 30. Non-Fiction Grade 2 Fry Graph-Gunning Fog Bland-Altman Plot

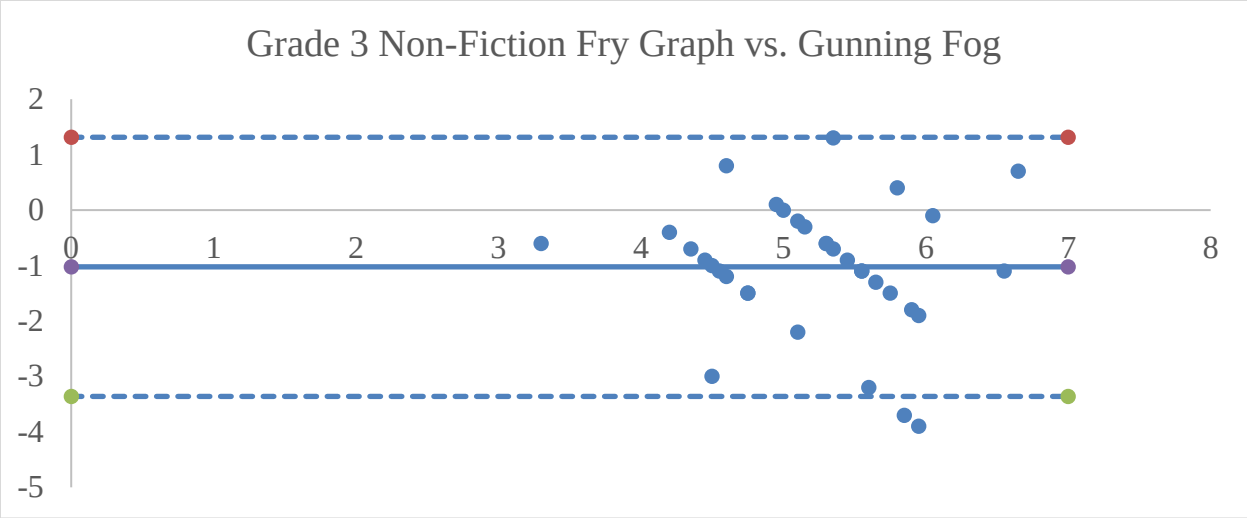


Figure 31. Non-Fiction Grade 3 Fry Graph-Gunning Fog Bland-Altman Plot

Fry Graph vs. Smog

The three (3) breakout data sets used to assess agreement for Fry Graph and Smog were Fiction Grade 1, Fiction Grade 5, and Non-Fiction Grade 3. All sets provided normally distributed data, therefore, the raw data were used to construct the Bland-Altman plots. Table 16 includes a breakdown of each of the three (3) comparisons.

Table 16

Fry Graph vs. Smog

	Fiction Grade 1	**Fiction Grade 5**	**Non-Fiction Grade 3**
Mean (Bias)	-1.39655	0.976923	0.582353
SD	0.902173	0.881432	1.174855
Upper LOA	0.371708	5.092923	2.88507
Lower LOA	-3.16481	-3.13908	-1.72036
Spread LOA	3.536518	8.232	4.605433
Percentage error	n/a*	n/a*	0.979
Correlation	0.007	0.346	0.141

**Note: percentage error not appropriate possibly due to extreme outliers*

As with each of the other Fry Graph analyses, the difference of each set falls within the allowed 1.5 grade levels suggesting possible agreement. Again, however, each Bland-Altman plot reveals the same negative linear pattern. As the average increases in each set, the difference decreases in a linear fashion. This appears to be a pattern when evaluating data with the Fry Graph readability index. The linear sets of data do not suggest a relationship between differences and averages, as would be expected when two measures agree. When two measures agree the scatter of data points will fall near the bias line. The data being analyzed do not fall consistently near the bias line.

Also, the spread of the limits of agreement is quite large for each of the three (3) sets. Although the majority of data points for both plots fall within the limits of agreement, the proportional error suggests that the two measures do not agree. The correlation for each of the sets also indicates little relationship between the two measures further indicating lack of agreement. Figures 32-34 include the Bland-Altman plots for the Fry Graph-Smog data sets analyzed.

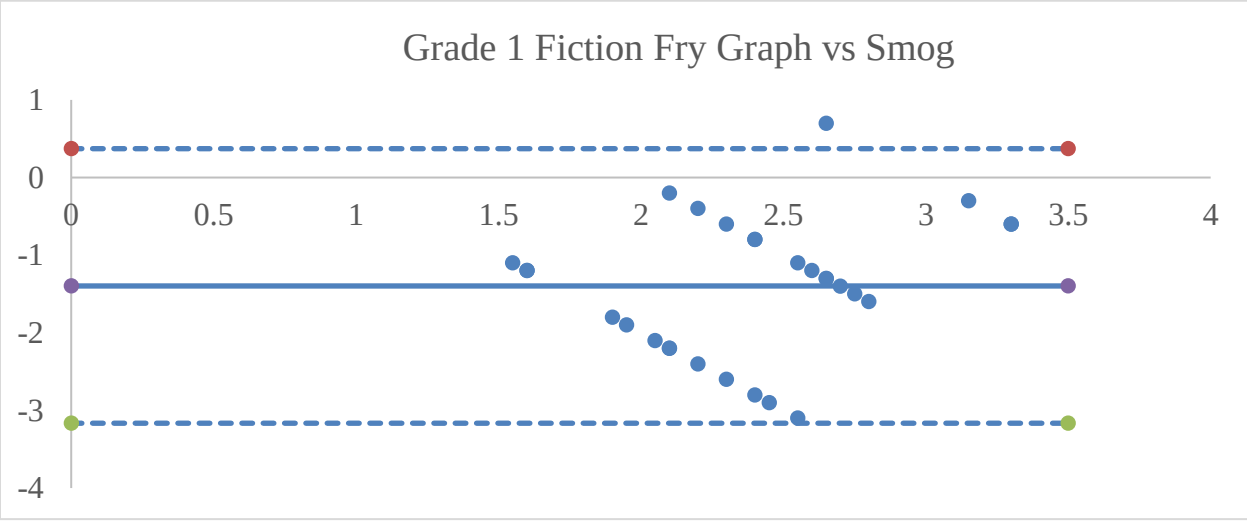


Figure 32. Fiction Grade 1 Fry Graph-Smog Bland-Altman Plot

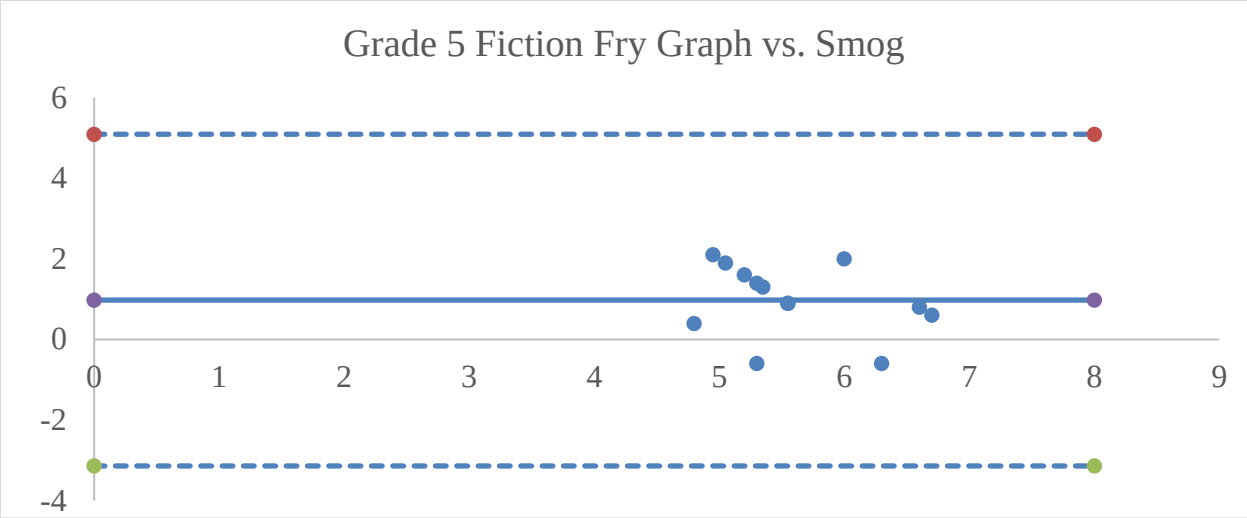


Figure 33. Fiction Grade 5 Fry Graph-Smog Bland-Altman Plot

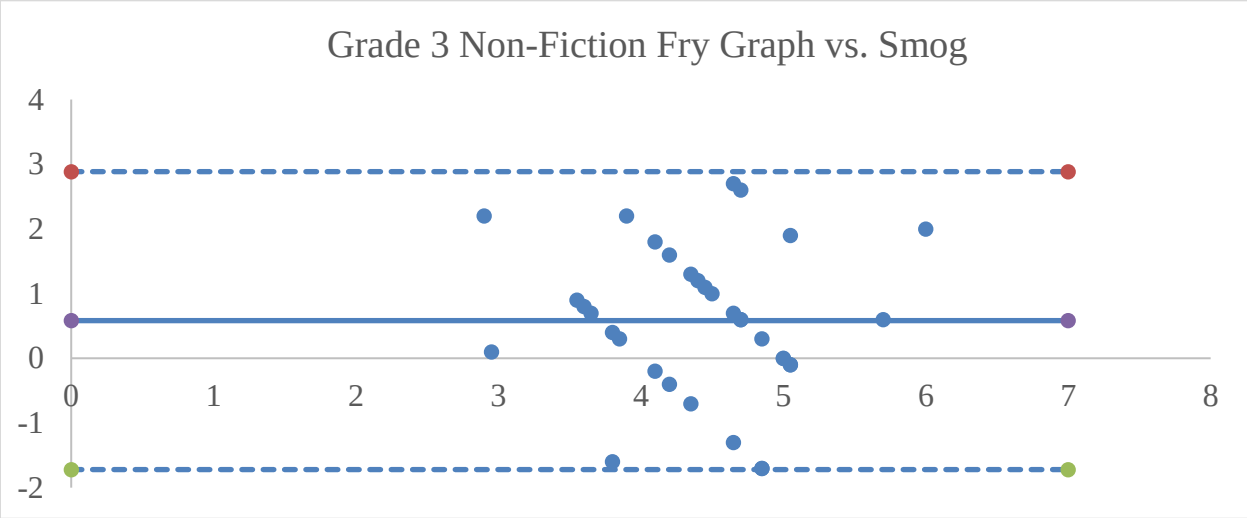


Figure 34. Non-Fiction Grade 3 Fry Graph-Smog Bland-Altman Plot

Dale-Chall vs. Spache

The three (3) breakout data sets used to assess agreement for Dale-Chall and Spache were Fiction Grade 4, Non-Fiction Grade 1, and Non-Fiction Grade 3. The Fiction Grade 4 set provided normally distributed data, therefore, the raw data were used to construct the Bland-Altman plot for this data. The Non-Fiction Grade 1 and the Non-Fiction Grade 3 data sets, however, provided non-normal distribution of data. A ratio transformation was performed. The ratio data were used to create the Bland-Altman plots. Table 17 includes a breakdown of each of the three (3)

comparisons.

Table 17

Dale-Chall vs. Spache

	Fiction Grade 4	**Non-Fiction Grade 1 (Ratio)**	**Non-Fiction Grade 3 (ratio)**
Mean (Bias)	1.78333	1.30918	1.41584
SD	0.59926	0.66419	0.44768
Upper LOA	2.95789	2.61099	2.2933
Lower LOA	0.60878	0.00074	0.53838
Spread LOA	2.349	2.604	1.755
Percentage error	0.40	0.618	0.337
Correlation	-0.1667	0.67	0.40

The difference for the Fiction Grade 4 data appears to exceed the 1.5 grade levels limit for agreement. The non-fiction sets were calculated using ratio data, however, the raw data difference falls within the 1.5 grade levels limit for agreement. The difference for Non-Fiction Grade 1 is 1.111 and the difference for Non-Fiction Grade 3 is 1.489, each suggesting possible agreement between methods. The spread of the limits of agreement are more narrow than other comparisons, however, each set does have some degree of proportional error. The Bland-Altman plots for the two non-fiction sets reveal several outliers that may skew the data making it difficult to assess agreement between the two methods. Figures 35-36 contain the two data comparisons for the non-fiction data.

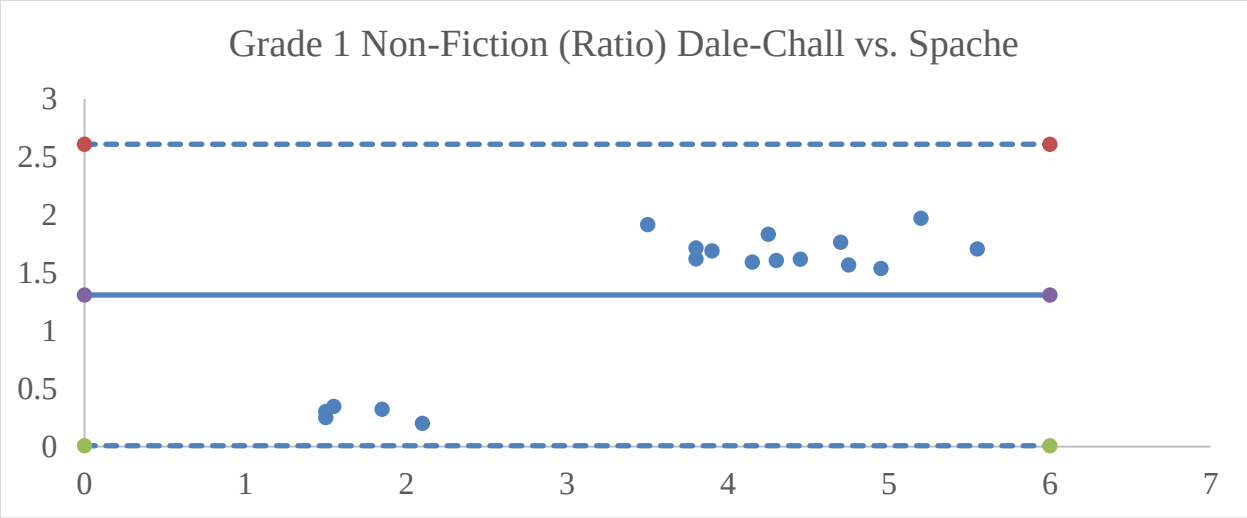


Figure 35. Non-Fiction Grade 1 Dale-Chall-Spache Bland-Altman Plot

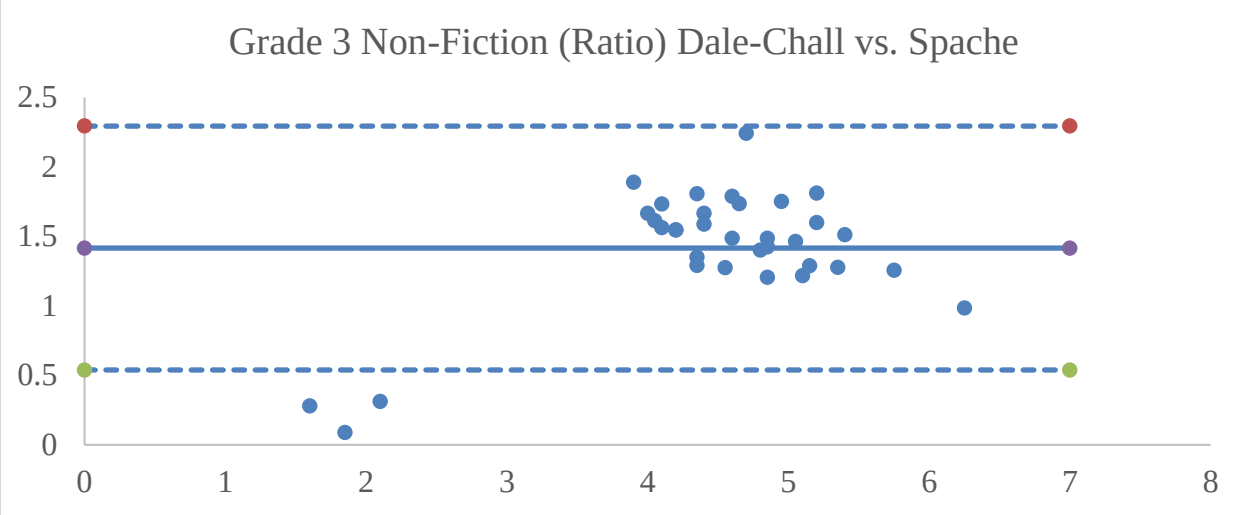


Figure 36. Non-Fiction Grade 3 Dale-Chall-Spache Bland-Altman Plot

In comparison, the Fiction Grade 4 Bland-Altman plot (see Figure 37) has a narrow spread of limits of agreement, however, the difference exceeds the 1.5 grade levels and a percentage error of 0.40 indicating proportional error exists within this data set.

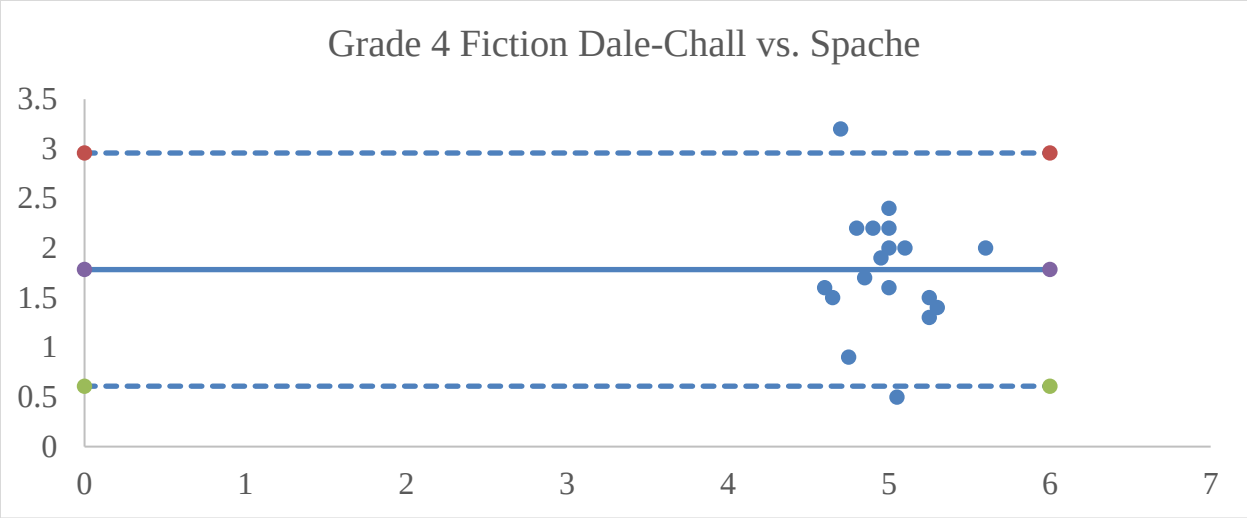


Figure 37. Fiction Grade 4 Dale-Chall-Spache Bland-Altman plot

Dale-Chall vs. Gunning Fog

The three (3) breakout data sets used to assess agreement for Dale-Chall and Gunning Fog were Fiction Grade 2, Non-Fiction Grade 2, and Non-Fiction Grade 4. All three (3) sets of data provided non-normal distribution of data. A ratio transformation was performed. The ratio data were used to create the Bland-Altman plots. Table 18 includes a breakdown of each of the three (3) comparisons.

Table 18

Dale-Chall vs. Gunning Fog

	Fiction Grade 2 (Ratio)	**Non-Fiction Grade 2 (ratio)**	**Non-Fiction Grade 4 (ratio)**
Mean (Bias)	1.445176	1.091492	0.858602
SD	0.415778	0.43523	0.227992
Upper LOA	2.260102	1.944543	1.305467
Lower LOA	0.63025	0.238442	0.411737
Spread LOA	1.629851	1.706101	0.89373

Percentage error	0.275	0.352	0.16
Correlation	-0.218	-0.0997	-0.161

The difference for the Fiction Grade 2 data appears to exceed the 1.5 grade levels limit for agreement based on the actual difference calculated for the raw data. The difference for this set was 1.6333. The non-fiction sets were also calculated using ratio data, however, the raw data difference falls within the 1.5 grade levels limit for agreement. The difference for Non-Fiction Grade 2 is 0.267 and the difference for Non-Fiction Grade 4 is -1.11, each suggesting possible agreement between methods. The spread of the limits of agreement are more narrow than other comparisons, also supporting possible agreement between the two methods. Proportional error remains low and may exist due to several outliers within the data sets. These outliers are apparent in the Bland-Altman plots in Figures 38-40. There appears to be agreement between the two measures when looking at the non-fiction data for each of the grade levels analyzed.

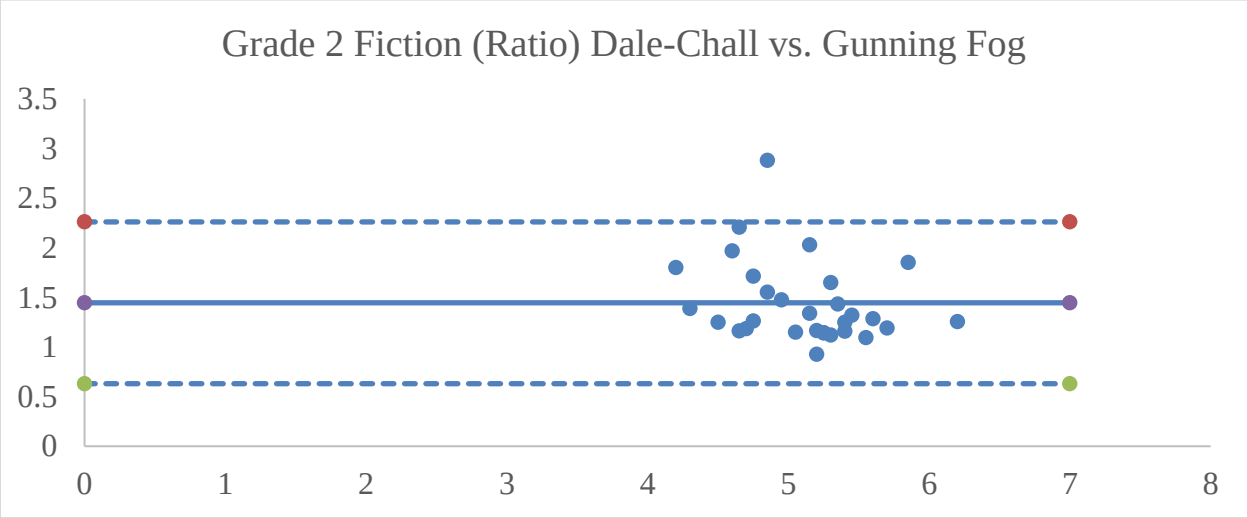


Figure 38. Fiction Grade 2 Dale-Chall-Gunning Fog Bland-Altman Plot

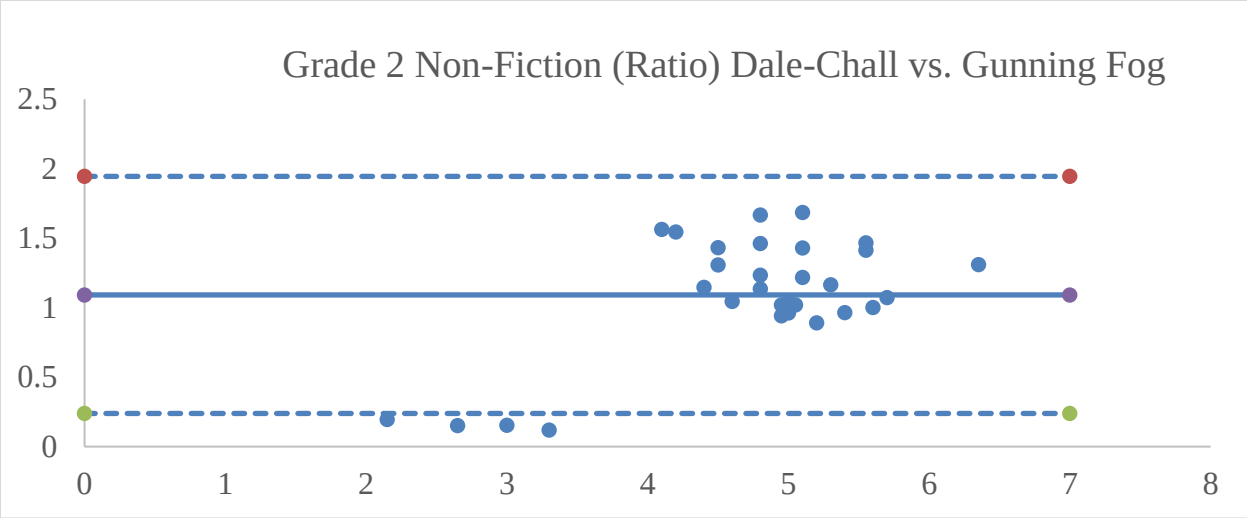


Figure 39. Non-Fiction Grade 2 Dale-Chall-Gunning Fog Bland-Altman Plot

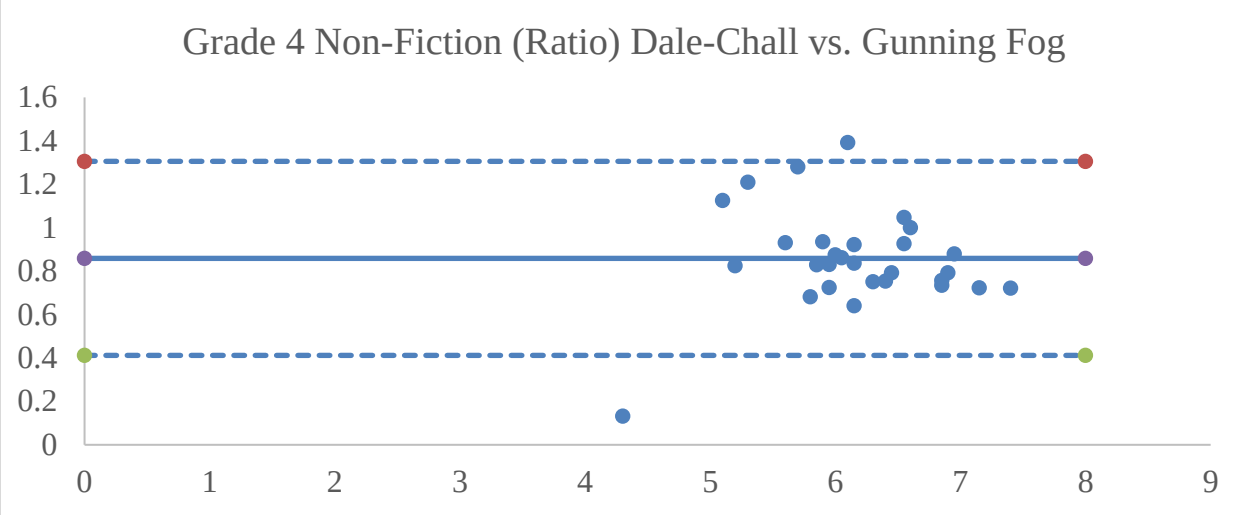


Figure 40. Non-Fiction Grade 4 Dale-Chall-Gunning Fog Bland-Altman Plot

Dale-Chall vs. Smog

The three (3) breakout data sets used to assess agreement for Dale-Chall and Smog were Fiction Grade 1, Non-Fiction Grade 1, and Non-Fiction Grade 4. All three (3) sets of data provided non-normal distribution of data. A ratio transformation was performed. The ratio data were used to create the Bland-Altman plots. Table 19 includes a breakdown of each of the three (3) comparisons.

