Textual Complexity in Dutch Physics Secondary Education Textbooks from 1965 to 2024

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The process of writing this thesis has been both a professional and personal journey, during which I gained a deeper understanding of the Dutch language, T-Scan, and textual research. I discovered that Dutch textual research is a rather niche field, yet it seems to spark a wide range of opinions, often expressed through blogposts, comments, and reviews. This made the project both intriguing and challenging.

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Abstract

Reading comprehension is an essential skill for functioning in society. However, the reading comprehension levels in the Netherlands are declining and therefore attention is given to reading comprehension instruction and education. One possible intervention is text simplification, which is often used in the context of second-language learning. However, research on the effectiveness of text simplification in education shows contradicting results and warnings are issued against oversimplification of texts, by comparing older and recent materials intuitively. Those claims are yet to be substantiated by systematic research.

Therefore, this research aims to systematically answer the question: *How has the textual complexity, in terms of text, sentence and word length, sentence complexity, word concreteness, lexical diversity and personal style, changed in Dutch physics textbooks for HAVO (year 3 and 4) regarding the topic of Newton's first law from 1965-2024?* This study explored the changes of textual complexity over time while controlling for the educational level, grade level and topic. This was done by investigating fragments from 39 educational textbooks. The quantification of text characteristics was performed by T-Scan, a software for Dutch textual analysis and a simple regression analysis was performed for every textual parameter in relation to the publishing year to explore changes over time.

Significant changes were found for four out of nineteen textual parameters. *Words by sentence* decreased by 21.8% from 1965 to 2024, the *Number of partial sentences* decreased by 55.7%, the *Density of general nomina* by 31.7% and the *Measure of textual lexical diversity* (*MLTD)* decreased by over 34.3%. Sentences have become shorter, and contain fewer partial sentences, but the overall number of words per text has slightly increased. This indicates a less complex text. Textual parameters like the word length, the number of additional elements or adjectives per partial sentence did not change significantly over time.

The biggest limitation of this research was the small sample size, therefore the statistical results should be used cautiously. Future research should investigate the changes in textual complexity over time for different topics as well, and compare those with each other.

In conclusion, this research found that educational texts pertaining Newton's first law on the HAVO level have become slightly less complex regarding sentence length, sentence structure and word variation. This study is the first step in bridging the gap between intuitive observations and structural textual complexity research, and hopefully influences the discussions about simplification of educational texts over time.

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Textual Complexity in Dutch Physics Secondary Education Textbooks from 1965 to 2024

Understanding written text is a crucial skill for effective participation in society (Van Den Broek & Espin, 2012). A substantial amount of information and communication is in written form. Examples are news, articles, books, letters, e-mails and texts messages. However, the textual characteristics of these informational sources have changed with the rise of the internet. Reading skills have adapted and reading has changed from close reading to hyper-reading, where texts are scanned for information (Serafini, 2012; van de Ven et al., 2023). Additionally, the rise of texting, which follows its own grammatical rules, is associated with the decline of correct language use and this influences adolescents' ability to write and read (Kaid et al., 2011; Luyten, 2024). This decline leads to raised attention in media and education to reading comprehension. The media for example portraits the decline of reading comprehension levels in the Netherlands and states that the decline is alarming (Gubbels et al., 2019; Ham et al., 2018; Koene, 2021; Nederlands Jeugdinstituut, 2023; Stichting Lezen, 2023). To reduce and counter this decline, reading comprehension education has gained importance. In Dutch elementary education reading comprehension is often taught as a standalone subject, and teaching materials have been developed to teach reading comprehension. Research by Alexander (2005) asks for attention for reading comprehension instruction even after the initial elementary years, as she advocates for a lifelong developmental perspective on reading comprehension. Additionally, reading comprehension education gains importance in secondary education, especially due to the declining national levels on the PISA test, which is taken among 15-year-olds (Koene, 2021; Luyten, 2024; PISA, 2019; van Gelderen, 2018). Improving reading comprehension in secondary education is often seen as part of the language lessons (Kennisrotonde, 2024). However, research has shown that interest and context contribute to comprehension (Fox & Alexander, 2004). Ideally, reading comprehension will be part of every school subject, so that students learn to read with a goal and extract interesting information from texts (CED groep, n.d.-a; Kennisrotonde, 2024). 'Reading to learn' should be the goal to increase reading comprehension levels (Moore, 2014; Van Den Broek & Espin, 2012) and successful participation in society.

With the decline of reading comprehension, special attention is drawn to the materials as well. Research has shown that simplifications of text are easier to comprehend than authentic texts (Crossley et al., 2012; Pander Maat & Ditewig, 2017). Yet, recent warnings have been issued to guard for oversimplification and call for language-rich texts in educational settings (e.g. Oxford University Press ELT, 2014; SLO, 2024; Smits & van Koeven, 2024; Zwik, 2025).

However, those warnings seem to be unsubstantiated until now and are based on intuitive observations. It is unknown to what extent Dutch educational texts have been simplified over time.

In research on textual complexity in Dutch novels and newspapers, Ham et al. (2018) found only a slight simplification over time, whereas Gamson et al. (2013) found that American third- and sixth grade reading textbooks became even more complex over time. As research regarding textual changes over time is limited and the results are contradicting, it is necessary to systematically investigate the changes in textual complexity of Dutch educational textbooks over time. This investigation will add knowledge to the topic of Dutch educational textbook simplifications and may impact educational policies regarding reading comprehension. The differences between educational textbooks seem to not have been investigated systematically over a bigger time period, but side-by-side comparisons have been made, where differences between two educational textbooks were investigated intuitively (Zwik, 2025). Additionally, the information gained from this investigation of textual complexity over time may be used to guide writing new educational materials, which will promote reading comprehension and 'reading to learn'.

The aim of this study is to explore the changes in textual complexity in Dutch educational textbooks over time. As the subject, topic and educational level all influence textual complexity (Berendes et al., 2018; Jin et al., 2020; Pander Maat & Dekker, 2016; Pander Maat & Ditewig, 2017) this research focuses on Dutch secondary physics education, the HAVO (Senior general secondary education; *in Dutch: Hoger Algemeen Voortgezet Onderwijs)* educational level and the topic of Newton's first law. This approach was chosen to lessen the effect of the factors educational level and topic on the measurement of textual complexity changes and to focus on the changes over time.

This report first discusses the definition of reading comprehension, followed by an exploration of the concept of *textual complexity*. This includes textual parameters, readability indices and textual complexity in education. Afterwards, the method, including the dataset and software T-Scan is described, followed by the results section. The report closes with a discussion of the results, implications and limitations of this research and concluding remarks.

Theoretical Framework

Reading Comprehension

Reading comprehension is often simplified as ‘understanding what you read’. Extensive research has been done on reading comprehension, underlying cognitive processes, interventions and factors influencing reading comprehension (e.g. Alexander & Fox, 2004; Fox & Alexander, 2004; Khodabandehlou, M., Jahandar, S. , Seyedi, G., Abadi, 2012; Mijs & Vernooij, 2016; Moore, 2014; Seigneuric & Ehrlich, 2005; Van Den Broek & Espin, 2012; Zainurrahman et al., 2024). This research resulted in detailed and comprehensive models of reading comprehension. Van den Broek and Espin (2012) aimed to combine the key components of those models into one *Integrated Model of Reading Comprehension (IMREC),* which describes a product and a process. The product of reading comprehension is a coherent mental representation of the text, integrated with the prior knowledge of the reader. The process of comprehension contains several automatic and strategic processes, like decoding, sensitivity to text structures, and integrating new with existing information. Those processes are limited by the working memory, level of automation and the readers’ experiences (Seigneuric & Ehrlich, 2005; Van Den Broek & Espin, 2012). As readers gain reading experience, they progress from the technical ability to read to the ultimate goal of reading to learn (Moore, 2014).

One factor that influences the reading process is the complexity of the text itself (RAND, 2002). The content of the text, word choices and linguistic features are factors influencing comprehension and text difficulty (RAND, 2002). A more complex text relies on a bigger piece of working memory, a higher extent of automation and decoding, and a higher sensitivity to complex sentence structures. Therefore, texts usually become more complex with the reader’s age and experience (Berendes et al., 2018; Jin et al., 2020). A more complex text is often perceived as difficult, however, text difficulty is always related to the reader, as text difficulty can be described as the effect textual complexity has on the reader (Pander Maat, 2017). Therefore, this research will focus on textual complexity and texts will be described as simple or complex.

Textual Complexity

Textual complexity is a multi-layered concept and is often described as an interaction of various textual parameters. Based on the research question or focus of a study, various parameters are chosen to investigate, which does not lead to one concise definition of the concept textual complexity (Dascalu et al., 2012; Gamson et al., 2013; Gervasi & Ambriola, 2002; Pander Maat & Dekker, 2016). Textual complexity is also defined based on the research topic and language, as linguistic features differ between languages (Berendes et al., 2018; Pander Maat et al., 2014; Pander

Maat & Dekker, 2016). In the Dutch context, textual complexity can be defined by several textual parameters and their interaction with each other, as a longer text with simple sentence structures might be less complex than a short text with complicated vocabulary and sentence structures (Kleijn, 2018).

Textual Parameters

Textual complexity in this context is defined by several textual parameters, which can be divided into six categories: (1) length, including text length, sentence length and word length, (2) sentence complexity, (3) concreteness, (4) lexical diversity, (5) personal style and (6) word frequency (based on: Pander Maat et al., 2014).

First, a longer text, sentence or word, requires a bigger part of the working memory from the reader and higher skills in decoding, than a shorter one (Pander Maat, 2017; Seigneuric & Ehrlich, 2005). Therefore, the longer the sentence or text, the higher the textual complexity. The length is described by parameters like *Number of sentences*, *Number of words*, *Words by sentence*, *Words by partial sentence*, *Letters by word* and *Morphemes by word*. A morpheme is defined as “the smallest distinctive unit of a language having a definite grammatical function” (Oxford reference, n.d.). For example, the word *unhappiness* has three morphemes, as ‘un’ indicates a negation, ‘happi’ is the word ‘happy’ and ‘ness’ describes a state. A word with a higher number of morphemes, usually contains a higher number of letters.

Second, sentence complexity describes how complex a sentence structure is. Simple sentences like ‘He eats a banana’ contain a subject, verb and object in a clear order. The complexity of a sentence can be increased by adding additional elements, partial sentences or changing the order or tense of the sentence (Gibson, 2000; Pander Maat, 2017; Pander Maat et al., 2014). For example, the sentence “Pieter eats a banana.” is less complicated than the sentence “After having been to school, where he learned how to draw and multiply, Pieter, who really loves fruit, eats a banana in his living room, while looking at the birds in the garden.”. This example contains four partial sentences. The sentence complexity can be described by parameters like *Number of partial sentences*, *Adjectives by partial sentence*, *Number of additional elements*, *Maximal dependency length*, *D-level of the sentence* and *Proportion sentences with D-level higher than 4*.
The *Maximal dependency length* (DL) indicates how many words are in between related words (head and dependent), which need to be stored in working memory to understand the sentence. The higher the DL the more complex a sentence is deemed. The maximum dependency length indicates the highest dependency length found in the text fragment. Dependencies can be found for various combinations. The sentence ‘***Peter**, my cousin from America, **writes** regularly.’* has a dependency length of 4 words between subject and verb. The sentence ‘*I **thought** I **was** late.’* has a dependency

length of 1 word between the verb and the verb form the verbal complement. An overview of textual dependencies can be found in Appendix A.

The D-level of a sentence describes the syntactical complexity of a sentence and is based on language acquisition research by Rosenberg and Abbeduto (1987; as cited in Covington et al., 2006). Levels reach from 1 (very simple sentences) to level 7 (complex sentences). The sentence '*I am going to meet John*' is classified as level 1, while the sentence '*John decided to leave Mary when he heard that she was seeing Mark*' is classified as level 7 (Covington et al., 2006).

The third group investigates the level of concreteness of words. The higher the proportion or density of concrete words, the lower the complexity is deemed, as more concrete words seem to make it easier to recall and comprehend (Sadoski, 2001). Concrete words are words that describe concrete objects or states and can be divided into strict and broad concrete nouns. Table 1 shows which word classes are classified as strict or broad concrete. The concreteness of words can be described by parameters like the *Proportion of strict concrete nouns*, *Proportion of broad concrete nouns* and *Density of general nomina*. General nomina are abstract words that are not domain-related like *idea, method, result* or *problem* (Pander Maat et al., 2021). Those words are often used to structure the text and will be contextualised within the text. In addition to nouns, other word classes, like adjectives and verbs can be used to describe textual complexity.

Table 1

Classification of Strict and Broad Concrete Nouns

Class	Example	Concreteness
1. Persons	Teacher	Strict and broad concrete
2. Plant and animals	Oak, bird	Strict and broad concrete
3. Utensil	Chair, hammer	Strict and broad concrete
4. Concrete substances	Curry, mud	Strict and broad concrete
5. Food and care	Milk, cigarette	Strict and broad concrete
6. Concrete other	Vulcano, gallbladder	Strict and broad concrete
7. Concrete event	Breathing	Strict and broad concrete
8. Place	Amsterdam, living room	Broad concrete
9. Time	Period, Holiday	Broad concrete
10. Unit of measurement	Euro, dB	Broad concrete

Note: Based on Pander Maat et al., 2021, table 4, p.51

Fourth, lexical diversity describes the variation of words within a text. If a text does not repeat words, it could be that the text includes a lot of information about different topics or that synonyms are used (Pander Maat et al., 2021). The classical measurement for information density is the *Type-Token-Ratio* (TTR), which divides the number of different words (types) by the total number of words (tokens) (Pander Maat et al., 2021). However, this measurement is dependent on the length of the text. The *Measure of lexical diversity* (MLTD) measures the variation of words within a text while correcting for the length of the text. The higher the number, the more variation in words is encountered (Pander Maat et al., 2014). The lexical diversity can also be described by the *Number of content words*. In the Dutch language content words and function words are distinguished from each other (Pander Maat et al., 2021). Content words are nouns, names, adjectives, adverbs and main verbs. Function words are pronouns, articles, prepositions, conjunctions, numerals, auxiliary verbs, linking verbs and interjections. A higher amount of content words indicates a more information dense text and a higher complexity.

Fifth, simplifications of texts were found to contain a more personal writing style (Pander Maat & Ditewig, 2017) and therefore a more personal writing style is deemed less complex. A more personal writing style can be indicated by a higher *Density of references to persons* and *Density of personal or possessive pronouns*.

Finally, word frequency indicates if a word is frequently used. Those classifications are based on frequency lists and are time-sensitive (Pander Maat et al., 2014; Pander Maat & Dekker, 2016). A word like floppy disk or typewriter may have been a frequently used word in the past, whereas these would currently not be. However, words like selfie, woke and veganism would be part of the presently frequently used words. Word frequency also depends on the context, as for example academic language differs from small talk.

Readability Indices

Readability indices aim to provide a measurement of overall complexity of the whole text by combining textual parameters in a mathematical formula (Benjamin, 2012). Commonly used indices include The Flesch-Kincaid Readability Ease and Grade level indicator (Readable, n.d.; Wrigley Kelly et al., 2021). Both are based on the number of sentences, the sentence length and word length. They are intended for English texts. In the Dutch context AVI-scores (*Dutch: Analyse van Indivudaliseringsvormen*) are often used for an indication of the technical level of the text and CLIB (*Dutch: Cito Leesbaarheidsindex voor het basisonderwijs*) as an indication of the reading comprehension level (Tip Onderwijs, 2024; Van Oosten et al., 2010). AVI-scores are based on the letters, length of words and difficulty of words and sentences (Uitgeverij Zwijsen, 2023). CLIB scores are based on the results of the CITO reading comprehension test, so a CLIB score of six would indicate that children in group 6 (aged 9-10) should score sufficiently on this reading test (CED groep, n.d.-b; de Boer, n.d.). AVI and CLIB indices are meant for Dutch elementary school-level texts. Another Dutch index is the LiNT-score (Dutch: *Leesbaarheidsinstrument voor Nederlandse Teksten)* (Kleijn, 2018). The LiNT-score has been developed for Dutch adolescent reading levels and is based on word frequency, the number of content words per sentence part, the proportion of broad concrete nouns and the maximal dependency length (Kleijn, 2018; Pander Maat et al., 2021). The LiNT-score categorises a text into one of four difficulty levels (1 = lowest difficulty, 4 = highest difficulty).

The advantage of a readability index is that one measurement is given to indicate the overall textual difficulty. This score can then easily be used to classify texts and helps students and teachers to indicate if a text has the appropriate difficulty level. Disadvantages of readability indices are that the index has to be developed for the intended language, as linguistic patterns differ, and that they use surface level indicators like word length as proxies for complex cognitive processes needed for reading comprehension (Benjamin, 2012). Additionally, readability indices use a very limited number of parameters to calculate the score. Therefore, the index only gives information about a small part of the textual complexity of the text.

Textual Complexity in Education

Texts have been used in education throughout time to convey information. The goal of those educational texts is to gain information about a specific topic, aid in the execution of experiments and guide in the understanding of the outcomes. With the decline of reading comprehension, attention is given to the texts in educational textbooks, as the primary goal is to convey the information about the topic. Pander Maat and Ditewig (2017) investigated how educational texts have been simplified in the context of Dutch history education and if those simplifications aided comprehension. They found that the versions of the text (authentic versus simplification) differed in their word complexity and frequency, concreteness, syntactic complexity and cohesion. Additionally, 'easier' versions scored higher on comprehension than the authentic versions of the text. This indicates that simplifications of text aid the understanding. Most of the research regarding the simplification of texts has been done in the context of second-language learning, as in this context texts are routinely simplified to increase comprehension, and the medical field, where medical texts are simplified for consumers (Crossley et al., 2012; Ondov et al., 2022; Pander Maat & Ditewig, 2017; Petersen & Ostendorf, 2007; Picton et al., 2025; Rets & Rogaten, 2021). Recently, the focus on text simplification research seems to be on automatic simplifications with the help of AI (Ondov et al., 2022; Picton et al., 2025). Research regarding text simplification aims to improve the understanding while keeping the informational content similar.

In the educational context a balance between authentic texts and simplifications is sought. Petersen and Ostendorf (2007) stated that both text simplifications and authentic texts have a place in education, as research found mixed results on whether or not simplifications are effective in an educational setting. In the Dutch context little research was found regarding text simplifications in education (Pander Maat & Ditewig, 2017). However, various reports, blogposts and articles were found regarding the inclusion of authentic texts (*Dutch: rijke teksten*) in education (e.g. Algoet et al., 2021; Koene, 2021; Pereira & Rijckaert, 2021; SLO, 2024; Smits & van Koeven, 2024; Zwik, 2025). Authentic texts contain rich vocabulary, are rich in function words and envelop a whole topic, whereas simplified texts are often less varied in vocabulary and contain less function words, which hinders comprehension (Pereira & Rijckaert, 2021). Algoet et al. (2021) stated that the Dutch language teachers were found to initiate reading tasks in combination with other subjects. The most common cooperation is Dutch language and history, where history texts are read and summarized (Algoet et al., 2021). Zwik (2025), and Smits and van Koeven (2024) call for more rich texts in educational textbooks, to improve the reading comprehension in all subjects and raise concerns for oversimplification of educational texts. Research has found that simplifications may improve comprehension, but if all educational texts are simplified, encountering real-life authentic texts outside the educational setting may be problematic for students who never had to read authentic texts. After discussions with teachers, it seems that teachers struggle with the balance between simple and authentic texts, as they want their students to understand the material, but also be prepared for more complex texts and real-life reading tasks, like reading government letters or informational work materials.

Text simplification research focuses on how to simplify texts without losing information, whereas educational blogposts and articles focus on the concerns of simplification. Zwik (2025) compared some educational textbooks side by side and found less text in more recent materials than in older materials. However, it is unclear if and in what way the text complexity itself has changed over time. To further this discussion, an investigation into whether or not educational texts have been simplified and in which way is needed.

Aim of Study

The aim of this research is to explore the changes in textual complexity in Dutch educational textbooks over time. Previous research regarding textual complexity focused on differences between educational levels, grade levels and text genres (Berendes et al., 2018; Ham et al., 2018; Jin et al., 2020; Pander Maat & Dekker, 2016). These studies found differences between genres, for example, the textual complexity of an academic paper is higher than of a sports article, and between grade levels and educational levels. Even the topic influences the complexity level of the text (Pander Maat & Ditewig, 2017). Since concerns regarding the reading comprehension level and oversimplification of educational texts are voiced (Algoet et al., 2021; Oxford University Press ELT, 2014; Zwik, 2025), it is necessary to substantiate these claims of simplification of educational texts. Where texts for second-language learners are routinely simplified (Petersen & Ostendorf, 2007; Rets & Rogaten, 2021), it is still unclear if and how Dutch educational texts have been simplified over time. This study aims to substantiate the claims of simplification over time in educational textbooks by systematically investigating Dutch educational textbooks from 1965 to 2024.

As educational level, grade level and topic influence the textual complexity, this study aims to decrease the influence of these factors by investigating a specific educational level, grade level and topic through time. Therefore, the topic of ‘Newton’s first law’ was selected, which is part of the Dutch secondary physics curriculum (HAVO). This topic is conceptual and aims at explaining the concept of inertia. Additionally, this topic does include few mathematical formulas, as formulas could influence the measurement of textual complexity. This specific topic is taught in year 3 and 4 (grade 9 and 10, students aged 13-16).

This study aims to answer the following research question: *How has the textual complexity, in terms of text, sentence and word length, sentence complexity, concreteness of words, lexical diversity and personal style, changed in Dutch physics textbooks for HAVO (year 3 and 4) regarding the topic of Newton’s first law from 1965-2024?*

Method

Context: Dutch Educational System

The Dutch educational system is characterised by diversity, as there are various educational tracks which can be divided into primary, secondary and tertiary education. To improve the attendance of secondary education and provide fitting education for every child, the *Educational law on secondary education* (*in Dutch: Wet op voortgezet onderwijs, aka: Mammoetwet*) was introduced in 1968 (Boekholt & de Booy, 1987; Historiek, 2022). This led to a big reorganisation of the Dutch secondary education. Since then several small changes have been made, like the introduction of the MBO (Senior secondary vocational education; *in Dutch: Middelbaar beroeps onderwijs*) and the introduction of the VMBO (Pre-vocational secondary education*; in Dutch: Voorbereidend middelbaar beroeps onderwijs*) in 1999 (OCO, 2008). Currently, the three major secondary educational tracks are VWO (Pre-university education; *in Dutch: Voorbereidend Wetenschappelijk Onderwijs),* HAVO (Senior general secondary education; *in Dutch: Hoger Algemeen Voortgezet Onderwijs)* and VMBO*.* HAVO and VWO prepare for academic higher education, whereas VMBO prepares for a more practical vocational education (Het Onderwijsloket, 2020).

Research Design

This research used a quantitative approach, following a trend study design, since trends over time were explored (Babbie, 2013). As in this research textual characteristics are quantified, this study takes a quantitative approach as opposed to the mainly qualitative studies in the domain of textual research.

Data Collection

Inclusion Criteria

Educational textbooks were included based on six inclusion criteria. (1) The included books needed to be Dutch physics textbooks, as different languages cannot be easily compared with each other regarding textual complexity. (2) Due to the reorganisation of Dutch secondary education in 1968, books needed to be published between 1965 and 2024 to be included. (3) The included textbooks had to be designed for HAVO or HAVO (combined) education, as the educational level influences the textual complexity. HAVO (combined) education are books that were indicated for VMBO/HAVO, HAVO/VWO or VMBO/HAVO/VWO education, as some books are intended for more than one educational level. (4) The textbooks needed to be non-thematic. Thematic textbooks are textbooks which order the information around a theme, like sports or space. The topic that can be related to this theme will then be explained in this context. Thematic textbooks differ from non-thematic textbooks, which are often ordered by physical sensation like forces or speed. (5) The included textbooks needed to be designed for year 3 or 4 of Dutch secondary education (students aged 13-16), as the grade level also influences the textual complexity. Those grade levels were chosen, due to the fact that the chosen topic would appear in those grade levels. (6) And finally, textbooks had to include a chapter or paragraph on ‘Newton’s first law’, the chosen topic. Fragments were chosen based on title or content. The final dataset for this research consisted of text fragments from 39 educational textbooks.

Procedure

To include as many textbooks as possible, several sources were contacted. The textbooks from the teacher training program for STEM teaching at the University of Twente were used to investigate how physics textbooks are structured and to fully define the inclusion criteria.

Afterwards, the inclusion criteria were used to select textbooks suited for this research. This led to the inclusion of 22 books from the department archives.

In addition, the Museum of Education in Dordrecht was visited. A pre-selection of books was made by a museum worker based on the inclusion criteria. In addition to the museum archives, the museum also curates the archives of the publisher Malmberg. A pre-selection of books from the Malmberg archive was done by the researcher based on an archive list. This led to the inclusion of 11 additional books. Furthermore, additional educational publishers (Nordhoff and ThiemeMeulenhoff) were contacted. Nordhoff and ThiemeMeulenhoff do not have an archive and no additional books could be included. A LinkedIn post was distributed to procure additional books. However, this led to no additional books. In addition, five local schools were contacted, which led to the inclusion of six additional books. Lastly, the digital archive of the Dutch Royal Library (*Dutch: Koninklijke Bibliotheek)* was investigated. This led to no additional books, as available books were already included from other sources.

For each included book the title, author(s), publication date, publisher, source, chapter title and fragment title were documented (see Appendix B). Text fragments were chosen based on the title of the chapter or on the content. So either the title contained *Newton's law* (26 fragments), or the glossary contained the term 'Newton' or 'inertia' (*Dutch: traagheid)* and the fragment was then selected based on the content (13 fragments).

Each selected text fragment on Newton's first law was photographed using Microsoft Lens to convert the physical text into a Word file. Since an automatic text conversion is not error-free, the files were checked by the researcher and adjusted where needed. The text fragments spanned a half up to four pages and only the running informational text was included. Questions, summaries, pictures and other titbits of information were excluded as these follow a different style than informational text. Formulas were included when they were part of the running text. Ultimately, this led to a dataset of 39 textbook fragments regarding Newton's first law, as every book contained one fragment on this topic.