Table 19

Dale-Chall vs. Smog

	Fiction Grade 1 (ratio)	**Non-Fiction Grade 1 (ratio)**	**Non-Fiction Grade 4 (ratio)**
Mean (Bias)	1.786602	1.570798	1.142672
SD	0.60442	0.980037	0.285339
Upper LOA	2.971266	3.491671	1.701936
Lower LOA	0.601939	-0.35007	0.583407
Spread LOA	2.369328	3.841745	1.118529
Percentage error	0.446	0.912	0.200
Correlation	-0.028	0.112	-0.064

The difference for the Fiction Grade 1 data appears to exceed the 1.5 grade levels limit for agreement based on the actual difference calculated for the raw data. The difference for this set was 2.231. The non-fiction sets were also calculated using ratio data, however, the raw data difference falls within the 1.5 grade levels limit for agreement. The raw data difference for Non-Fiction Grade 1 is 1.417 and the difference for Non-Fiction Grade 4 is 0.566, each suggesting possible agreement between methods. The spread of the limits of agreement are more narrow than other comparisons, especially for Fiction Grade 1 and Non-Fiction Grade 4, also supporting possible agreement between the two methods. Proportional error remains low for Fiction Grade 1 and Non-Fiction Grade 4 and may exist due to several outliers within the data sets. The Non-Fiction Grade 1 data set has a larger set of outliers that may cause the increase in proportional error. These outliers are apparent in the Bland-Altman plots in Figures 41-43. There appears to be agreement between the two measures when looking at the Non-Fiction Grade 4 data set only.

Both the Fiction Grades 1-5 and Non-Fiction Grades 1-5 produce Bland-Altman plots that suggest agreement between the two measures. The difference of each is within the 1.5 grade levels and both have a narrow limit of agreement. See Appendix B for the Bland-Altman plots.

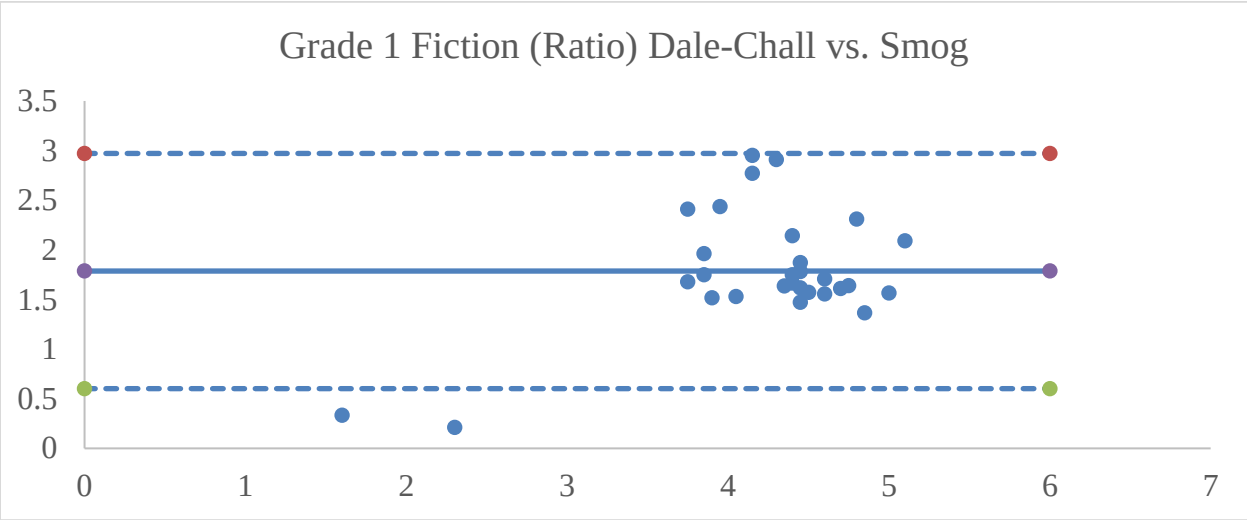


Figure 41. Fiction Grade 1 Dale-Chall-Smog Bland-Altman Plot

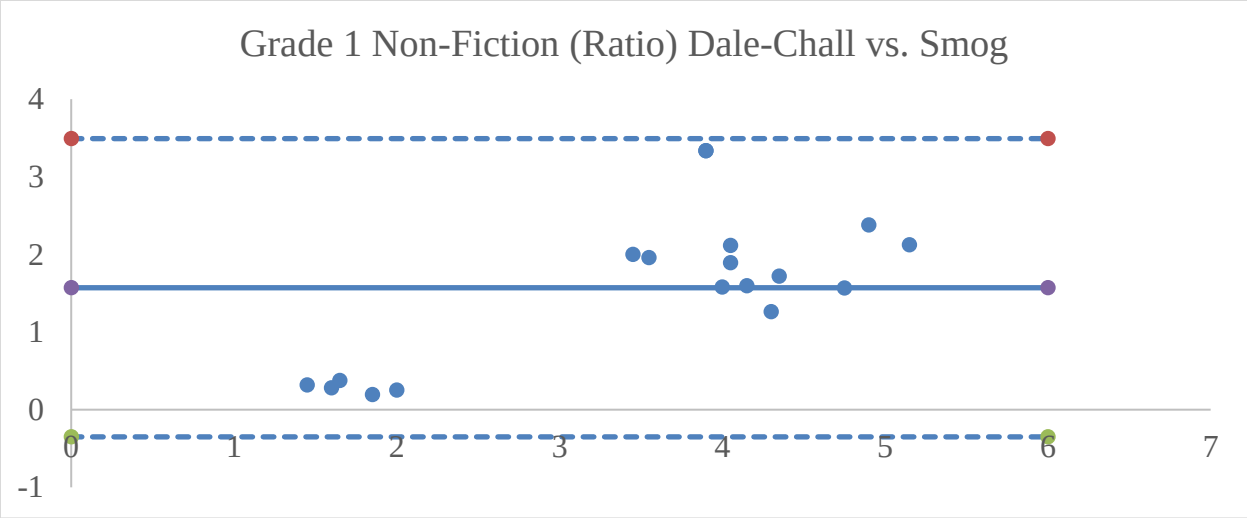


Figure 42. Non-Fiction Grade 1 Dale-Chall-Smog Bland-Altman Plot

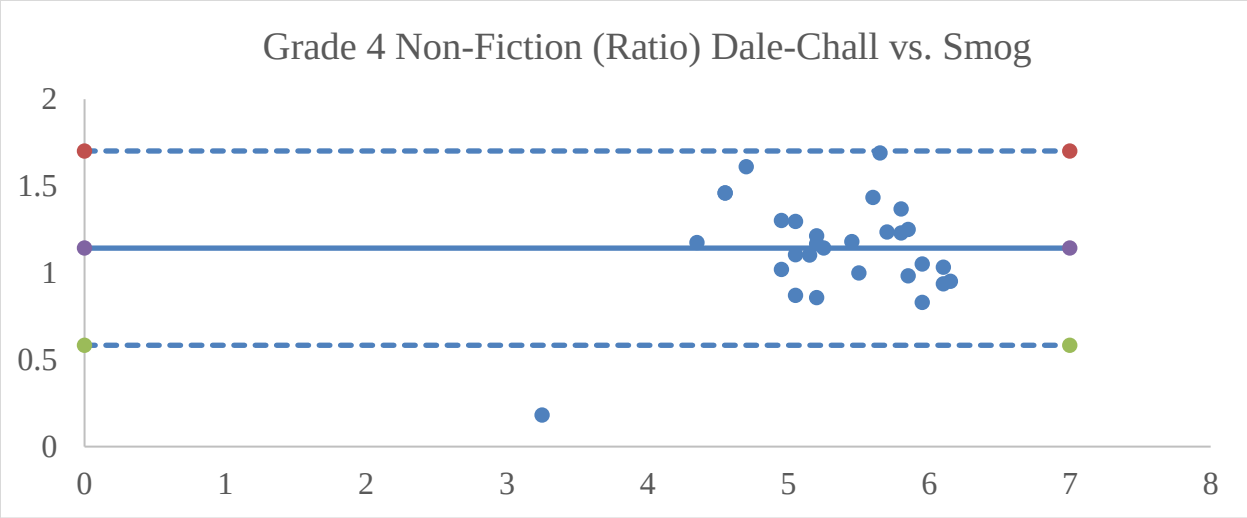


Figure 43. Non-Fiction Grade 4 Dale-Chall-Smog Bland-Altman Plot

Spache vs. Smog

The three (3) breakout data sets used to assess agreement for Spache and Smog were Fiction Grade 4, Non-Fiction Grade 2, and Non-Fiction Grade 3. All sets provided normally distributed data, therefore, the raw data were used to construct the Bland-Altman plots. Table 20 includes a breakdown of each of the three (3) comparisons.

Table 20

Spache vs. Smog

	Fiction Grade 1	**Non-Fiction Grade 2**	**Non-Fiction Grade 3**
Mean (Bias)	-0.344444	-0.06	-0.40294
SD	0.766368	0.861674	1.268615
Upper LOA	1.157637	1.628882	2.083545
Lower LOS	-1.846526	-1.74888	-2.88943
Spread LOA	3.004163	3.377764	4.972972
Percentage error	0.734	0.981	n/a*
Correlation	0.126	0.088	-0.139

**Note: percentage error not appropriate possibly due to extreme outliers*

The difference for each of the data sets falls within the *a priori* set 1.5 grade levels suggesting possible agreement. The spread of the limits of agreement for each set is wide and the percentage error for all sets is high, therefore, proportional error exists within all data sets analyzed. Based on the Bland-Altman plots in Figures 44-46, several outliers exist within each data set and the scatter of data points is less condensed around the bias line than desirable. The data do not support agreement between the two measures.

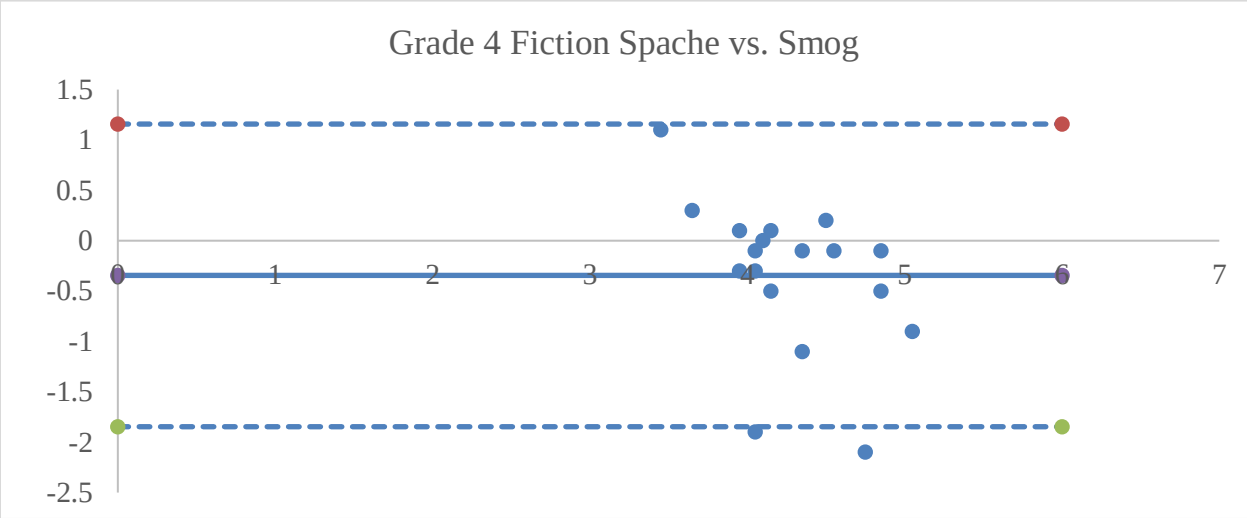


Figure 44. Fiction Grade 4 Spache-Smog Bland-Altman Plot

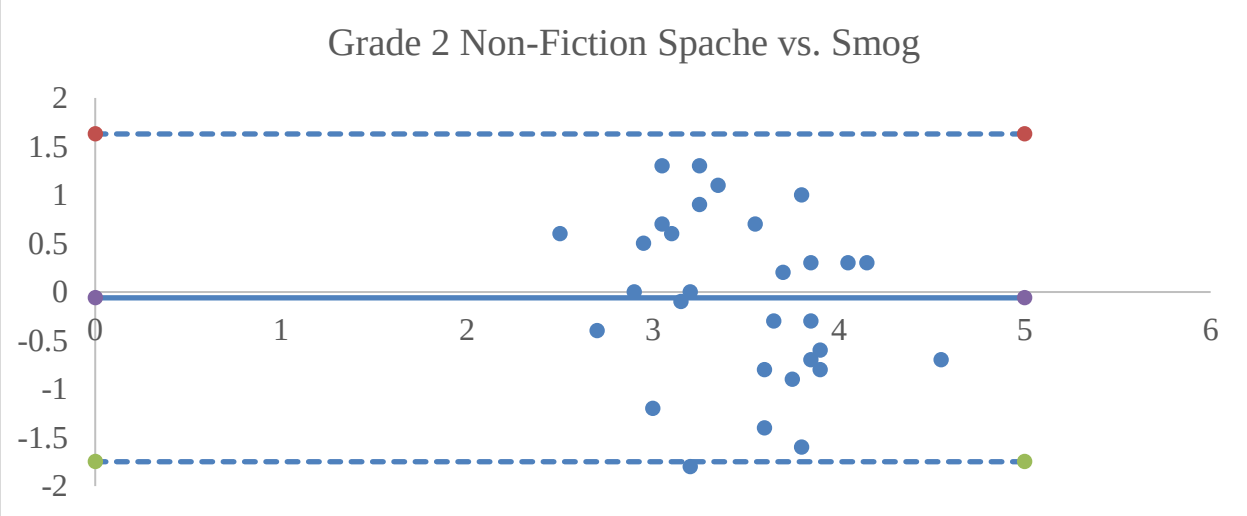


Figure 45. Non-Fiction Grade 2 Spache-Smog Bland-Altman Plot

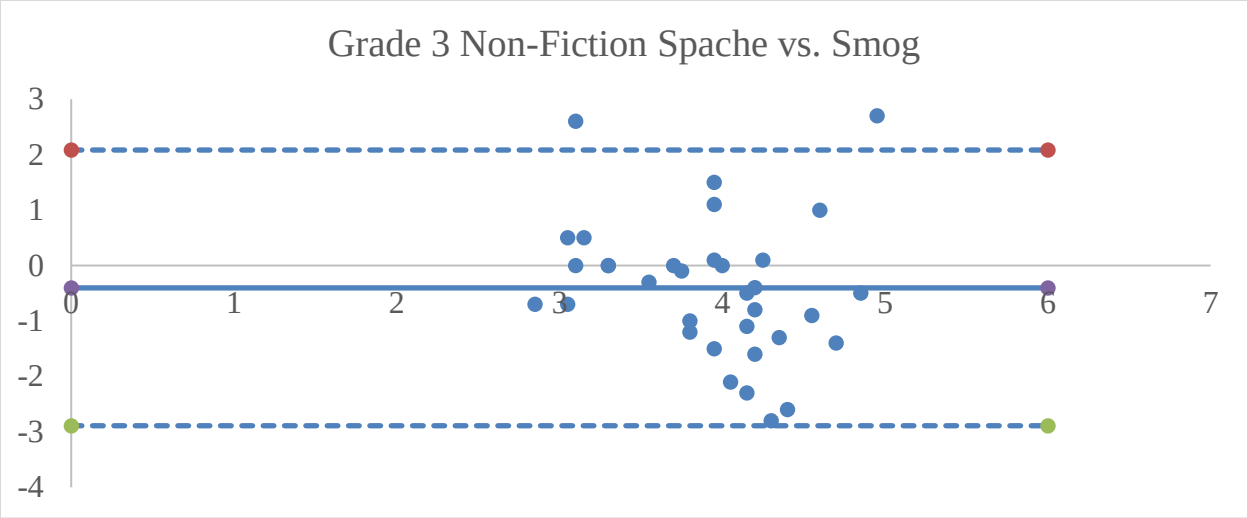


Figure 46. Non-Fiction Grade 3 Spache-Smog Bland-Altman Plot

Gunning Fog vs. Smog

The three (3) breakout data sets used to assess agreement for Gunning Fog and Smog were Fiction Grade 2, Fiction Grade 5, and Non-Fiction Grade 3. The Fiction Grade 2 and Fiction Grade 5 data sets provided normally distributed data, therefore, the raw data were used to construct the Bland-Altman plots for these data sets. The Non-Fiction Grade 3 data set, however, provided non-normal distribution of data. A ratio transformation was performed. The ratio data were used to create the Bland-Altman plot. Table 21 includes a breakdown of each of the three (3) comparisons.

Table 21

Gunning Fog vs. Smog

	Fiction Grade 2	**Fiction Grade 5**	**Non-Fiction Grade 3 (ratio)**
Mean (Bias)	0.61	1.961538	1.426775
SD	0.554822	1.726528	0.284959
Upper LOA	1.697451	5.345532	1.985295
Lower LOA	-0.47745	-1.422456	0.868254
Spread LOA	2.174903	6.767988	1.117041

Percentage error	0.507	0.958	0.195
Correlation	0.726	-0.235	0.85

The difference for the Fiction Grade 2 set meets the 1.5 grade levels and has an acceptable spread for limits of agreement. The percentage error at 0.507, however, suggests proportional error within the data set. Therefore, the two measures do not appear to agree for Fiction Grade 2.

The difference for Fiction Grade 5 and Non-Fiction Grade 3 exceeds the 1.5 grade levels set for agreement. The Non-Fiction Grade 3 data were calculated using ratio transformations therefore it is necessary to look at the raw data difference which was 1.605882. Based on the Bland-Altman plot for Non-Fiction Grade 3 in Figure 47, the data are scattered in a condensed manner around the bias line with the exception of one outlier. This may contribute to the slightly raised difference. The spread of the limits of agreement is narrow and the proportional error is low. However, removing the outlier from the data set does not lower the difference enough to fall within the *a priori* set limits of 1.5 grade levels for agreement. Therefore, the data analyzed do not suggest agreement between the two measures. The Bland-Altman plots for Fiction Grade 2 and Fiction Grade 5 are in Figures 48-49.

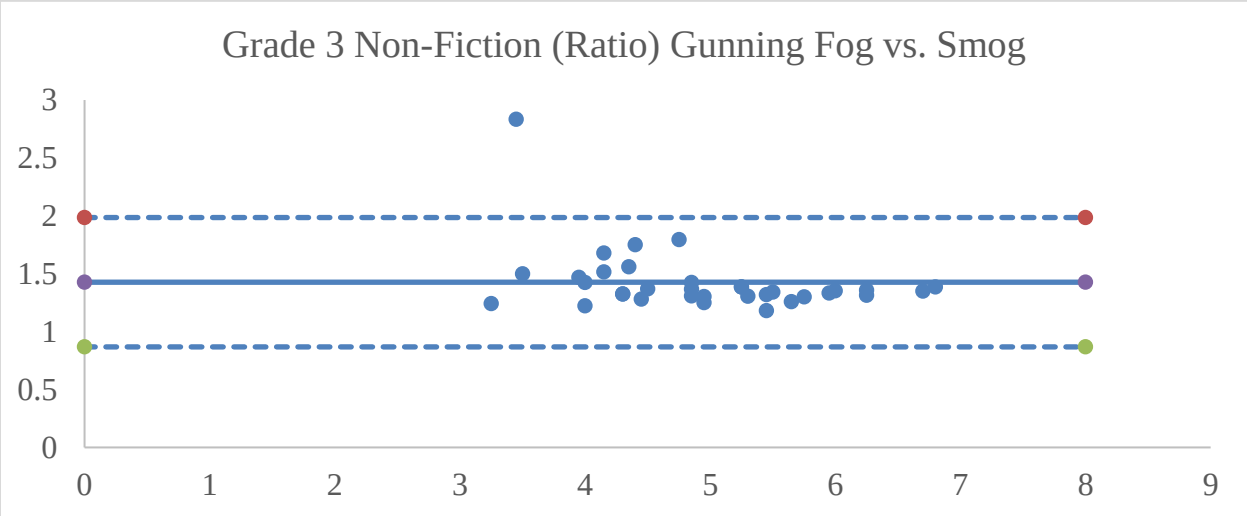


Figure 47. Non-Fiction Grade 3 Gunning Fog-Smog Bland-Altman Plot

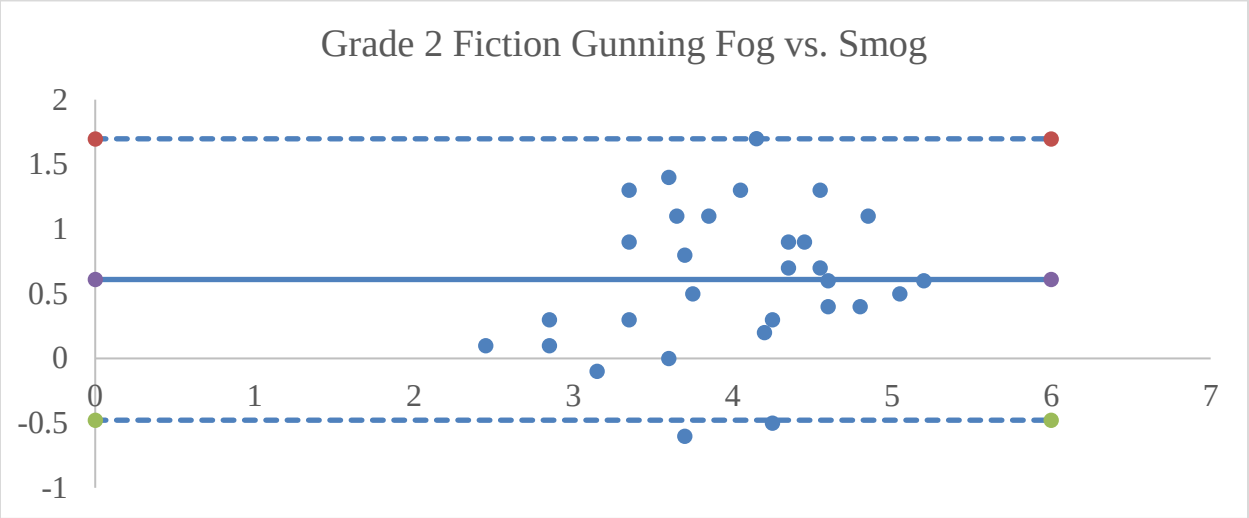


Figure 48. Fiction Grade 2 Gunning Fog-Smog Bland-Altman Plot

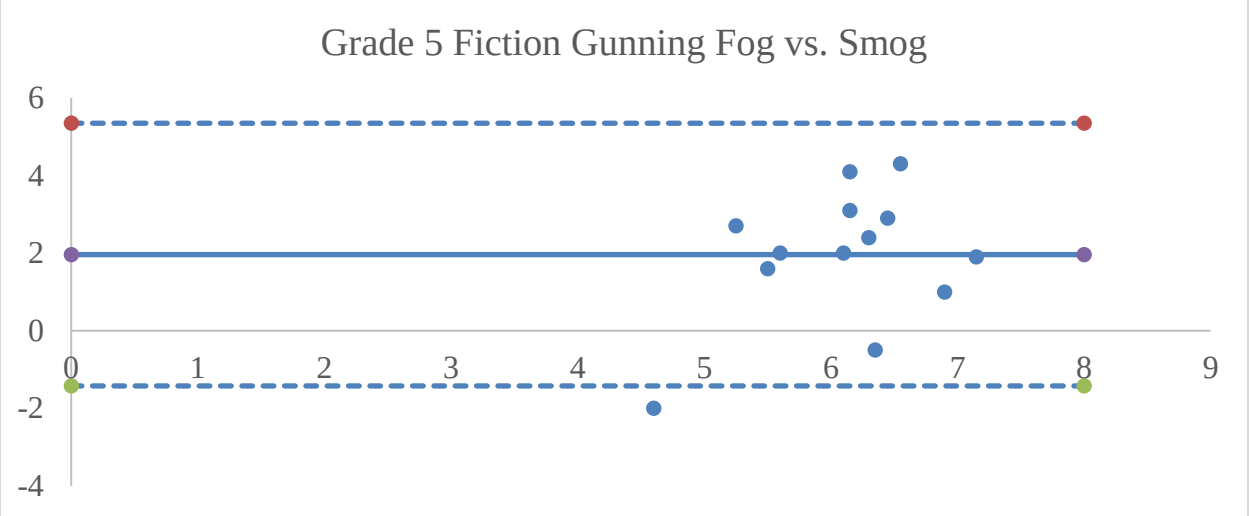


Figure 49. Fiction Grade 5 Gunning Fog-Smog Bland-Altman Plot

CHAPTER 5 Conclusions and Recommendations

The Bland-Altman plot was used to assess agreement between six (6) reading indices. The resulting fifteen (15) analyses resulted in agreement, or near agreement, among nine (9) comparisons. Near agreement was determined when the difference between the two instruments was just slightly over the 1.5 grade level set *a* priori but still resulted in narrow limits of agreement, low proportional error, and produced a Bland-Altman plot where data points clustered around the bias line. The spread of the limits of agreement is narrow when instruments suggest agreement (Myles & Cui, 2007; Moen, 2016). Stevens et al. (2015) pointed out that with this method of agreement, the probability deemed to suggest agreement and therefore interchangeability is context-specific and is not a statistical decision. This decision is subjective and is determined based on subject-matter expertise. The set standard can be less conservative in a practical, education setting as opposed to a clinical setting where the consequences of the results could cause physical harm.

The Bland-Altman plot is inappropriate if there is any variability between measures. This discrepancy was found when attempting to compare Flesch Reading Ease and Coh-Metrix L2 with any of the other six (6) indexes. Flesch-Kincaid Grade Level, Fry Graph, Spache, Gunning Fog, Dale-Chall and Smog all provide a construct equivalent to a grade level. Flesch Reading Ease provides a numerical value 0-100, not a grade level equivalent. Flesch-Kincaid Grade Level converts the Flesch Reading Ease score into a grade-level equivalency based on the American grade-level system (Burke, 2010). Coh-Metrix L2 provides a numerical value rooted in text-based processes and cohesion features (Crossley, Greenfield, & McNamara, 2008; Graesser, McNamara, Louwerse, & Zhiquiang, 2004; Gallagher, Fazio, & Gunning, 2012). It was deemed necessary to remove the two (2) indexes from the study due to the discrepant measures.

Several of the comparisons rendered non-normal, or heteroscedastic, data sets requiring ratio transformation. According to Chhapola, Kanwal, and Brar (2015), "transformation of data usually renders the scatter of differences as homoscedastic" (p. 385). The ratio transformation of data is one method of addressing non-normality. The ratios of two measures can be plotted against the average of the two measures (Bland & Altman, 1999; Chhapola, Kanwal, & Brar, 2015). The transformation of data allows Bland-Altman plots to be reasonably robust when encountering non-normal data. The data are more compressed with less proportional error evident and less influenced by outliers when using transformed data. This allows for easier interpretation of the data in most cases.

The Flesch-Kincaid Grade Level index suggested agreement with Dale-Chall and Spache; and near agreement with Gunning Fog and Smog. The Dale-Chall index suggested agreement with Gunning Fog and Smog when the genre evaluated was non-fiction; and suggested near agreement with Spache, when the genre evaluated was non-fiction. The comparison of Dale-Chall and Gunning Fog when the genre was fiction suggested near agreement with a difference only slightly higher than the set standard of 1.5 grade levels. The Dale-Chall index proves to be a strong index to use with non-fiction genre, especially when sample sizes are large. Set comparisons that did not illustrate agreement have apparent outliers that may affect the outcome of agreement. The Spache reading index and Gunning Fog appear to agree particularly with large sample sizes. The non-fiction plot of all grade levels had narrow limits of agreement and a Bland-Altman plot with data points clustered near the bias line. The fiction plot was similar to the non-fiction plot, however, the spread of the limits of agreement was slightly wider. These results suggest that Flesch-Kincaid Grade Level and Dale-Chall can be used interchangeably with each other and with the Spache index, the Gunning Fog index and the Smog index.

The Fry Graph posed several problems when compared to the other reading indexes. Each of the Bland-Altman plots comparing Fry Graph with another reading index produced a plot containing linear sets of data points. Figure 50 is an example of a plot outcome using Fry Graph as the comparison.

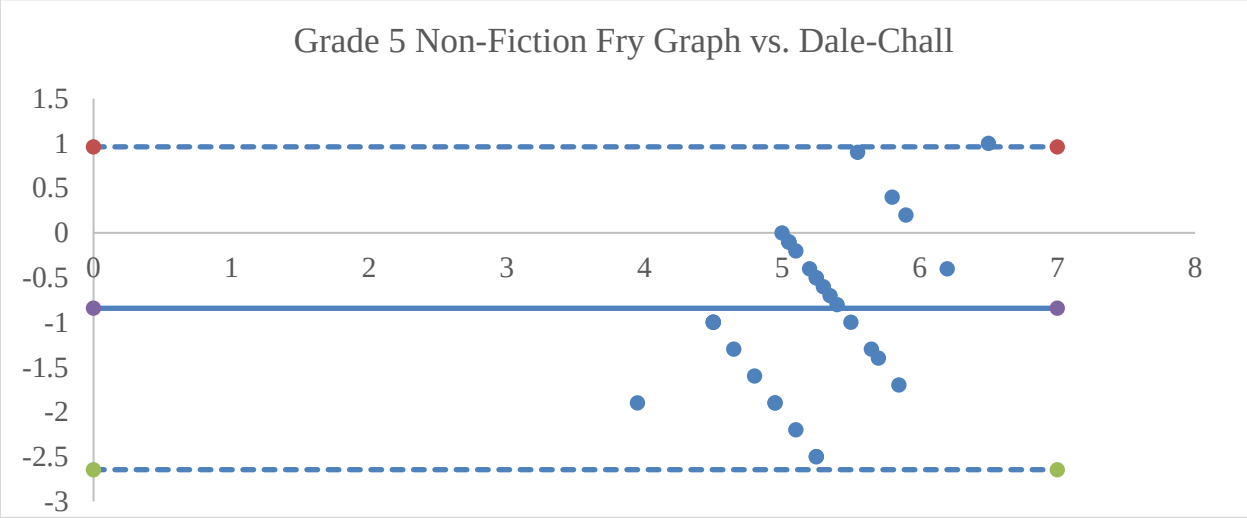


Figure 50. Fry Graph Plot Example.

For each comparison, the proportional error is evident, as well as fixed bias. As the average increases within the data set, the difference decreases. This is consistent among all comparisons using Fry Graph. While Fry Graph provides a grade level equivalent like each of the other indexes analyzed, it gives a discreet grade-level value unlike the other five (5) indexes, which provide a continuous grade-level value. This difference most likely results in the proportional error evident in all Fry Graph comparisons. Therefore, Bland-Altman may not be an appropriate method of comparison using Fry Graph.

Practical implications emerged in addition to the evidence of agreement between certain readability indexes. Bland-Altman plots are quantitative in nature because of the mathematical manipulation of the data, however, subject-matter expertise is required to determine an appropriate judgment regarding agreement (Ludbrook, 2010). This gives the practitioner an opportunity to

determine which measures more closely relate to one another and provide similar outcomes. Flesch-Kincaid Grade Level index and Dale-Chall index both suggested agreement or near agreement with the other indices, with the exception of the Fry Graph. Although the variances among readability formulas suggest imperfection, they offer probability statements and estimate text difficulty, making each index appropriate to use alone or interchangeably when determining text grade-level (Gallagher, Fazio, & Gunning, 2012). Ultimately, the safest and most predictable means of selecting a readability index for text evaluation would be to choose one instrument and use it exclusively. This will ensure consistency and provide similar outcomes. It is important to note, the Dale-Chall formula and the Smog index are recommended for use with texts at Grade 4 level or above (Begeny & Greene, 2014; Gallagher, Fazio, & Gunning, 2012).

Because of the differences among readability formulas, caution must be used when employing the indices to identify texts for instructional or intervention purposes (Begeny & Greene, 2014). This study identifies possible agreement, or interchangeability, between reading indexes. No suggestion regarding the use of a particular index for text identification is endorsed. There is little evidence that readability indexes are valid measures of text difficulty when compared to reading performance and must be considered as only one metric for understanding text difficulty (Begeny & Greene, 2014). Practitioners should utilize readability indexes as one method of assessing text readability. According to Goldman & Lee (2014) "text selection must also take into account the match or mismatch between what students bring to particular texts and what comprehension of those texts requires in the way of knowledge of the conventions of text structure, disciplinary content, and disciplinary-inquiry practices" (p. 298). Measuring text readability requires assessing both quantitative and qualitative factors that contribute to text complexity, as well as task considerations (Gallagher, Fazio, & Gunning, 2012).

Limitations of the Study

One limitation of the study is sample sizes. Grade-level sets, as well as genre sets for each comparison are not equally represented, limiting the extent of the data analyses. Sample sizes began equal across all grade levels and genres. Due to the discrepancies identified between publisher leveling and readability index leveling, some samples required removal. This limitation has also been noted in previous research findings. Other researchers have found that particular passages are often classified by grade level very differently across varying readability formulas (Begeny & Greene, 2014; Ardoin, Suldo, Witt, Aldrich, & McDonald, 2005; Ardoin, Williams, Christ, Klubnik, & Wellborn, 2010; Compton, Appleton, & Hosp, 2004). It also illustrates the subjectivity of text leveling. Small samples sizes may weaken the findings of the study. Chhapola et al. (2015) reported when sample size (*n)* increased, standard error (SE) decreased and the confidence interval (CI) of limits of agreement were narrower; when *n* is insufficient, then CI of limits of agreement are wider.

Time and resources also limited the size of each reading passage. Each passage was approximately 100-200 words in length. Often a few multisyllabic words can increase the readability score of a text especially when shorter passages are utilized (Burke, 2010). When choosing 100 words from a text of 150 pages the chances of the passage representing the publisher's stated grade level are greatly reduced. Longer passages would provide more accurate grade leveling which could impact study outcomes.

Another limitation of the study is failure to consider qualitative features that impact comprehension and readability. Readability indices provide only one (1) measure to assist practitioners in text selection whether for instructional or assessment purposes. Many factors need to be considered when selecting a text: format, reader schema, illustrations, curriculum, book

length, and overall text complexity. All these need to be weighed in relation to the reader's ability.

Finally, the formulae of readability indexes are unique and complex. Some readability indexes are constructed using specific high frequency words that affect scoring of non-fiction texts. Non-Fiction texts contain technical, and often scientific, vocabulary that would not appear on high frequency word lists. They also contain charts, tables, graphs and other diagrams that are not part of readability calculations. Readability levels are often underestimated in non-fiction text (Gallagher, Fazio, & Gunning, 2012). Other readability indexes are recommended for specific grade levels. Calculations in the present study were made using all readability indexes with all grade level data.

Further Research

Future research could include replicating the current study with larger sample sizes, longer passages, and including other readability indexes that measure the same construct, grade-level equivalency, to support or refute the findings of interchangeability within this study. The use of readability indexes appropriate for specific grade levels should be controlled for within the study. This would add to the findings and provide significant value to practitioners.

The ambiguous nature of Fry Graph and its lack of compatibility with other readability indexes represents another outcome from the present study that would warrant further research. Fry Graph is a well-established measure, however, the presentation of data with discreet values versus continuous values is problematic. Ludbrook (2010) recommended the use of regression analysis when calibrating one method against another or to detect bias (fixed or proportional) between two methods of measurement when the measurements are on an interval scale. Further research might include identifying a method or instrument, including other means of data transformation, to compare Fry Graph to other measures that would result in more meaningful

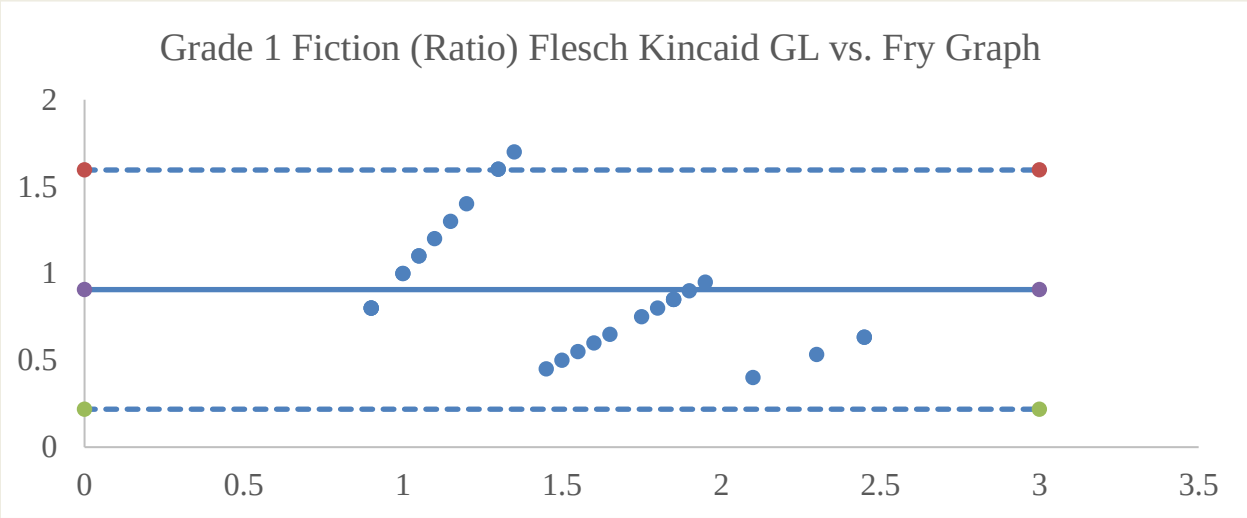
data.

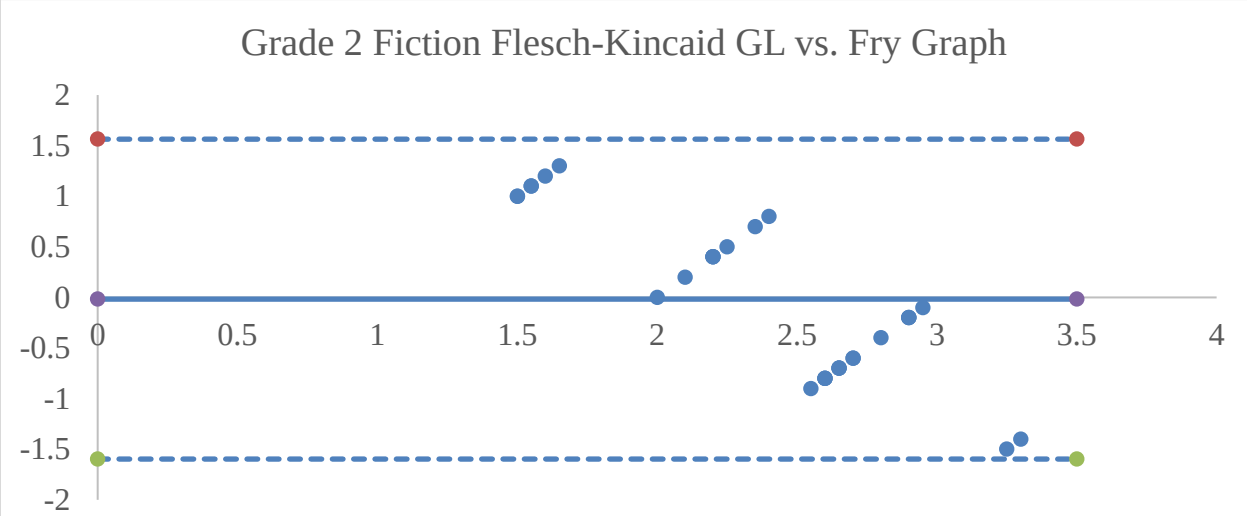
Another research consideration is to investigate why two (2) measures, or readability indexes, that purport to measure grade-level equivalency do not correlate. Bland and Altman (1983) stated one purpose of the difference plot is to detect a relationship between the differences and averages. In the absence of an actual relationship, the B-A plot can suggest a significant relationship exists (Stevens, Steiner, & MacKay, 2015). The reverse can also be true as evident with Fry Graph. The correlation of Fry Graph with Flesch-Kincaid Grade Level, Gunning Fog and Smog all indicate a significant relationship between measures but lack agreement.

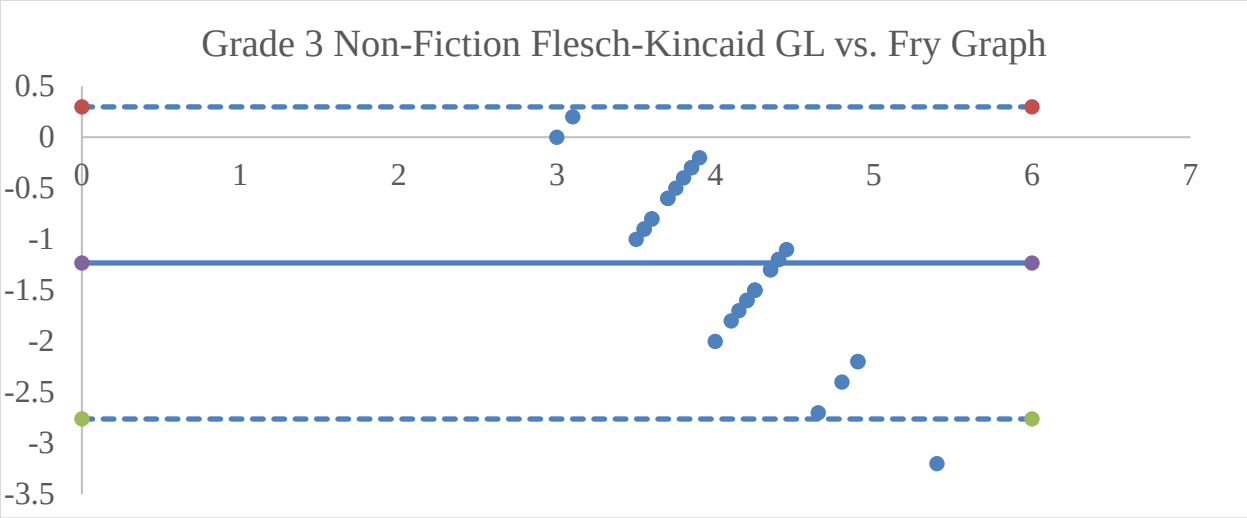
APPENDIX

APPENDIX A: BLAND-ALTMAN PLOTS FOR INDIVIDUAL GRADE LEVELS AND GENRES

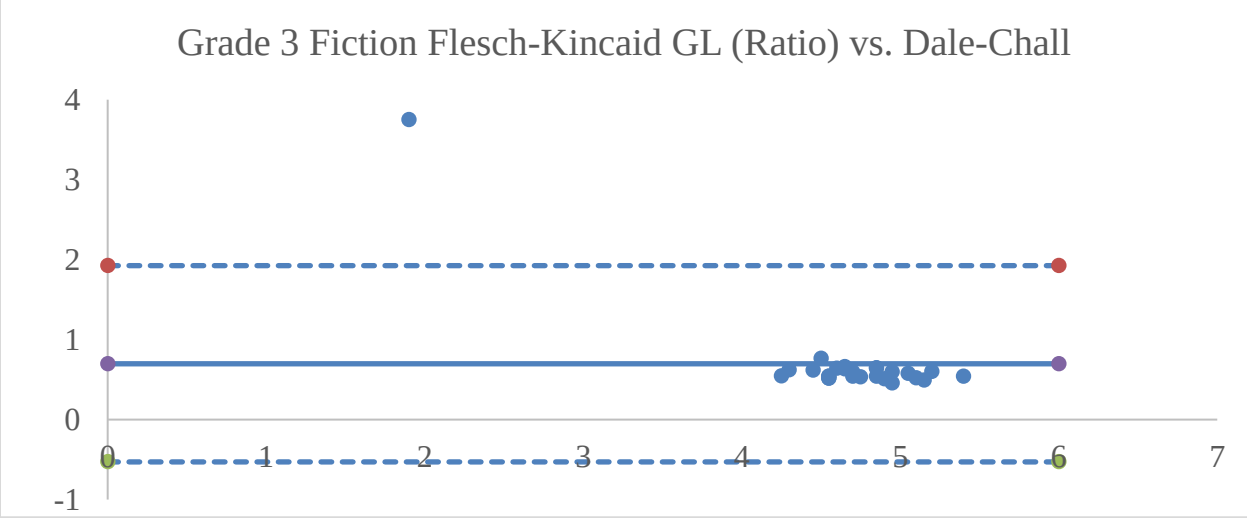
1. Flesch-Kincaid Grade Level vs. Fry Graph

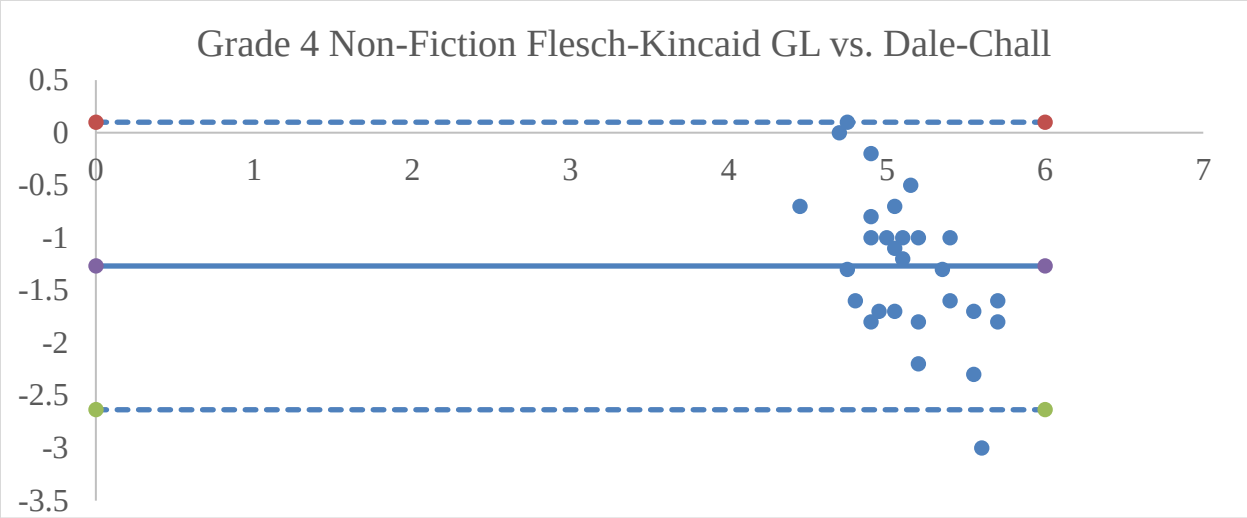


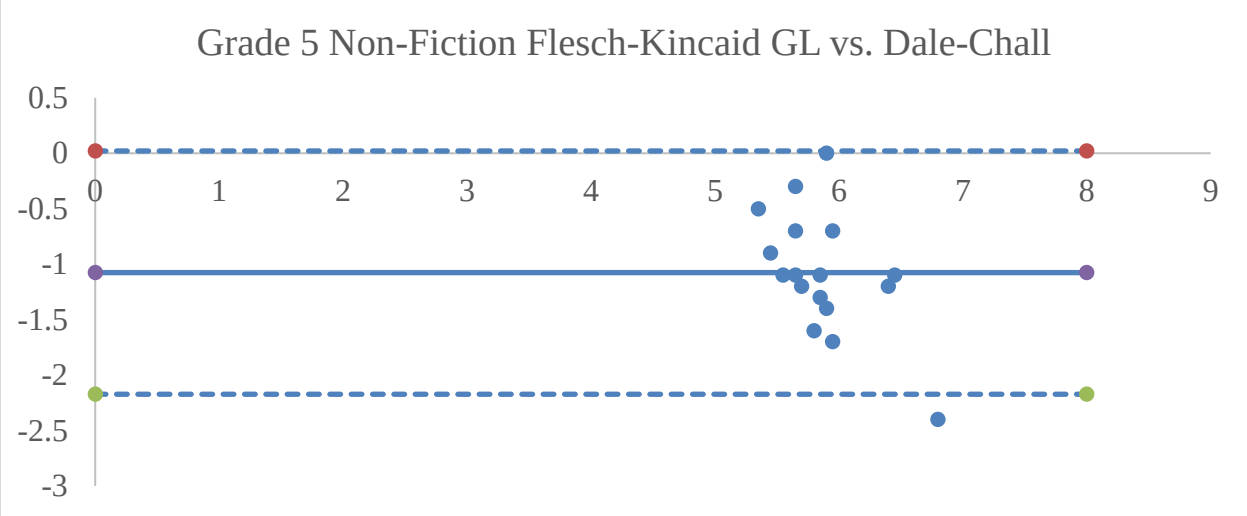




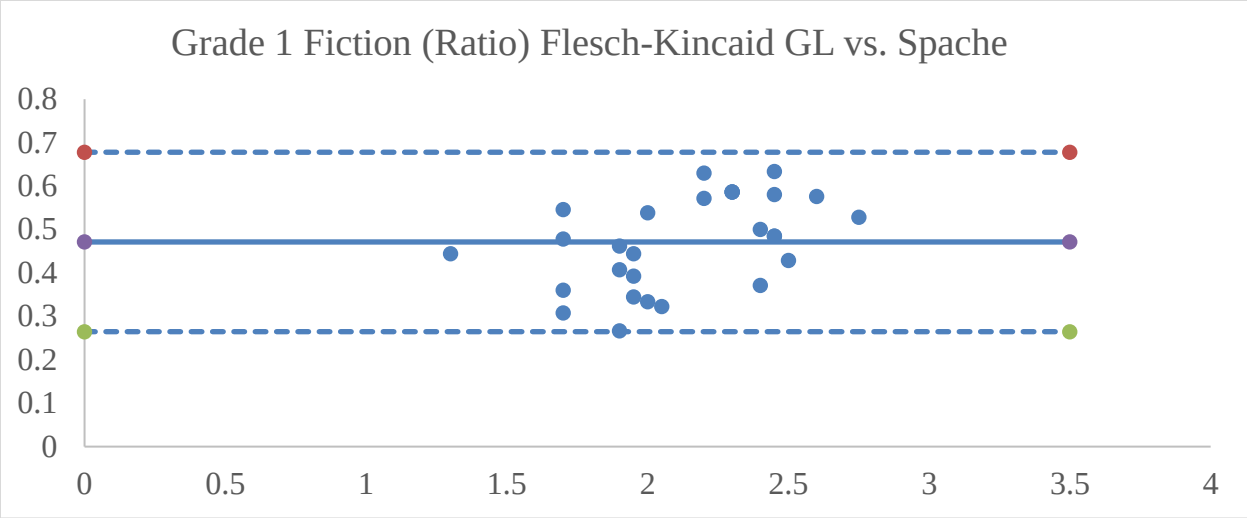
2. Flesch-Kincaid Grade Level vs. Dale-Chall

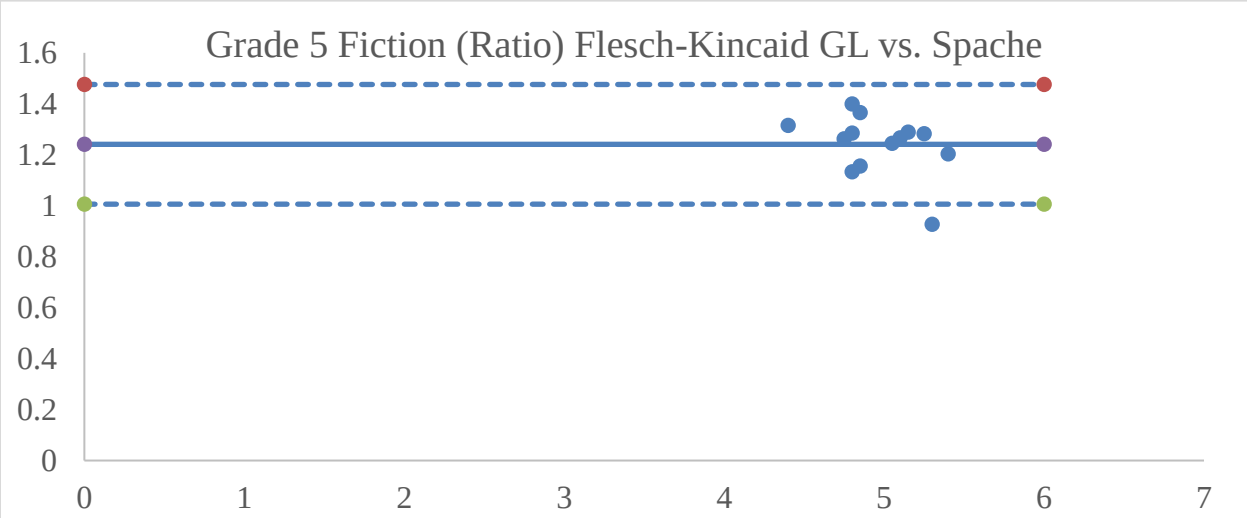


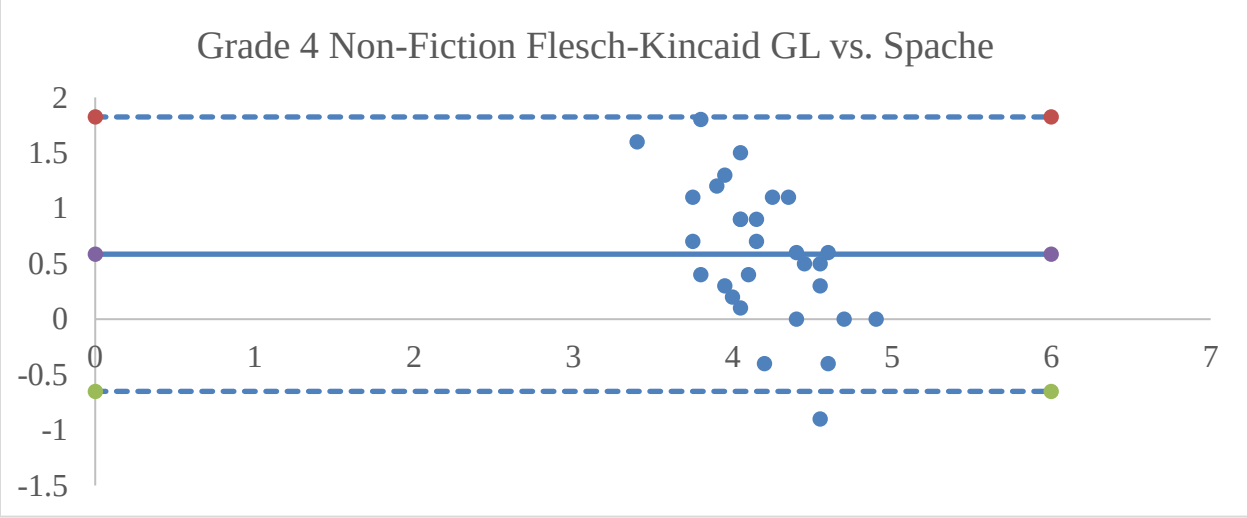




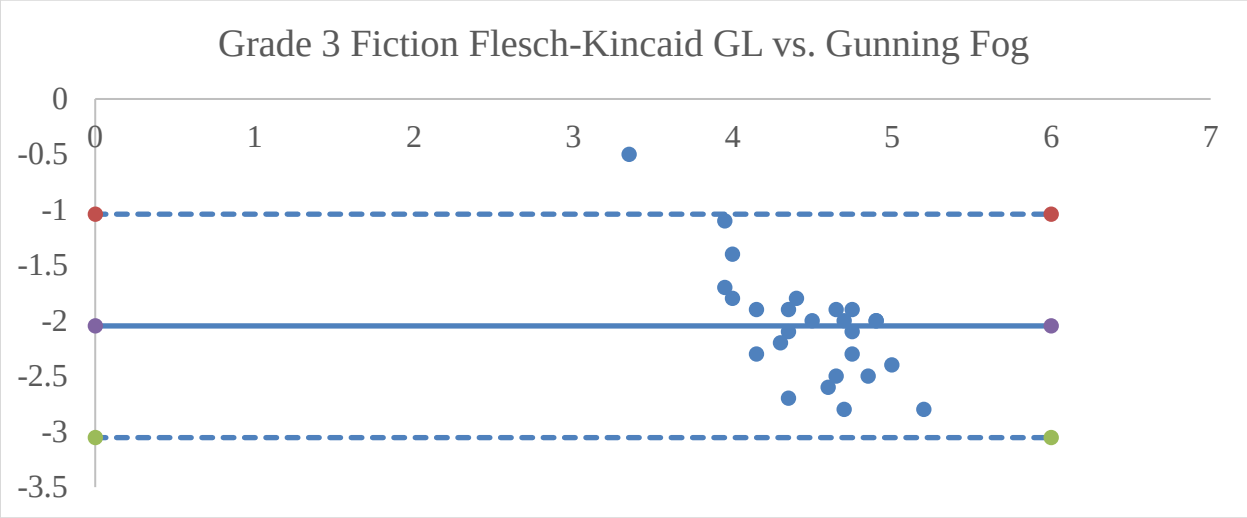
3. Flesch-Kincaid Grade Level vs. Spache