Materials

The used dataset consists of 39 text fragments from Dutch physics educational textbooks. The books were published between 1965 and 2024 by 13 different publishers (see Table 2). Since some publishing houses were combined over time, the publisher was not considered as a variable to be investigated. For example, *Thieme* and *Meulenhoff* are listed as individual publishers as well as *ThiemeMeulenhoff*, the combined publisher.

Table 2

Publishers and the Number of Included Books

Publisher	Number of Books
Agon Elsevier	1
Boom voortgezet onderwijs	1
Educaboek, Tjeenk Willink/Noorduijn bv	1
EPN	1
Malmberg	14
Meulenhoff Educatief	1
Nijgh Versluys	2
Nordhoff	2
Thieme	2
ThiemeMeulenhoff	4
Uitgeversmij J.H.Kok	1
Van Walraven bv	5
Wolters-Nordhoff	4

In the Netherlands educational textbooks are often part of a series of textbooks (in Dutch: *lesmethode*), where books will have the same title. In this research the term 'series' is used for all books, even though several only include one book. It is possible that those books were standalone books, or were part of a series. Therefore, 20 textbook series were included in this research, with 7 books being the biggest group (see table 3). As the data for each individual series is limited, series with 3 or more books were colour indicated in the results, and only visual investigations were done, like checking for clusters or clearly visible trends. Additionally, books from the same series were published by different publishers and sometimes written by the same or different groups of authors. As educational textbooks are often written by groups of authors, it is unclear which fragment was written by which author and therefore, the author was not investigated as a variable. A complete overview of the dataset can be found in Appendix B.

Table 3

Textbook Series Included (Based on Textbook Title)

Textbook Series	Number of Books
Elementaire natuurkunde	1
Eureka	1
Exact natuurkunde	1
Fysica	1
Gewoon…Natuurkunde	1
Het natuurkundeboek	1
Natuurkunde B1	2
Natuurkunde…doen!	1
Natuurkunde op corpusculaire grondslag	4
Natuurkunde overal	1
Natuurkunde voor nu en straks	1
Newton	3
Nova	7
Overal natuurkunde	2
Polaris	1
Pulsar	1
Repetitieboek natuurkunde	1
Scoop	1
Systematische natuurkunde	7
Thuis in natuurkunde	1

The preferred educational level was HAVO education (25 books), but combined education is common in the Netherlands and therefore HAVO combined educational books were included as well. 11 books were included from HAVO/VWO education and 2 books from MAVO/HAVO/VWO education. The oldest book from 1965 belonged to the VHMO (Preparatory Higher and Secondary Education; *in Dutch: Voorbereidend Hoger en Middelbaar Onderwijs*) educational level, which indicated a combination of different levels similar to the HAVO/VWO level of the current system (Wikipedia, 2024). This book was published before the introduction of the *Mammoetwet,* but it can be assumed that this book was still used in 1968. All books belonged to year 3 or 4 (student aged 13-16) , as those were the years the topic of forces was taught. Sometimes books indicated their use in the second part of the education, which indicates that teachers could choose in which year they would use this book.

Instrumentation and Data Analysis

T-Scan

The quantification of text characteristics was done by T-Scan (https://tscan.hum.uu.nl/tscan/). T-Scan is a software tool used to analyse Dutch text and has been developed by researchers from the University of Utrecht, with a first version published in 2014. It can generate around 400 text parameters, pertaining to lexical structures and word usage. T-Scan itself is based on several tools and resources: Frog, Alpino, SoNaR and SUBTLEX-NL, referencelists (*Dutch: Referentie Bestand Nederlands*), wordlists and Wopr (Pander Maat et al., 2014, 2021). Those are, among others, used to indicate which words belong to which category, estimate if a word is frequently used, and classify words and sentences.

In this research 19 parameters regarding length, sentence complexity, word concreteness, lexical diversity and personal style were investigated. The aspect of word frequency was not included in this research, as changes over time were investigated. Frequently used words are time sensitive and would not be relevant for the context of this research. The included textual parameters for this research can be found in table 4.

Table 4

Textual Complexity in Parameters

	Text Parameters	Sentence (S) or word (W) version
	Length	
1	Number of sentences in the text (Zin_per_doc)	S
2	Number of words in the text (Word_per_doc)	W
3	Words by sentence (Wrd_per_zin)	S
4	Words by partial sentence (Wrd_per_dz)	S
5	Letters by word, without names (Let_per_wrd_zn)	W
6	Morphemes by word, without names (Morf_per_wrd_zn)	W
	Sentence Complexity	
7	Number of partial sentences per sentence (Bijzin_per_zin)	S
8	Adjectives by partial sentence without the relative clauses (Bijv_bep_dz_zbijzin)	S
9	Number of additional elements in comparison with the situation without conjunction (Extra_kconj_dz)	S
10	Maximal dependency length (AL_max)	S
11	D-level of the sentences in the text (D_level)	S
12	Proportion sentences with D-level higher than 4 (D_level_gd4_p)	S
	Concreteness	
13	Proportion of strict concrete nouns (Conc_nw_strikt_p)	W
14	Proportion of broad concrete nouns (Conc_nw_ruim_p)	W
15	Density per 1000 words of general nomina (Alg_nw_d)	W
	Lexical Diversity	
16	Measure of textual lexical diversity for content words without general adverbs (MLTD_inhwrd_zonder_abw)	W
17	Number of content words by partial sentence, without adverbs (Inhwrd_dz_zonder_abw)	S
	Personal Style	
18	Density per 1000 words of references to persons (Pers_ref_d)	W
19	Density per 1000 words of personal and possessive pronouns (Pers_vnw_d)	W

Note: In brackets the name of the parameters in T-Scan

Procedure

To ensure proper classification by T-Scan, the texts needed to be formatted into UTF-8 files, and adjusted. All curly apostrophes and quotation marks had to be replaced with straight ones. Formulas that were not part of the running text were excluded, which was the case in one text fragment. Abbreviations were formatted without periods in between, to be recognised by T-Scan as words. Otherwise T-Scan might categorise them as sentences containing one word.

Furthermore, enumerations and titles may skew the sentence complexity structure, therefore two versions of the text were made. A word version (W) and a sentence version (S), which led to a total of 78 text fragments. Only the sentence version needed additional formatting. Titles would skew the sentence structure parameters as titles are not ended with a period and are often unfinished sentences. Therefore, titles were skipped in the sentence version. Introductory words before a statement were seen as titles as well and skipped, like example 1.a (Table 5). If the introduction was a complete sentence, it was included like in example 1.b (Table 5) .

Table 5

Examples of Original and Formatted Text Passages

Example	Original	Adjusted
1a	Conclusie: Zolang de kracht werkt, blijft de snelheid veranderen. *(Thuis in natuurkunde, 1990)*	### Conclusie: Zolang de kracht werkt, blijft de snelheid veranderen.
1b	Samenvattend kun je dan zeggen: Als een voorwerp geen resulterende kracht ondervindt, blijft het in rust of blijft het eenparig rechtlijnig bewegen. *(Systematische Natuurkunde 1998)*	No adjustment
2	Dan zijn er volgens de eerste wet van Newton twee mogelijkheden: 1.Is het voorwerp in rust, dan blijft het in rust. 2.Beweegt het voorwerp, dan kan het uitsluitend eenparig rechtlijnig blijven bewegen. *(Systematische Natuurkunde, 1991)*	Dan zijn er volgens de eerste wet van Newton twee mogelijkheden: Is het voorwerp in rust, dan blijft het in rust. Beweegt het voorwerp, dan kan het uitsluitend eenparig rechtlijnig blijven bewegen.
3	De snelheid van een voorwerp: neemt toe als de resulterende kracht in de richting van de snelheid werkt (versnelde beweging); neemt af als de resulterende kracht tegengesteld gericht is aan de snelheid (vertraagde beweging); verandert van richting als de resulterende kracht en de snelheid niet dezelfde richting hebben. *(Overal Natuurkunde, 2012)*	De snelheid van een voorwerp: neemt toe als de resulterende kracht in de richting van de snelheid werkt (versnelde beweging); ### neemt af als de resulterende kracht tegengesteld gericht is aan de snelheid (vertraagde beweging); ### verandert van richting als de resulterende kracht en de snelheid niet dezelfde richting hebben.

Note: ### in front excludes the line from analysis

Enumerations are often unfinished sentences and would interfere with the classification of sentence parameters. If an enumeration was a list of complete sentences, they were formatted as complete sentences, see example 2 (Table 5). In addition, the letters or numbers in front of the list were deleted. If an enumeration started with a partial sentence and were followed by partial sentences, the first listed item was included in the full sentence and the other list items were excluded, see example 3 (Table 5).

T-Scan classifies periods, exclamation marks, question marks or semi-colons as sentence stops. The text was checked for unnecessary or illogical stops, like exclamation marks in the middle of a sentence for emphasis. These illogical stops were removed. Additionally, the texts were checked for unnecessary or illogical use of colons (:), as T-Scan will identify a sentence divided by a colon as partial sentence. If the text contained sentences divided by colons, which clearly were full sentences, the colon was changed to a semi-colon (;). Lastly, full sentences in between brackets were kept as full sentences and the brackets were removed.

In total 78 text fragments were analysed by T-Scan. An overview of the used T-Scan settings can be found in Appendix C. Table 4 indicates if a parameter was calculated from the word or sentence version.

Statistical Analysis

The data was combined into an Excel file including the description of the text fragments and the 19 parameters. Parameters were chosen either from the analysis of the word or sentence version as described in Table 4. The publication date was reformatted as years from 0 to 59 (0 = 1965, 59 = 2024). The statistical software Rstudio (version 2029.09.1+394) was used to analyse the data. For each parameter the mean, standard deviation, and minimum and maximum value were calculated. The correlation between the variables was calculated to investigate possible relationships between variables, as all variables describe an aspect of textual complexity. For each parameter the normality, linearity, and interdependency assumptions were tested by plotting of the data. Then a linear regression analysis was performed with time in years as the independent variable and the text parameter as the dependent variable, to investigate the parameter over time. Even if the normality assumption was violated, a regression analysis was performed to produce a graphical representation with a general trendline. The graphs included a colour for every book series with three or more books, to visualise possible patterns within a series. All other books were indicated with the colour black. The data was checked for outliers and the regression analysis was repeated without the outliers, to investigate the influence of outliers. The normality assumption was investigated numerically for the parameters, with and without outliers, by performing the Shapiro-Wilk test on the residuals of the regression. Both versions were included in the results.

Results

Descriptive Statistics

For each parameter, the mean, standard deviation, minimum value and maximum value can be found in Table 6.

Table 6

Descriptive Statistics

	Descriptive statistics				
	Variable	**M**	**SD**	**Min**	**Max**
	Length				
1	Number of sentences	35.26	14.69	5.00	62.00
2	Number of words	595.80	234.89	92.00	1086.00
3	Words by sentence	16.86	3.28	12.38	31.90
4	Words by partial sentence	8.88	1.15	7.29	12.80
5	Letters by word	4.94	0.23	4.44	5.39
6	Morphemes by word	1.41	0.05	1.27	1.51
	Sentence Complexity				
7	Number of partial sentences	0.89	0.33	0.31	2.10
8	Adjectives by partial sentence	1.10	0.42	0.51	2.70
9	Number of additional elements	0.15	0.08	0.00	0.48
10	Maximal dependency length	7.20	1.46	5.41	10.85
11	D-level	3.10	0.73	2.02	5.00
12	D-Level higher than 4	0.41	0.13	0.22	0.80
	Concreteness				
13	Proportion strict concrete nouns	0.26	0.07	0.13	0.40
14	Proportion broad concrete nouns	0.33	0.09	0.21	0.53
15	Density of general nomina	46.51	18.72	14.93	97.83
	Lexical Diversity				
16	MLTD	66.84	57.15	21.17	358.65
17	Content words by partial sentence	3.80	0.48	2.98	5.03
	Personal Style				
18	Density references to persons	49.96	21.08	11.13	122.98
19	Density personal and possessive pronouns	33.81	20.14	0.00	85.37

Correlation

The correlation between the 19 parameters has been tested. The results can be found in Table 7. Six strong positive correlations ($r > .80$) were found. The *Number of sentences* and *Number of words* are positively correlated ($r = .94$). The *Number of letters per word* correlated positively with the *Number of morphemes per word* ($r = .81$). The *Number of adjectives* correlated positively with the *Number of words per partial sentence* ($r = .94$). The *Proportion of strict concrete* and *broad concrete words* correlated positively *(r* =.88). The *Number of content words* correlated positively with the

Number of words in a partial sentence (*r* =.93). The *Number of content words* also correlated positively (*r* =.86) with the *Number of adjectives per partial sentence*. No strong negative correlations (*r* < -.80) were found.

Table 7

Correlation Matrix

	Number of sentences	Number of words	Words by sentence	Words by partial sentence	Letters by word	Morphemes by word	Number of partial sentences	Adjectives by partial sentence	Number of additional elements	Maximal dependency length	D-level	D-level higher than 4	Proportion strict concrete nouns	Proportion broad concrete nouns	Density of general nomina	MLTD	Content words by partial sentence	Density references to persons	Density personal and possessive pronouns
Number of sentences	1.00																		
Number of words	.94	1.00																	
Words by sentence	-.39	-.12	1.00																
Words by partial sentence	-.26	-.12	.50	1.00															
Letters by word	-.19	-.13	.34	.12	1.00														
Morphemes by word	-.08	-.05	.20	-.02	.81	1.00													
Number of partial sentences	-.29	-.13	.65	-.21	.30	.31	1.00												
Adjectives by partial sentence	-.21	-.06	.47	.94	.13	-.07	-.28	1.00											
Number of additional elements	-.09	-.03	.17	.55	-.02	.00	-.33	.55	1.00										
Maximal dependency length	-.57	-.36	.72	.44	.27	.13	.37	.43	.32	1.00									
D-level	-.15	.01	.50	-.21	.29	.40	.71	-.17	-.21	.38	1.00								
D-level higher than 4	-.16	-.03	.46	-.16	.28	.42	.62	-.13	-.21	.36	.94	1.00							
Proportion strict concrete nouns	.19	.23	.01	-.27	-.16	-.22	.22	-.31	-.48	-.08	.04	-.05	1.00						
Proportion broad concrete nouns	.23	.29	.07	-.23	-.13	-.18	.25	-.27	-.34	.03	.05	-.05	.88	1.00					
Density of general nomina	-.48	-.51	.11	.17	.29	.08	-.10	.24	.14	.20	-.08	-.06	-.22	-.37	1.00				
MLTD	.01	.08	.17	-.18	-.06	-.16	.26	-.12	-.24	.03	.22	.09	.40	.57	-.22	1.00			
Content words by partial sentence	-.19	-.04	.45	.93	.24	.14	-.17	.86	.54	.37	-.21	-.20	-.23	-.20	.14	-.17	1.00		
Density references to persons	-.02	-.06	-.13	-.47	.01	.05	.22	-.43	-.51	-.20	.20	.17	.35	.40	-.23	.67	-.47	1.00	
Density personal and possessive pronouns	.13	.08	-.22	-.62	-.02	.19	.26	-.59	-.47	-.35	.31	.27	.18	.25	-.33	.49	-.60	.86	1.00

Note: Green cells are strong positive correlations >.80; Red cells are strong negative correlations <-.80 (non-existent)

Normality of Data

Histograms of the data were created to explore the spreading of the data (Appendix D) and the Shapiro-Wilk test was performed on the regression residuals to test normal distribution of the data (Table 8). The data for *Words per sentence* and *Number of adjectives* were not normally distributed, but when the outlier is removed the data is normally distributed. For *MLTD,* even with the removal of the outlier, the data is not normally distributed, and there is no strong correlation to another variable which could be investigated instead. The data for *Words by partial sentence*, *Number of additional elements* and *Maximum dependency length*, were not normally distributed and no strong correlation with other variables were found. The data for *D-level higher than 4* was not normally distributed but there was a strong correlation with *D-level*, which is normally distributed. Similarly, the data for *Proportion of broad concrete nouns* was not normally distributed, but a strong correlation with *Proportion of strict concrete nouns* was found, which in turn is normally distributed.

Table 8

Results of Shapiro-Wilk Test

	Variable	W	p
	Length		
1	Number of sentences	0.97	.369
2	Number of words	0.95	.088
3	Words by sentence	0.85	**<.001**
	Words by sentence (w/o outlier)	0.97	.399
4	Words by partial sentence	0.91	**.003**
5	Letters by word	0.97	.265
6	Morphemes by word	0.98	.864
	Sentence Complexity		
7	Number of partial sentences	0.95	.110
	Number of partial sentences (w/o outlier)	0.98	.823
8	Adjectives by partial sentence	0.86	**<.001**
	Adjectives by partial sentence (w/o outlier)	0.94	.056
9	Number of additional elements	0.82	**<.001**
10	Maximal dependency length	0.89	**.001**
11	D-level	0.95	.116
12	D-level higher than 4	0.94	**.043**
	Concreteness		
13	Proportion strict concrete nouns	0.97	.473
14	Proportion broad concrete nouns	0.94	**.041**
15	Density of general nomina	0.97	.281
	Lexical Diversity		
16	MLTD	0.68	**<.001**
	MLTD (w/o outlier)	0.90	**.002**
17	Content words by partial sentence	0.96	.240
	Personal Style		
18	Density references to persons	0.95	.060
	Density references to persons (w/o outlier)	0.99	.968
19	Density personal and possessive pronouns	0.95	.095

Note: Bold p-values are significant < .05, performed on the regression residuals

Regression Analysis

The focus of this study was to investigate changes in textual complexity over time. Therefore an regression analysis was performed with each textual parameter as outcome variable and the year of publishing as explanatory variable. The outcome of the regression analysis can be found in Table 9. Significant changes over time were found for four out of nineteen parameters ($p = .1$, two-tailed, which corresponds to $p = .05$, one-tailed): *Words by sentence* ($p = .020$), *Number of partial sentences* ($p = .052$), *Density of general nomina* ($p = .073$) and *MLTD* ($p = .065$). However, *Words by sentence* and *MLTD* were not normally distributed (Table 8). A closer investigation showed that the residuals for *Words by sentence* would be normally distributed if the outlier was removed. The regression then became non-significant ($p = .123$). The same investigation was done for *MLTD*, but here the distribution remained not normally distributed. The parameters *Number of sentences, Number of words, Words by partial sentence, Letters by word, Morphemes by word, Adjectives per partial sentence, Number of additional elements, Maximal dependency length, D-level, D-level higher than 4, Proportion strict concrete nouns, Proportion broad concrete nouns, Content words by partial sentence, Density references to persons* and *Density personal and possessive pronouns* showed non-significant results ($p > .1$).

Table 9

Results of Regression Analysis

	Variable	Intercept	Coefficient	t(df)	p	r
	Length					
1	Number of sentences	29.38±4.60	0.19±0.13	1.48(37)	.147	.24
2	Number of words	539.66±74.90	1.86±2.14	0.87(37)	.391	.14
3	Words by sentence*	18.91±0.98	-0.07±0.03	-2.42(37)	**.020**	-.37
	Words by sentence (w/o outlier)	*17.45±0.72*	*-0.03±0.02*	*-1.58(36)*	*.123*	*-.25*
4	Words by partial sentence*	8.87±0.37	0.00±0.01	0.04(37)	.972	.15
5	Letters by word	4.97±0.07	-0.00±0.00	-0.36(37)	.724	-.06
6	Morphemes by word	1.40±0.02	0.00±0.00	0.43(37)	.673	.07
	Sentence Complexity					
7	Number of partial sentences	1.06±0.10	-0.01±0.00	-2.01(37)	**.052**	-.31
	Number of partial sentences (w/o outlier)	*0.95±0.09*	*-0.00±0.00*	*-1.17(36)*	*.251*	*-.19*
8	Adjectives by partial sentence*	1.12±0.14	0.00±0.00	-0.17(37)	.868	-.03
	Adjectives by partial sentence (w/o outlier)	*1.10±0.11*	*0.00±0.00*	*-0.56(36)*	*.582*	*-.09*
9	Number of additional elements*	0.14±0.03	0.00±0.00	0.34(37)	.736	.06
10	Maximal dependency length*	7.75±0.46	-0.02±0.01	-1.41(37)	.168	-.23
11	D-level	3.25±0.23	-0.01±0.01	-0.77(37)	.444	-.13
12	D-level higher than 4*	0.42±0.04	0.00±0.00	-0.23(37)	.818	-.04
	Concreteness					
13	Proportion strict concrete nouns	0.29±0.02	0.00±0.00	-1.42(37)	.164	-.23
14	Proportion broad concrete nouns*	0.35±0.03	0.00±0.00	-0.77(37)	.447	-.13
15	Density of general nomina	55.73±5.77	-0.30±0.16	-1.85(37)	**.073**	-.29
	Lexical Diversity					
16	MLTD*	95.67±17.57	-0.95±0.50	-1.90(37)	**.065**	-.30
	*MLTD (w/o outlier)**	*72.15±10.20*	*-0.42±0.29*	*-1.47(36)*	*.152*	*-.24*
17	Content words by partial sentence	3.73±0.15	0.00±0.00	0.45(37)	.655	.07
	Personal Style					
18	Density references to persons	52.99±6.76	-0.10±0.19	-0.52(37)	.608	-.08
	Density references to persons (w/o outlier)	*46.83±5.85*	*0.04±0.16*	*0.24(36)*	*.814*	*.04*
19	Density personal and possessive pronouns	36.12±6.47	-0.08±0.18	-0.41(37)	.682	-.07

Note: Bold p-values are significant < 0.1(two-tailed), name* are not normally distributed

The correlation (r) is computed, as it is advised to include the direction of the relationship (Babbie, 2013). The highest value was found for *Words by sentence* (r = -.37) which can be classified as moderate (Bhandari, 2021). Three other parameters are classified as moderate: *Number of partial sentences* (*r*= -.31), *Density of general nomina* (*r* = -.29) and *Measure of Textual Lexical Diversity* (*MLTD)* (*r* = -.30). Those four parameters are indicated as performing a significant trend over time. Small correlations (.10 < *r* <.25) were found for the following parameters: *Number of sentences* (*r* =.24), *Number of words* (*r* =.14), *Words by partial sentence* (*r* =.15), *Maximal dependency length* (*r* = -.23), *D-level* (*r* = -.13), *Proportion strict concrete nouns* (*r* = -.23) and *Proportion broad concrete nouns* (*r* = -.13). This analysis led to visual representations of the data which included mostly non-significant trend lines (for all parameters see Appendix E). Several findings are highlighted here, due to being significant, or showing clusters or contrary results within series.

The *Number of sentences* and *Number of words* (Figure 1a) show an upward trend (non-significant). There seems to be no visible trend within the series, except for *Newton* where a declining trend is visible, contrary to the overall trend. The *Nova* texts seem to cluster together more than other series. This means that texts regarding Newton's first law have become slightly longer over time, in the number of words and sentences. The *Number of words by sentence* show a downward trend over time, with one clear positive outlier in 1965 (see Figure 1b). Even though the trend is significant (p = .020), the data is not normally distributed (W = 0.85, p < .001). This means that sentences contain fewer words over time. Based on the regression equation, sentences in 1965 contained 18.91 words, whereas sentences in 2024 contained 14.78 words. This is equivalent to a 21.8% decrease.

The *Number of partial sentences by sentence* follows a similar trend, with one clear outlier in 1965 (see Figure 1c). The number of partial sentences declines over time, with no clear trend within a series. This trend is significant (p =.052) and the data is normally distributed (W =0.95, p =.110). This means that recent texts contain fewer partial sentences than older texts. Based on the regression equation, sentences in 1965 contained 1.06 partial sentences, whereas sentences in 2024 contained 0.47 partial sentences. This is equivalent to a 55.7% decrease.

The *Maximal dependency length* shows a downward non-significant trend. Interestingly, *Nova* textbooks seem to cluster closely together and the *Newton* textbooks are all above the regression line (see Figure 1d). This means that the maximal dependency length has shortened over time.

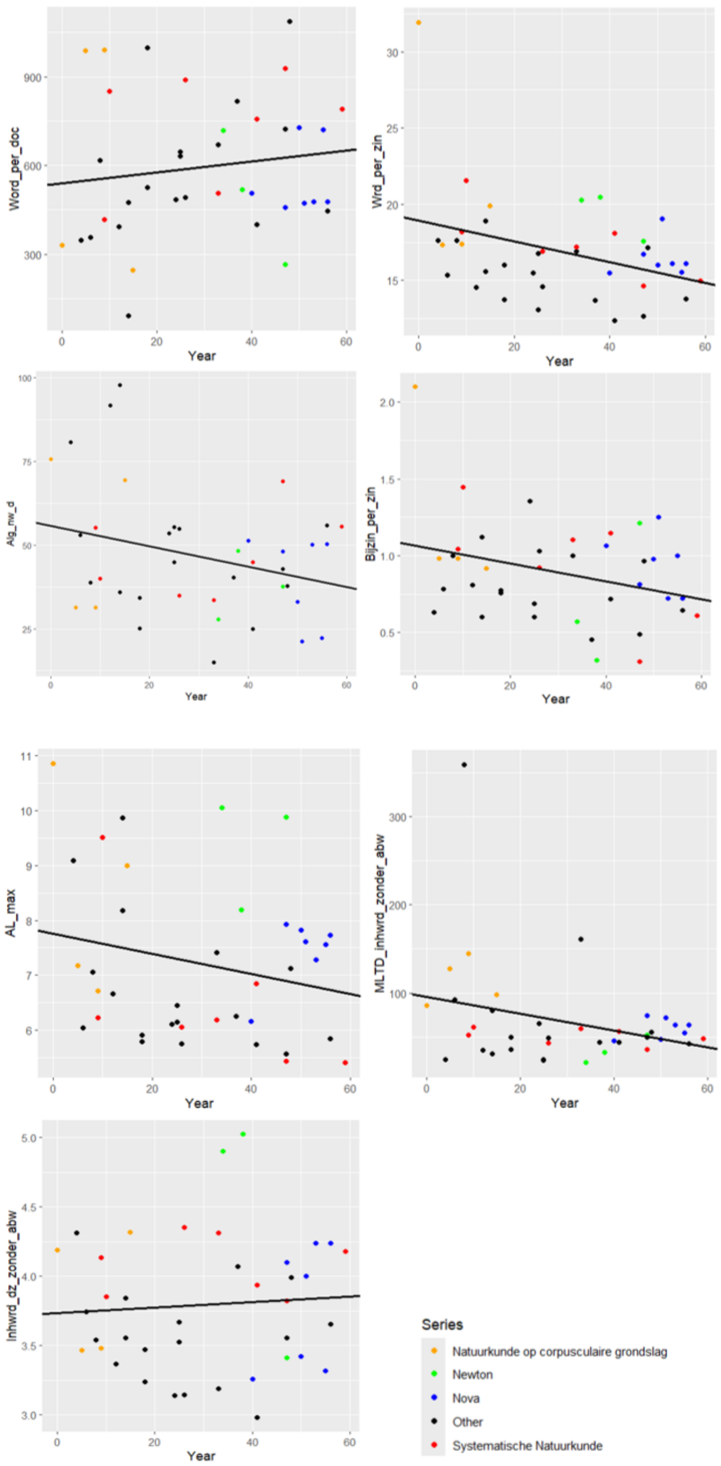
The *Number of strict and broad concrete nouns* as well as the *Density of general nomina* (Figure 1e) show a downward trend, with the *Density of general nomina* being significant (p =. 073) and normally distributed (W = 0.97, p = .281). This indicates that less concrete nouns are used over time, as well as less general nomina, like *idea* or *method.* Based on the regression equation, sentences in 1965 contained 55.73 general nomina per 1000 words, whereas the density was 38.03 in 2024. This equates to a 31.7% decrease.