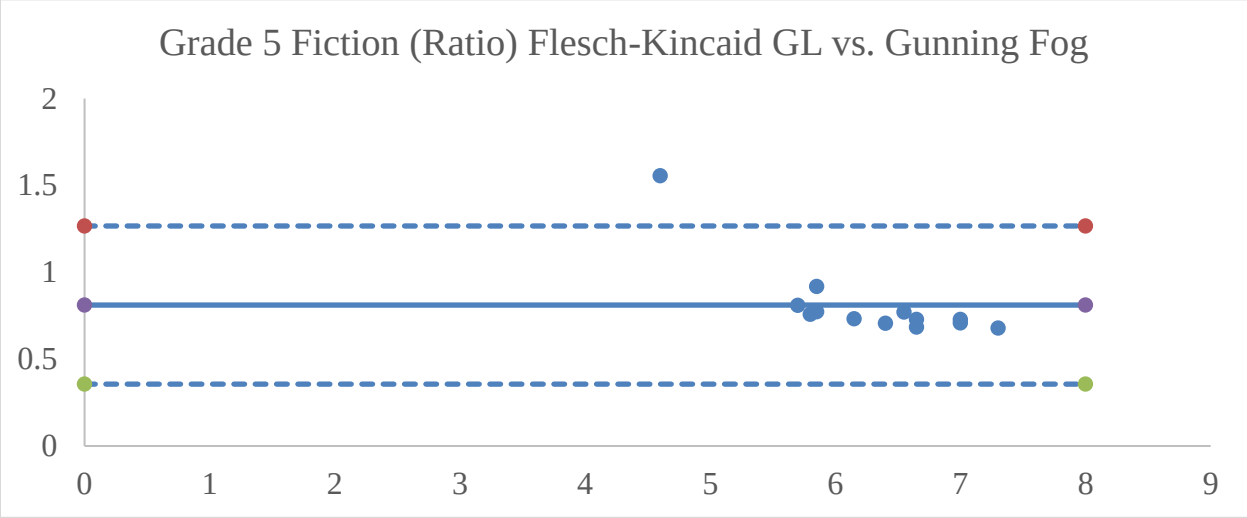

Grade 1 Fiction (Ratio) Flesch-Kincaid GL vs. Spache
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
2.5
3
3.5
4

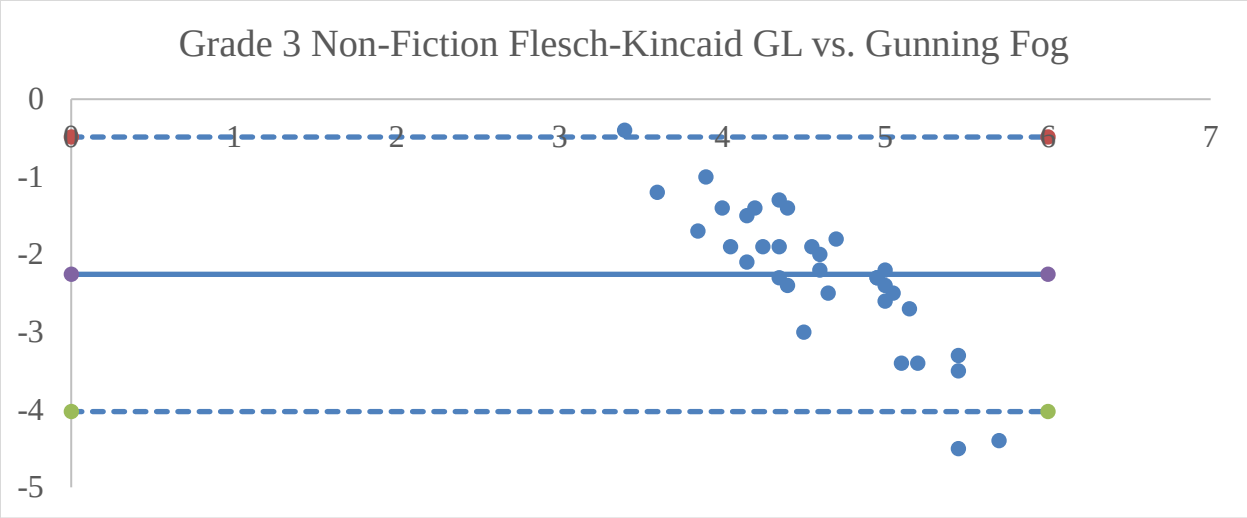

Grade 5 Fiction (Ratio) Flesch-Kincaid GL vs. Spache
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
7


Grade 4 Non-Fiction Flesch-Kincaid GL vs. Spache
2
1.5
1
0.5
0
-0.5
-1
-1.5
0
1
2
3
4
5
6
7

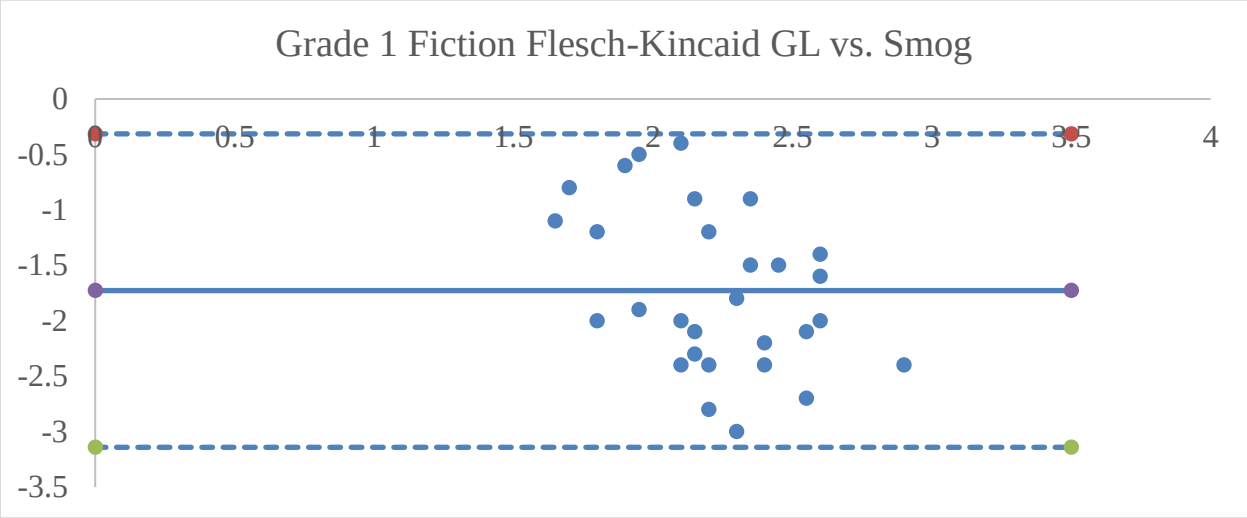
4. Flesch-Kincaid Grade Level vs. Gunning Fog

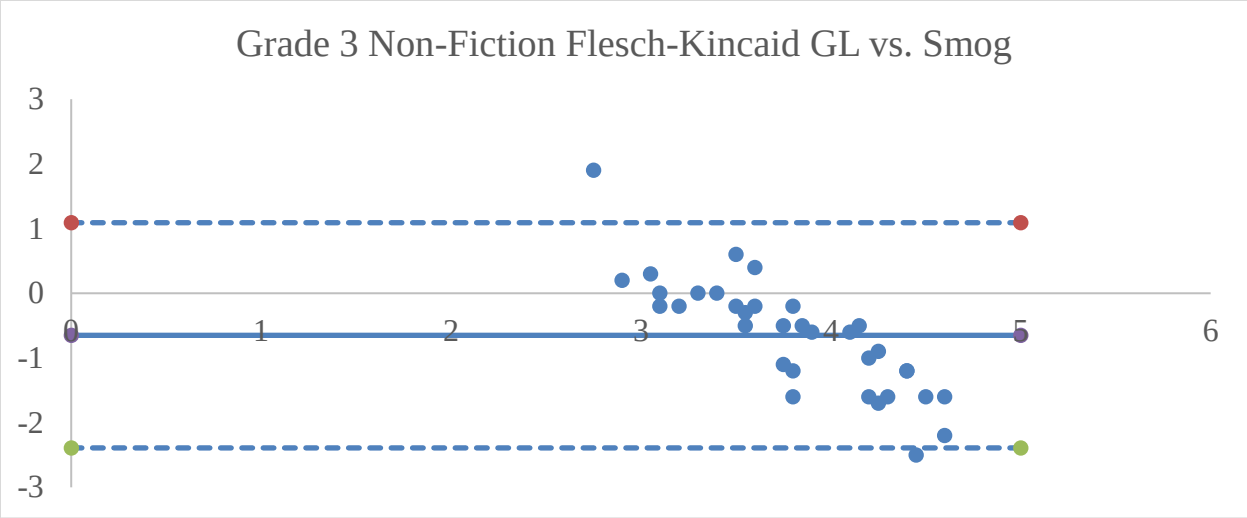


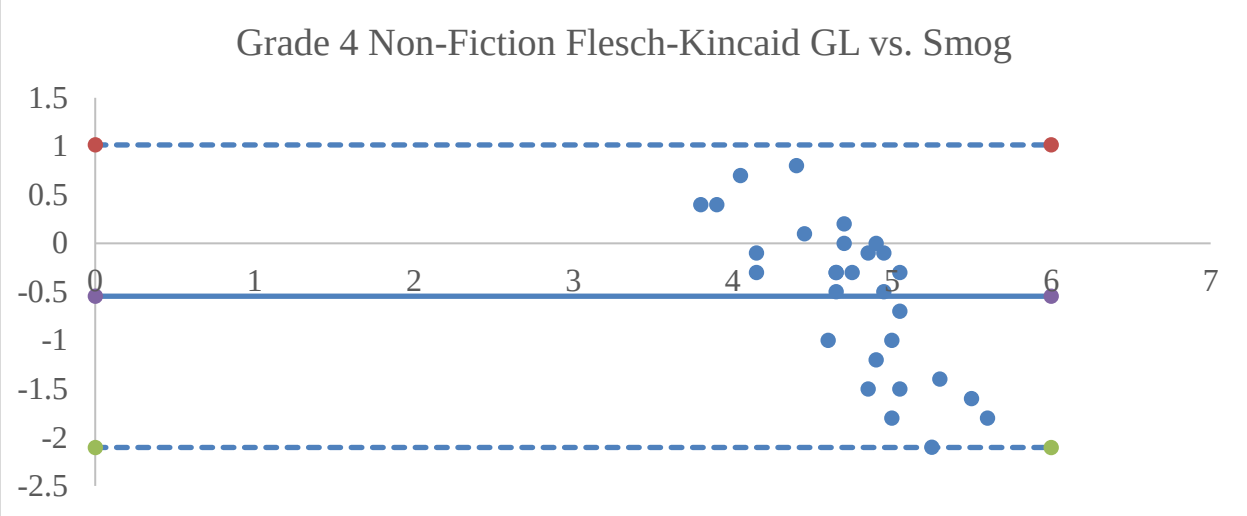




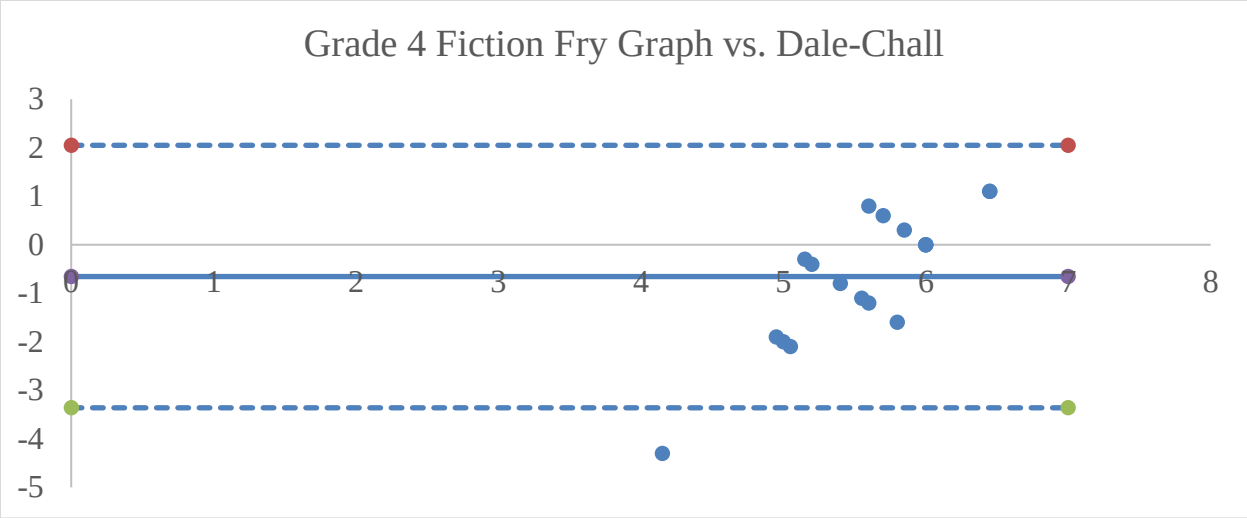
5. Flesch-Kincaid Grade Level vs. Smog

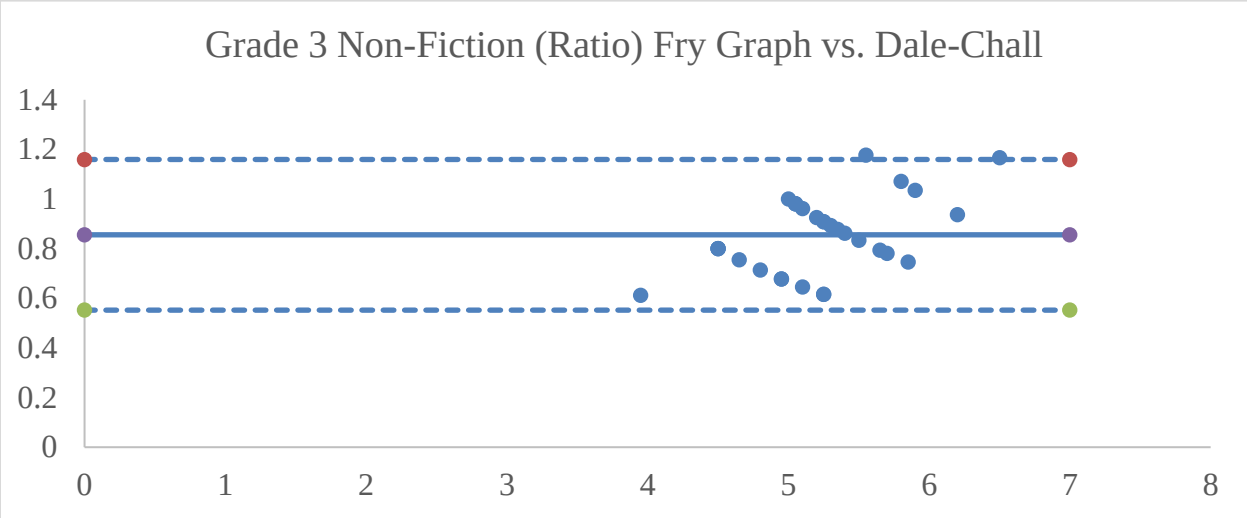


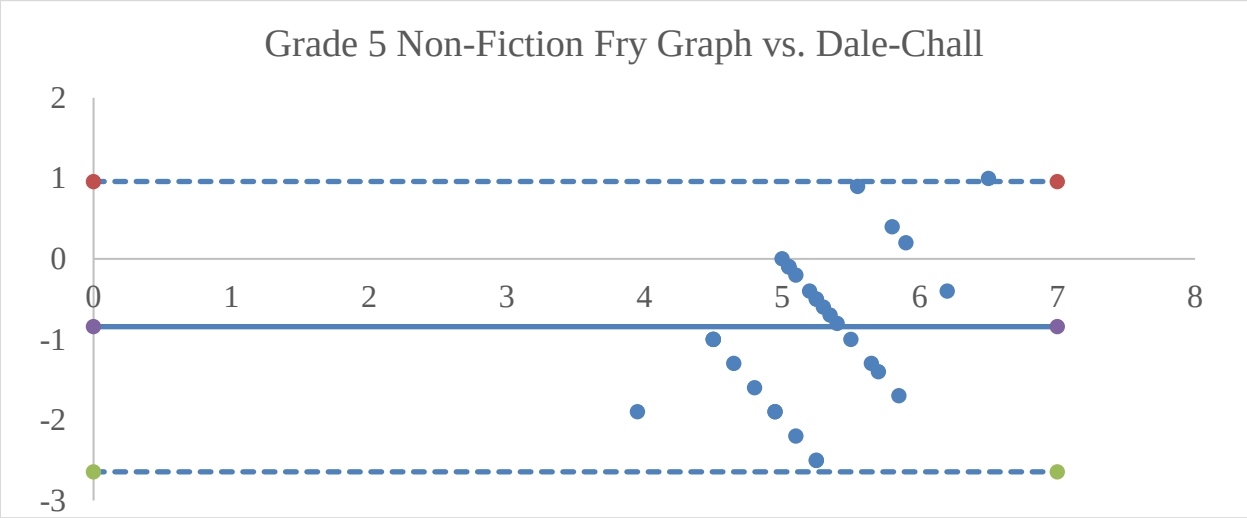




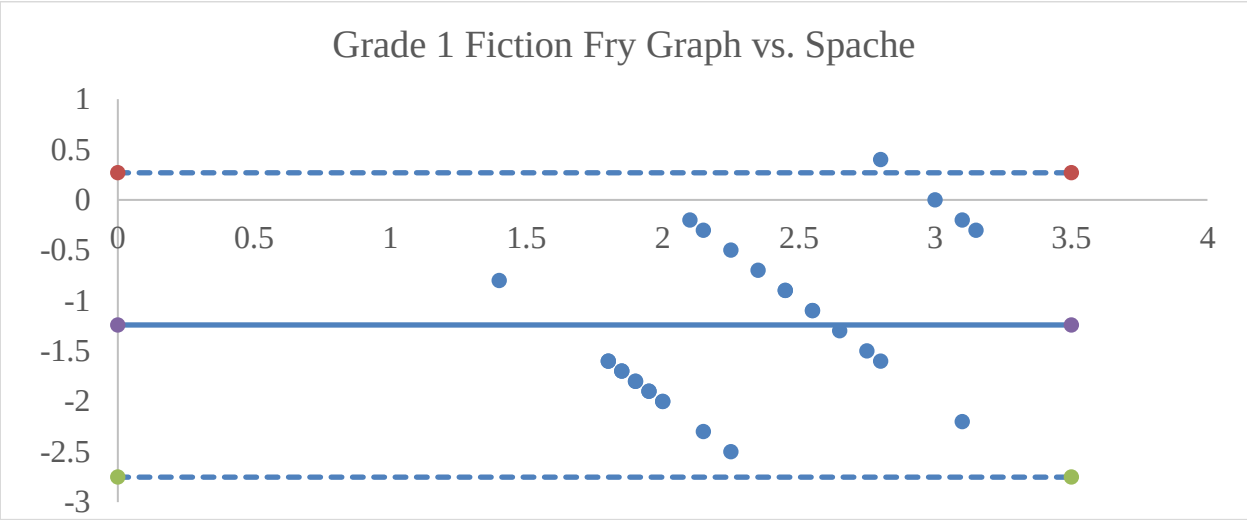
6. Fry Graph vs. Dale-Chall

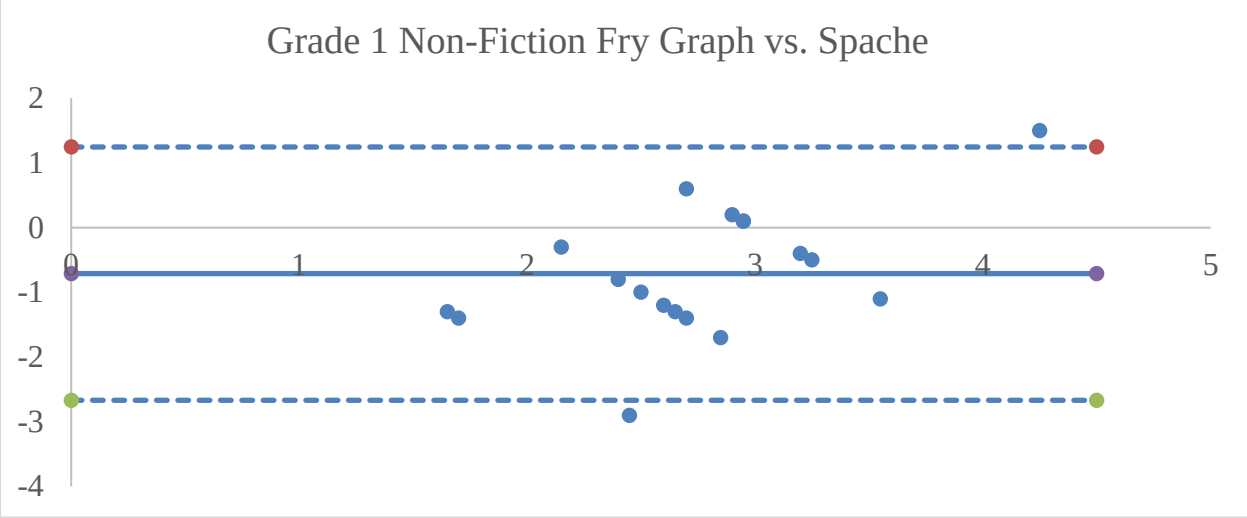

Grade 4 Fiction Fry Graph vs. Dale-Chall
3
2
1
0
-1
-2
-3
-4
-5
0
1
2
3
4
5
6
7
8

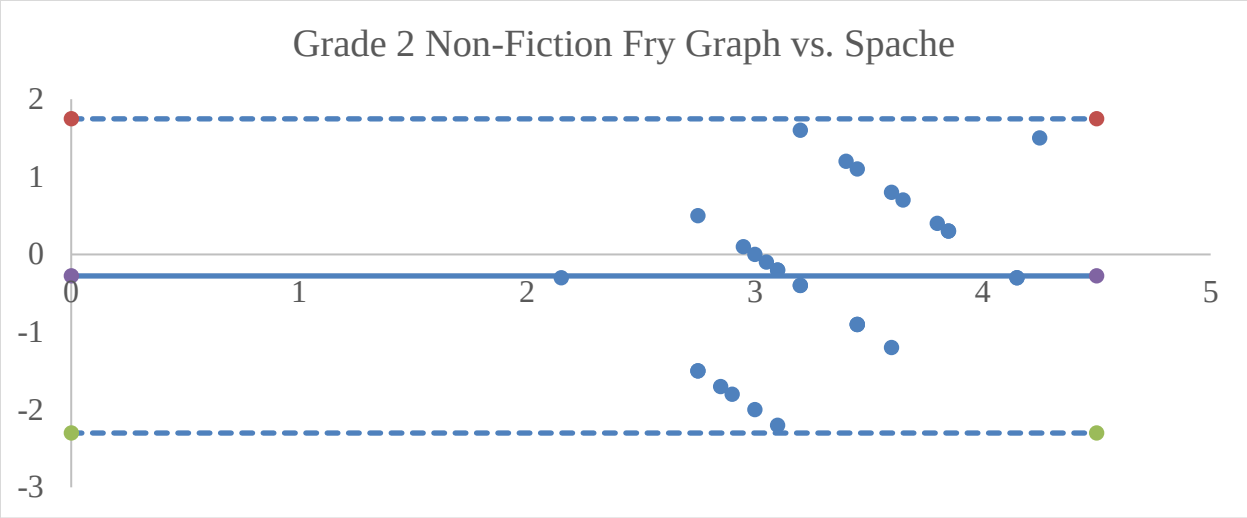

Grade 3 Non-Fiction (Ratio) Fry Graph vs. Dale-Chall
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
7
8


Grade 5 Non-Fiction Fry Graph vs. Dale-Chall
2
1
0
-1
-2
-3
0
1
2
3
4
5
6
7
8

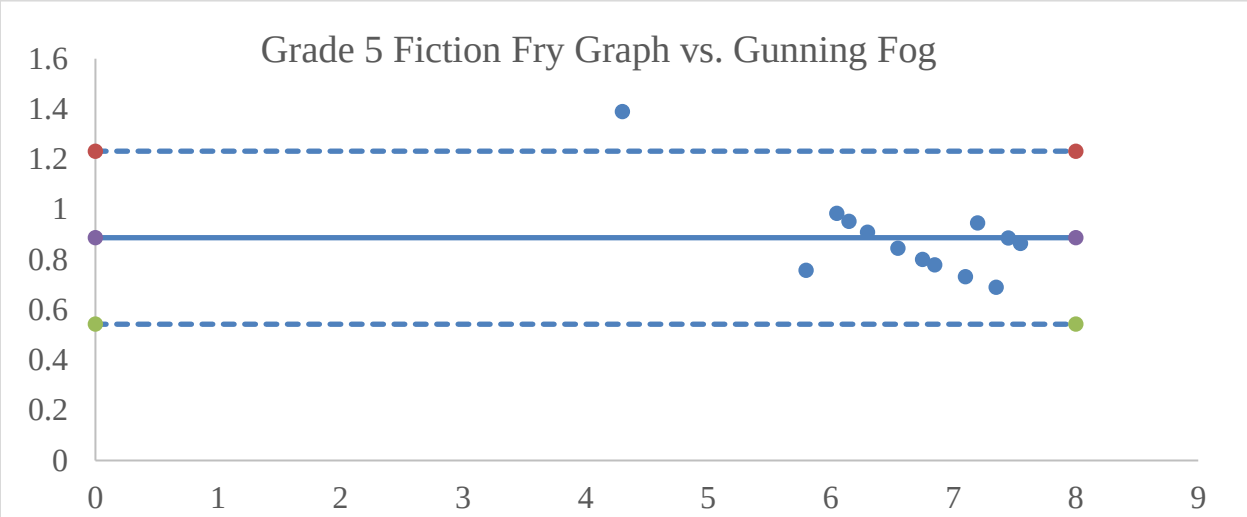
7. Fry Graph vs. Spache

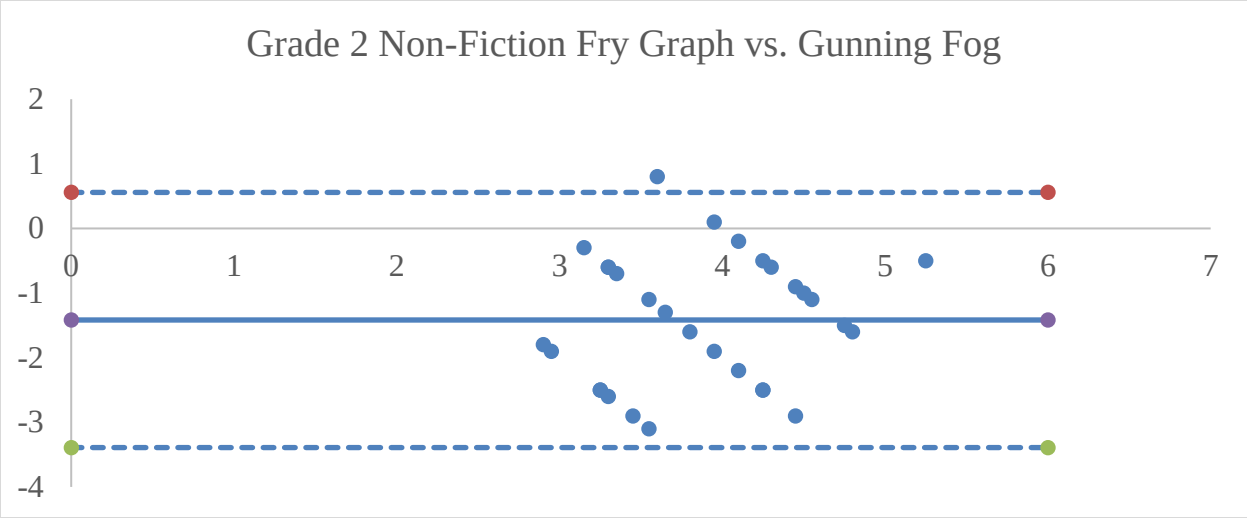


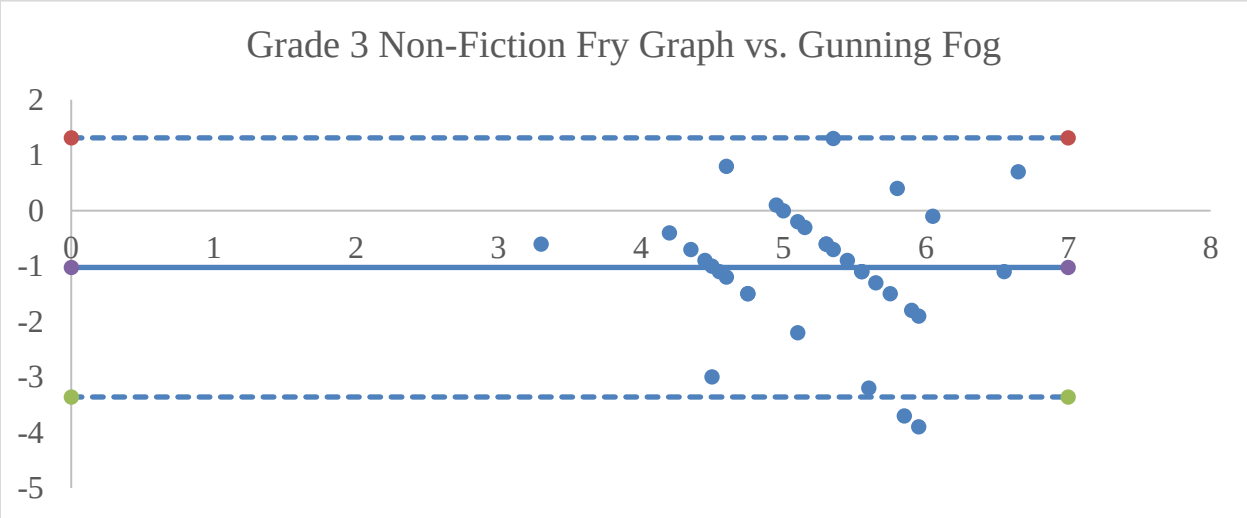




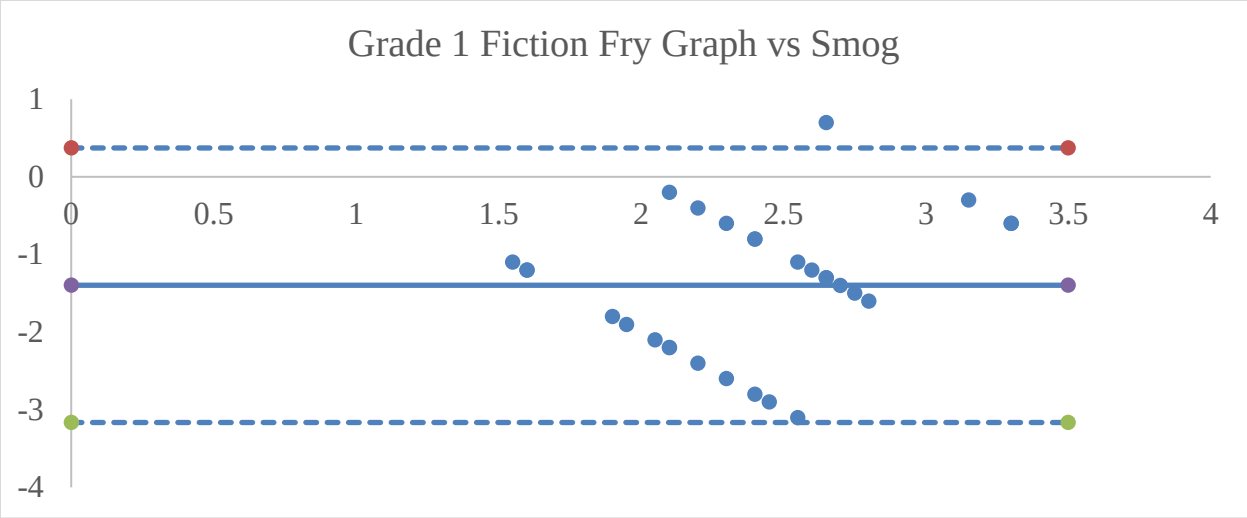
8. Fry Graph vs. Gunning Fog

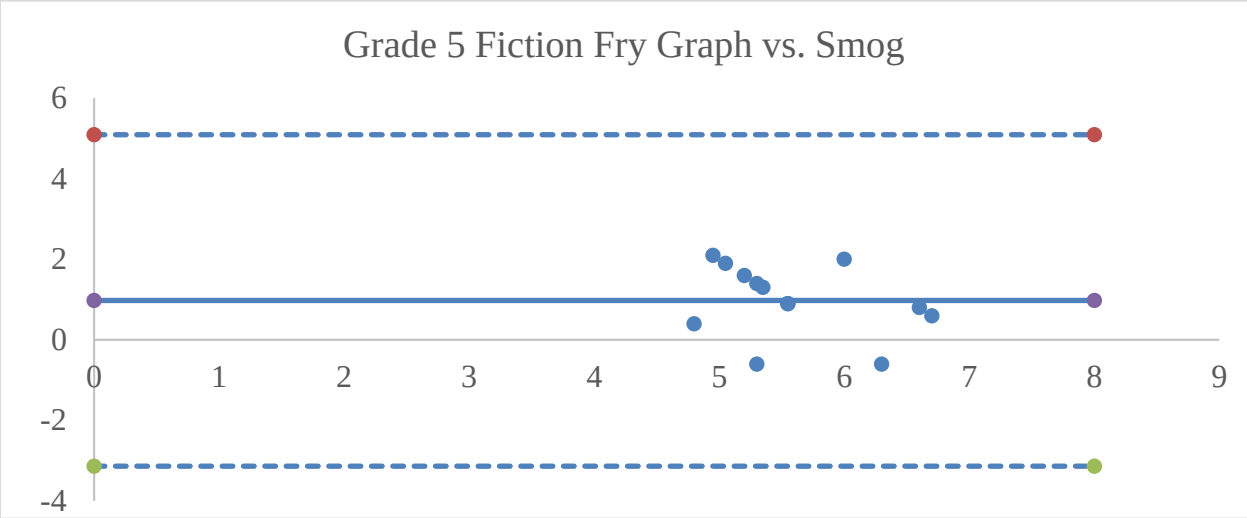


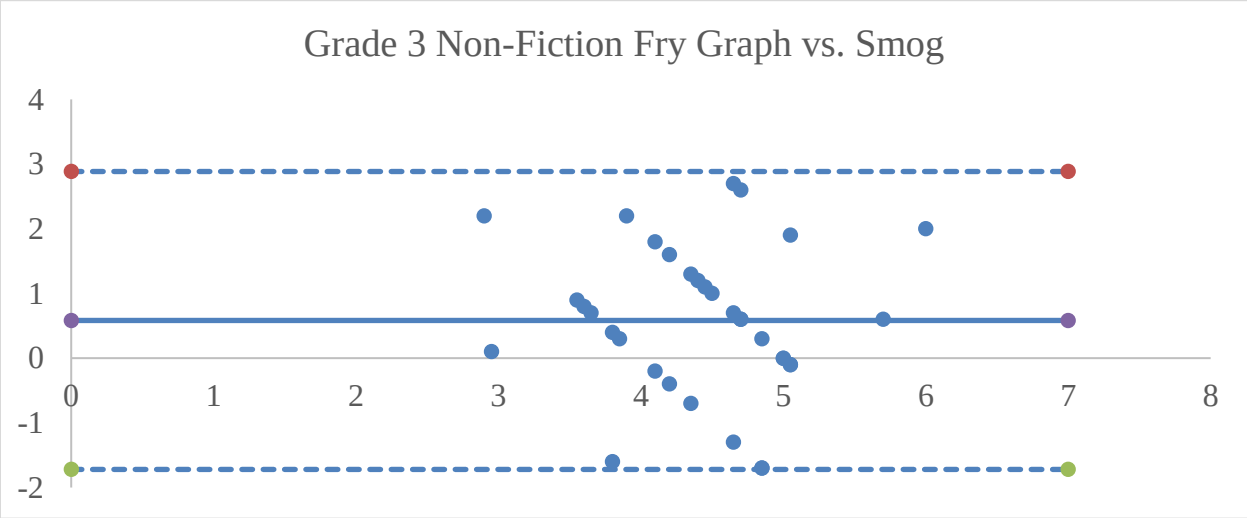




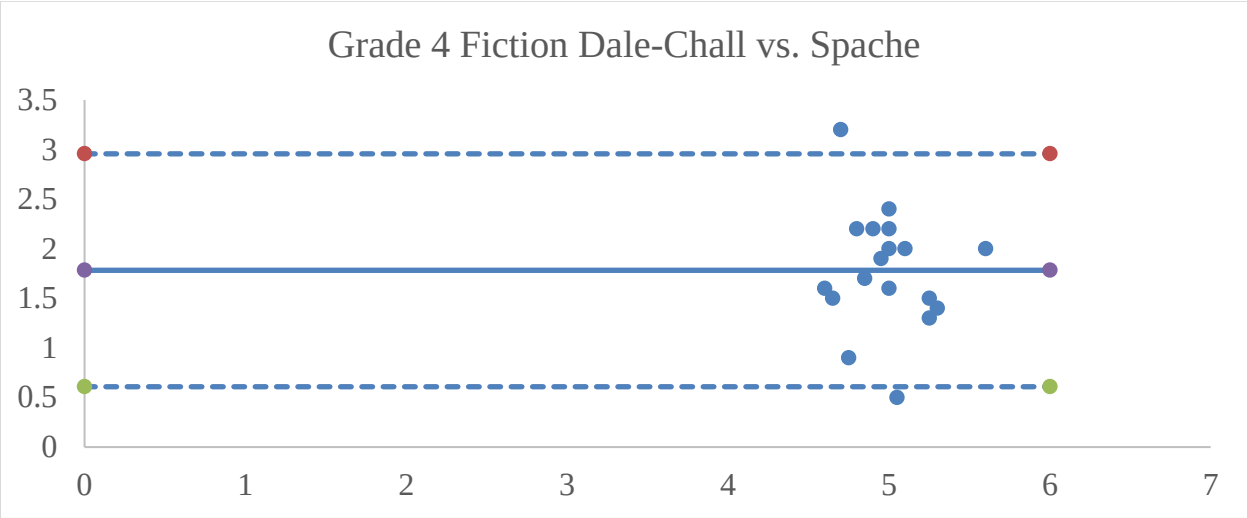
9. Fry Graph vs. Smog

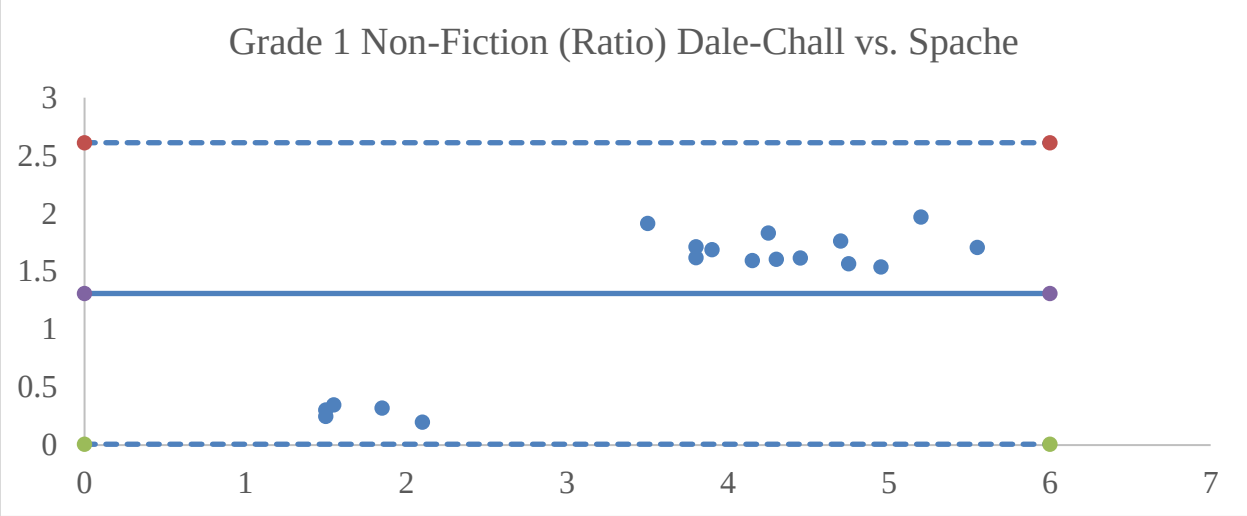

Grade 1 Fiction Fry Graph vs Smog
1
0
-1
-2
-3
-4
0
0.5
1
1.5
2
2.5
3
3.5
4

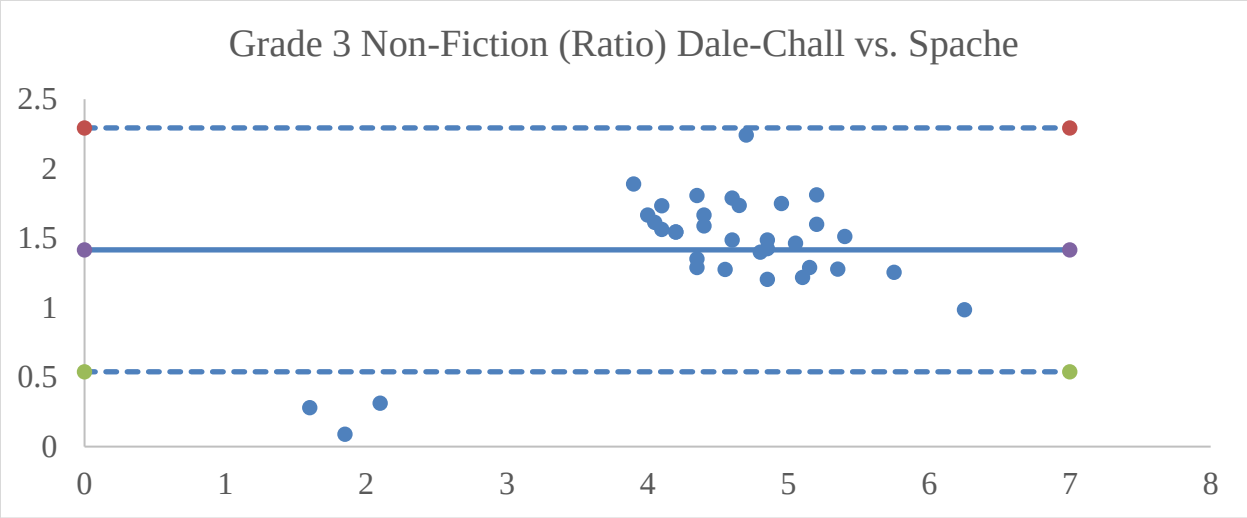

Grade 5 Fiction Fry Graph vs. Smog
6
4
2
0
-2
-4
0
1
2
3
4
5
6
7
8
9


Grade 3 Non-Fiction Fry Graph vs. Smog
4
3
2
1
0
-1
-2
0
1
2
3
4
5
6
7
8

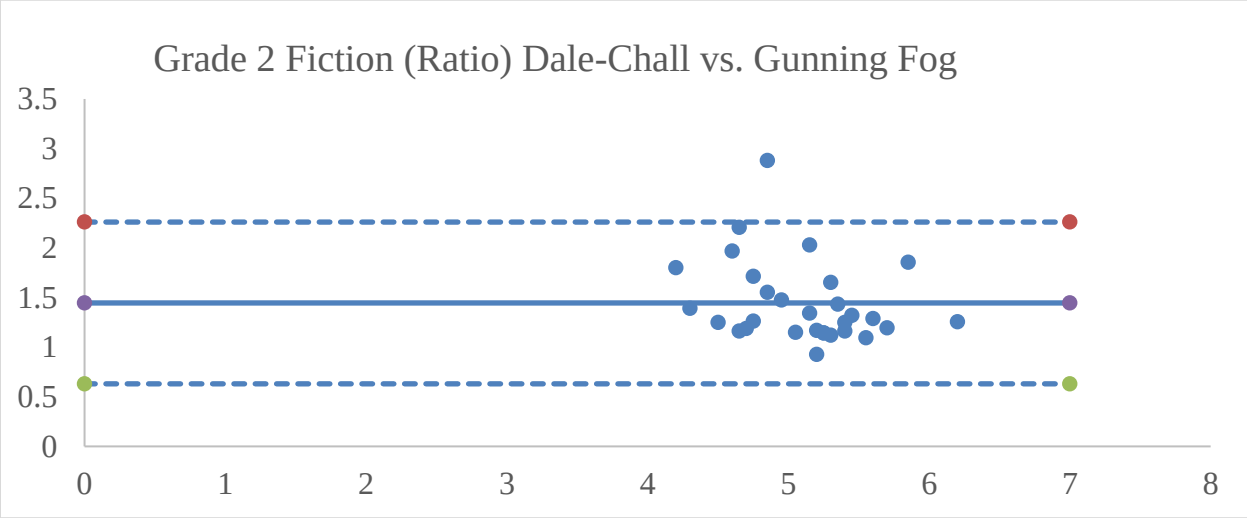
10. Dale-Chall vs. Spache

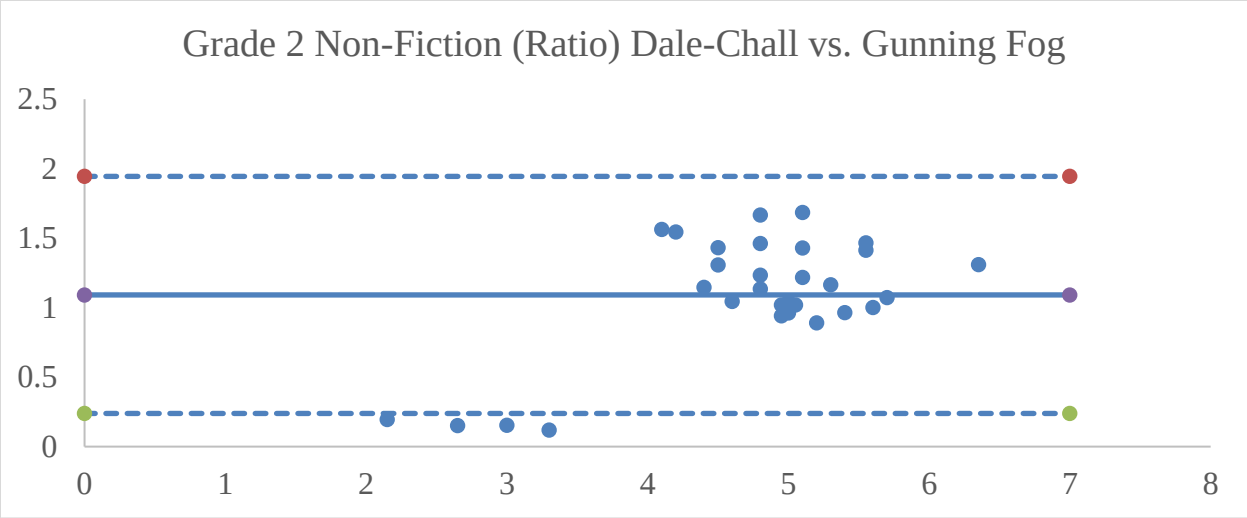


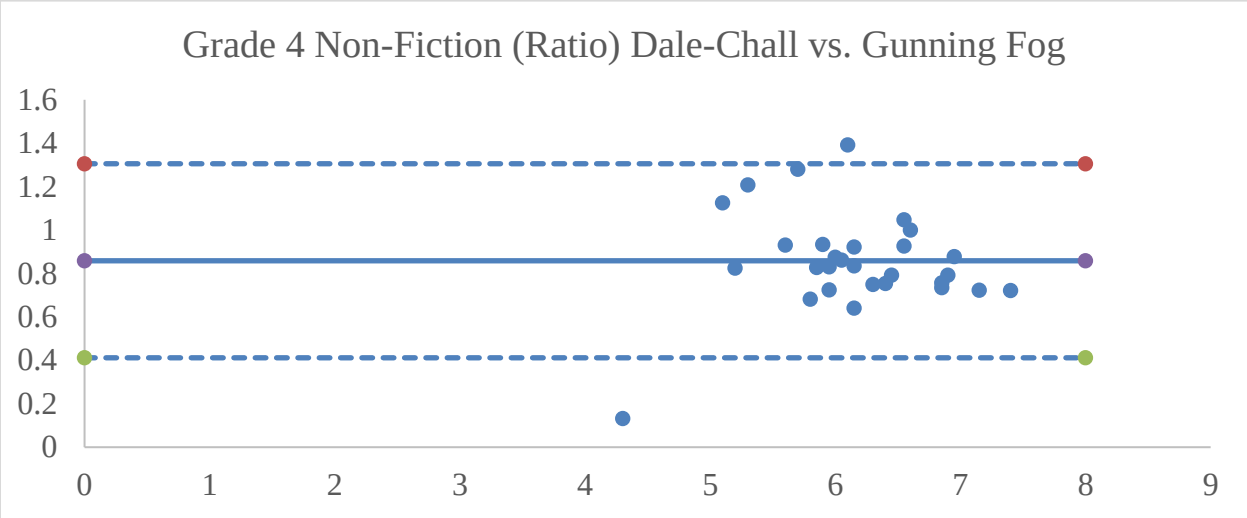




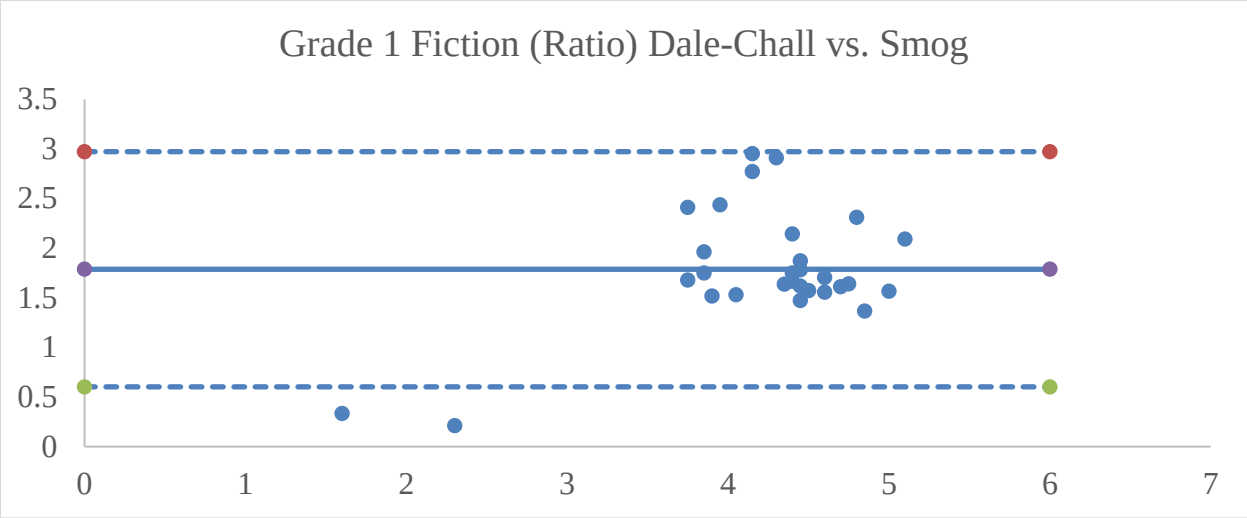
11. Dale-Chall vs. Gunning Fog

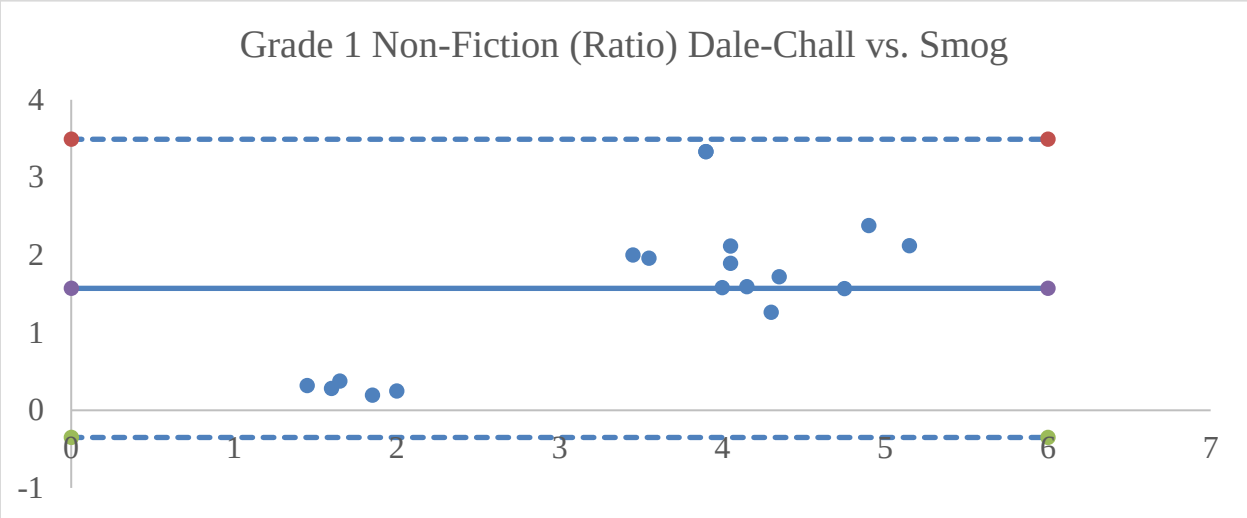


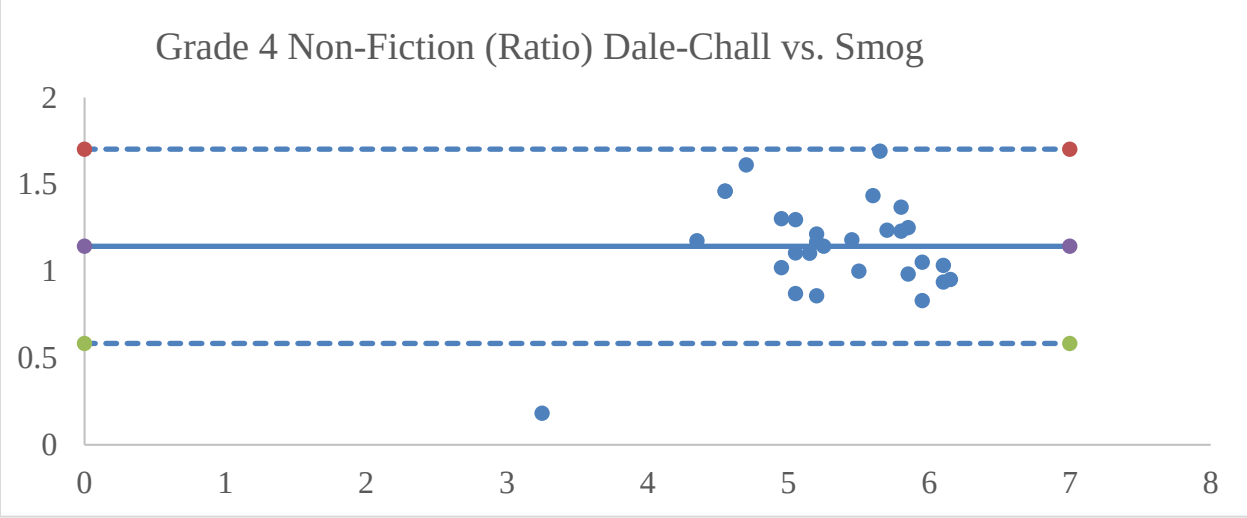




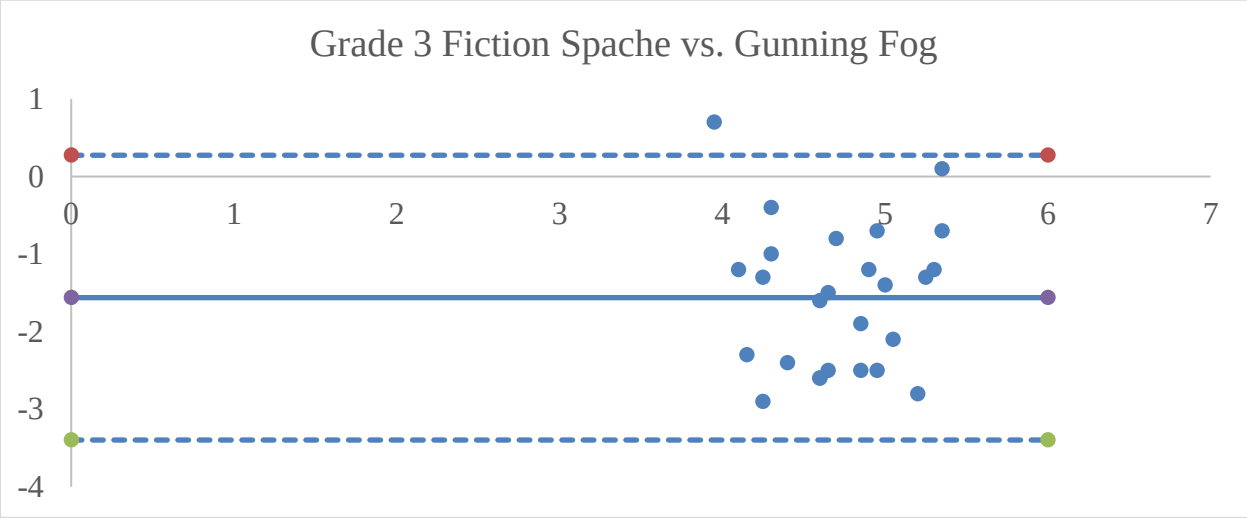
12. Dale-Chall vs. Smog