The *Measure of Lexical Diversity* (MLTD) shows a downward trend with a clear outlier (see Figure 1f). A closer investigation showed that the outlier is the text that elaborates on the life of Newton. The change over time is significant ($p = .065$), but the data is not normally distributed ($W = 0.68$, $p < .001$). Based on the regression equation, texts in 1965 had a MLTD of 95.67, whereas texts in 2024 had a MLTD of 39.37. This equates to a 58.8% decrease. The regression analysis was repeated without the outlier. Then the change over time is non-significant ($p = .152$). Based on this regression equation, texts in 1965 had a MLTD of 72.15, whereas texts in 2024 had a MLTD of 47.37. This is equivalent to a 34.3% decrease. This indicates that recent texts use less variation in words than older texts, but the results should be used cautiously. Contrary to the overall trend, the series *Newton* shows an upward trend over time, which indicates more variation in words in recent texts (based on visual investigation).

The *Number of content words by partial sentence* showed an almost indiscernible upward trend (see Figure 1g). Again the *Newton* series is interesting, as one data point is on the lower end of the spectrum, whereas two points are on the high end of the spectrum. A closer investigation showed that the two books with values around 5 were written by a different team of authors than the book with a value around 3.4. A higher number of content words is associated with higher information density and therefore higher textual complexity.

Figure 1

Trend analysis



Note: Number of words (1a, top left). Words by sentence (1b, top right). Density of general nomina (1c, second row left). Number of partial sentences (1d, second row right). Maximal dependency length (1e, third row left). MLTD (1f, third row right). Number of content words (1g, lower left).

Discussion and Conclusion

Reading comprehension is an integral skill for every participant in society, but the reading comprehension levels are declining in the Netherlands. Reading comprehension education is gaining in importance. Recently, discussions about authentic texts and simplifications in educational settings are rising, as the results about simplifying texts to improve reading comprehension are contradicting. Most warnings are issued based on intuitive observations from teachers and educators. However, it is unclear how exactly textual complexity has changed over time and a structural investigation of textual complexity changes over time is needed. This research aims at substantiating the discussion around textual complexity changes and investigated the following question: *How has the textual complexity, in terms of text, sentence and word length, sentence complexity, concreteness, lexical diversity and personal style, changed in Dutch physics textbooks for HAVO (year 3 and 4) regarding the topic of Newton's first law from 1965-2024?*

Main Findings

Regression Analysis

Nineteen textual parameters regarding length, sentence complexity, word concreteness, lexical diversity and personal style have been investigated over time. A simple regression analysis was performed for every textual parameter, with the year of publishing as the independent variable. Fifteen of the nineteen parameters showed a non-significant change over time. Due to the small sample size and non-normal distributions, the p-value in this research is to be seen as a rough indicator and the statistical power of the regression analysis is rather low. Four out of nineteen parameters showed a significant change over time: *Words by sentence*, *Number of partial sentences*, *Density of general nomina* and *MLTD*. However, *Words by sentence* and *MLTD* were not normally distributed. All four parameters showed a downward trend. Over the timeframe of 59 years, *Words by sentence* has decreased by 21.8%, *Number of partial sentences* by 55.7%, *Density of general nomina* by 31.7% and *MLTD* by 58.8% (with outlier) or 34.3% (without outlier). This means that over time fewer words have been used per sentence. The sentences have become shorter, which is in line with the expectation as shorter sentences imply less complex sentences, due to the needed working memory to decode and understand the sentences. Additionally, the number of partial sentences has decreased. This means that the texts contain fewer partial sentences per sentence, which is in line with the finding that sentences have become shorter. Shorter sentences usually contain fewer partial sentences. Again this indicates that sentences have become less complex.

The *Density of general nomina* has decreased as well. General nomina are words like *idea*, *problem* or *method*, which are not domain-related and are often contextualized within the text. The decrease of this parameter is interesting, as with a conceptual topic such as 'Newton's first law', the density of general nomina would be expected to not change over time. The topic is a basic, conceptual topic and it would be unsurprising if the explanation of this topic stayed similar over time. The decrease of general nomina might indicate that the conceptual topic is described by different words over time. Additionally, the proportion of strict and broad concrete nouns is declining (non-significantly), which would indicate less concrete words and more abstract words. Interestingly, the general nomina, which are part of abstract word classes, are not rising. As overall more words are used per text, the increase in words has to come from different word classes than the three that were explored in this research.

The *Measure of Lexical Diversity* (MLTD) has decreased as well over time. This means that the topic is explained with less variation in word usage. Closer investigation found that the most variation in words and highest MLTD was found for a text which elaborated on the life of Newton. Overall, the trend indicates less variation in words. This is especially interesting, when viewed in combination with the upward trend for *Number of words*. So, more words are used to describe the topic of inertia, but the words are less varied.

Investigation of the different series of titles showed no clear trends within a group of textbooks. No statistical investigation was done with a group since the sample size would be between three and seven and too small. However, based on visual inspection, the *Nova* books seem to cluster more closely together than other series. This may be due to the fact that the *Nova* books included, spanned a shorter timeframe than some of the other series. Therefore, it is possible that fewer changes between the texts have been made. Additionally, the findings for the *Newton* books were found contrary to the general trendline in some parameters (*Number of sentences, Number of words, Proportion strict concrete nouns, MLTD* and *Density of references to persons*). The sample size for this group is very small (3) and therefore no definitive results can be given, but is interesting to see that this one series seems to be different from the others. Textbooks are often written by a group of authors and subsequent versions of the same series might be written by a different group. Therefore, it is possible that differences within a series may be due to author and style changes. Educational textbooks also need to follow changes in regulations and standards and are therefore often revised.

Correlation

This research investigated 19 textual parameters over time. Six strong positive correlations were found (see Table 10). Those correlations were unsurprising. A higher number of sentences correlated with a higher number of words, since words are part of sentences. As expected the number of letters and morphemes per word correlated. Those two parameters are conceptually very similar and in subsequent research the investigation of one parameter may be enough. As the number of letters is an easier-to-grasp concept than morphemes, subsequent research should incorporate the parameter *Letters by word*. The same reasoning can be found for the proportion of strict and broad concrete nouns. Nouns that are classified as strict concrete are also broad concrete, only broad concrete nouns include places, times and units of measurement. Therefore, investigation of one parameter may be sufficient. As the proportion of broad concrete nouns incorporates the strict concrete nouns, it would be advised to incorporate this parameter.

Table 10

Strong Correlation Pairs (r > .80)

Number of sentences	Number of words
Letters by word	Morphemes by word
Number of adjectives	Number of words by partial sentence
Proportion strict concrete nouns	Proportion broad concrete nouns
Number of content words	Number of adjectives per partial sentence
Number of content words	Number of words by partial sentence

Additionally, the *Number of words* and *Number of sentences* strongly correlate. This means in this research one of the two parameters might have been sufficient. In subsequent research, however, both should be investigated as the correlation may not be found in other texts. It is possible that a longer text contains more words, but less sentences, so the sentences might be longer. This outcome would also be found in the parameter *Words by sentence*, which indicates the mean length of a sentence by the number of words. All three parameters together give the most detailed view of sentence and text length.

Implications

A lot of attention has been given to reading comprehension education and simplifications of text have been found to improve understanding. However, warnings have been issued to guard for oversimplification and to keep the balance between focusing on understanding and teaching the skill of reading complex texts. Previous research on text simplifications focused on improving comprehension while keeping the informational content similar or differences between authentic texts and simplifications for second-language learners. No research was found that investigated changes in textual complexity over time while controlling for the educational level, grade level and topic. This research is the first step in closing that gap by quantifying textual complexity within a specific educational level, grade level and topic, to investigate changes over time. This outcome may be used to substantiate the discussion about oversimplification and domain learning regarding reading comprehension. This study showed that textual complexity changed slightly over time in HAVO educational materials. The investigated materials may still be used to further the skill of complex reading and collaboration between science and language teachers may be advised. The analysis of Dutch texts with T-Scan may also be used in the writing of new educational materials, to ensure texts have the intended level of complexity and safeguard for oversimplification. The outcomes may even inform curriculum design and policy, for example revisions of the Dutch core gaols for education (*Dutch: kerndoelen*), where text aspects may be explicitly stated.

Previous research investigated the differences between text genres and educational levels. This research adds to the scientific knowledge base, as a different context and changes over time within a specific topic (Newton's first law) were investigated. Additionally, T-Scan aims to become a tool for professional writers, informing them about complexity levels, genre-conformity and which parts of their text need reassessing (Pander Maat et al., 2014). To reach this aim, T-Scan needs to be used in various research and contexts. Based on this research, which included formulas within the text, further development of T-Scan should include the possibility of working with formulas. Currently, each character within the formula is seen as a word, but formulas in mathematical or physical text may be better classified as a unique category. Intuitively, a text with fewer formulas, will be less complex than a text with a lot of formulas.

Limitations and Future Research

Some limitations have to be considered when interpreting the results of this research. The sample size (n = 39) was small and non-random, as most educational textbooks are not archived and are probably thrown away, when not in use anymore. At least 50 textbooks would be needed to perform a reliable regression analysis (Wilson Van Voorhis & Morgan, 2007). Therefore, the statistical results are an indication and should be treated accordingly. A permutation test may improve the statistical outcomes, but fell outside of the scope of this research. As a permutation test is a non-parametric test, this would also tackle the violation of the normality assumption which was present in several parameters (Friston et al., 2007; Wilber, 2019).

This research focused on one specific topic to investigate the changes over time while controlling for the topic, as the topic influences the textual complexity (Pander Maat & Ditewig, 2017). It would be really interesting to investigate these trends in other topics within the same subject and how those relate to each other. Future research might investigate various topics over time and compare the results. This would further the understanding of textual complexity in Dutch educational materials and might substantiate the current findings. Additionally, more combinations of comparisons are possible, like including the same topic from different educational levels.

As this research is exploratory, changes over time have been described, but it is still unclear if those changes have been beneficial or influential on the reading comprehension. Therefore, future research should investigate the relationship between the trends in textual complexity and the reading comprehension level within the Netherlands. That research should include a broad definition of textual complexity, like the current study and focus on specific topics rather than an overall score.

Conclusion

This research aimed to explore the changes in textual complexity in Dutch Physics secondary education from 1965 to 2024 within the topic of Newton's first law. This was done by investigating 19 textual parameters regarding text, sentence and word length, sentence complexity, concreteness, lexical diversity and personal style. This exploration found that sentences have become shorter, contain fewer partial sentences, but that the number of additional elements and adjectives per partial sentence remains the same. The personal style of the texts, and the word length, in letters and morphemes, is similar for all texts throughout time, while less varied words, fewer concrete nouns and fewer general nomina are used. As textual complexity is a multi-faceted concept, which is based on various parameters and their interaction, this research cannot give a clear answer to the question if the texts have become less or more complex, but describes the changes over the past 60 years. The shorter sentences and fewer partial sentences imply less complexity, while the fewer concrete nouns imply more complexity. Interactions between parameters have not been inspected in this research. So future research should focus on the interaction of those parameters, investigate if other Physics topics follow the same trends, and if differences between topics are discernible.

In conclusion, this research is the first step in bridging the gap between intuitive observations of text simplification over time and the evidence-based findings of textual complexity research. This study investigated changes in textual complexity over time, while controlling for the educational level, grade level and topic. Based on these results, the next step is to investigate the textual complexity for different topics and subjects to broaden the understanding of textual changes over time in Dutch education.

References

Alexander, P. (2005). The path to competence: A lifespan developmental perspective on reading. *Journal of Literacy Research*, *37*(4), 413–436. https://doi.org/10.1207/s15548430jlr3704_1

Alexander, P., & Fox, E. (2004). A Historical Perspective on Reading Research and Practice. In *Theoretical Models and Processes of Reading* (5th ed.). International Reading Association. http://www.researchgate.net/publication/255654818

Algoet, M., van Dingenen, M., Hauben, M., Verhelst, L., Pereira, C., & Rijckaert, H. (2021). *Rijke teksten in alle vakken*.

Babbie, E. (2013). *The practice of social research* (Vol. 13).

Benjamin, R. G. (2012). Reconstructing readability: Recent developments and recommendations in the analysis of text difficulty. *Educational Psychology Review*, *24*(1), 63–88. https://doi.org/10.1007/s10648-011-9181-8

Berendes, K., Vajjala, S., Meurers, D., Bryant, D., Wagner, W., Chinkina, M., & Trautwein, U. (2018). Reading demands in secondary school: Does the linguistic complexity of textbooks increase with grade level and the academic orientation of the school track? *Journal of Educational Psychology*, *110*(4), 518–543. https://doi.org/10.1037/edu0000225

Bhandari, P. (2021). *Correlation Coefficient: Types, Formulas & Examples*. https://www.scribbr.com/statistics/correlation-coefficient/

Boekholt, P. Th. F. M., & de Booy, E. P. (1987). *Geschiedenis van de school in Nederland vanaf de middeleeuwen tot aan de huidige tijd*. Van Gorcum. https://www.dbnl.org/tekst/boek009gesc01_01/colofon.php

CED groep. (n.d.-a). *Begrijpend lezen in andere vakken*. Kenniscentrum Begrijpend Lezen - Voortgezet Onderwijs. Retrieved March 7, 2025, from https://www.kenniscentrumbegrijpendlezen.nl/vo/begrijpend-lezen-in-andere-vakken

CED groep. (n.d.-b). *Kan ik met behulp van de Cito begrijpend leestoets het Nieuwsbegripniveau bepalen?* Nieuwsbegrip. Retrieved March 7, 2025, from https://www.nieuwsbegrip.nl/page/661/kan-ik-met-behulp-van-de-cito-begrijpend-leestoets-het

Covington, M. A., Brown, C., Naci, L., He, C., & Brown, J. (2006). *How complex is that sentence? A proposed revision of the Rosenberg and Abbeduto D-Level Scale*. https://www.researchgate.net/publication/254033869

Crossley, S. A., Allen, D., & McNamara, D. S. (2012). Text simplification and comprehensible input: A case for an intuitive approach. *Language Teaching Research*, *16*(1), 89–108. https://doi.org/10.1177/1362168811423456

Dascalu, M., Trausan-Matu, S., & Dessus, P. (2012). Towards and integrated approach for evaluating textual complexity for learning purposes. *Advances in Web-Based Learning- ICWL 2012*, 268–278.

de Boer, M. (n.d.). *Ontdek alles over het leesniveau van je kind*. Retrieved March 7, 2025, from https://wijzeroverdebasisschool.nl/uitleg/leesniveau

Fox, E., & Alexander, P. A. (2004). *Reading, interest, and the model of domain learning: A developmental model of interest, knowledge, and strategy use in text comprehension*.

Friston, K. J. ., Ashburner, John., Kiebel, Stefan., Nichols, Thomas., & Penny, W. D. . (2007). *Statistical parametric mapping : the analysis of funtional brain images*. Elsevier/Academic Press.

Gamson, D. A., Lu, X., & Eckert, S. A. (2013). Challenging the Research Base of the Common Core State Standards: A Historical Reanalysis of Text Complexity. *Educational Researcher*, *42*(7), 381–391. https://doi.org/10.3102/0013189X13505684

Gervasi, V., & Ambriola, V. (2002). *Quantitative assessment of textual complexity*.

Gibson, E. (2000). The dependency locality theory:A distance-based theory of linguistic complexity. In Y. Miyashita, A. P. Marantz, & W. O'Neil (Eds.), *Image,language, brain* (pp. 95–126). MIT Press.

Gubbels, J., Van Langen, A., Maassen, N., & Meelissen, M. (2019). *Resultaten PISA-2018 in vogelvlucht*. https://doi.org/10.3990/1.9789036549226

Ham, L., Lenth, L., Pander Maat, H., & Stolk, F. (2018). Zijn romans en kranten sinds 1950 eenvoudiger geworden? *Tijdschrift Voor Nederlandse Taal- En Letterkunde*, 300–323.

Het Onderwijsloket. (2020). *Het Nederlandse onderwijssysteem*. https://www.onderwijsloket.com/kennisbank/artikel-archief/hoe-zit-het-nederlandse-onderwijssysteem-in-elkaar/

Historiek. (2022). *Mammoetwet van 1968 - Wet op het voortgezet onderwijs*. https://historiek.net/mammoetwet-1968-betekenis-definitie/84129/

Jin, T., Lu, X., & Ni, J. (2020). Syntactic complexity in adapted teaching materials: differences among grade levels and implications for benchmarking. *Modern Language Journal*, *104*(1), 192–208. https://doi.org/10.1111/modl.12622

Kaid, J., Ali, M., Beg, M. S., Hasnain, S. I., & Salim Beg, M. (2011). *The Linguistic Features of Texting Linguistic Features and Patterns of Texting: Results of a Case Study at an Indian University*. https://www.researchgate.net/publication/320196556

Kennisrotonde. (2024, July). *Begrijpend lezen in alle vakken*. https://www.kennisrotonde.nl/begrijpend-lezen-in-alle-vakken

Khodabandehlou, M., Jahandar, S. , Seyedi, G., Abadi, R. (2012). The impact of self-directed learning strategies on reading comprehesion. *International Journal of Scientific & Engineering Research*, *3*(7), 1–9.

Kleijn, S. (2018). *Clozing in on readability. How linguistic features affect and predict text comprehension and on-line processing.* LOT, Netherlands Graduate School.

Koene, Y. (2021, June 1). *Begrijpend lezen begint bij de noodzaak tot lezen*. https://www.cps.nl/blog/2021/06/01/Begrijpend-lezen-begint-bij-de-noodzaak-tot-lezen

Luyten, H. (2024). Examining the relationship between online chatting and PISA reading literacy trends (2000-2018). *Computers in Human Behavior*, *156*. https://doi.org/10.1016/j.chb.2024.108198

Mijs, D., & Vernooij, K. (2016). Beter tekstbegrip door intensief lezen "Close Reading" onder de loep. *Tijdschrift for Remedial Teaching*, *05*, 22–25.

Moore, A. L. (2014). *A research review of cognitive skills, strategies, and interventions for reading comprehension*.

Nederlands Jeugdinstituut. (2023, December 6). *Leesvaardigheid in Nederland slechter*. https://www.nji.nl/nieuws/leesvaardigheid-in-nederland-slechter

OCO. (2008, January 3). *Invoering van het vmbo*. https://www.onderwijsconsument.nl/invoering-van-het-vmbo/

Ondov, B., Attal, K., & Demner-Fushman, D. (2022). A survey of automated methods for biomedical text simplification. In *Journal of the American Medical Informatics Association* (Vol. 29, Issue 11, pp. 1976–1988). Oxford University Press. https://doi.org/10.1093/jamia/ocac149

Oxford reference. (n.d.). *Morpheme*. Retrieved November 7, 2024, from https://www.oxfordreference.com/display/10.1093/oi/authority.20110803100210358

Oxford University Press ELT. (2014, November 6). *The importance of content rich texts to learners and teachers*. https://teachingenglishwithoxford.oup.com/2014/11/06/the-importance-of-content-rich-texts-to-learners-and-teachers/

Pander Maat, H. (2017). Zinslengte en zinscomplexiteit. *Tijdschrift Voor Taalbeheersing*, *39*(3), 297–328. https://doi.org/10.5117/TVT2017.3.PAND

Pander Maat, H., & Dekker, N. (2016). Tekstgenres analyseren op lexicale complexiteit met T-scan. *Tijdschrift Voor Taalbeheersing*, *38*(3), 236–304. https://doi.org/10.5117/TVT2016.3.PAND

Pander Maat, H., & Ditewig, S. (2017). Hoe worden onderwijsteksten vereenvoudigd, en helpt dat? *Tijdschrift Voor Taalbeheersing*, *39*(2), 245–263. https://doi.org/10.5117/TVT2017.2.MAAT

Pander Maat, H., Kraf, R., & Dekker, N. (2021). *Handleiding T-Scan*.

Pander Maat, H., Kraf, R., van den Bosch, A., Dekker, N., van Gompel, M., Kleijn, S., Sanders, T., & van der Sloot, K. (2014). T-Scan: a new tool for analyzing Dutch text. *Computational Linguistics in the Netherlands Journal*, *4*, 53–74. http://tst-centrale.org/nl/producten/corpora/sonar-corpus/6-85

Pereira, C., & Rijckaert, H. (2021). Werken met rijke teksten voor beter leesbegrip en meer leesmotivatie. *35ste HSN-Conferentie*.

Petersen, S. E., & Ostendorf, M. (2007). Text Simplification for Language Learners: A Corpus Analysis. *Speech and Language Technology in Education, SLaTE 2007*, 69–72. https://doi.org/10.21437/slate.2007-20

Picton, B., Andalib, S., Spina, A., Camp, B., Solomon, S. S., Liang, J., Chen, P. M., Chen, J. W., Hsu, F. P., & Oh, M. Y. (2025). Assessing AI Simplification of Medical Texts: Readability and Content Fidelity. *International Journal of Medical Informatics*, *195*. https://doi.org/10.1016/j.ijmedinf.2024.105743

PISA. (2019). *PISA 2018 Assessment and Analytical Framework*. OECD. https://doi.org/10.1787/b25efab8-en

RAND. (2002). *Reading for understanding: Toward an R&D program in reading comprehension*. RAND.

Readable. (n.d.). *Flesch Reading Ease and the Flesch Kincaid Grade Level*. Retrieved February 24, 2025, from https://readable.com/readability/flesch-reading-ease-flesch-kincaid-grade-level/

Rets, I., & Rogaten, J. (2021). To simplify or not? Facilitating English L2 users' comprehension and processing of open educational resources in English using text simplification. *Journal of Computer Assisted Learning*, *37*(3), 705–717. https://doi.org/10.1111/jcal.12517

Sadoski, M. (2001). Resolving the effects of concreteness on interest, comprehension, and learning important ideas from text. *Educational Psychology Review*, *13*(3), 263–281.

Seigneuric, A., & Ehrlich, M. F. (2005). Contribution of working memory capacity to children's reading comprehension: A longitudinal investigation. *Reading and Writing*, *18*, 617–656. https://doi.org/10.1007/s11145-005-2038-0

Serafini, F. (2012). Reading Multimodal Texts in the 21st Century. In *RESEARCH IN THE SCHOOLS Mid-South Educational Research Association* (Vol. 19, Issue 1).

SLO. (2024, May 27). *Rijke teksten en wereldoriëntatie*. https://www.slo.nl/thema/meer/samenhang-primair-onderwijs/taal-samenhang/rijke-teksten/

Smits, A., & van Koeven, E. (2024, October 9). *Geletterdheid en schoolsucces: Arme teksten in zaakvakmethodes*. https://geletterdheidenschoolsucces.blogspot.com/2024/10/stop-met-het-vertalen-van-aanbodsdoelen.html?m=1

Stichting Lezen. (2023, December 5). *Leesprestaties Nederlandse middelbare scholieren gaan achteruit*. https://www.lezen.nl/onderzoek/leesprestaties-nederlandse-middelbare-scholieren-gaan-achteruit/

Tip Onderwijs. (2024, June 10). *Betekenis: AVI-niveau*. 2024. https://tiponderwijs.nl/begrip/avi-niveau/

Uitgeverij Zwijsen. (2023). *Zelf het AVI-niveau bepalen van een kinderboek*. https://www.zwijsen.nl/lezen/zelf-het-avi-niveau-bepalen-van-een-kinderboek/

van de Ven, I., Hakemulder, F., & Mangen, A. (2023). 'TL;DR' (Too Long; Didn't Read)? Cognitive Patience as a Mode of Reading: Exploring Concentration and Perseverance. *Scientific Study of Literature*, *12*(1), 68–86. https://doi.org/10.61645/ssol.176

Van Den Broek, P., & Espin, C. A. (2012). Connecting cognitive theory and assessment: Measuring individual differences in reading comprehension. *School Psychology Review*, *41*(3), 315–325. https://doi.org/10.1080/02796015.2012.12087512

van Gelderen, A. (2018). *Begrijpend lezen: Wat is dat?*

Van Oosten, P., Tanghe, D., & Hoste, V. (2010). *Towards an Improved Methodology for Automated Readability Prediction*. http://tst.inl.nl/en/producten.