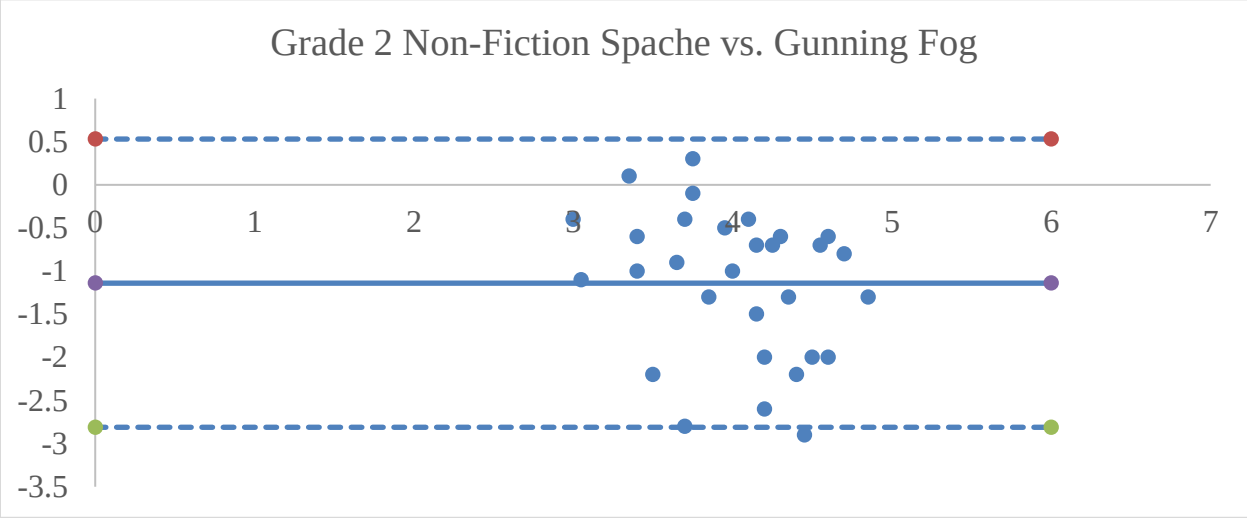

Grade 1 Fiction (Ratio) Dale-Chall vs. Smog
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7

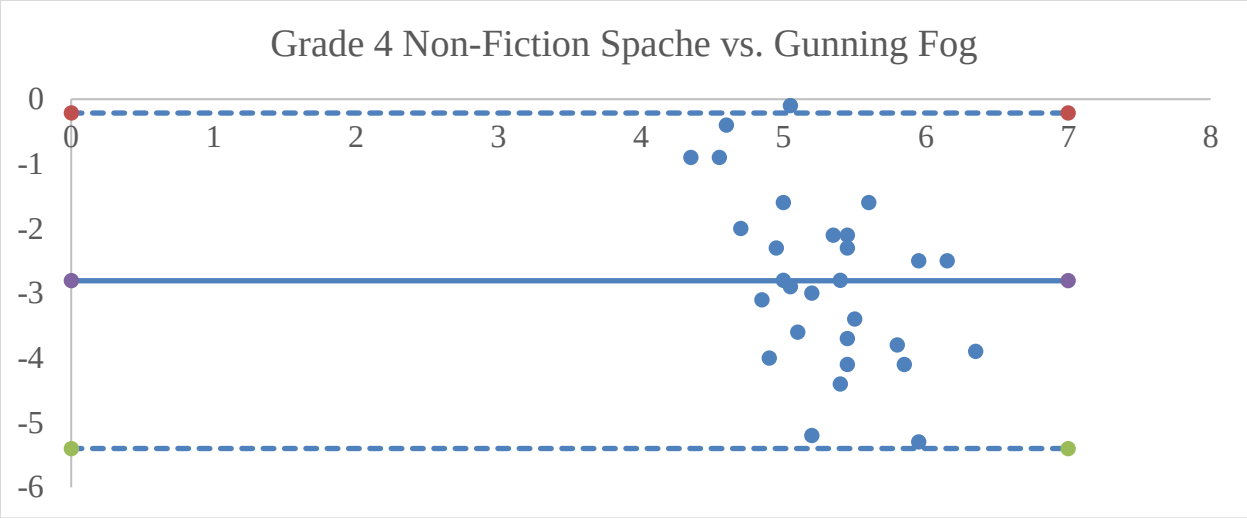

Grade 1 Non-Fiction (Ratio) Dale-Chall vs. Smog
4
3
2
1
0
-1
0
1
2
3
4
5
6
7


Grade 4 Non-Fiction (Ratio) Dale-Chall vs. Smog
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8

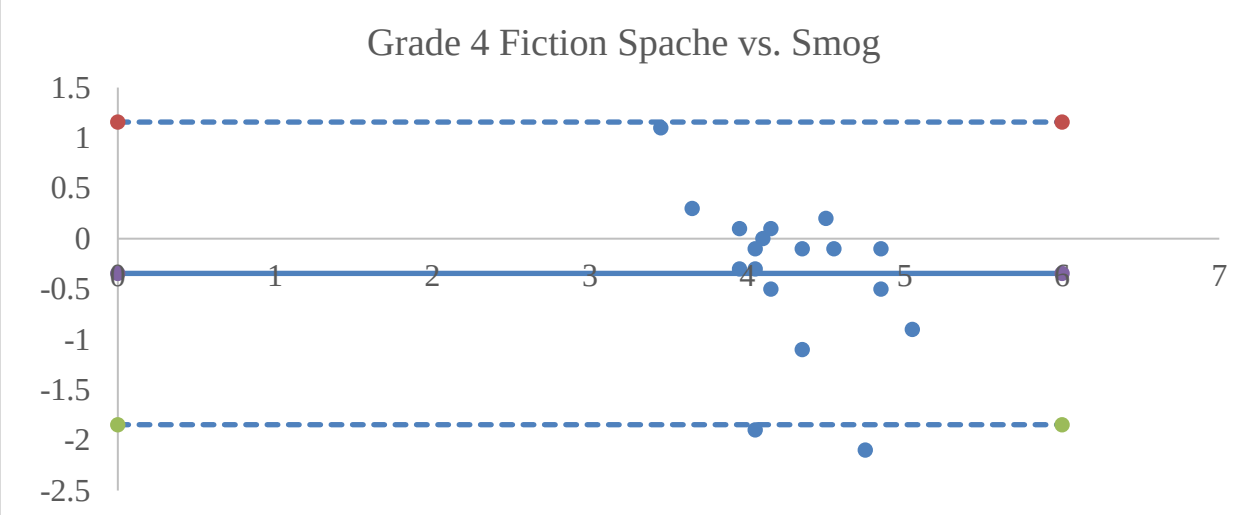
13. Spache vs. Gunning Fog

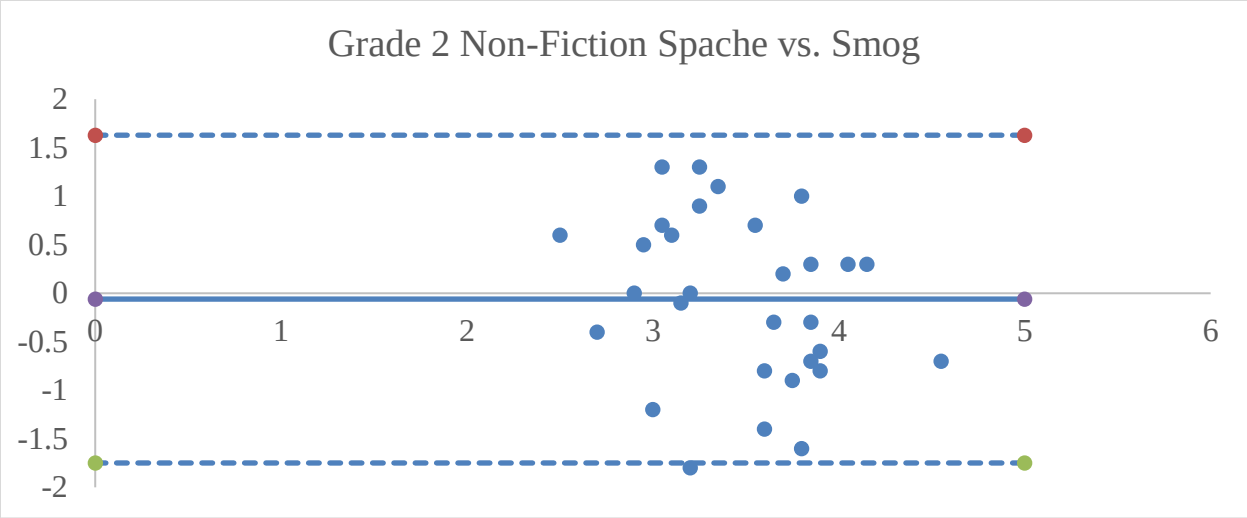


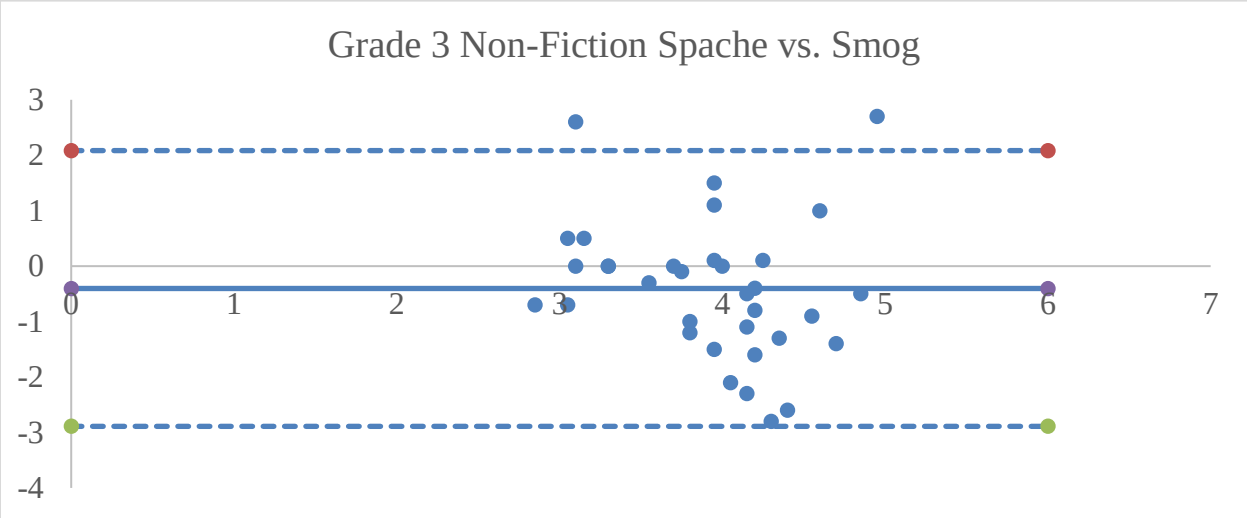




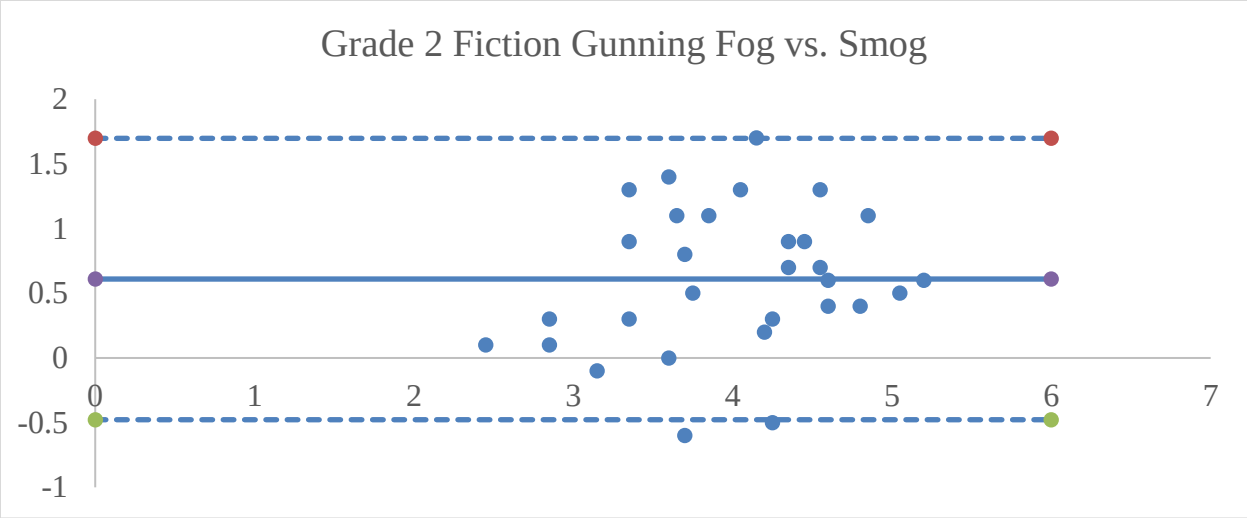
14. Spache vs. Smog

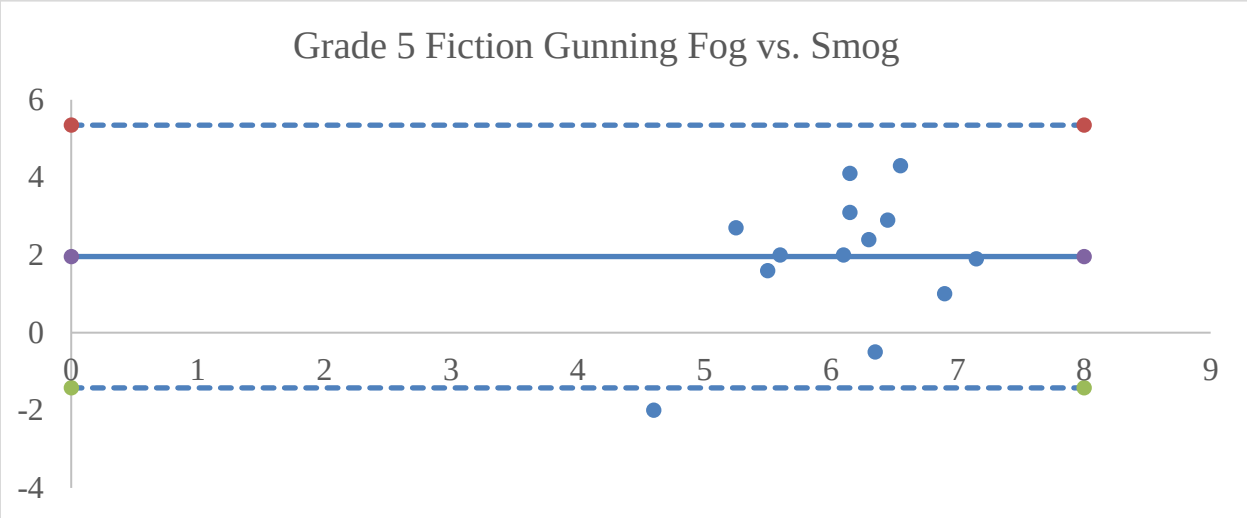


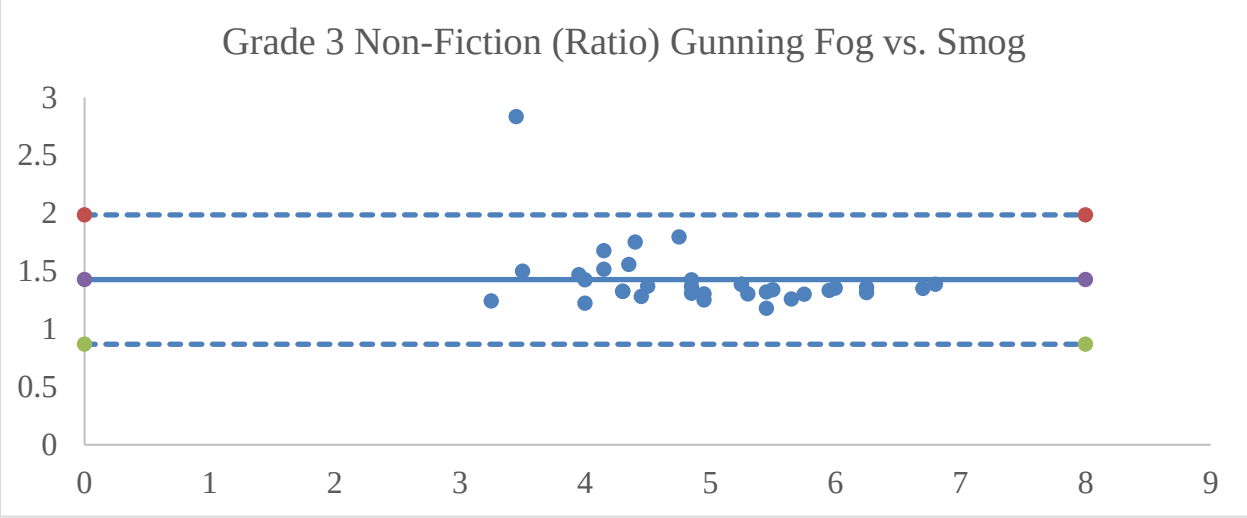




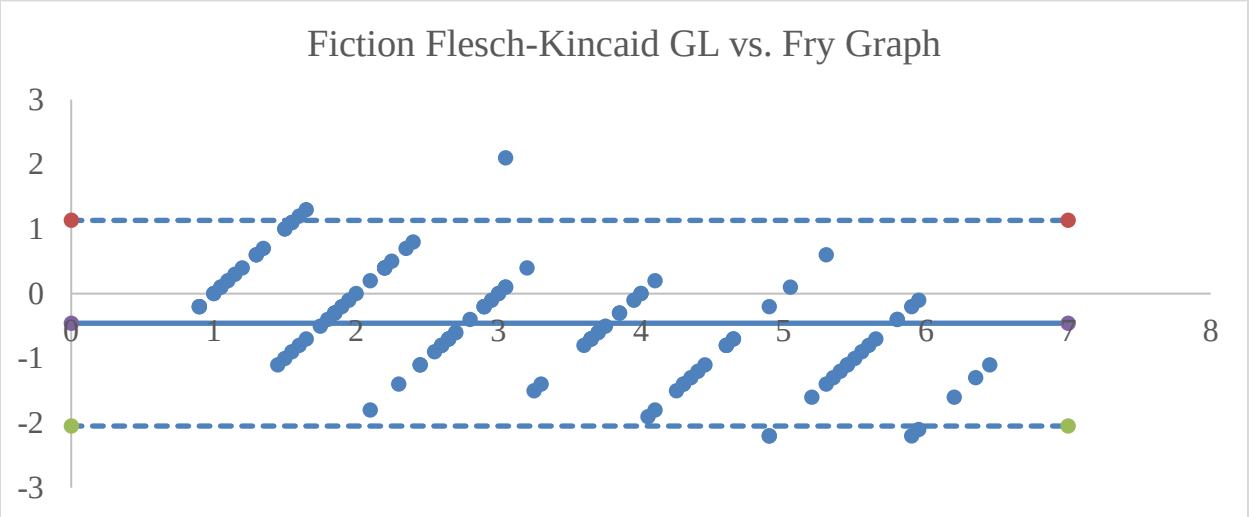
15. Gunning Fog vs. Smog

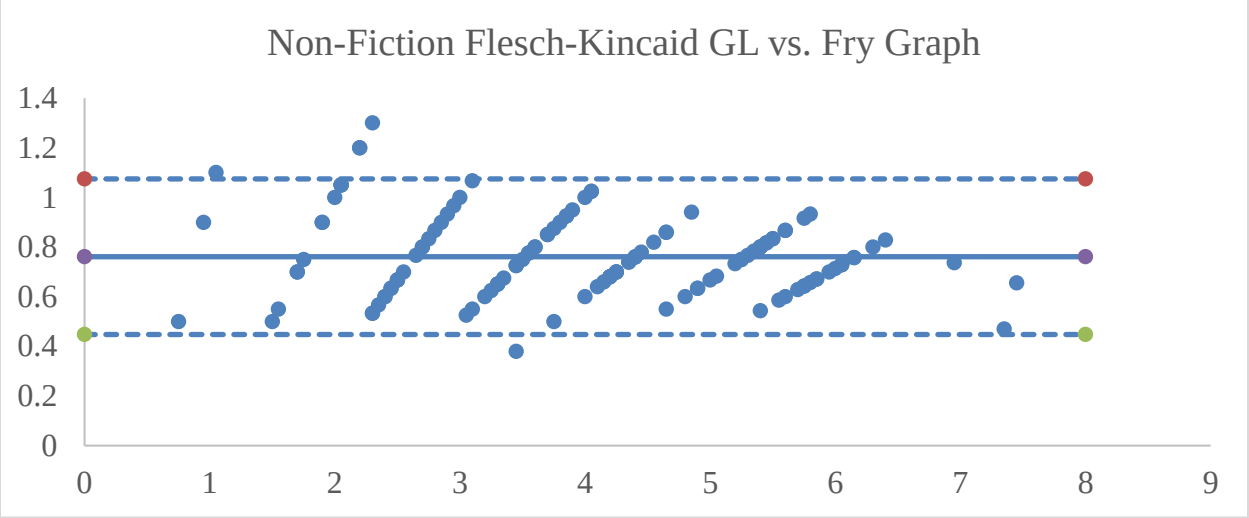

Grade 2 Fiction Gunning Fog vs. Smog
2
1.5
1
0.5
0
-0.5
-1
0
1
2
3
4
5
6
7

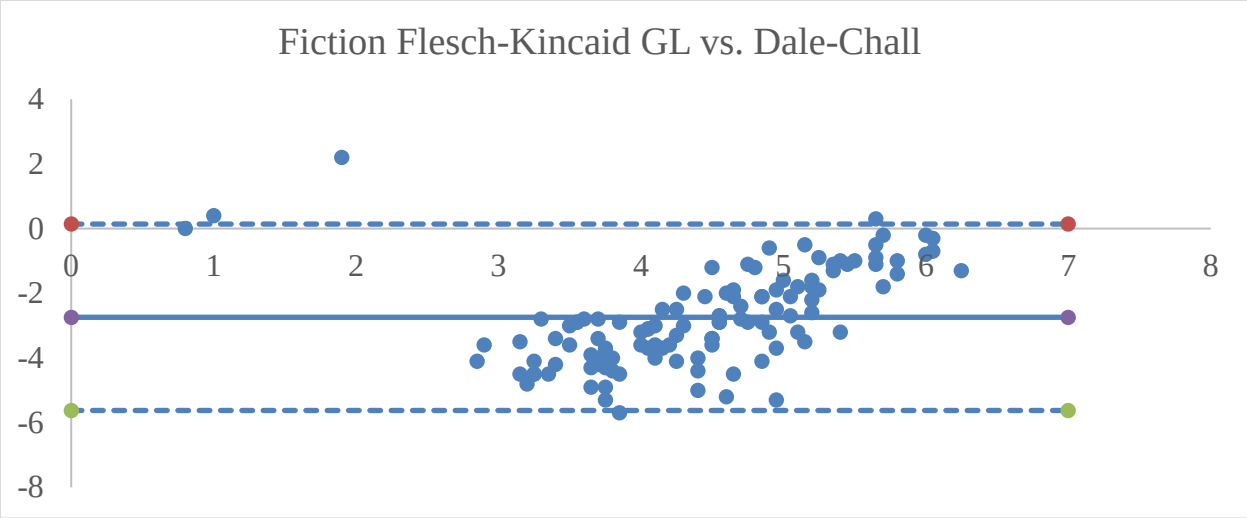

Grade 5 Fiction Gunning Fog vs. Smog
6
4
2
0
-2
-4
0
1
2
3
4
5
6
7
8
9

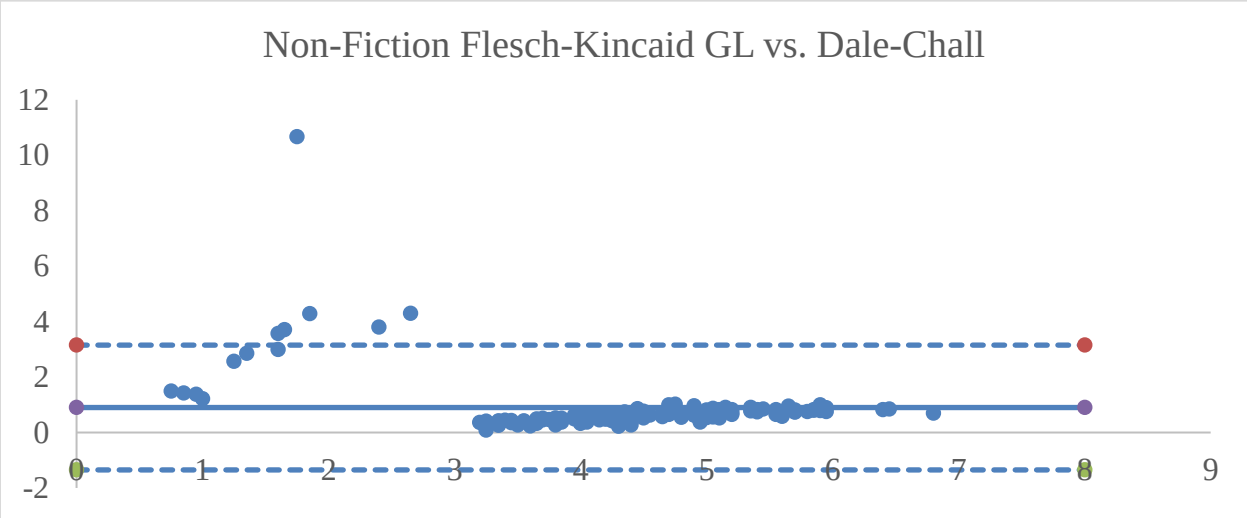

Grade 3 Non-Fiction (Ratio) Gunning Fog vs. Smog
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8
9

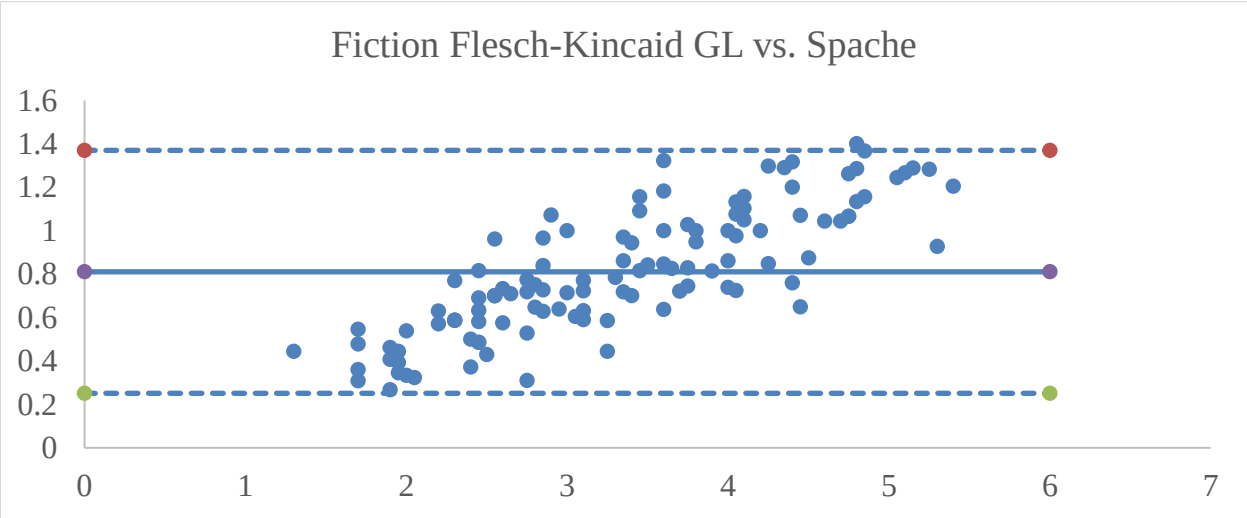
APPENDIX B: BLAND-ALTMAN PLOTS BY GENRE, ALL GRADE LEVELS

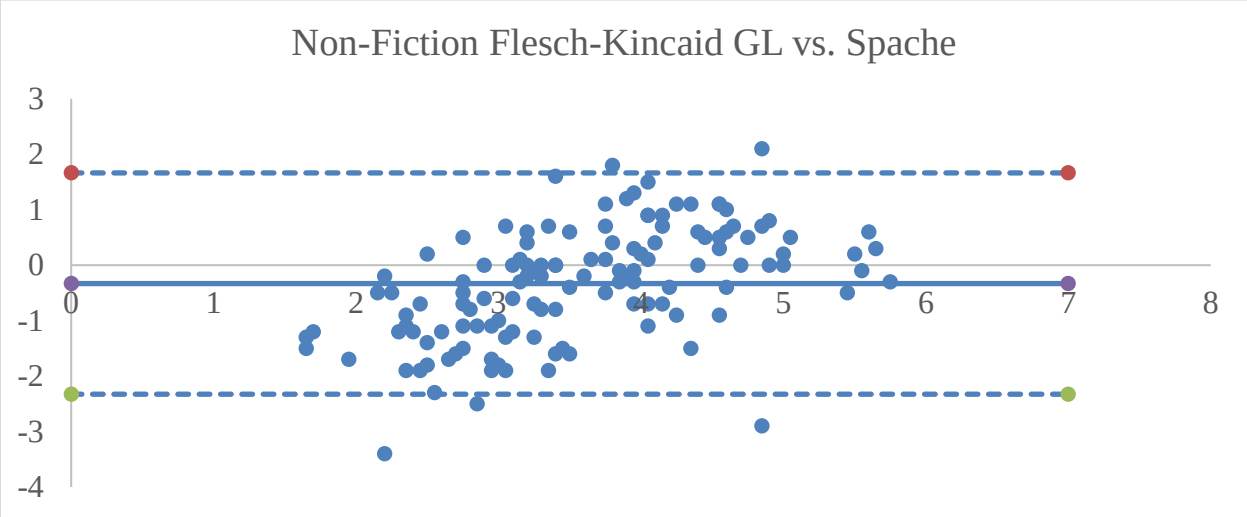


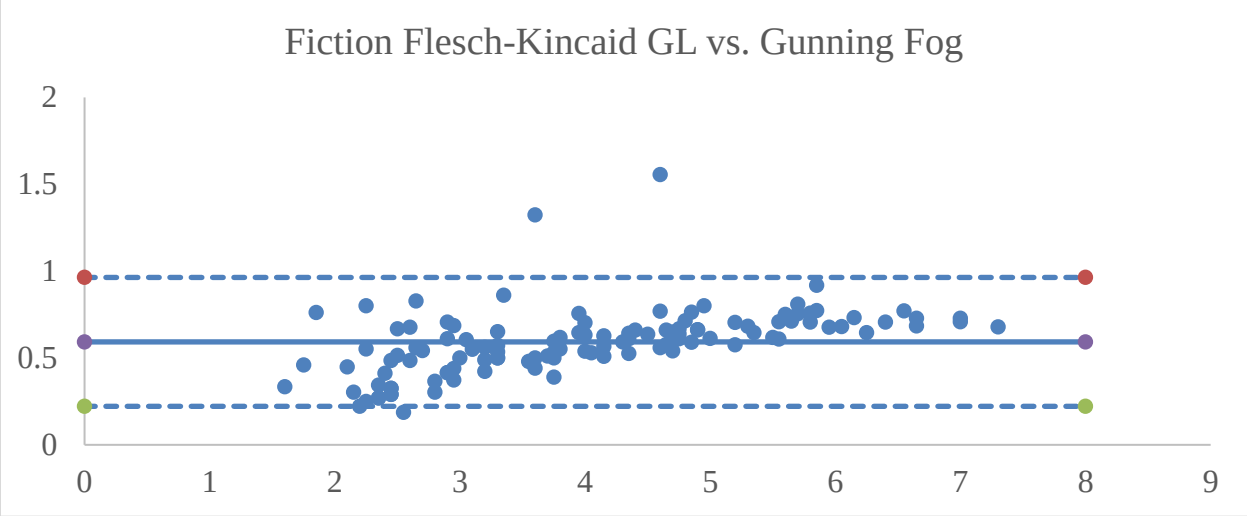


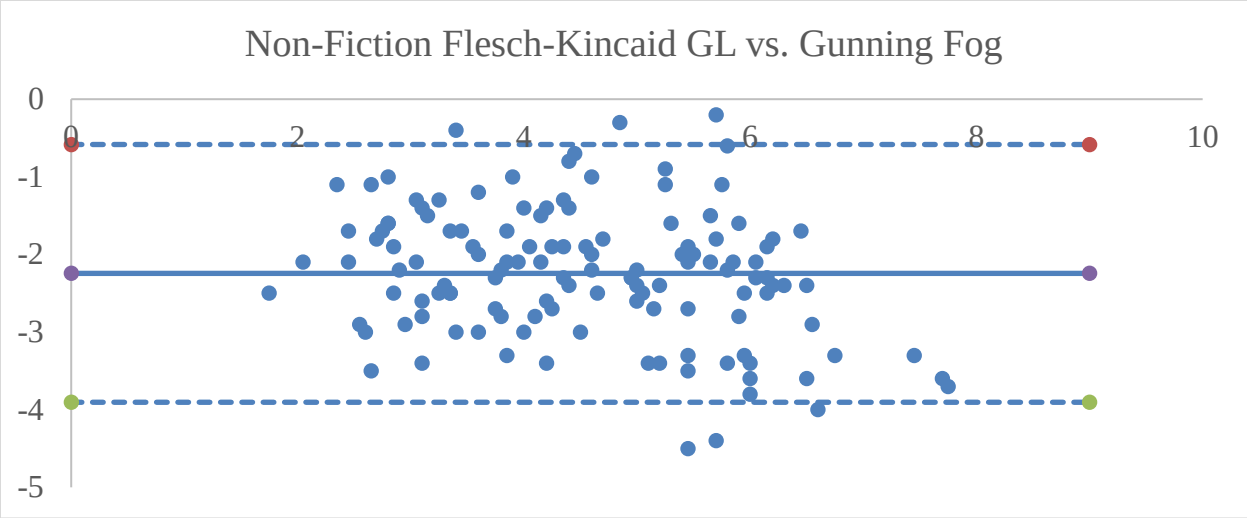

Fiction Flesch-Kincaid GL vs. Dale-Chall
4
2
0
-2
-4
-6
-8
0
1
2
3
4
5
6
7
8

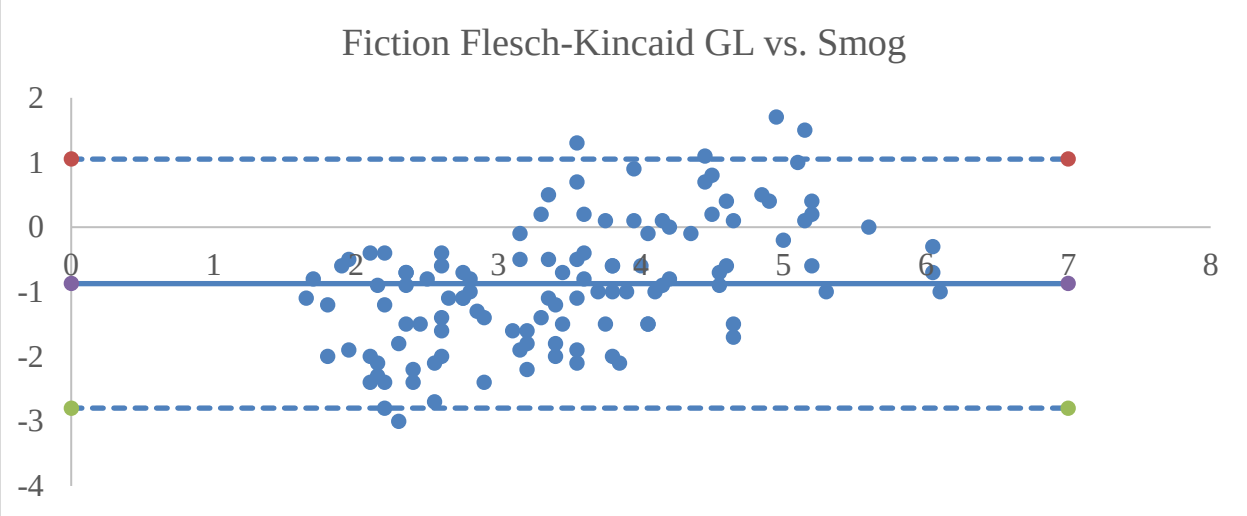

Non-Fiction Flesch-Kincaid GL vs. Dale-Chall
12
10
8
6
4
2
0
-2
0
1
2
3
4
5
6
7
8
9

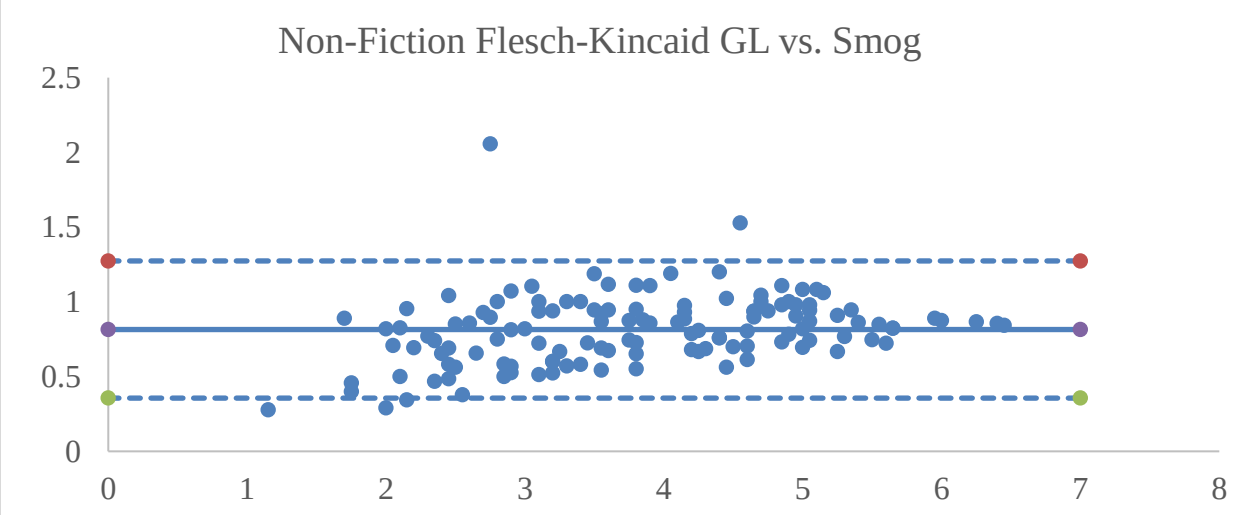

Fiction Flesch-Kincaid GL vs. Spache
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
7

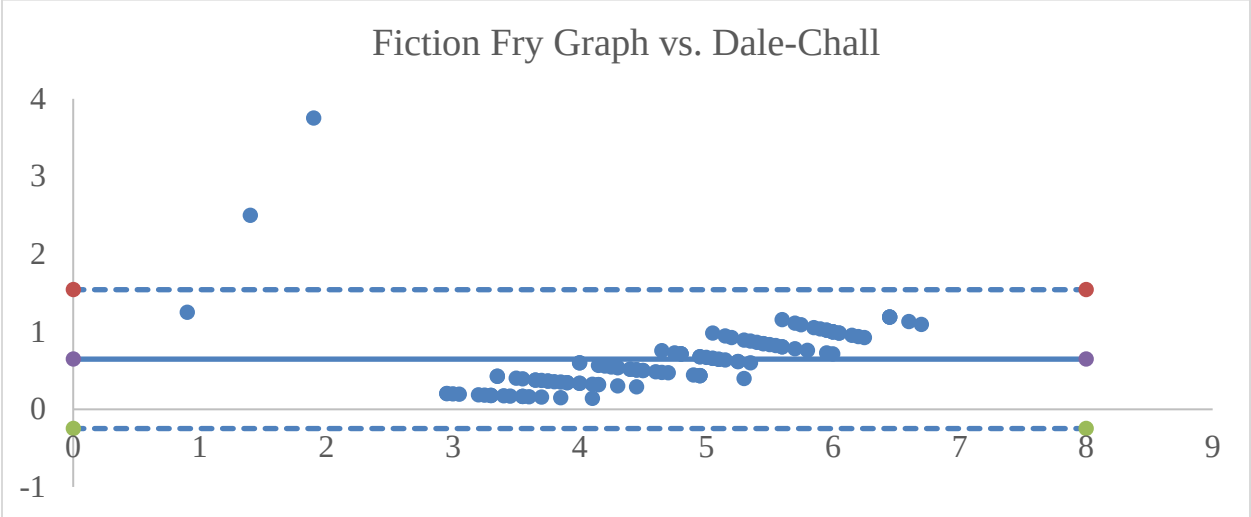

Non-Fiction Flesch-Kincaid GL vs. Spache
3
2
1
0
-1
-2
-3
-4
0
1
2
3
4
5
6
7
8

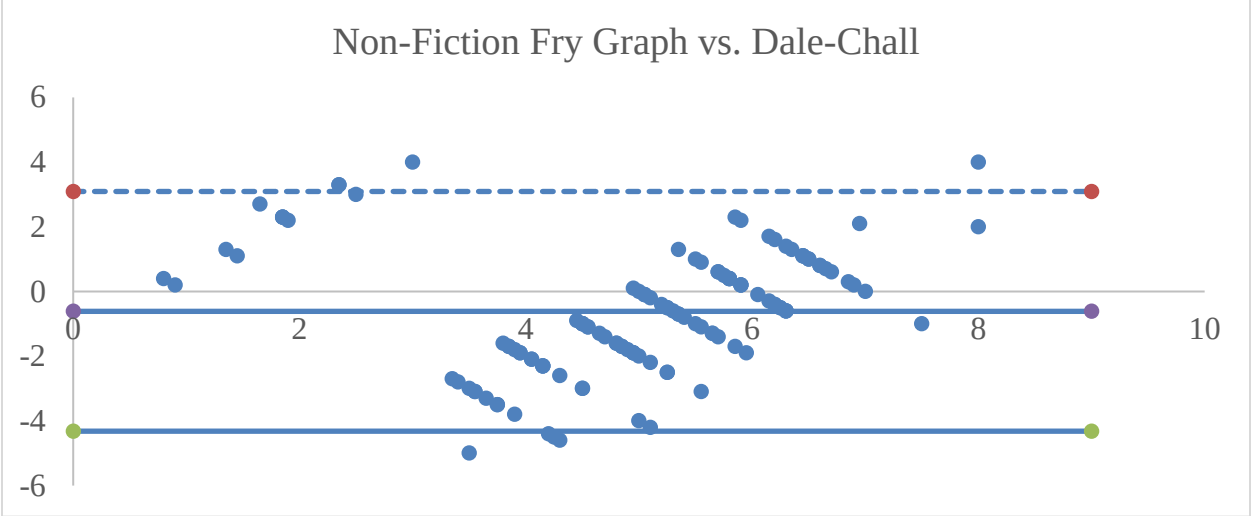

Fiction Flesch-Kincaid GL vs. Gunning Fog
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8
9

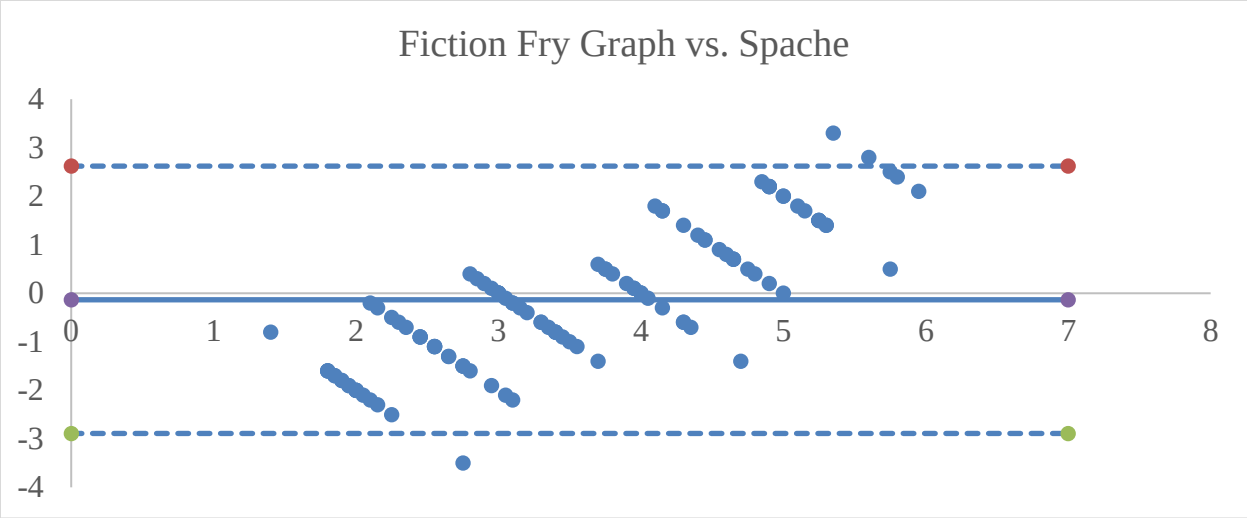

Non-Fiction Flesch-Kincaid GL vs. Gunning Fog
0
-1
-2
-3
-4
-5
0
2
4
6
8
10

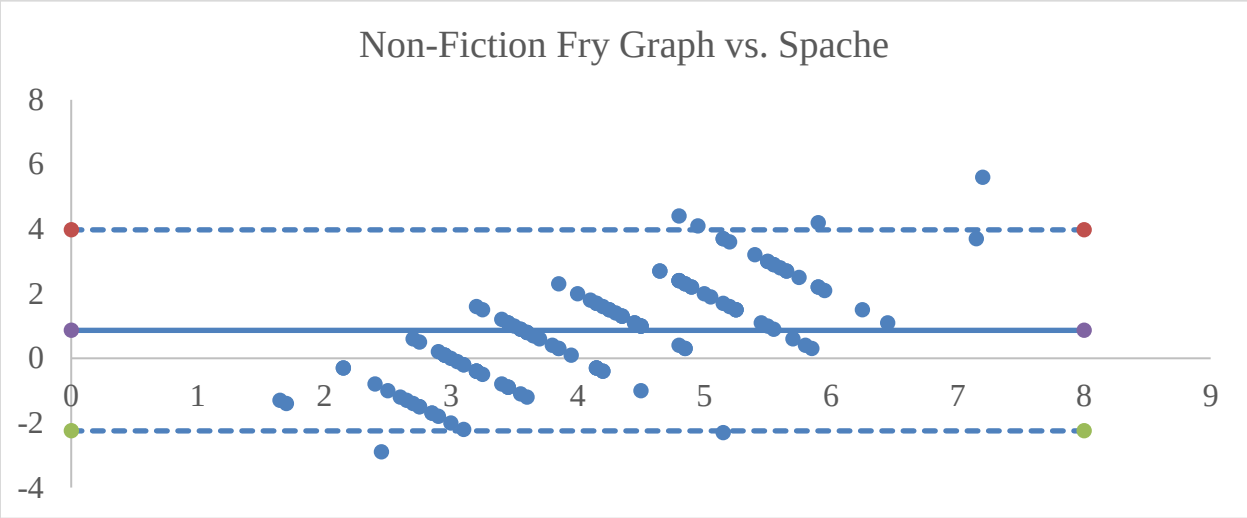

Fiction Flesch-Kincaid GL vs. Smog
2
1
0
-1
-2
-3
-4
0
1
2
3
4
5
6
7
8

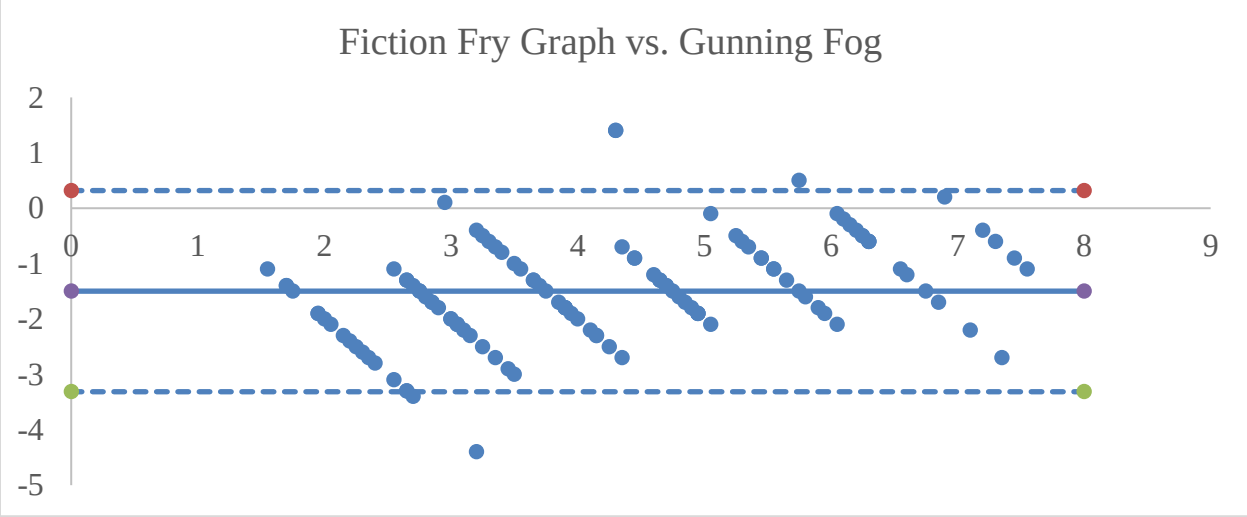

Non-Fiction Flesch-Kincaid GL vs. Smog
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8