Wikipedia. (2024). *VHMO*. https://nl.wikipedia.org/wiki/VHMO

Wilber, J. (2019). *Permutation Test: Visual Explanation*. https://www.jwilber.me/permutationtest/

Wilson Van Voorhis, C. R., & Morgan, B. L. (2007). Understanding power and rules of thumb for determining sample sizes. *Tutorials in Quantitative Methods for Psychology*, *3*(2), 43–50. https://doi.org/10.20982/tqmp.03.2.p043

Wrigley Kelly, N. E., Murray, K. E., McCarthy, C., & O'Shea, D. B. (2021). An objective analysis of quality and readability of online information on COVID-19. *Health and Technology*, *11*(5), 1093–1099. https://doi.org/10.1007/s12553-021-00574-2

Zainurrahman, Yusuf, F. N., & Sukyadi, D. (2024). Text readability: its impact on reading comprehension and reading time. *Journal of Education and Learning*, *18*(4), 1422–1432. https://doi.org/10.11591/edulearn.v18i4.21724

Zwik, M. (2025, February 7). *Tekstarm III*. https://wij-leren.nl/Tekstarm-iii.php

Appendix A

Overview of Dependencies in T-Scan

Soort lengte	**Voorbeelden**
AL werkwoord- subject	**- Peter**, mijn neef uit Canada, **schrijft** regelmatig. Het gaat bij een complex subject zoals hierboven altijd om de lengte tussen het hoofd van het subject en het werkwoord. **- Ik ben** gisteren naar de bioscoop **gegaan**. N.B. Bij een complexere werkwoordgroep, zoals in de tweede zin hierboven, wordt het gemiddelde genomen van de afstanden tussen *ik* en *ben* (0) en die tussen *ik* en *gegaan* (4). Dit 'middelen' bij meerdelige werkwoordsgroepen gebeurt alleen bij de AL werkwoord-subject, niet bij de lengtes tussen AL en (indirect) object. **- Ik zag** hem op straat lopen. N.B. In samengestelde zinnen worden meerdere subject-ww-combinaties bekeken, zowel die in hoofdzinnen als bijzinnen, zelfs in non-finiete bijzinnen. In de derde zin gaat het bijvoorbeeld om de afstanden tussen *ik* en *zag* en tussen *hem* en *lopen*. **- Het is** niet vreemd *dat **ik** hem **zag***. N.B. Omdat er hier sprake is van een onderwerpszin, worden in deze zin drie lengtes gemiddeld: die tussen *het* en *is* (0), die tussen *ik* en *zag* (1), en die tussen het hoofd van de onderwerpszin *dat ik hem zag* en het

	werkwoord van de hoofdzin *is* (5). Het gemiddelde is dus 2. N.B. Bij deze afstand wordt het predicaatsnomen buiten beschouwing gelaten (ook al kan het deel uitmaken van het verbale complement).
AL werkwoord- direct object	Karel **gaf** mij een geweldige **roman**.
AL werkwoord- indirect object	Karel **gaf mij** een geweldige roman.
AL werkwoord- voorzetselgroep	Thea **woonde** al jaren **bij** haar moeder.
AL zelfstandig naamwoord- lidwoord	Ik heb **de** lange **man** niet gezien.
AL voorzetsel- naamwoord	**In** dat kleine **café** zijn er veel bieren op tap.
AL werkwoord- werkwoord uit verbaal complement	Ik **dacht** gisteren dat ik te laat **was**. Ik **nodig** hem uit om te **komen eten**. Ik **beloofde** gisteren te **komen**. Ik **heb** hem al jaren niet meer **gezien**. Het gaat hier om afstanden tussen het hoofdwerkwoord en het werkwoord uit het verbale complement daarvan. Als verbaal complement rekent Alpino niet alleen finiete en infiniete bijzinnen, maar ook voltooid-deelwoordgroepen en passief-deelwoordgroepen (‘ppart’-knopen). N.B. Als er twee afstanden van dit type voorkomen, worden die gemiddeld. Dat leidt in de volgende zin tot een gemiddelde van 2.5, omdat de eerste afstand (wilde-prikken) 5 bedraagt en de tweede (zou-zijn) 0: Ze **wilde** zo snel mogelijk een datum **prikken** voordat haar buik te groot **zou zijn** .

	N.B. Bestaat de werkwoordelijke groep in de objectzin uit meerdere werkwoorden, dan wordt de afstand tussen het hoofdzins-werkwoord en het objectzin-werkwoord verdeeld over de verschillende werkwoorden; dat leidt tot lagere scores. en gemiddeld. Dat leidt soms tot lagere lengtes: zo wordt in ‘Ik **beloofde** gisteren te **zullen komen’** de afstand van twee woorden verdeeld over twee werkwoorden, wat een score van 1 oplevert.
AL voegwoord - werkwoord bijzin	Ik ging naar huis **omdat** ik moe **geworden was**. Hij zei **dat** zijn moeder gek **was**. Ik ga naar huis **om** dat te **doen.** Het gaat om alle werkwoorden, dus zowel persoonsvormen als werkwoordelijke complementen.
AL voegwoord - hoofden van de bijbehorende conjuncten	Ik heb hem twee **boeken** gegeven **en** drie hele kleine **plantjes**. Ik **gaf** hem een boek **en** hij **was** niet eens blij. N.B. De aard van het ‘hoofd’ hangt af van de aard van de door het voegwoord verbonden conjuncten. Het gemiddelde van de conjuncten wordt genomen. Bovendien worden alle voegwoorden in de zin meegenomen. Dit is soms verwarrend, omdat een zin als ‘Het **was** echt een super chill hostel **en** er **was** een super chille **woonkamer en dakterras**’ twee voegwoorden (tweemaal ‘en’) met elk twee conjuncten bevat. Er worden

	dan vier afstanden gemiddeld (5-1-0-0), wat een waarde van 1.5 oplevert.

Note: Pander Maat, H., Kraf, R., & Dekker, N. (2021), p. 39-40

Appendix B

Dataset Overview

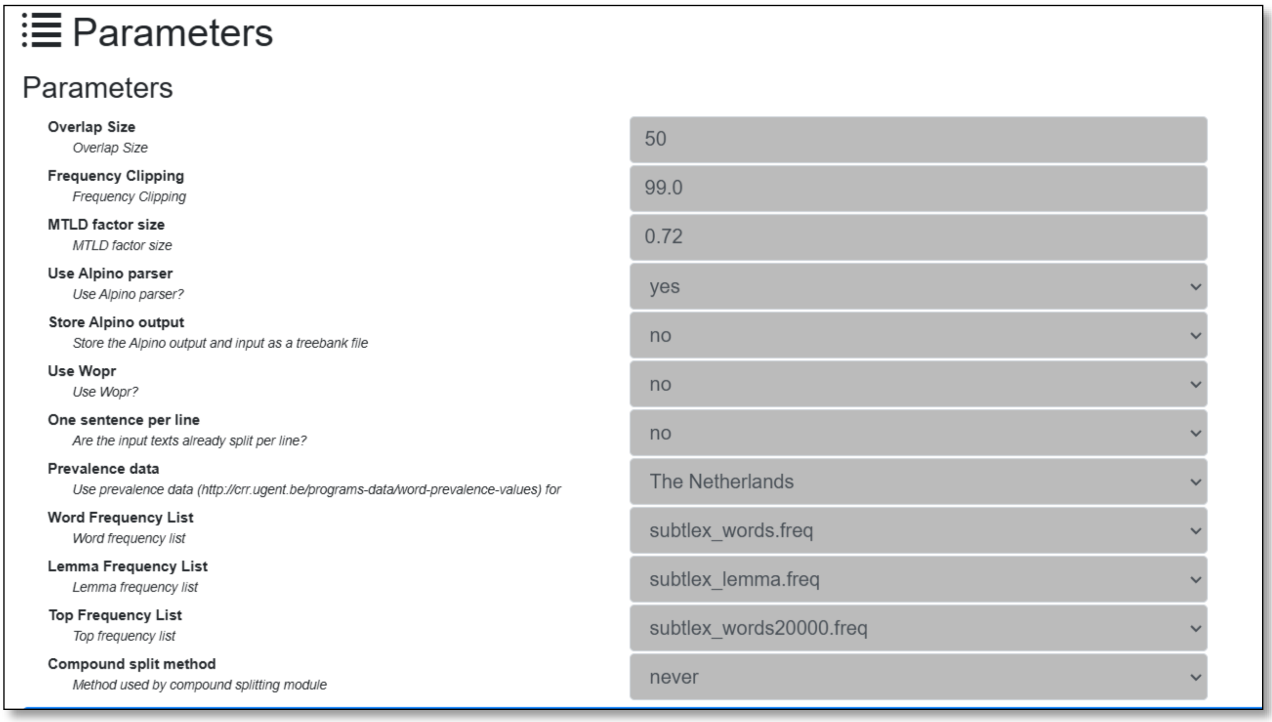
1	Input	year_published	series	publisher	author	level	class	Source	Chapter	Fragment_titel
2	1965NKcorpusBB	1965	Natuurkunde op corpusculaire grondslag	Malmberg	dr. J. Schweers, drs. P. van Vianen	VHMO	BB	Onderwijs museum Dordrecht	Dynamica en krachtenleer	Eerste fundamentele wet: traagheidswet
3	1969RepNKBB	1969	Repetitieboek natuurkunde	Wolters-Noordhoff	drs. L.H. Kammerer, dr.J.H. Raat	H/V	BB	Onderwijs museum Dordrecht	Groep 1- algemene begrippen	Traagheid der materie; massa
4	1970NKcorpusH3	1970	Natuurkunde op corpusculaire grondslag	Malmberg	dr. J. Schweers, drs. P. van Vianen	H	3	Onderwijs museum Dordrecht	Mechanica, Bewegingen en krachten	Traagheidswet
5	1971NKHV4	1971	Natuurkunde B1	Agon Elsevier	drs. F. Jägers	H/V	4	Onderwijs museum Dordrecht	Kracht en beweging	Wet van de traagheid
6	1973NKdoenH3	1973	Natuurkunde...Doen!	Uitgeversmij J.H. Kok Kampen	J.Jardine, vertaling: drs.D. van Genderen, A. Polman	H	BB	UT	Newton 1- Defintie van een kracht	Newton
7	1974NKcorpusH3	1974	Natuurkunde op corpusculaire grondslag	Malmberg	dr. J. Schweers, drs. P van Vianen	H	3	Onderwijs museum Dordrecht	Mechanica, Bewegingen en krachten	Traagheidswet
8	1974SystNKHBB	1974	Systematische Natuurkunde	Van Walraven bv	drs. J.W. Middelink	H	BB	Onderwijs museum Dordrecht	De leer van de krachten	De eerste wet van Newton of de wet van de traagheid
9	1975SystsNKHVBB	1975	Systematische Natuurkunde	Van Walraven bv	drs.J.W. Middelink	H/V	BB	Onderwijs museum Dordrecht	Krachten	De eerste wet van Newton of de wet van de traagheid
10	1977elementairMHV2	1977	Elementaire natuurkunde	van Walraven bv	ir. F.J. Engelhard	M/H/V	2	UT	Kracht	Dynamische en statische werking
11	1979NKBHV2	1979	Het natuurkundeboek	Wolters-Noordhoff	J.R. Bette, drs. W.H. van den Dool, E.Elbertsen, S.T. Klaij, drs. J.P.Paulides, L.L.A. Popma, W.J. Verrijp, W.C. Vink	H/V	2	UT	Bewegingen	Verrijkingsstof
12	1979NKHVBB	1979	Natuurkunde B1	Educaboek, Tjeenk Willink/Noorduijn b.v.	dr. A. Botzen, dr. F.W. Nijhoff, dr. C.P. Koene, dr. J.G.E.M. Backus	H/V	BB	UT	Uitbreiding van de bewegingsleer	Dynamica: de wetten van Newton
13	1980NKcorpusH3	1980	Natuurkunde op corpusculaire grondslag	Malmberg	dr. J. Schweers, drs. P van Vianen	H	3	UT	Kinematica of bewegingsleer 1, 1e wet van Newton	1e wet van Newton; de traagheidswet
14	1983exactMHV3	1983	Exact Natuurkunde	Meulenhoff Educatief Amsterdam	W.E. Bijker, J. Kortland, J.van der Rijst, A.J. de Wever	M/H/V	3	UT	Kracht en vervoer	Beweging (vanaf Newtonse model)
15	1983GewoonNK	1983	Gewoon...Natuurkunde 3	Malmberg	Keith Johnson, Jos Loonen, Ad Oomens, Jan Vink	H/V	BB	Onderwijs museum Dordrecht	Snelheid en versnelling	De eerste wet van Newton
16	1989FysicaHV4	1989	Fysica	Malmberg	drs. J. Masschelein, drs. P Cox, drs. J. Moors, drs. W. van den Munckhof	H/V	4	UT	Kracht en beweging	De bewegingswetten van Newton

1	Input	year_published	series	publisher	author	level	class	Source	Chapter	Fragment_titel
17	1990NKnuHV4	1990	Natuurkunde voor nu en strak	Thieme	ir.R. Langras, drs. A.J.F.Koopmans, m.m.v: M. Huizer, R. de Jonge, F.H. Peters	H/V	4	UT	Krachten	Traagheid
18	1990ThuisHV2	1990	Thuis in Natuurkunde	Van Walraven bv	ir. F.J. Engelhard	H/V	2	UT	Kracht	Twee wetten van Newton
19	1991EurekaHV3	1991	Eureka	Malmberg	Th. Smits, R. Tromp	H/V	3	Onderwijs museum Dordrecht	Kracht en beweging	Tegenwerkende krachten
20	1991SystNKNKH4	1991	Systematische Natuurkunde	Van Walraven bv	drs. J. W. Middelink	H	4	UT	Krachten	Eerste wet van Newton (wet van de traagheid)
21	1998ScoopHBB	1998	Scoop	Wolters-Noordhoff	Hubert Biezeveld, Louis Mathot	H	BB	UT	Kracht	Twee wetten van Newton
22	1998SystNKH12	1998	Systematische Natuurkunde	Nijgh Versluys	drs. J.W. Middelink, ir. F.J. Engelhard, J.G. Brunt, drs. R.W. de Jong, drs. J.H. Moors, drs. H.A.M. Ottink	H	BB	UT	Kracht en moment	Eerste wet van newton
23	1999NewtonHBB	1999	Newton	Thieme	Koos Kortland, Huib van Bergen, Rob Langras, Peter Over, Paul Verhagen, Jan Wijbenga	H	BB	UT	Verkeersveiligheid-kracht en beweging	Nettokracht
24	2002NKoveralH1	2002	Natuurkunde overal	EPN	P.G. Hogenbirk, J.D. Jager, Th.J.A.Timmers, J. Gravesteijn, K.W. Walstra	H	BB	UT	Snelheid en kracht	Beweging en de resulterende kracht
1	Input	year_published	series	publisher	author	level	class	Source	Chapter	Fragment_titel
25	2003NewtonH21	2003	Newton	ThiemeMeulenhoff	Koos Kortland, Huib van Bergen, Rob Langras, Peter Over, Paul Verhagen, Jan Wijbenga	H	BB	UT	Krachten in de sport	Krachtenevenwicht
26	2005NovaHV3	2005	Nova	Malmberg	Th. Smits, H. Geurts, R. Tromp	H/V	3	Onderwijs museum Dordrecht	Bewegen	Kracht en beweging
27	2006PulsarHB	2006	Pulsar	Wolters-Noordhoff	Leo te Brinke, Ton van den broek, Sjef Buil, Yo van Dijk, Jan van Heugten, Gerben de Jong, Peter Koopmans, Rob Ouwerkerk, Jos Verbeek	H	BB	UT	Kracht en beweging	Traagheid
28	2006SystNKH4	2006	Systematische Natuurkunde	Nijgh Versluys	drs. Ir. Geert van Eekelen, drs. Rene de Jong, dr. Ir. Koert van der Lingen, dr. Ir. Evert-Jan Nijhof, drs. Harrie Ottink, ir. Frans Tiemeijer, drs. Jacqueline Wooning	H	4	UT	Krachten	De eerste wet van Newton
1	Input	year_published	series	publisher	author	level	class	Source	Chapter	Fragment_titel
29	2012NewtonH4	2012	Newton	ThiemeMeulenhoff	Mark Dirken, Jan Flokstra, Aart Groenewold, Kees Hooyman, Koos Kortland, Pieter Lukey, Peter Over, Pier Siersma	H	4	UT	Sport en verkeer; Versnellen en vertragen	De 1e en 2e wet van Newton
30	2012Nova H4	2012	Nova	Malmberg	Fons Alkemade, Rick Cremers, Peter van Hoeflaken, Bart-Jan van Lierop, Emile Verstraelen	H	4	UT	Krachten	De eerste wet van Newton
31	2012overalNKH4	2012	Overal Natuurkunde	Noordhoff	Robert Bouwens, Paul Doorschot, Geert van Eekelen, Andre van der Hoeven, Marten van der Lee, Joost van Reisen, Annemieke Vennix	H	4	UT	Kracht en beweging	Kracht en beweging
32	2012SystNKH4	2012	Systematische Natuurkunde	ThiemeMeulenhoff	drs. Bart van Dalen, drs. Johan van Dongen, drs. Rene de Jong, dr.ir. Koert van der Lingen, dr.ir. Evert-Jan Nijhof, Hein Vink	H	4	UT	Krachtwetten	De eerste wet van Newton

	Input	year_published	series	publisher	author	level	class	Source	Chapter	Fragment_titel
33	2013overalNKH3	2013	Overal Natuurkunde	Nordhoff	Hans Poorthuis, Paul Diederen, Ed van Steenbergen, Paul Verhagen	H	3	Grundel	Bewegen in het verkeer	Remmen
34	2015NovaH3	2015	Nova	Malmberg	L. Lenders, F. Molin, R. Tromp, Medewerking: Th. Smits	H	3	Onderwijs museum Dordrecht	Kracht en beweging	Voortstuwen en tegenwerken
35	2016NovaH3	2016	Nova	Malmberg	L. Lenders, F.Molin, R. Tromp	H	3	Grundel	Kracht en beweging	Kracht, massa en versnelling
36	2018NovaH4	2018	Nova	Malmberg	Rick Cremers, Louis lenders, Francois Molin	H	4	Grundel	Krachten	De eerste wet van Newton
37	2020NovaH3	2020	Nova	Malmberg	L. Lenders, S. Michon, F. Molin, R. Tromp	H	3	Grundel	Kracht en Beweging	Voortstuwen en tegenwerken
38	2021NovaH4	2021	Nova	Malmberg	Rick Cremers, Louis lenders, Francois Molin	H	4	Grundel	Krachten	De eerste wet van Newton
39	2021PolarisH4	2021	Polaris	Boom voortgezet onderwijs	Eikelkamp, Freek Hoogeveen, Peter Koopmans, Maarten Mies, Dirk-Jan van de Poppe, Donald Staal, Arjen Wielemaker	H	3	UT	Kracht en beweging	De eerste wet van Newton
40	2024SystNKH4	2024	Systematische Natuurkunde	ThiemeMeulenhoff	Keurentjes, John van Polen, Mark Bosman, Maarten Duinstee, Torsten van Goolen, Kees Hooyman, Koos Kortland, Michel Philippens, Hein Vink	H	4	Grundel	Krachtwetten	De eerste wet van Newton

Appendix C

T-Scan Settings



Parameters

Parameters

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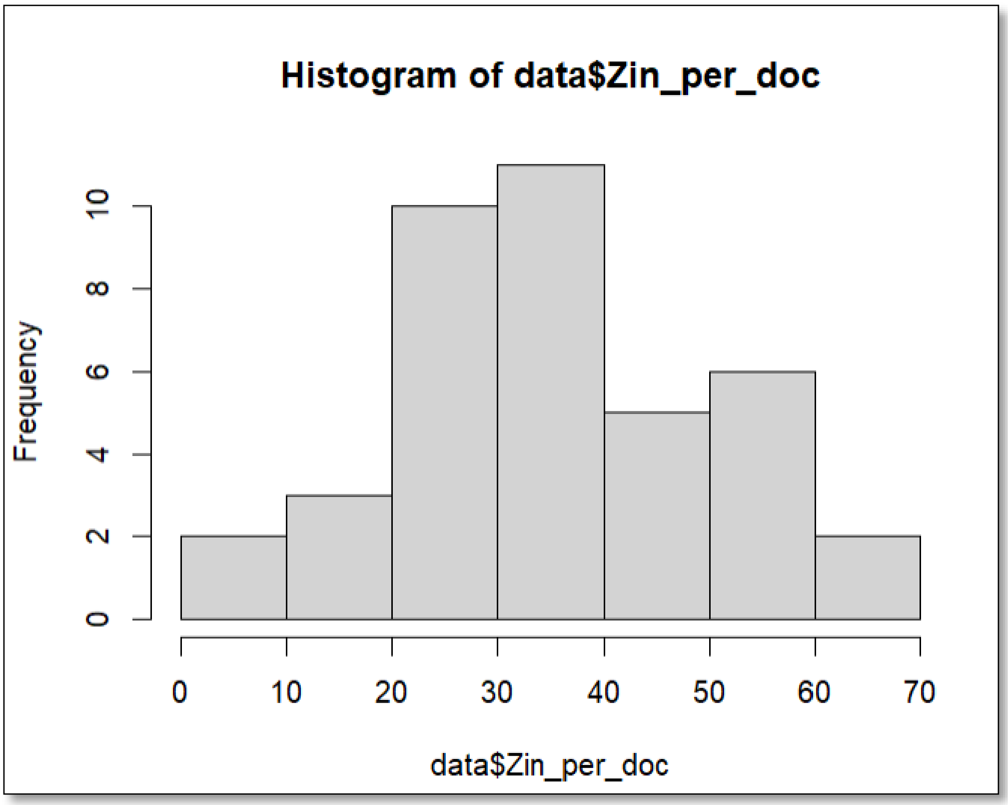
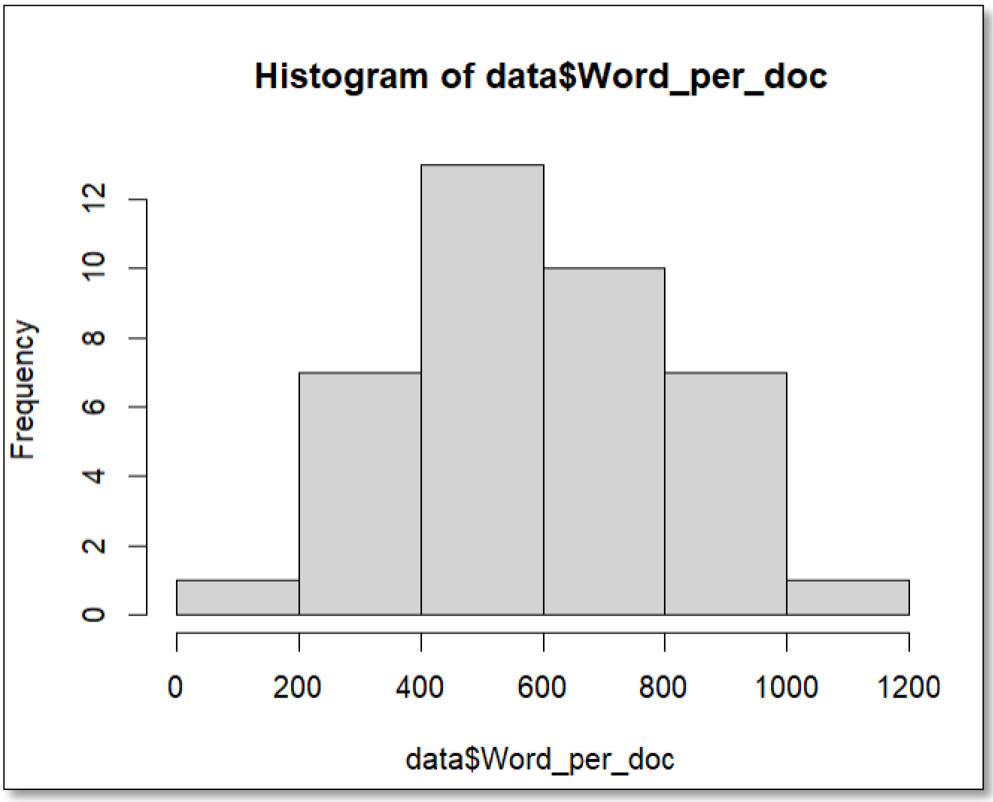
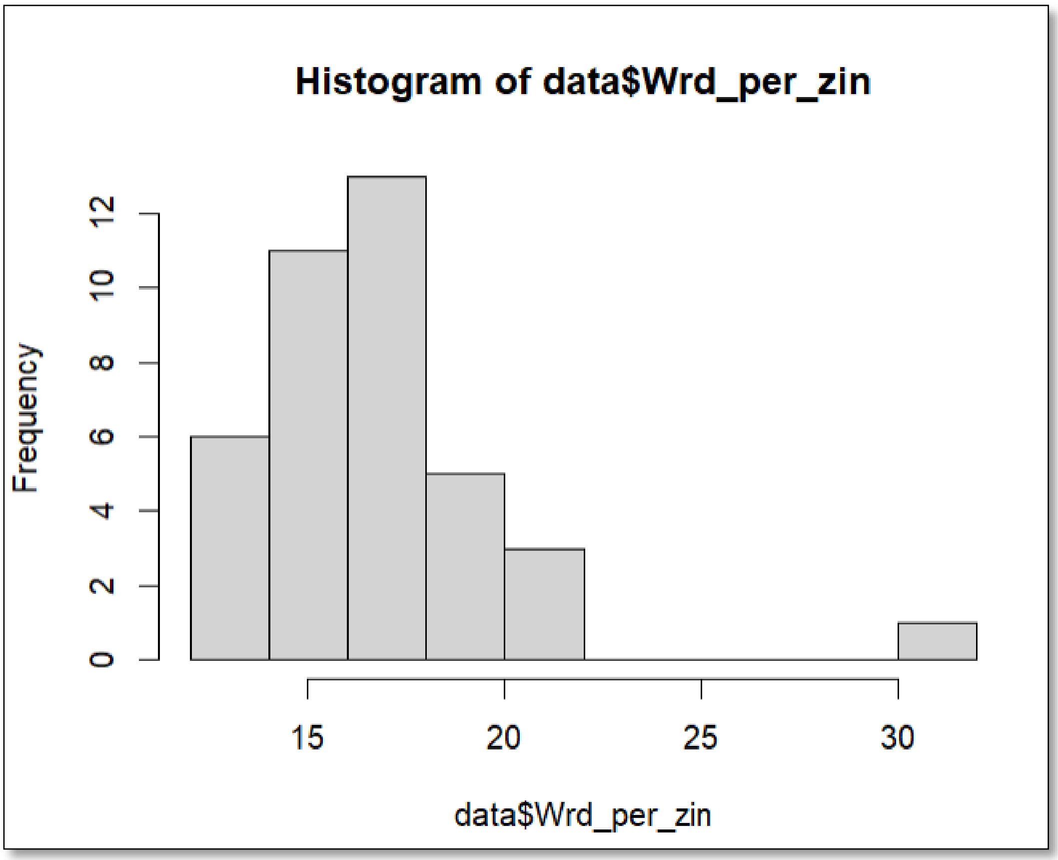
Use Alpino parser *Use Alpino parser?*	yes
Store Alpino output *Store the Alpino output and input as a treebank file*	no
Use Wopr *Use Wopr?*	no
One sentence per line *Are the input texts already split per line?*	no
Prevalence data *Use prevalence data (http://crr.ugent.be/programs-data/word-prevalence-values) for*	The Netherlands
Word Frequency List *Word frequency list*	subtlex_words.freq
Lemma Frequency List *Lemma frequency list*	subtlex_lemma.freq
Top Frequency List *Top frequency list*	subtlex_words20000.freq
Compound split method *Method used by compound splitting module*	never