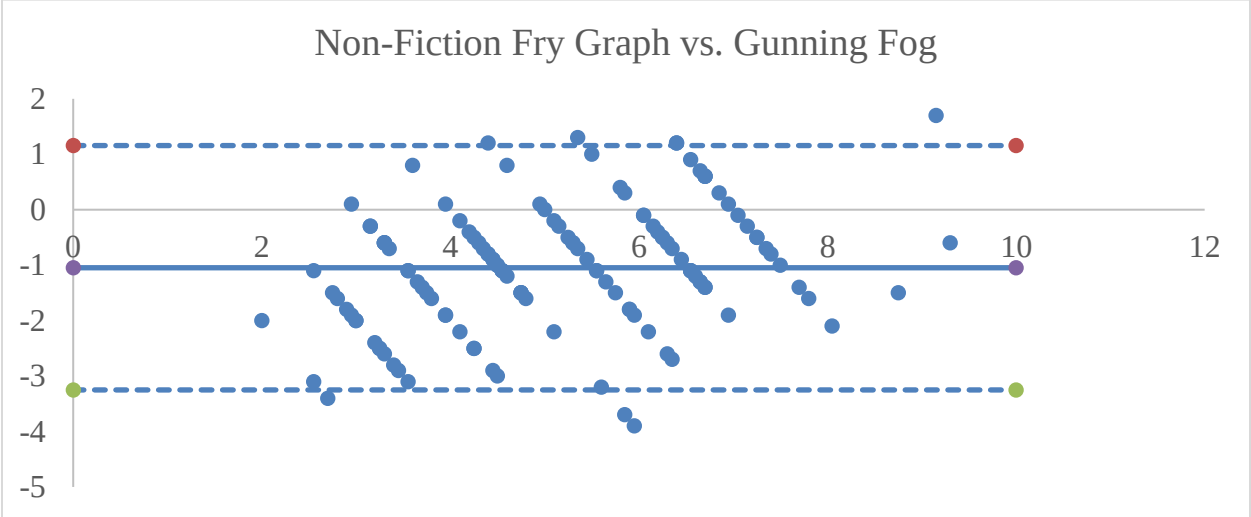

Fiction Fry Graph vs. Dale-Chall
4
3
2
1
0
-1
0
1
2
3
4
5
6
7
8
9

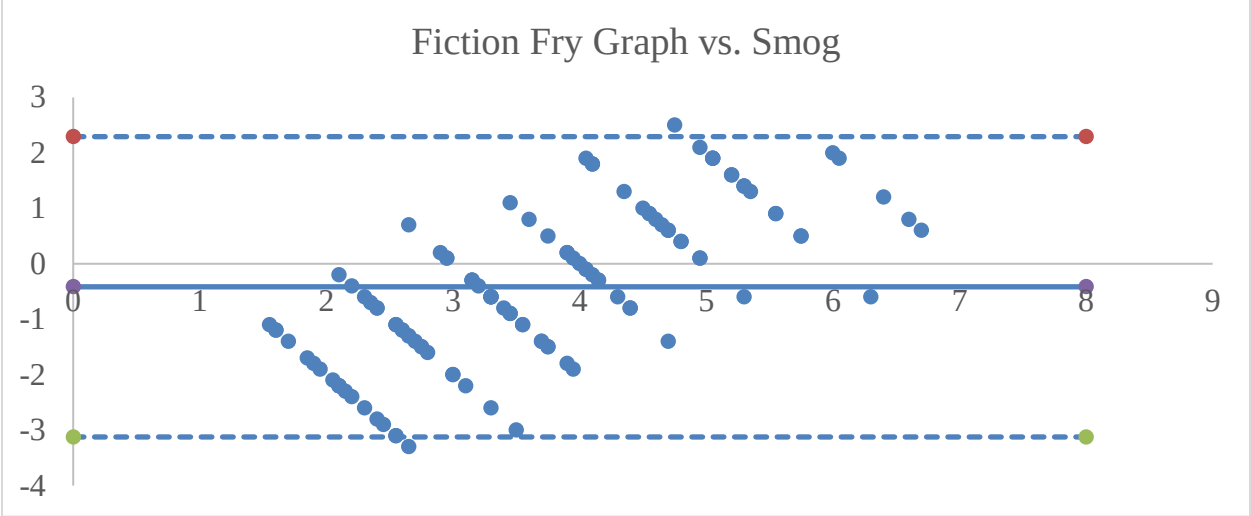

Non-Fiction Fry Graph vs. Dale-Chall
6
4
2
0
-2
-4
-6
0
2
4
6
8
10

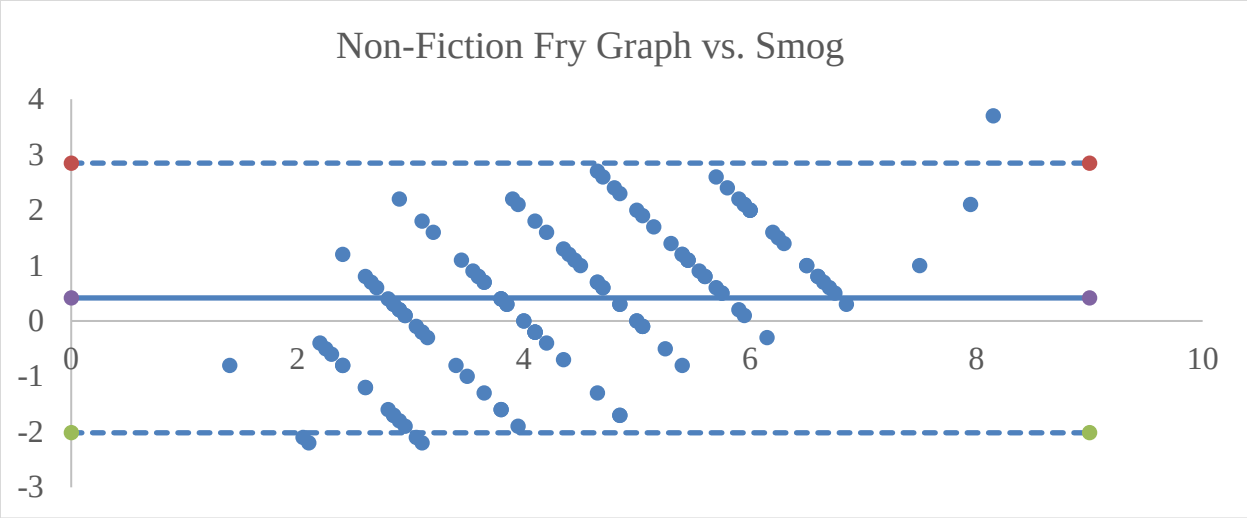

Fiction Fry Graph vs. Spache
4
3
2
1
0
-1
-2
-3
-4
0
1
2
3
4
5
6
7
8

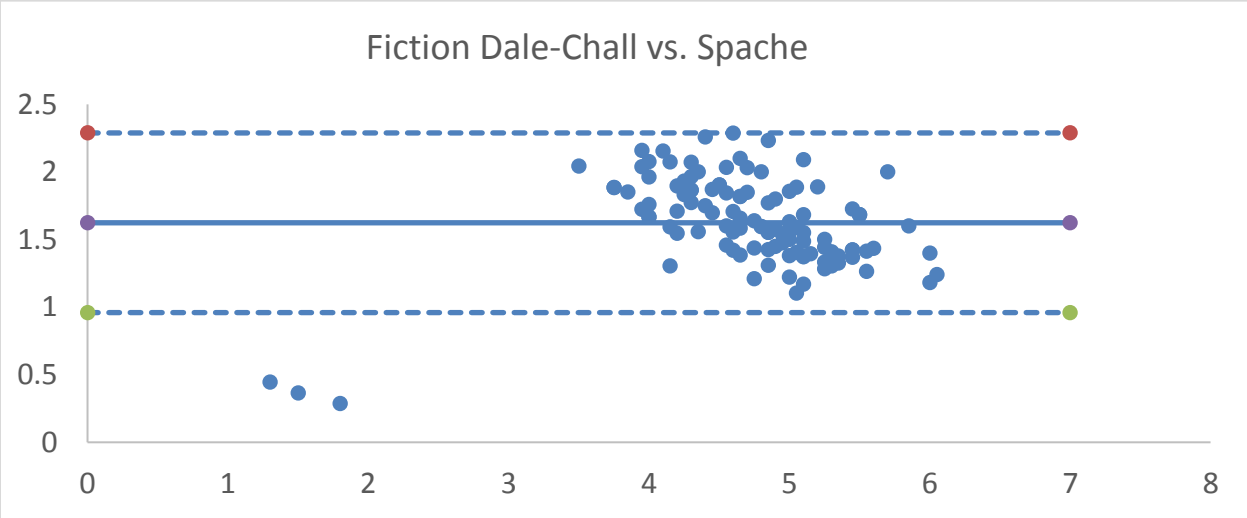

Non-Fiction Fry Graph vs. Spache
8
6
4
2
0
-2
-4
0
1
2
3
4
5
6
7
8
9

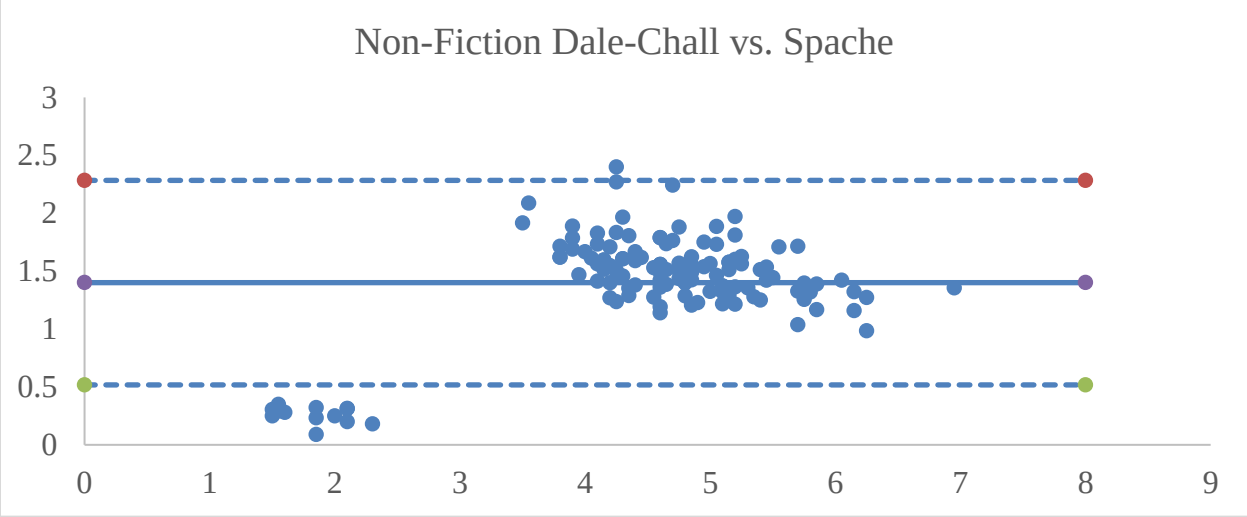

Fiction Fry Graph vs. Gunning Fog
2
1
0
-1
-2
-3
-4
-5
0
1
2
3
4
5
6
7
8
9

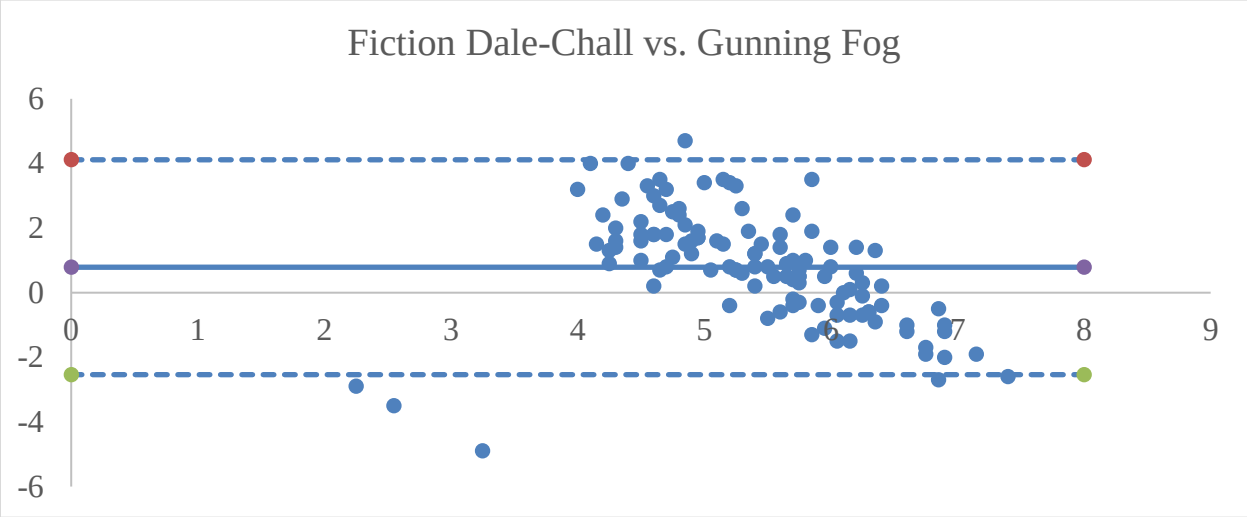

Non-Fiction Fry Graph vs. Gunning Fog
2
1
0
-1
-2
-3
-4
-5
0
2
4
6
8
10
12

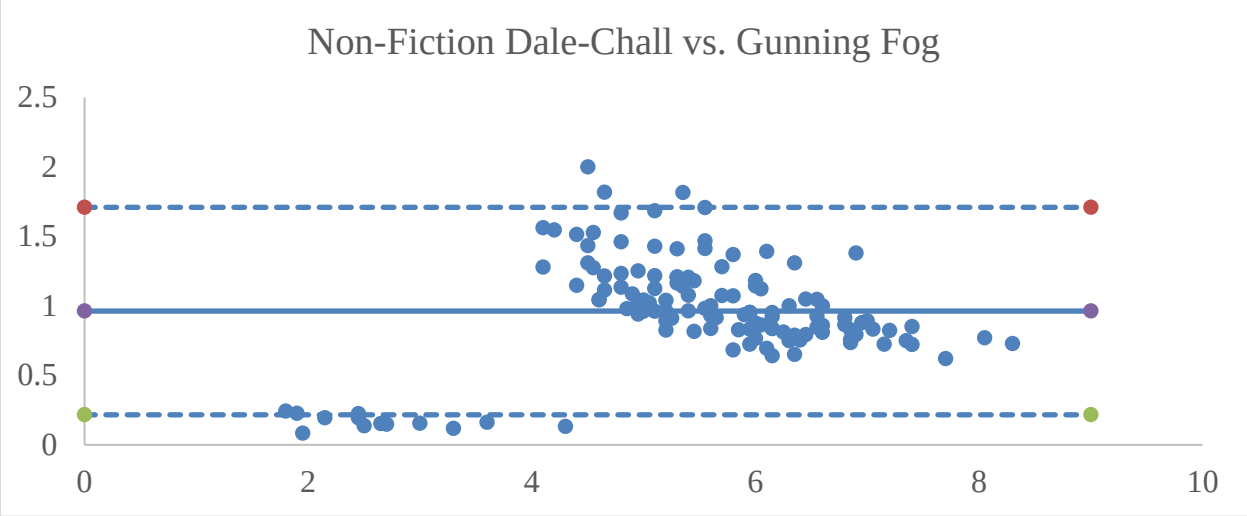

Fiction Fry Graph vs. Smog
3
2
1
0
-1
-2
-3
-4
0
1
2
3
4
5
6
7
8
9

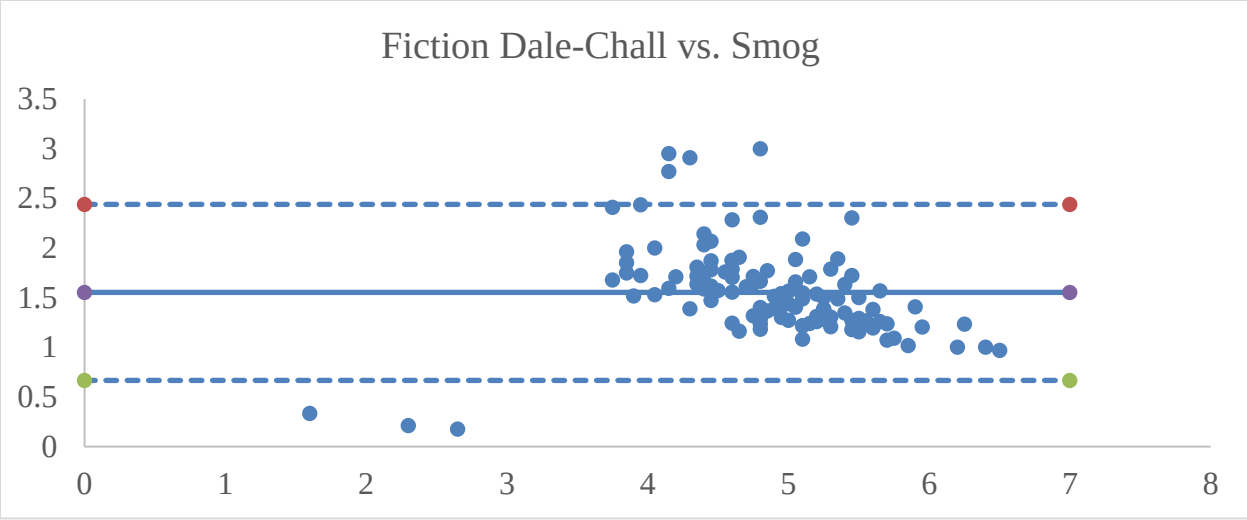

Non-Fiction Fry Graph vs. Smog
4
3
2
1
0
-1
-2
-3
0
2
4
6
8
10

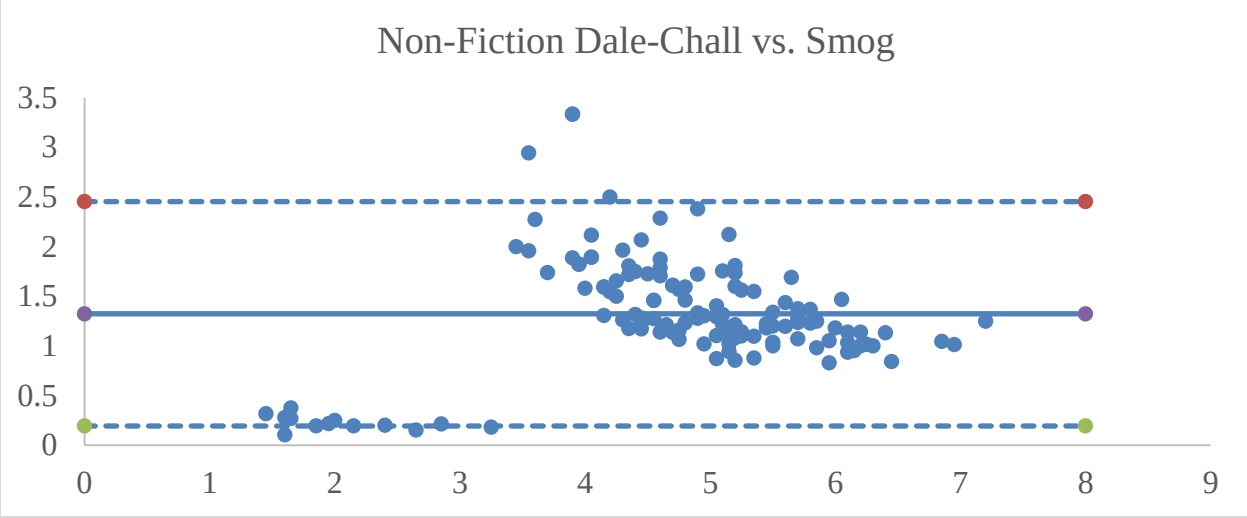

Fiction Dale-Chall vs. Spache
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8

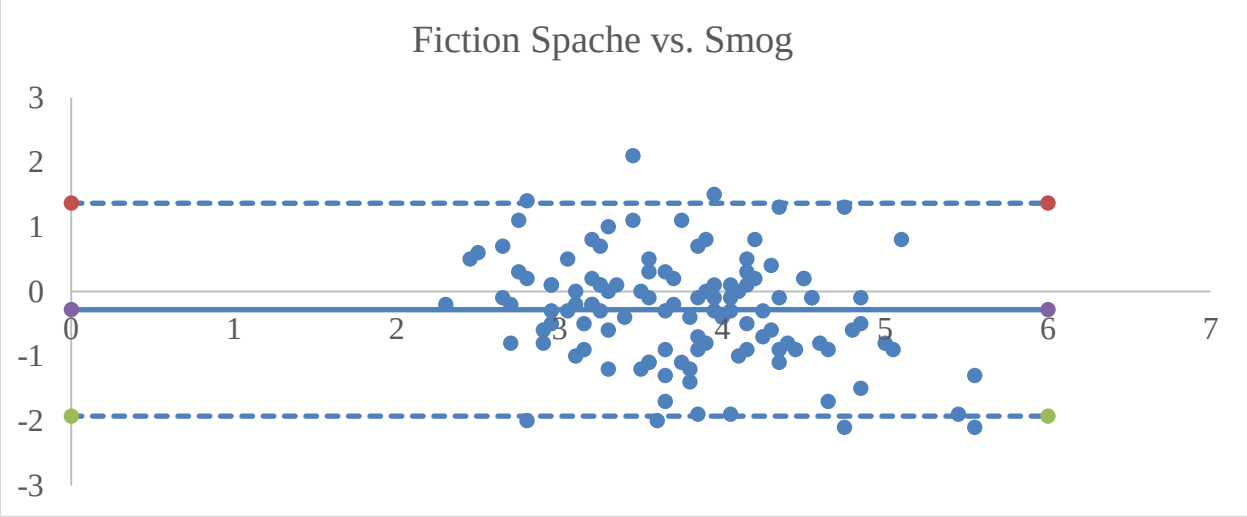

Non-Fiction Dale-Chall vs. Spache
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8
9

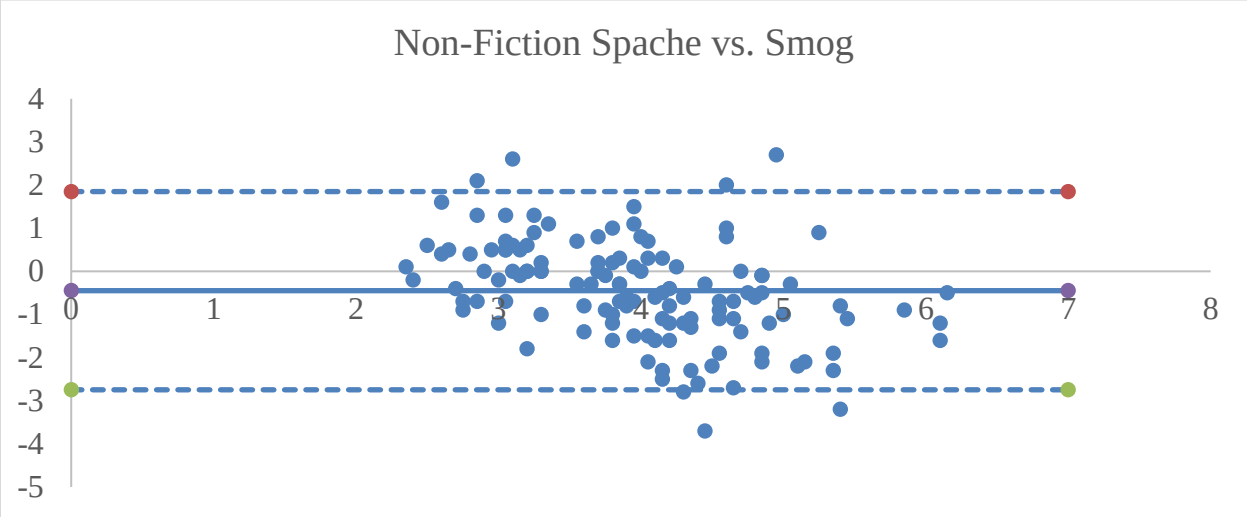

Fiction Dale-Chall vs. Gunning Fog
6
4
2
0
-2
-4
-6
0
1
2
3
4
5
6
7
8
9

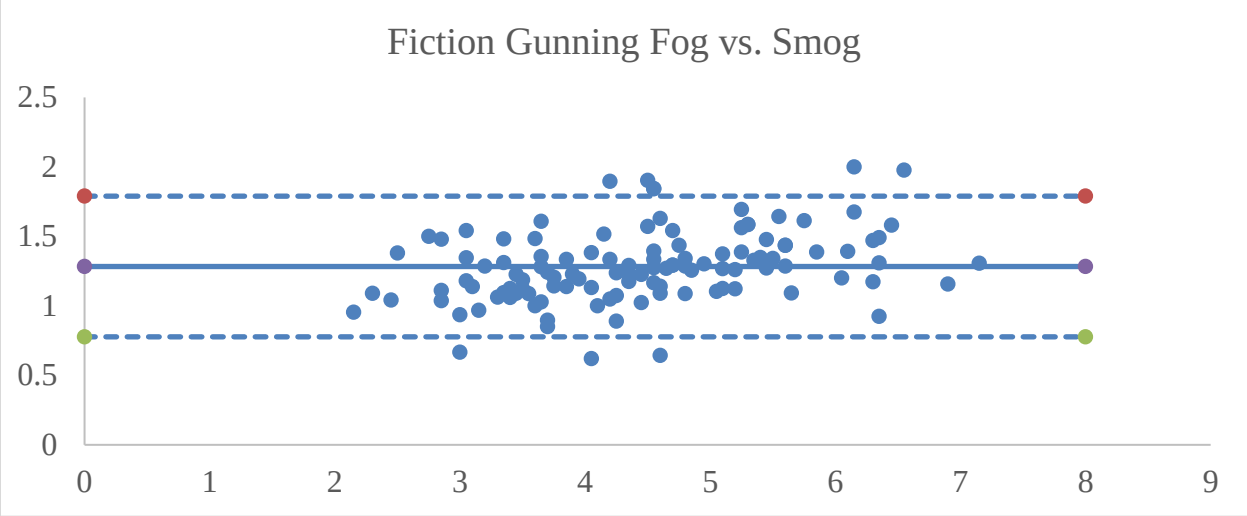

Non-Fiction Dale-Chall vs. Gunning Fog
2.5
2
1.5
1
0.5
0
0
2
4
6
8
10


Fiction Dale-Chall vs. Smog
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8


Non-Fiction Dale-Chall vs. Smog
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8
9


Fiction Spache vs. Smog
3
2
1
0
-1
-2
-3
0
1
2
3
4
5
6
7


Non-Fiction Spache vs. Smog
4
3
2
1
0
-1
-2
-3
-4
-5
0
1
2
3
4
5
6
7
8


Fiction Gunning Fog vs. Smog
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ABSTRACT

COMPARISON OF READABILITY INDICES WITH GRADES 1-5 NARRATIVE AND EXPOSITORY TEXTS

by

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Advisor: Dr. Shlomo Sawilowsky

Major: Education Evaluation and Research

Degree: Doctor of Philosophy

The problem that exists when using one or more readability indexes to ascertain a text grade level is the varied outcomes received on any given text from readability indexes that purport to measure the same construct. This study aims to provide practitioners with data to make informed decisions regarding interchangeability of readability indexes. A total of $n = 244$ narrative ($n = 116$) and expository texts ($n = 128$) passages from grades 1-5 were evaluated using the following readability indexes: Flesch-Kincaid Grade Level, Fry Graph, Spache, Dale-Chall, Gunning Fog, and Smog. Fifteen (15) comparison sets were analyzed using Bland-Altman method to assess for agreement. An *a priori* set standard of 1.5 grade levels was used as an acceptable difference. Other considerations for agreement included narrow limits of agreement, low proportional error, and a Bland-Altman plot where data points clustered around the bias line. Of the fifteen (15) comparison sets, nine (9) resulted in agreement, or near agreement. Based on the findings of the study and the subjectivity of the Bland-Altman method, it is recommended that practitioners select one readability index for text evaluation and use it exclusively. No particular index was recommended for use. The use of readability indexes should be one of several means of evaluating a text.

AUTOBIOGRAPHICAL STATEMENT

Susan Harden was born April 28, 1972 in East Grand Rapids, Michigan. She grew up in Rochester Hills, MI where she graduated from Rochester High School in 1990. Following high school Susan spent two years at Michigan State University before transferring to Oakland University where she earned her Bachelor of Science in Elementary Education with a major in mathematics in 1996. She continued on at Oakland University to earn a Master of Arts in Teaching Reading and Language Arts in 2004.

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