Appendix D

Data Histograms



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25
30
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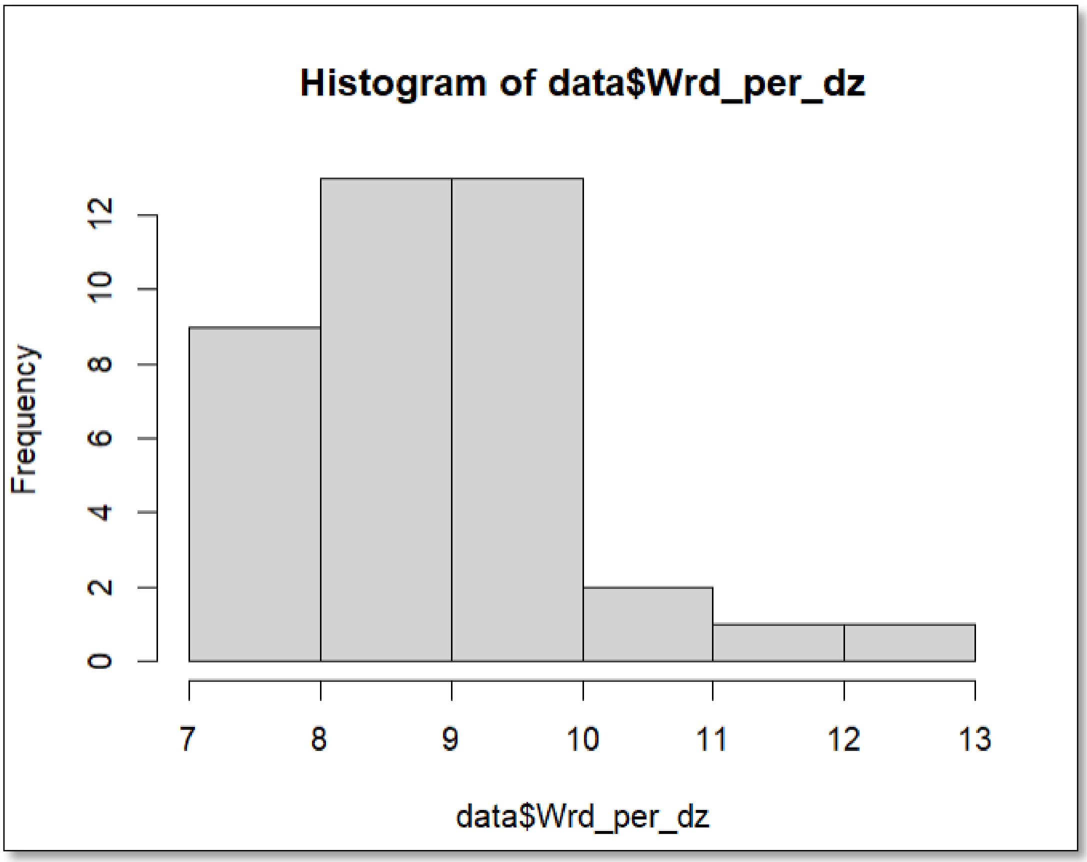
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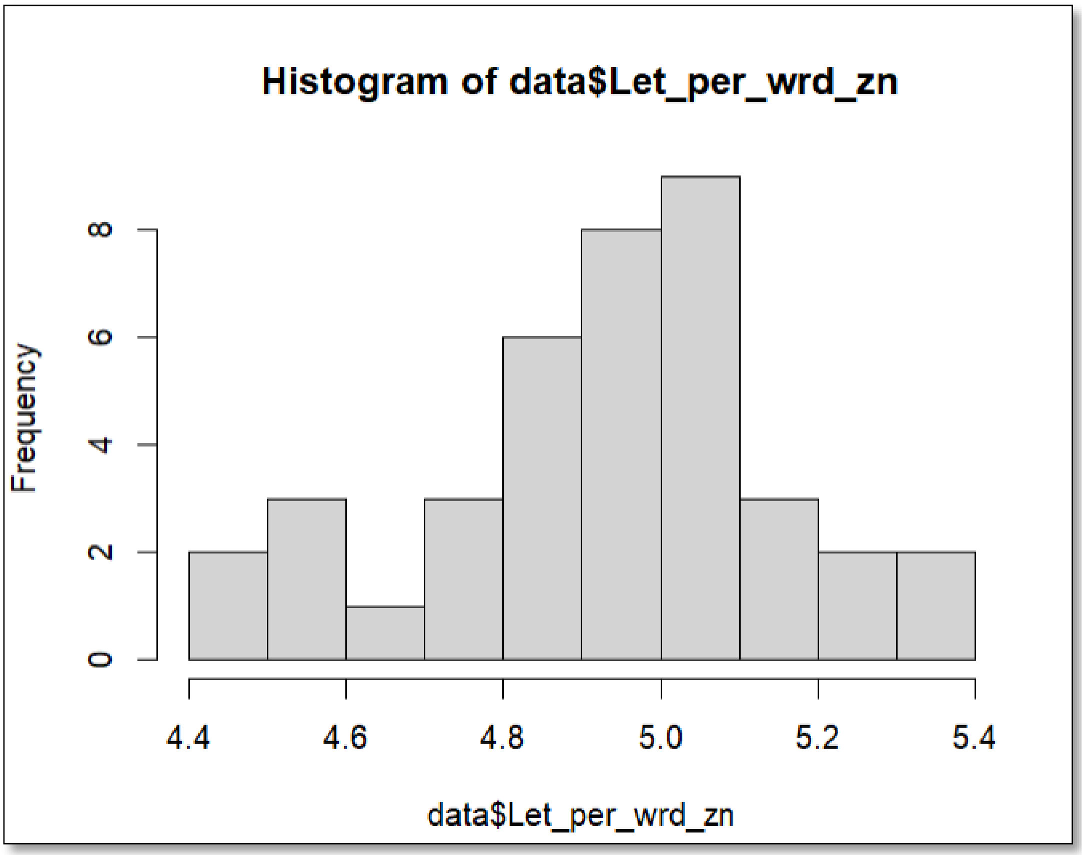
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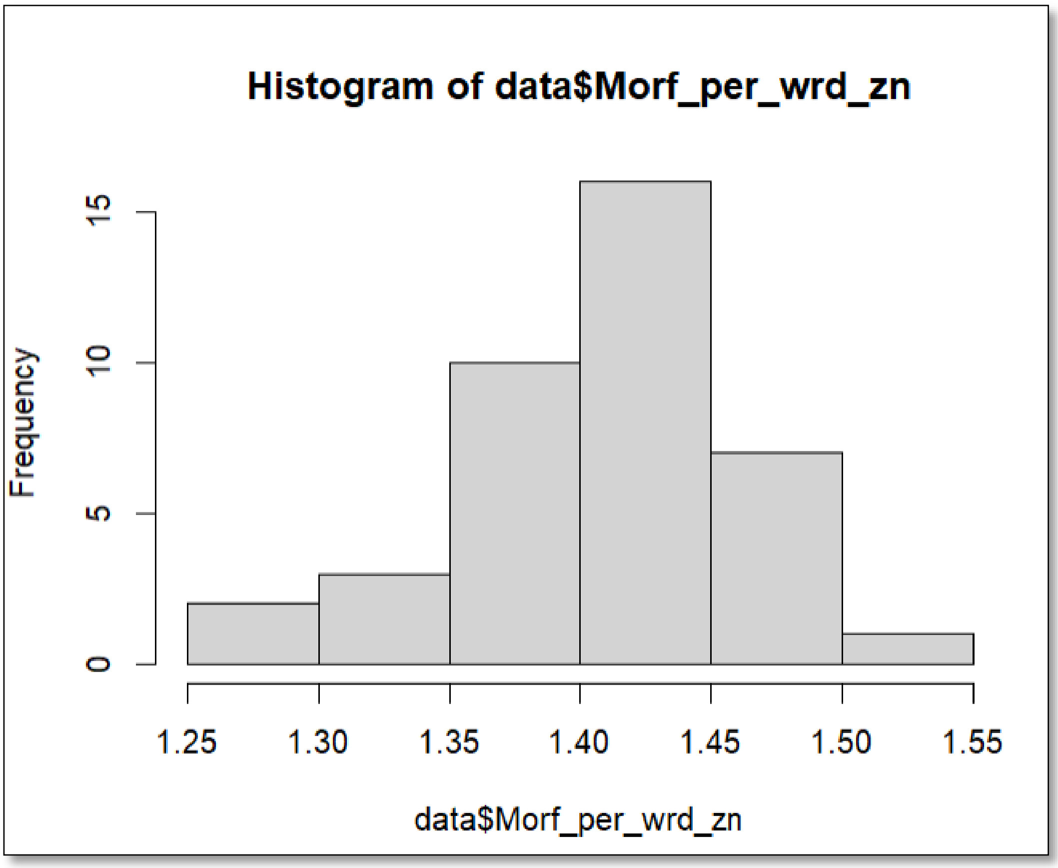
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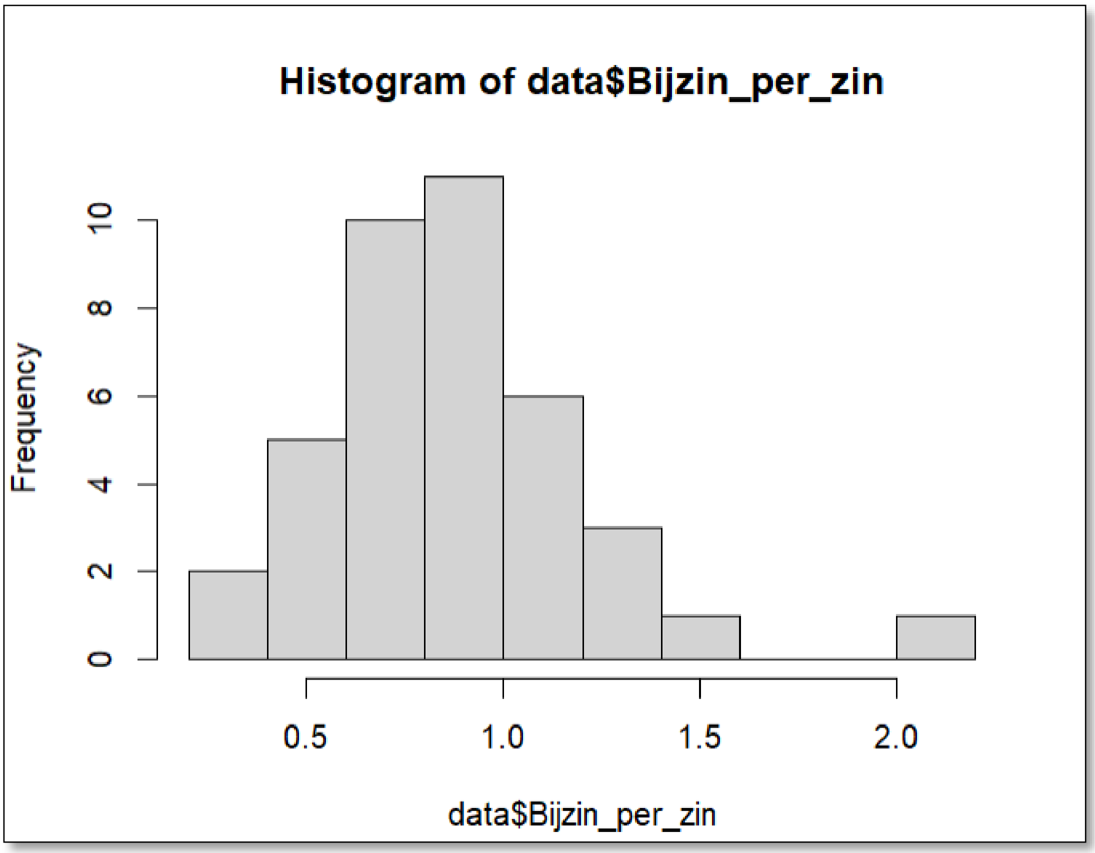
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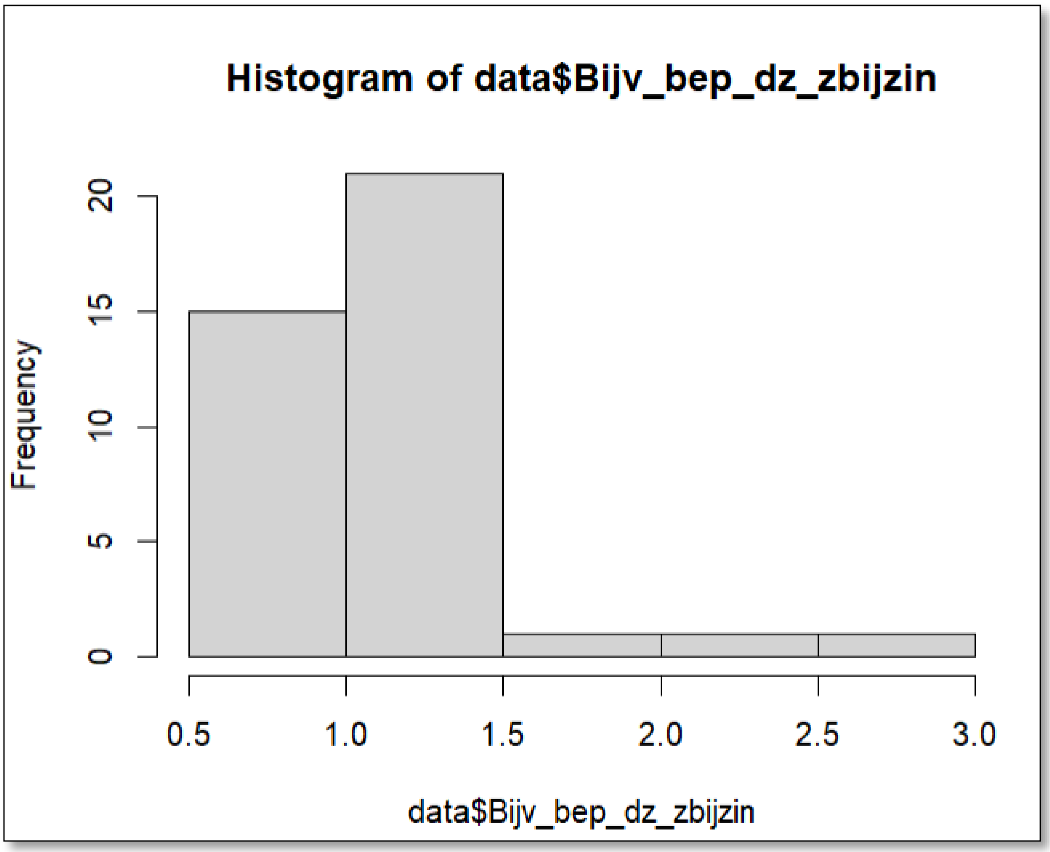
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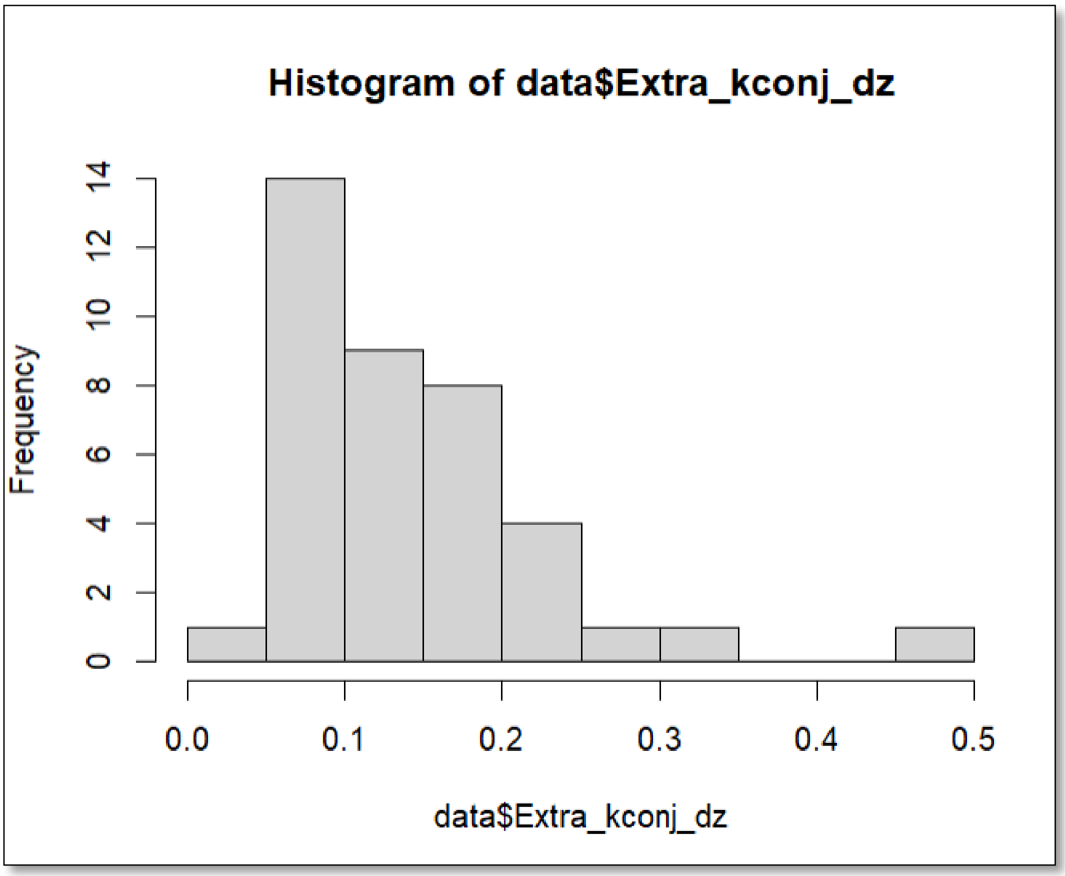
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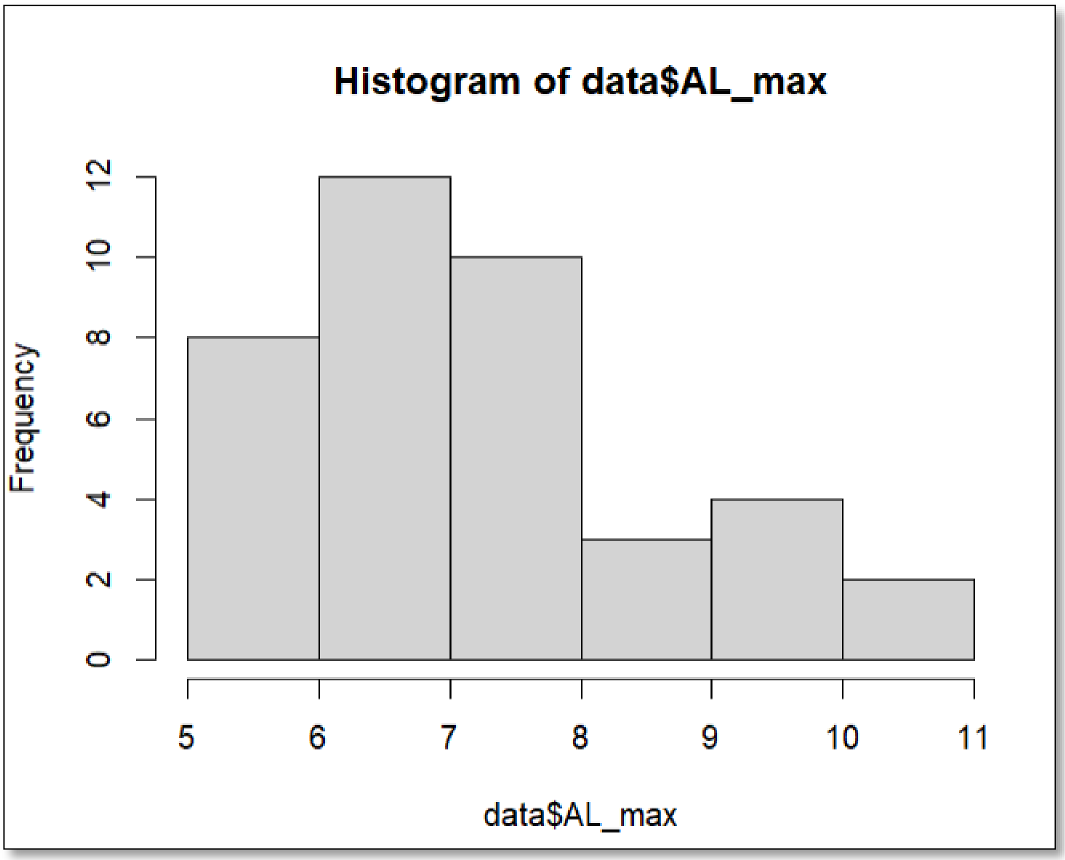
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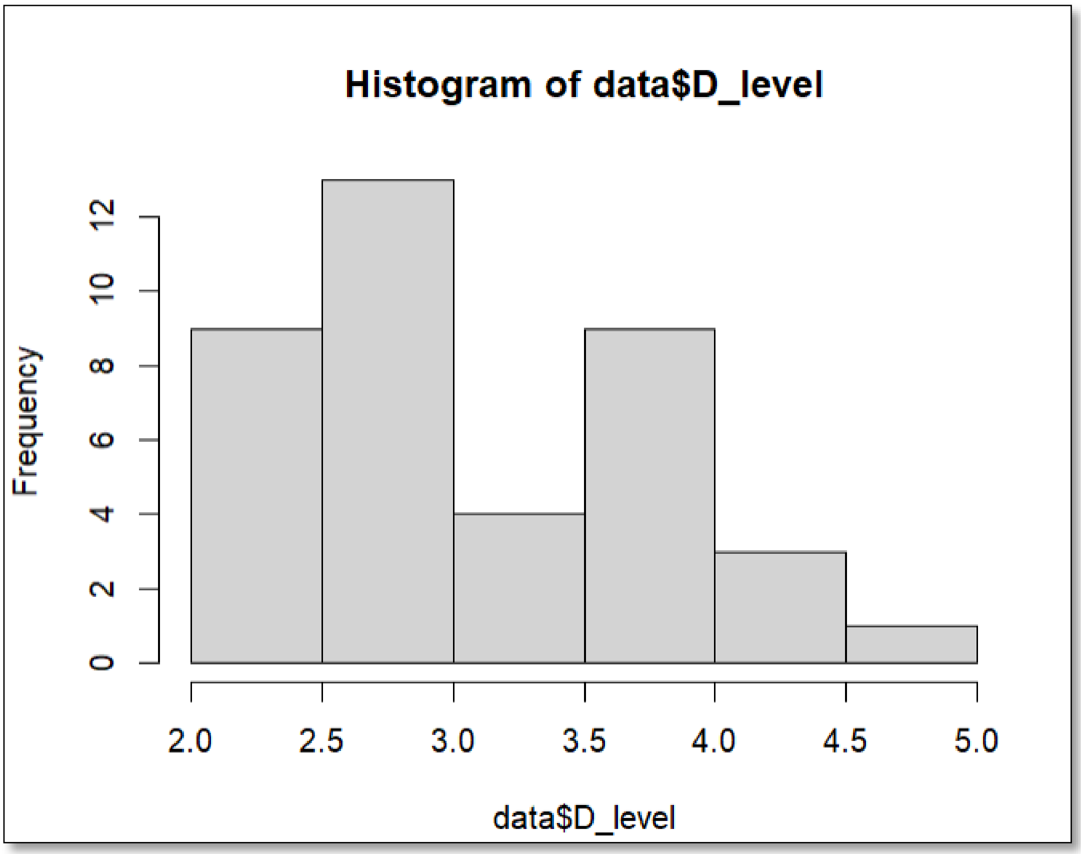
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5.0
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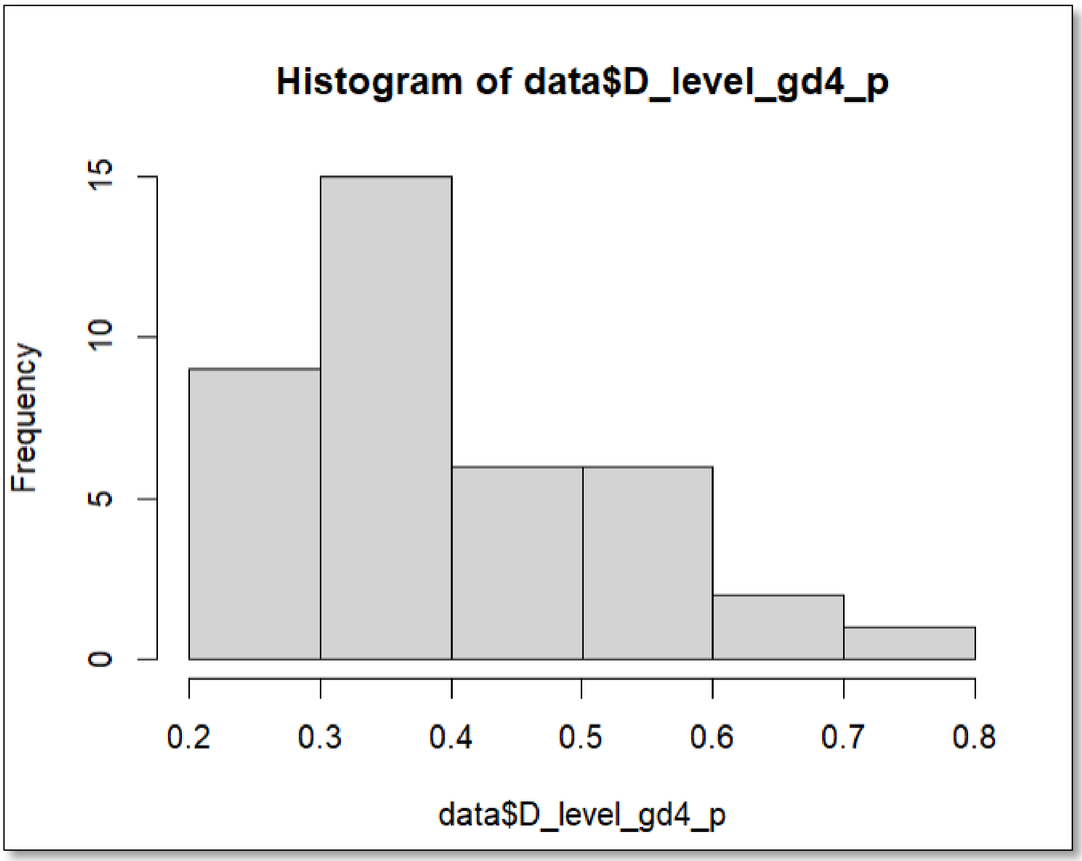
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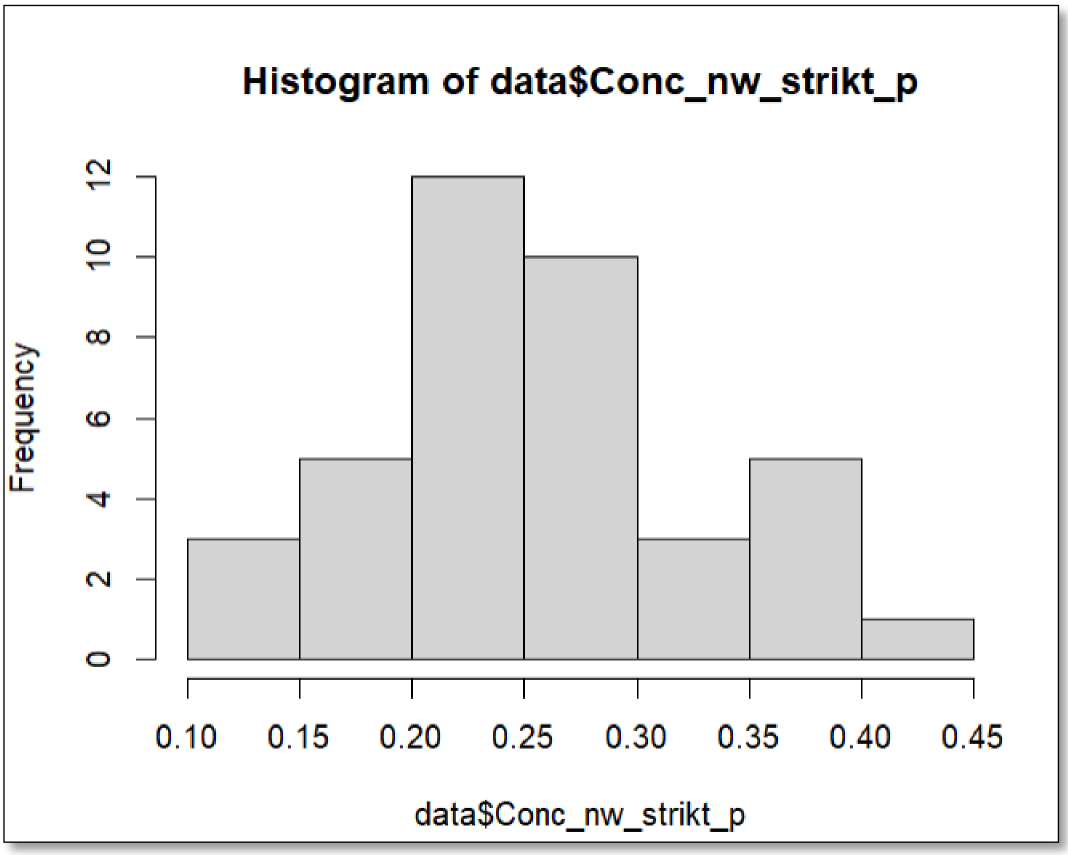
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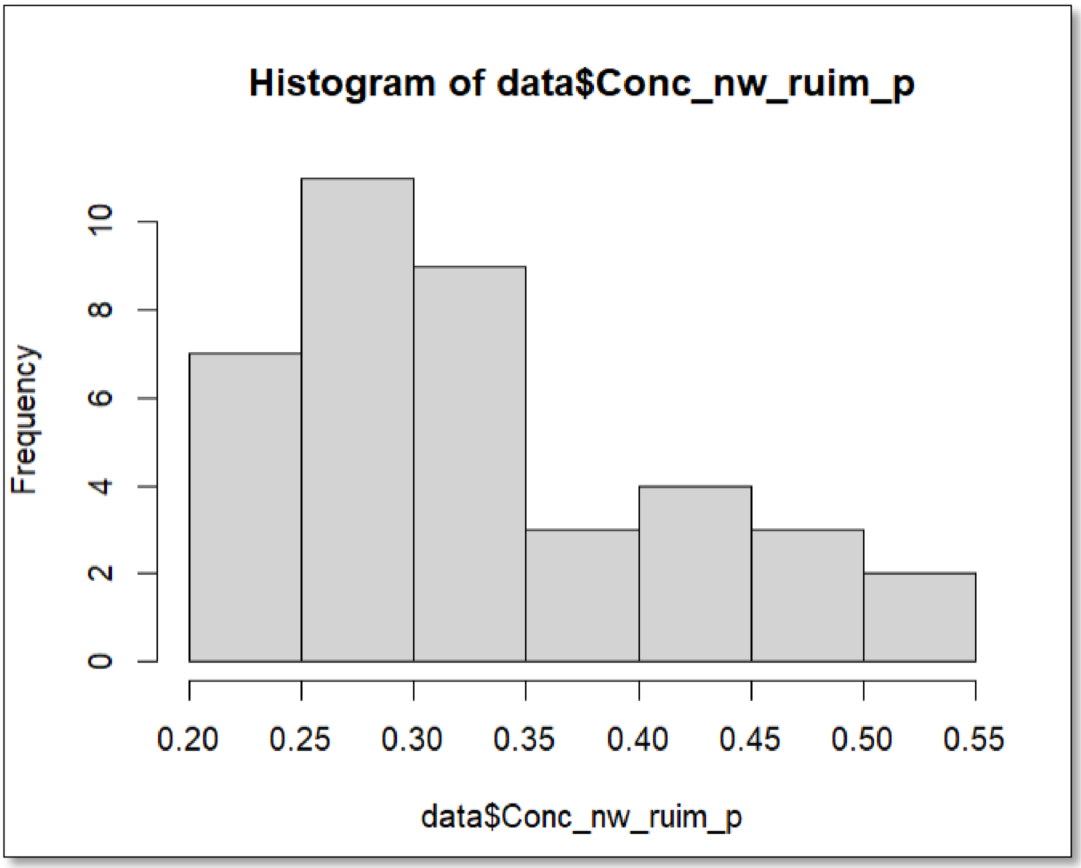
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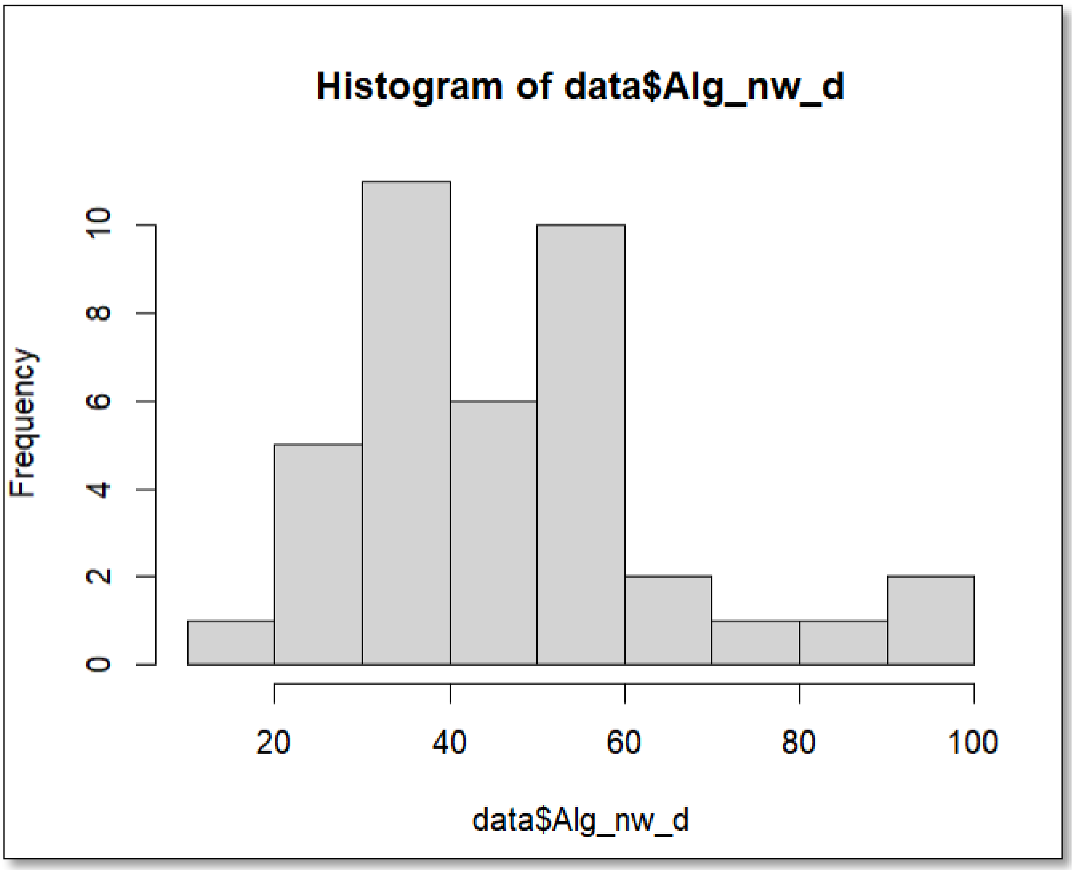
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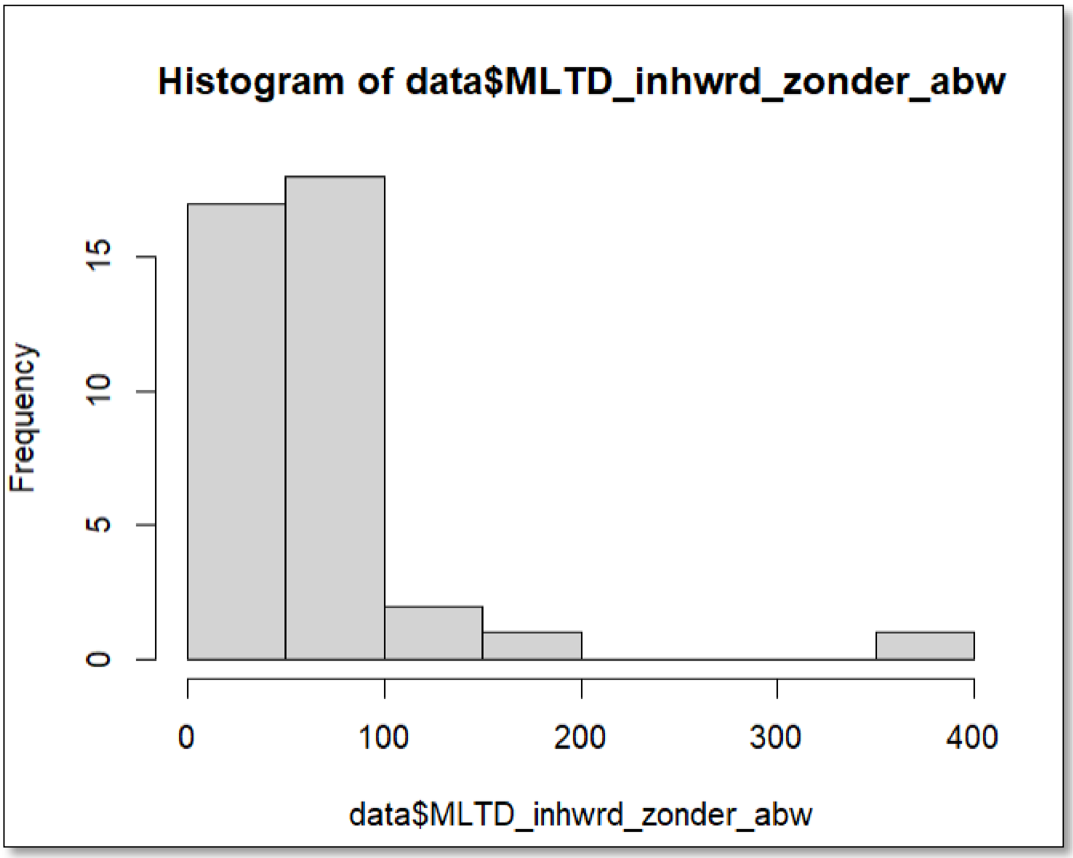
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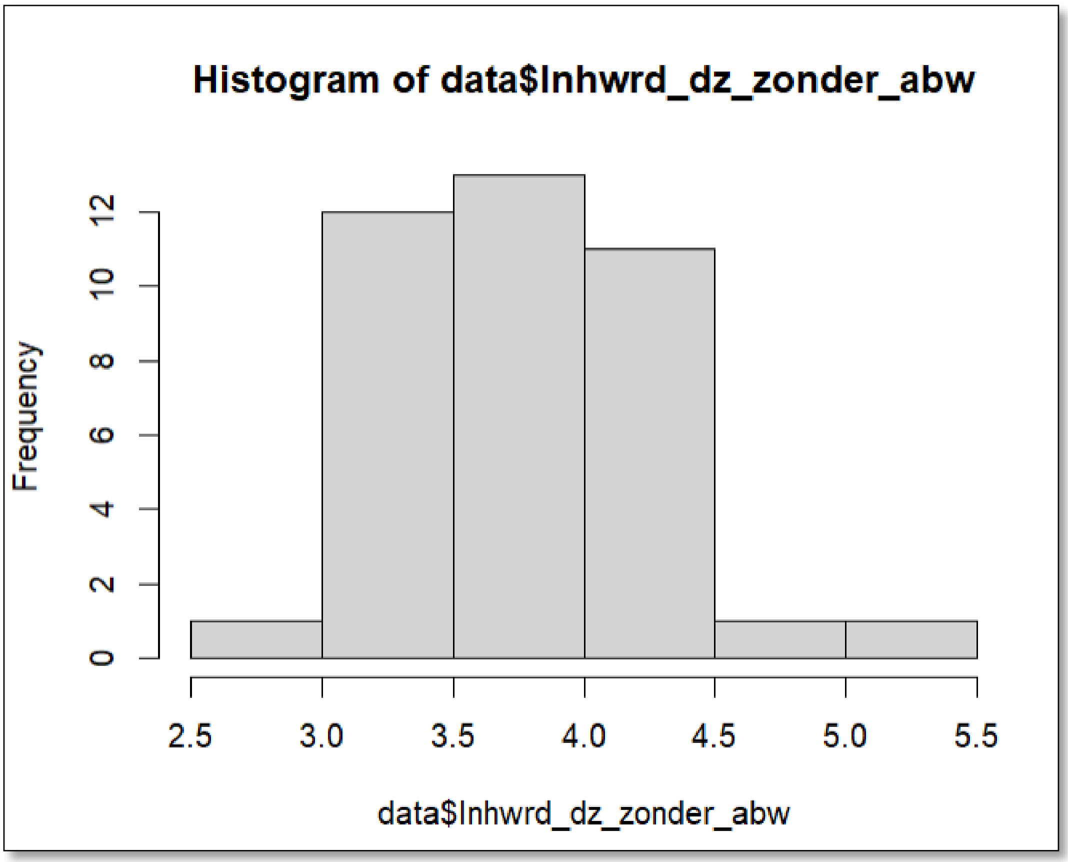
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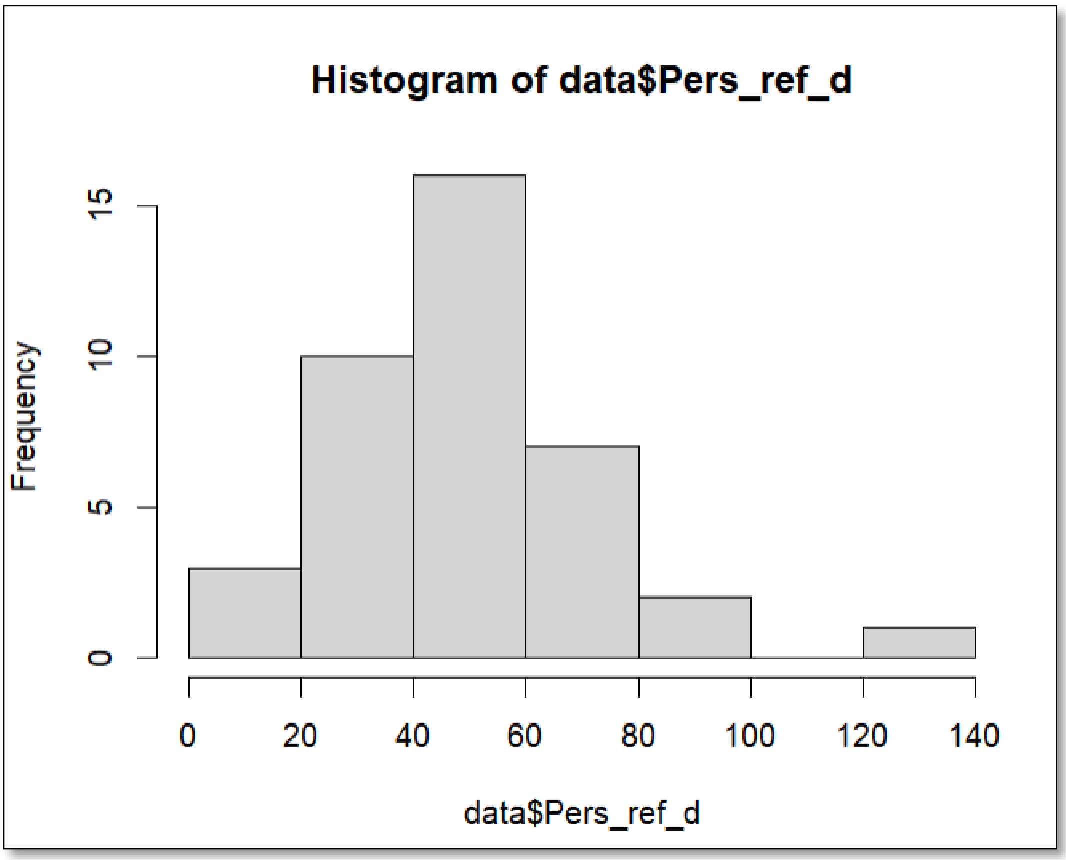
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140
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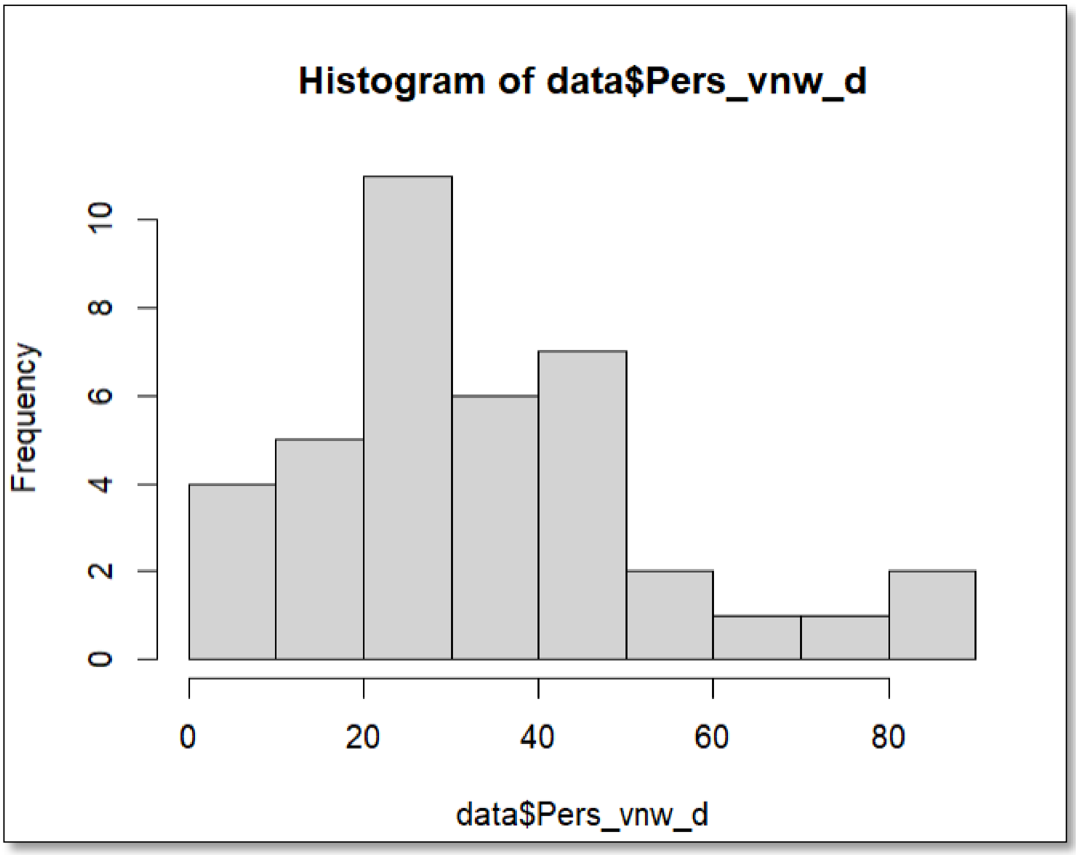
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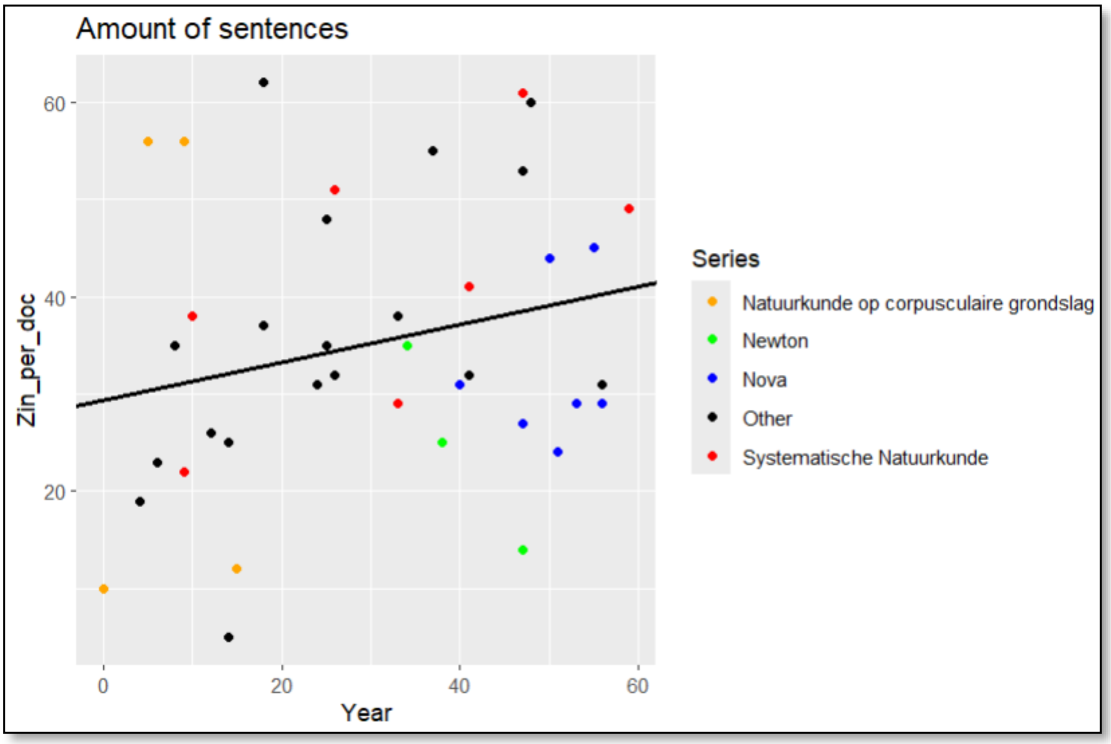
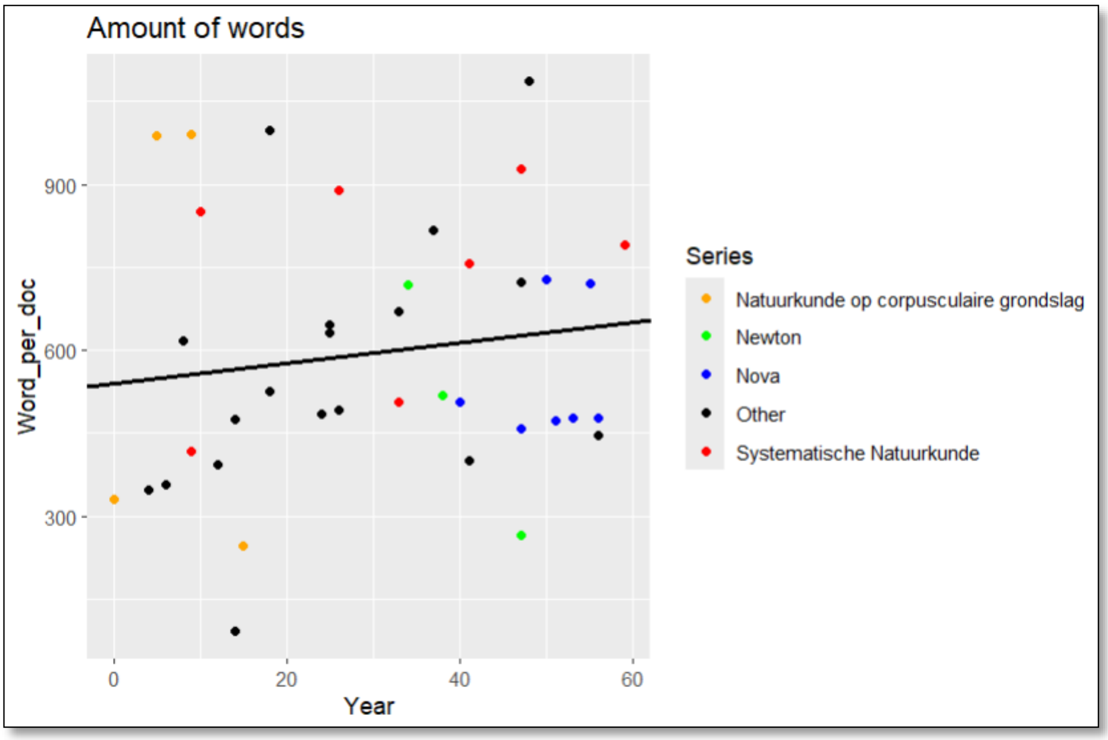
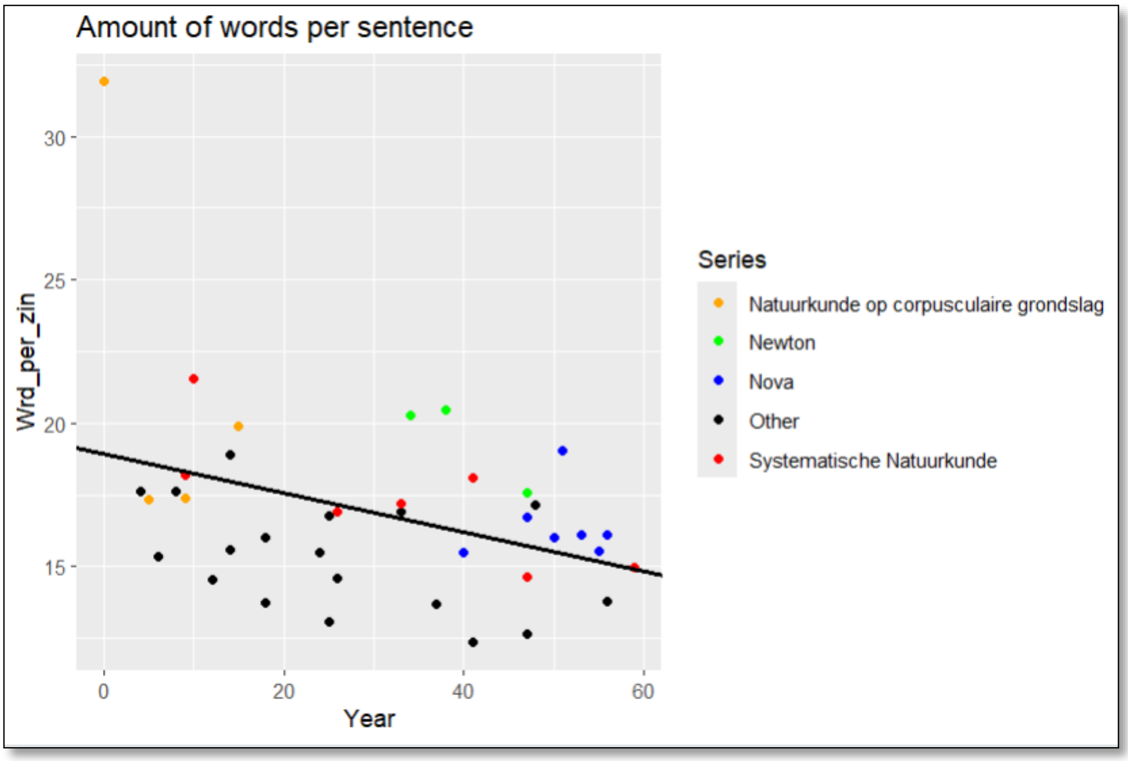
Appendix E

Regression Figures of all 19 Parameters



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60
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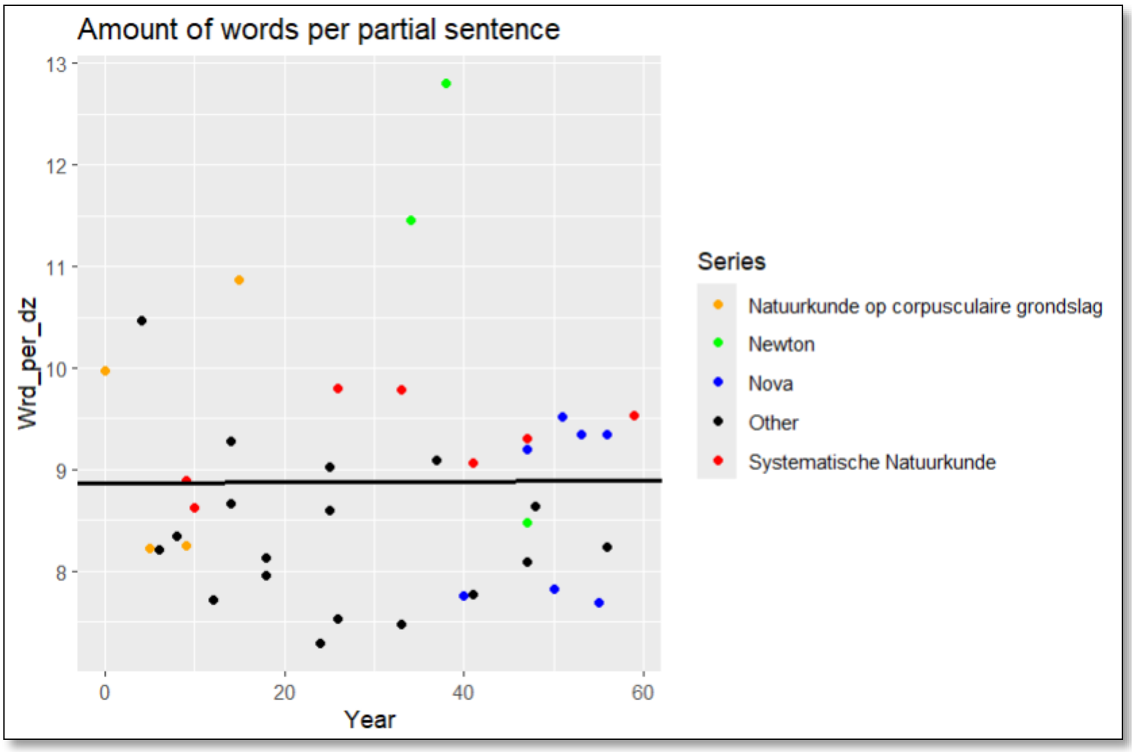
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
Systematische Natuurkunde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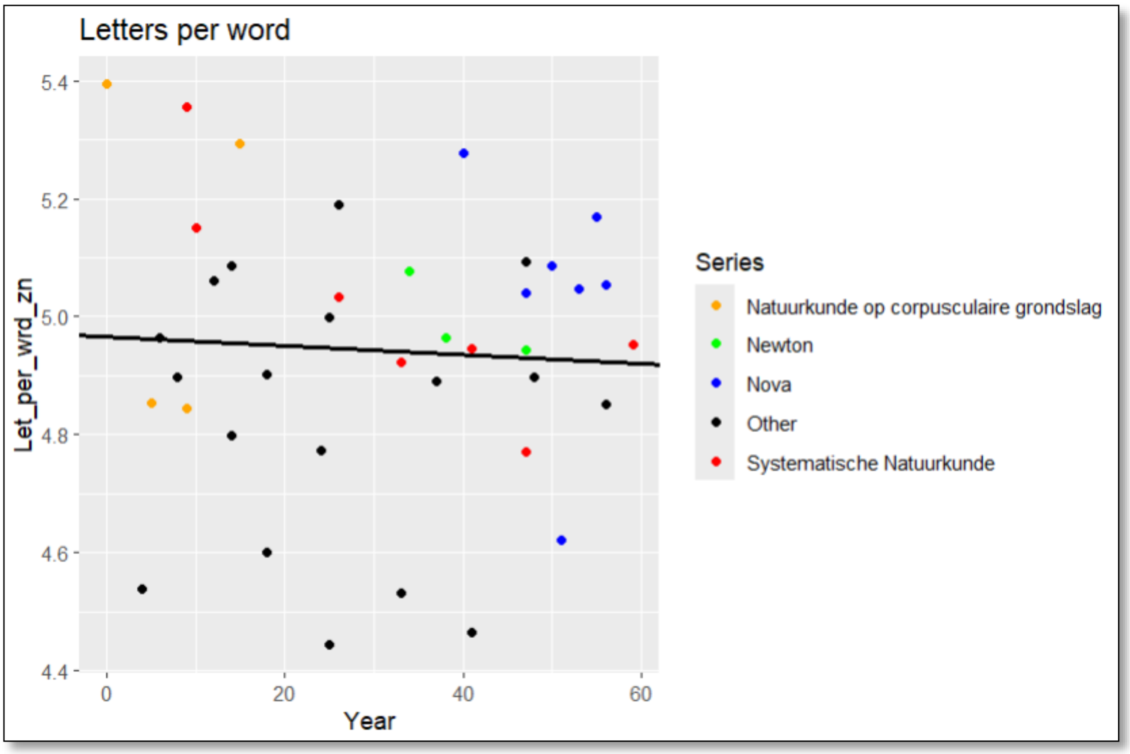
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
Systematische Natuurkunde



Letters per word
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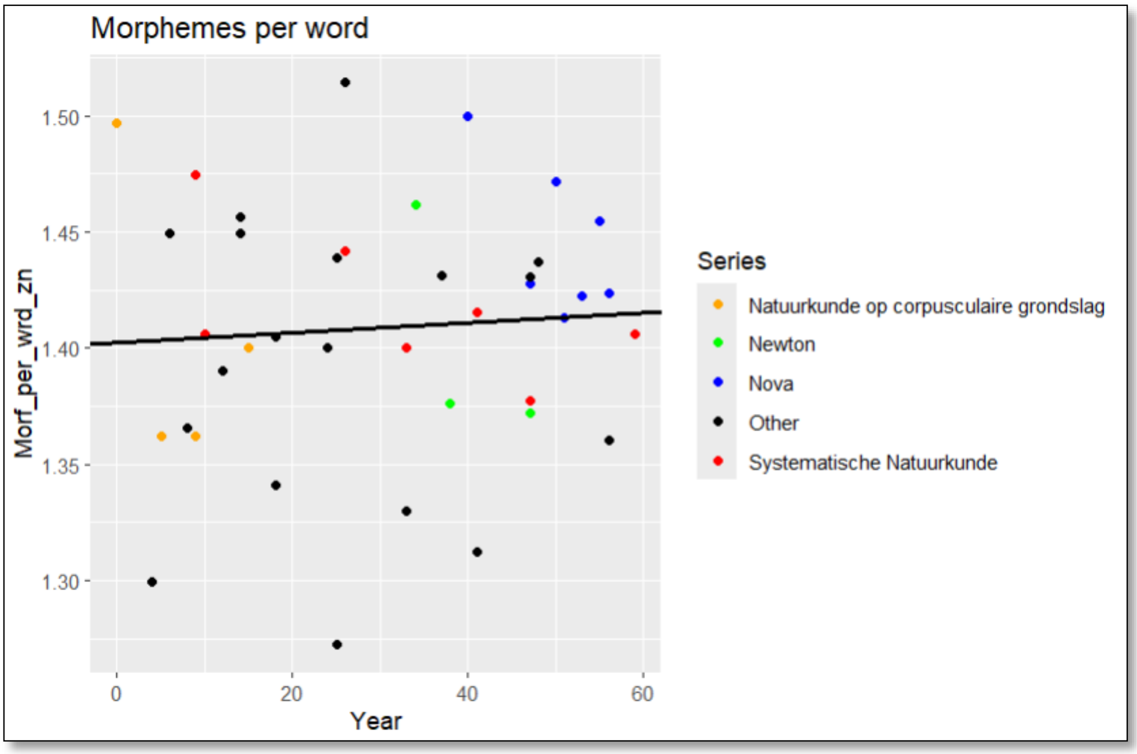
5.0
4.8
4.6
4.4
0
20
40
60
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
Systematische Natuurkunde



Morphemes per word
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1.45
1.40
1.35
1.30
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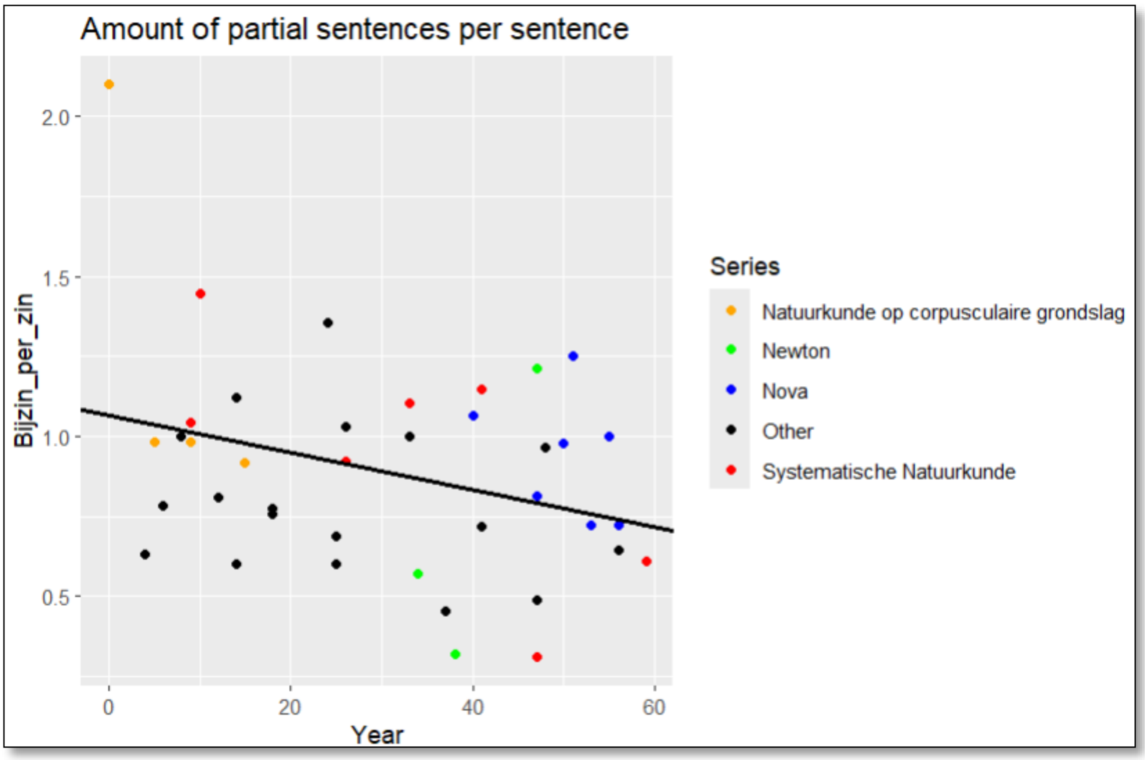
20
40
60
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
Systematische Natuurkunde


Amount of partial sentences per sentence
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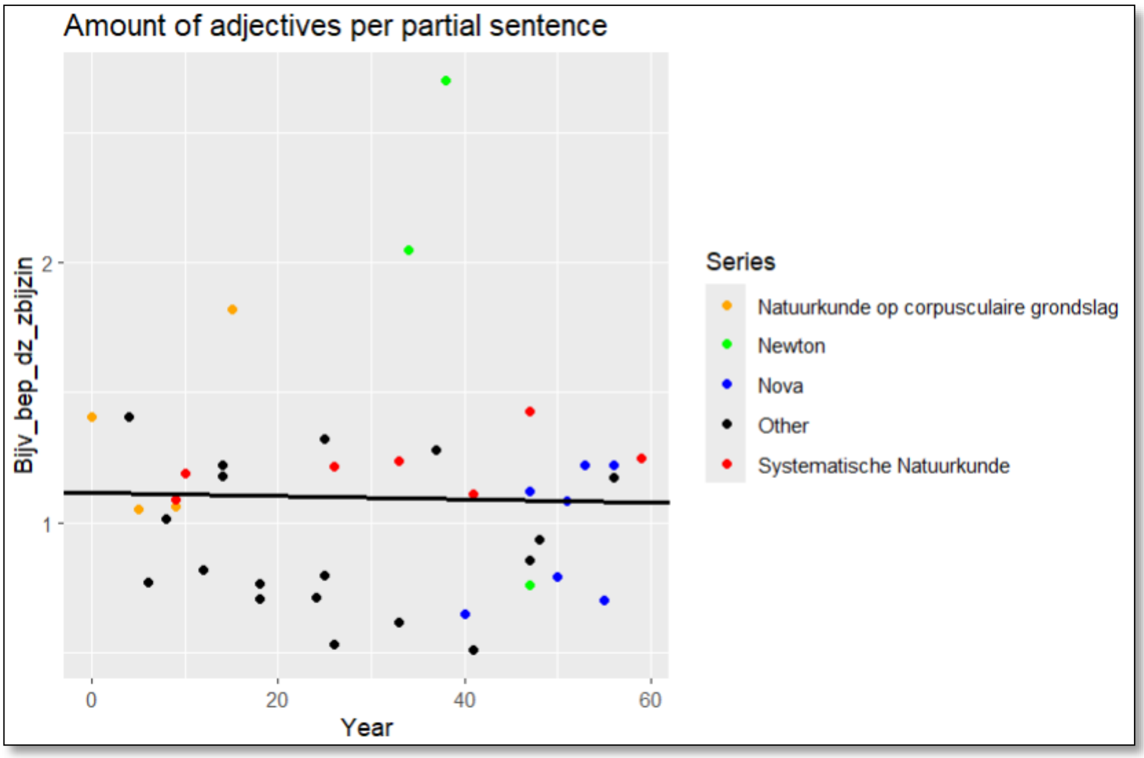
60
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
Systematische Natuurkunde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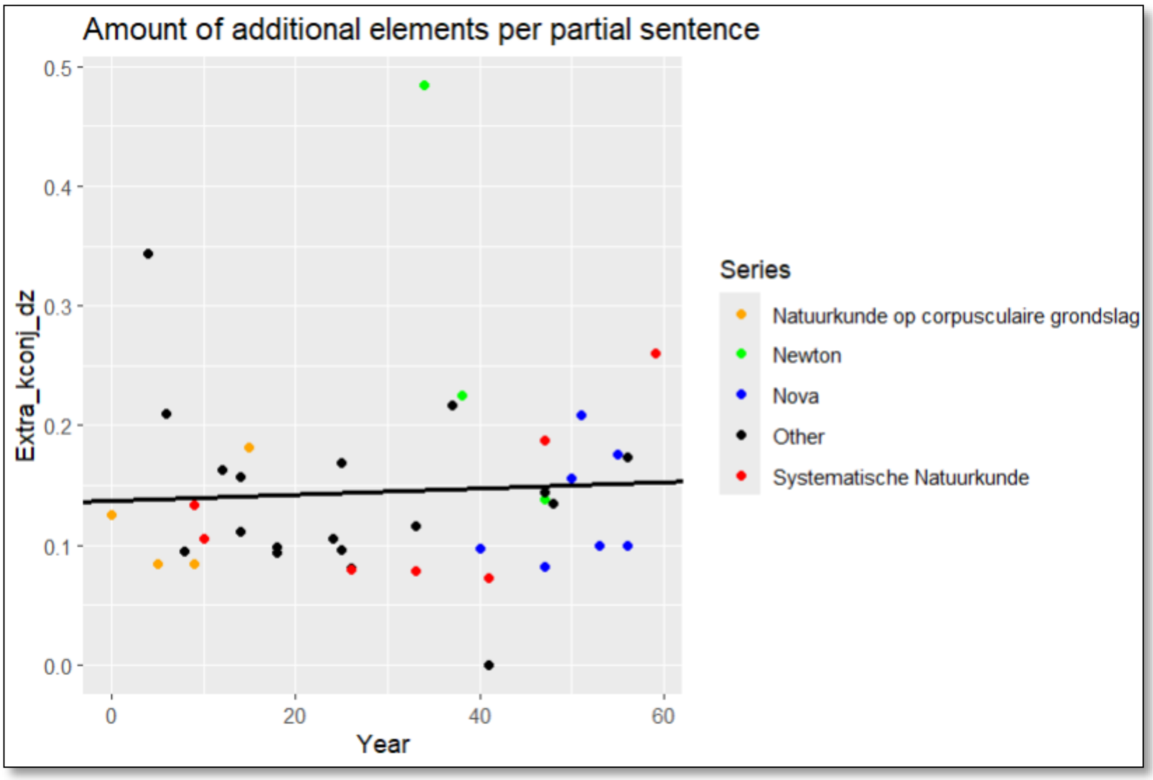
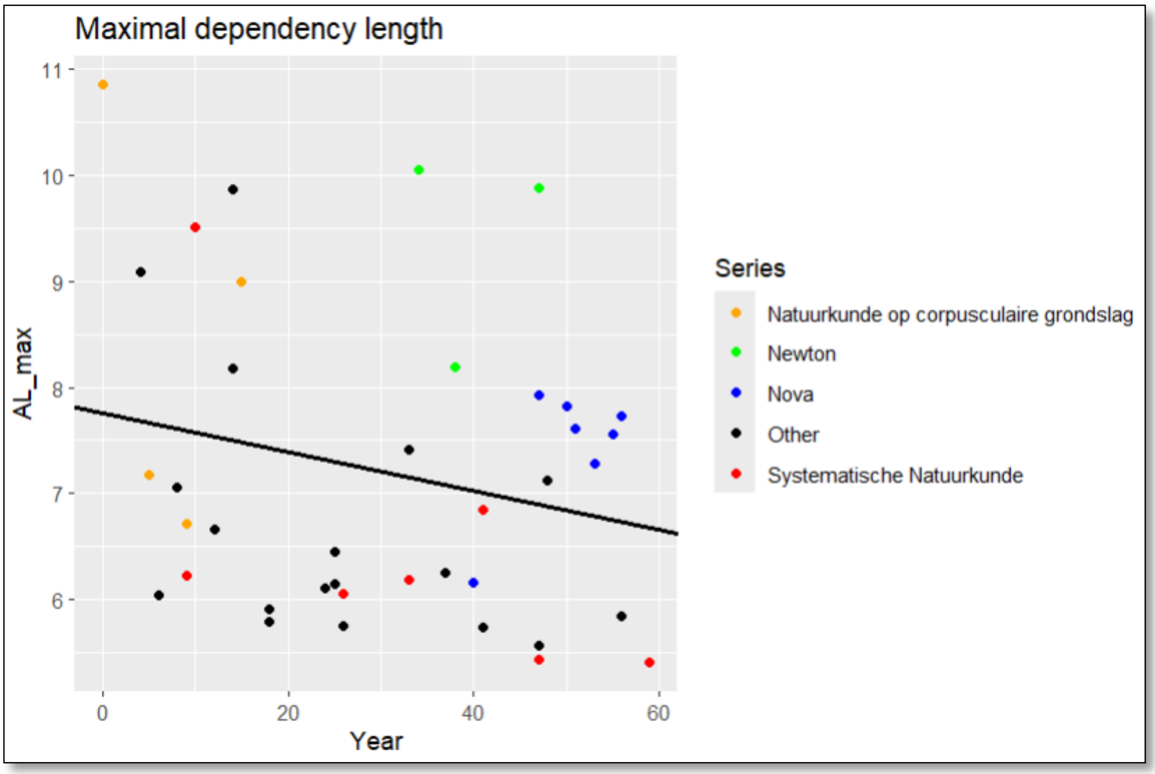
0
20
40
60
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
Systematische Natuurkunde



Amount of additional elements per partial sentence
Extra_kconj_dz
0.5
0.4
0.3
0.2
0.1
0.0
0
20
40
60
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
Systematische Natuurkunde



Maximal dependency length
AL_max
11
10
9
8
7
6
0
20
40
60
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
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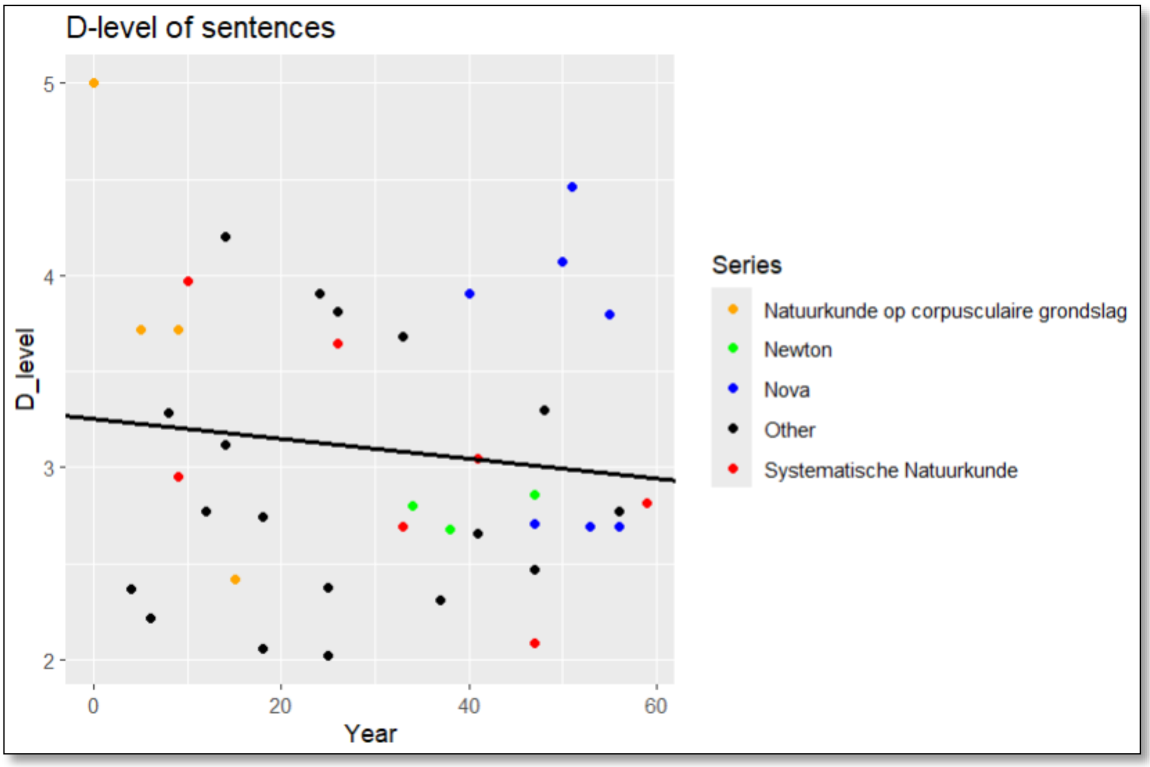
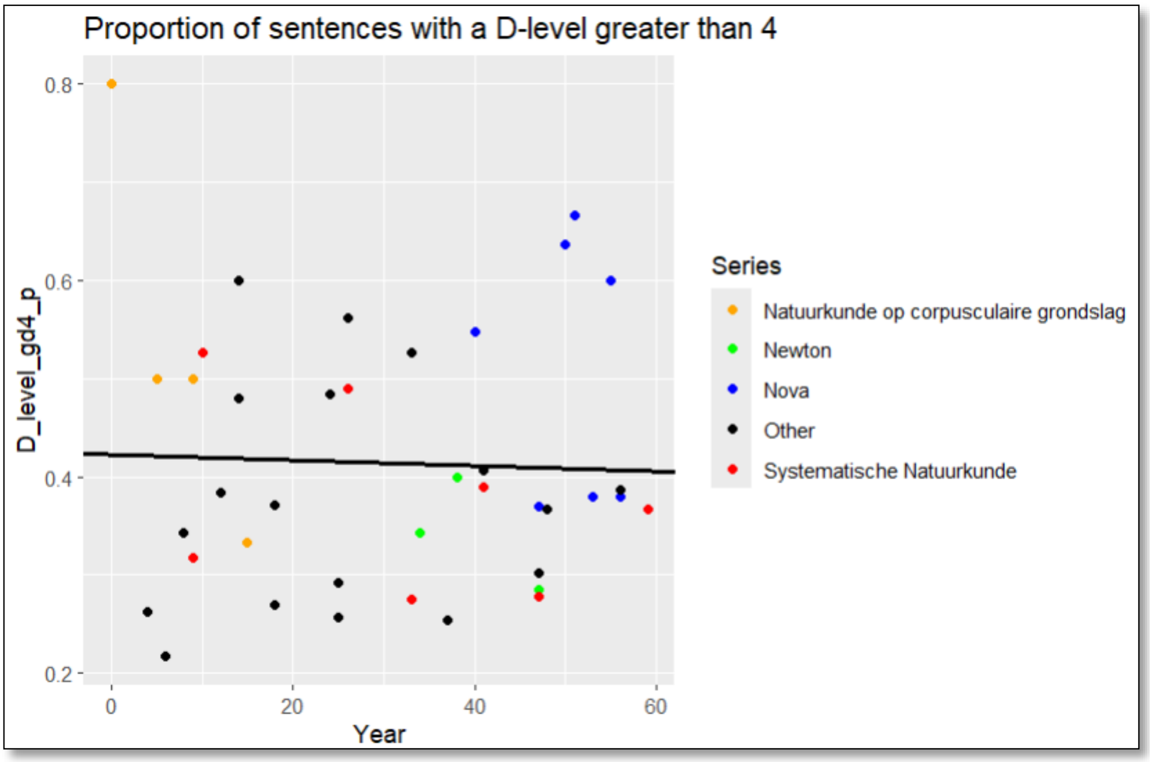
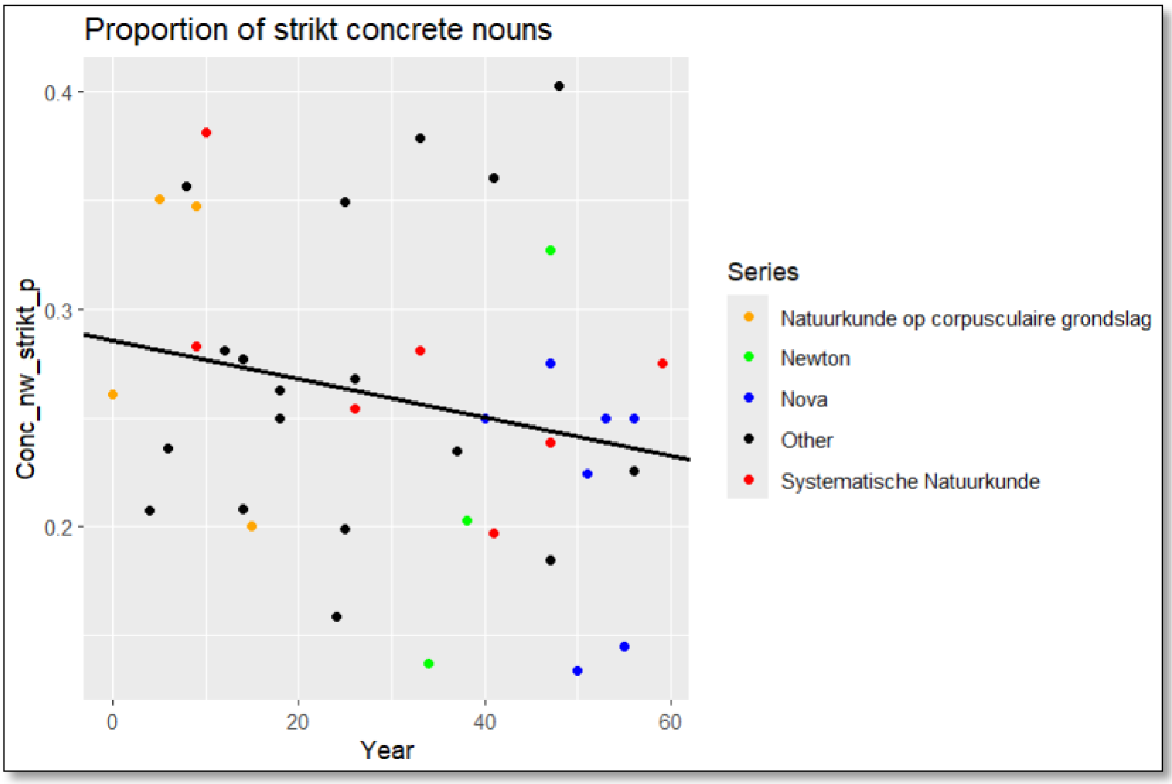
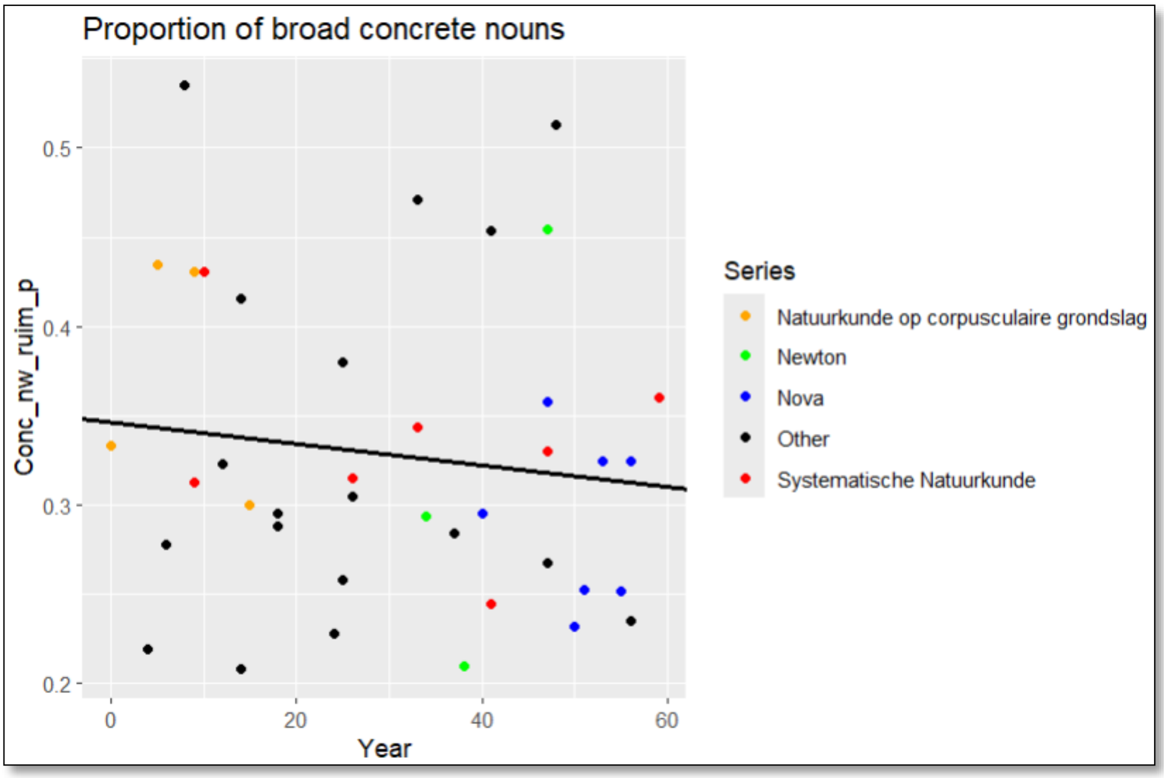
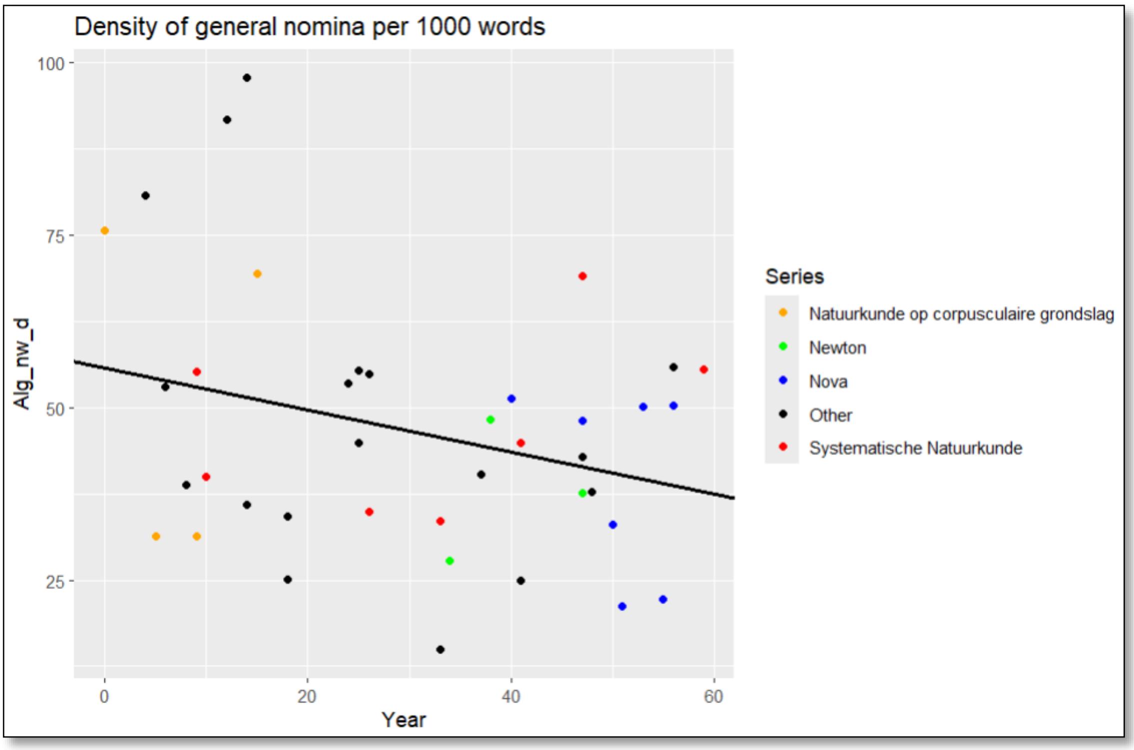
Systematische Natuurkunde

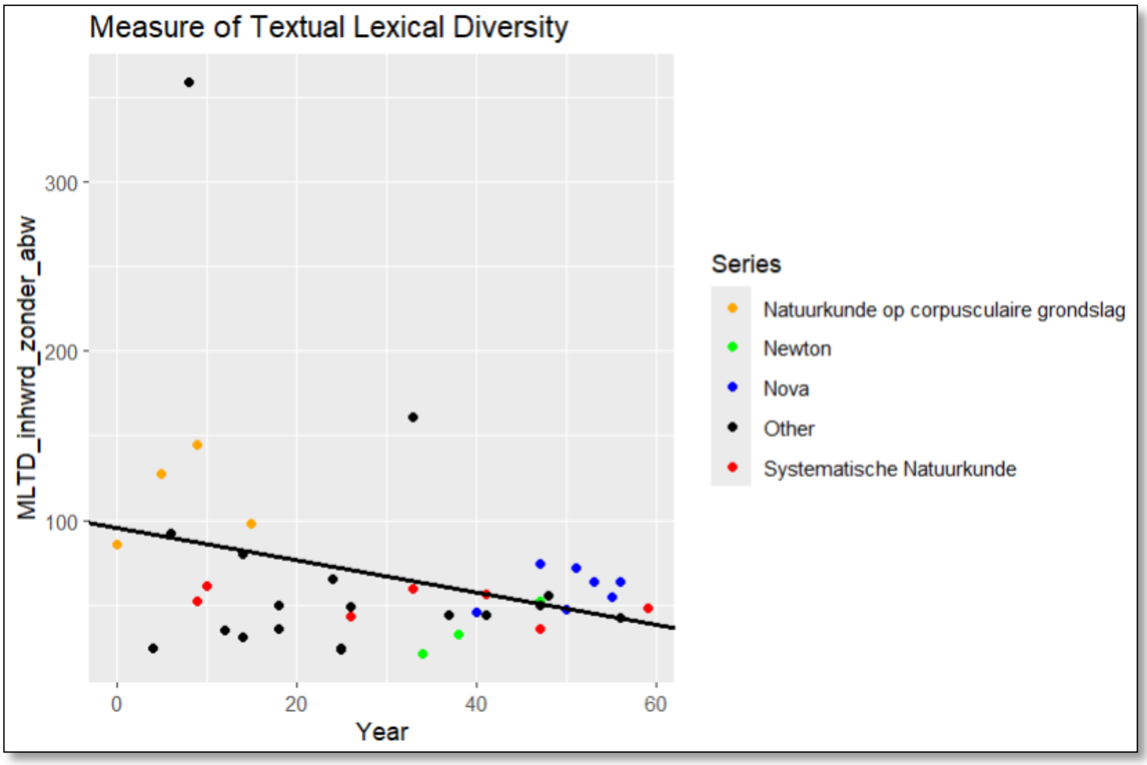

D-level of sentences
5
4
3
2
D_level
0
20
40
60
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
Systematische Natuurkunde

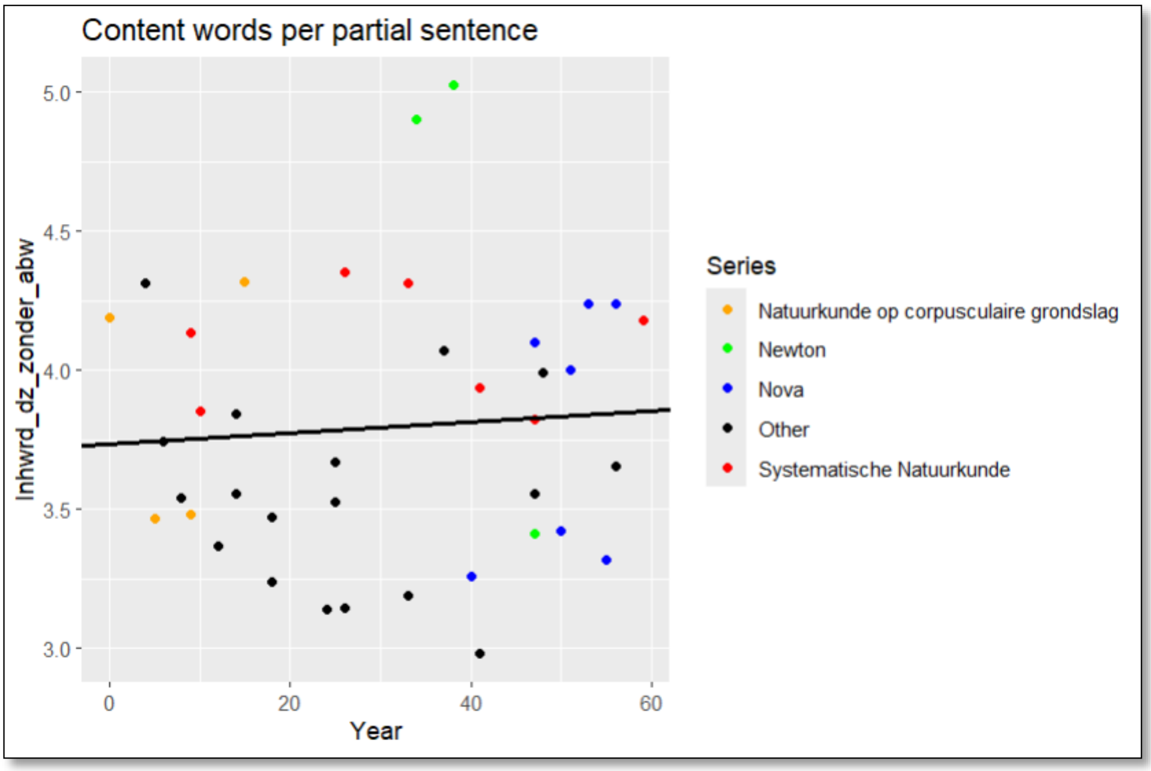

Proportion of sentences with a D-level greater than 4
0.8
0.6
0.4
0.2
D_level_gd4_p
0
20
40
60
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
Systematische Natuurkunde


Proportion of strikt concrete nouns
Conc_nw_strikt_p
0.4
0.3
0.2
0
20
40
60
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
Systematische Natuurkunde


Proportion of broad concrete nouns
Conc_nw_ruim_p
0.5
0.4
0.3
0.2
0
20
40
60
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
Systematische Natuurkunde


Density of general nomina per 1000 words
100
75
50
25
Alg_nw_d
0
20
40
60
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
Systematische Natuurkunde


Measure of Textual Lexical Diversity
300
200
100
MLTD_inhwrd_zonder_abw
0
20
40
60
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
Systematische Natuurkunde


Content words per partial sentence
Inhwrd_dz_zonder_abw
5.0
4.5
4.0
3.5
3.0
0
20
40
60
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
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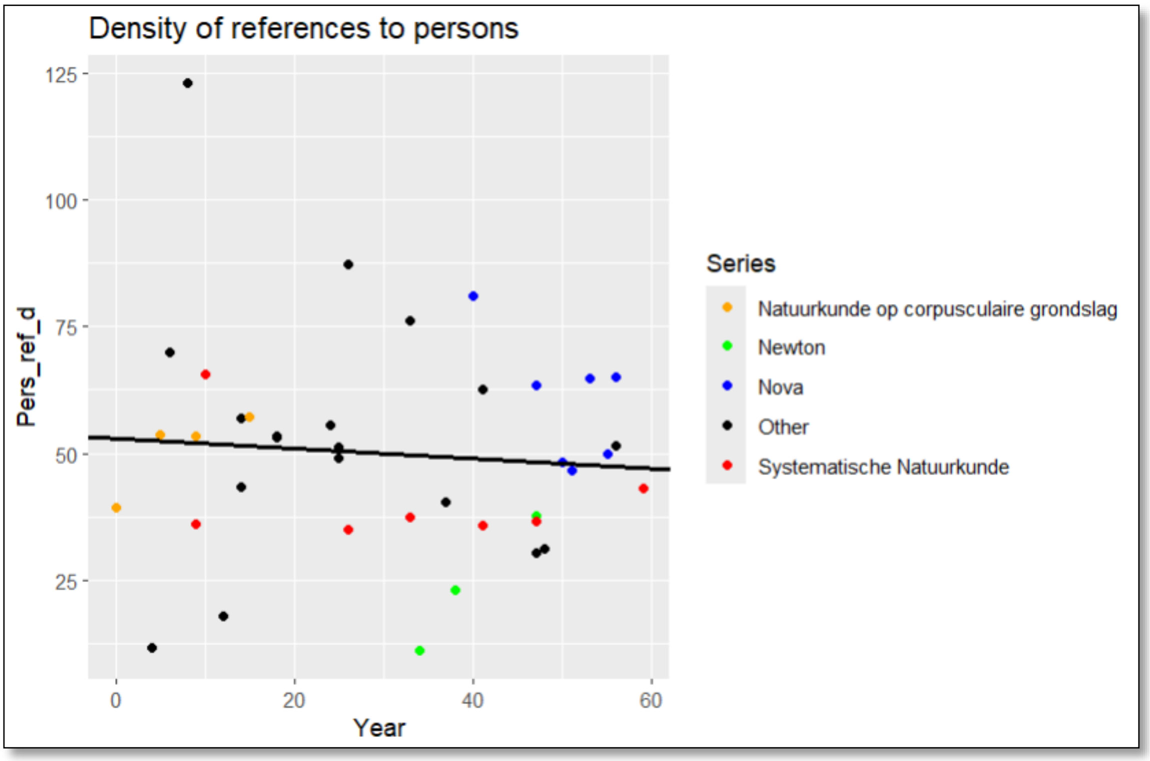
Density of references to persons
Pers_ref_d
125
100
75
50
25
0
20
40
60
Year
Series
Natuurkunde op corpusculaire grondslag
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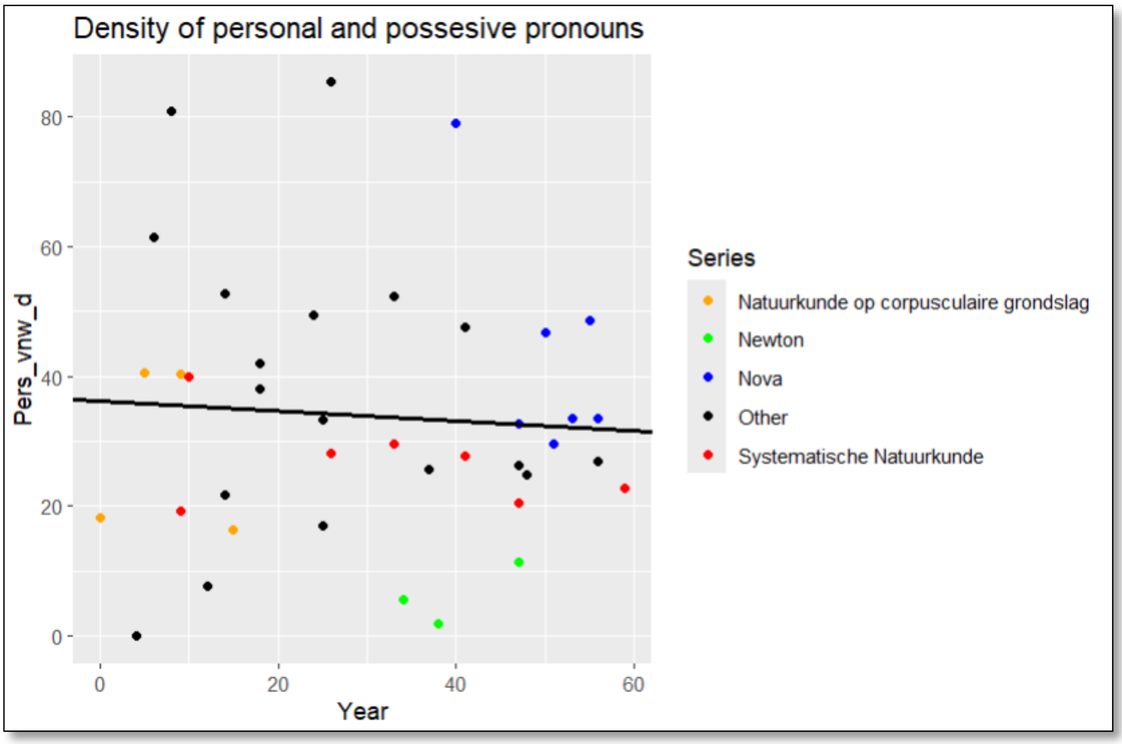
Density of personal and possesive pronouns
80
60
40
20
0
Pers_vnw_d
0
20
40
60
Year
Series
Natuurkunde op corpusculaire grondslag
Newton
Nova
Other
Systematische Natuurkunde