# Reading Easy Language texts written by public authorities: Evidence from eye tracking

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## Abstract

Previous research has shown that word length, frequency and word repetition influence word reading times (Rayner 1998; 2009). Guidelines for Easy Language advise writers to use frequent and short words, and to repeat words instead of using synonyms. However, some of these guidelines are based on research that has been misinterpreted, simplified, or is outdated (Wengelin 2015), and studies focusing on effects of word length, frequency and word repetition among adult readers in the Easy Swedish target group are lacking. This eye-tracking study investigated the reading of Easy Language texts written by public authorities, as well as the effects of word length, frequency, and word repetition on readers in a day centre for people with intellectual disabilities. The results showed significant effects for word length and frequency in all readers. In addition, the effects were significantly greater in the target group than in the control group. The effects for word repetition were not as clear, affecting only one of the reading measures. Furthermore, the study revealed poor comprehension rates in the target group, i.e., when asked, they were not able to reproduce the main contents of the texts. The significantly greater effects of word length and frequency suggest that the related Easy Language guidelines are valid for this group of readers. The poor comprehension rates indicate that the texts were too difficult for these readers.

**Keywords:** Easy Language, Easy Swedish, easy-to-read texts, eye tracking, public authority communication, lättläst

## 1  Introduction

Following democratic values and the aim to increase inclusion, the publication of Easy Language texts has grown considerably over recent decades (e.g., Lindholm & Vanhatalo 2021). As services become increasingly digitized, more

and more information and public services are only available online. However, the EU Web Accessibility Directive (2016/2102) encourages providing people with disabilities with better web accessibility, but it neglects aspects of accessible language. Readers in the heterogeneous target group of Easy Language, e.g., people with intellectual disabilities, are especially vulnerable. Despite the variety of needs and challenges in this group of readers, public authorities tend to publish only one Easy Language text version (instead of adapting different texts or materials to meet different needs within the Easy Language target group), hoping it will be suitable for all the readers in this group (e.g., Forsberg 2014).

Easy Language has been defined as an "easy-to-understand variety" (Maaβ 2020: 12), but conceptualizations and definitions have varied (Arle & Frondén 2022).[1] The Swedish equivalent term lättläst has been defined as "broadly controlled natural language, […] a subset of natural languages obtained by restricting the grammar and vocabulary in order to reduce or eliminate ambiguity and complexity" (Heimann Mühlenbock 2013: 22). However, the term usually refers to texts "that are, or should be, comprehensible for struggling readers" (Arle & Frondén 2022). The terms Easy to Read (easy-to-read texts) and Easy-Read have been used to describe the same concept (see e.g., Karreman et al. 2007; Fajardo et al. 2014; Sutherland & Isherwood 2016; Arle & Frondén 2022). In this study, the term Easy Language is used as a translation of the Swedish terms *lättläst* and *lätt språk*, when referring to written language, spoken language, and signed language; and Easy Swedish when specifically referring to the Swedish language.[2] Although Easy Language texts can differ greatly, the usual characteristics of such texts are reduced text complexity on the word and sentence level, a simple and airy layout, and reduced content load (Heimann Mühlenbock 2013; Maaβ 2020; Arle & Frondén 2022). Despite a reduced content load, however, Easy Language texts can still be longer than

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[1] Also internationally, the conceptualizations of Easy Language and closely related concepts, such as Plain Language, Accessible Language, Accessible Communication, and Comprehensibility, have differed, (e.g., Maaβ 2020; Moonen 2021; Hansen-Schirra et al. 2021). For a discussion on the conceptualizations, see Arle & Frondén (2022).

[2] The Swedish term *lättläst* and the equivalent Finnish term *selkokieli* have been translated into *Easy Language* in linguistic research (e.g., Bohman 2021; Leskelä 2021; O'Donnell & Ramdén 2021; Arle & Frondén 2022). A comparison of guidelines for English, Swedish and Finnish languages show great similarities, i.e., the same or similar advice (e.g., LL-Center; MTM; Sundin 2007; Lundberg & Reichenberg 2008; IFLA 2010; Österlund 2011; Selkokeskus 2022). The German term *Leichte Sprache* has also been translated into Easy Language (e.g., Hansen-Schirra & Maaβ 2020; Pappert & Bock 2020; Schiffl 2020; Borghardt et al. 2021; Hansen-Schirra et al. 2021).

the original texts (e.g., Maaβ 2020).

Sets of guidelines (e.g., LL-Center; MTM) for writing such texts are provided by and for professionals working with Easy Language texts (e.g., Bohman 2021: 544–547; Lindholm & Vanhatalo 2021: 12, 15–16, 18). However, some of these guidelines are based on research that has been misinterpreted, simplified, or outdated (Wengelin 2015; Arle & Frondén 2022). Having scrutinized the psycholinguistic research literature, Wengelin (2015) found, for example, that the use of the passive voice[3] (except for the reversible passive voice) does not in itself cause poorer comprehension. It can, however, result in a more complex sentence structure (Wengelin 2015). Updated information about the validity of the guidelines for Easy Language is thus needed. In word-level guidelines for Easy Swedish (see Table 1) it is stated that writers should use short and frequent words and repeat words instead of using synonyms. This is supported by previous eye-movement research that has shown that longer words and infrequent words attract longer fixations, and that the repetition of words in the same text attracts shorter fixations in both adult and developing readers (e.g., Rayner 1998; 2009). However, studies focusing on such effects on adult readers in the Easy Swedish target group are lacking, and it remains unclear what actually is easy to comprehend for different readers in the Easy Language target group (Sutherland & Isherwood 2016; Arle & Frondén 2022). Despite the heterogeneity of the target group, guidelines for Easy Swedish are often written with the whole group in mind, and not specific subgroups. Furthermore, producers of Easy Swedish texts seldom carry out reception surveys, so we have very little information on the reception of Easy Swedish texts (Domeij & Spetz 2014).

This eye-tracking reading study at a day centre for people with intellectual disabilities in Finland examines the reading of Easy Language texts written by public authorities. It also investigates how word length, frequency, and repetition influence fixations and whether their effects on these readers and non-disabled readers differ. If these effects are significantly greater among readers with disabilities, the results add validity to the related word-level guidelines for Easy Language. Methodologically, eye-tracking measures were combined with open-ended questions posed during the eye-tracking experiment (e.g., Gutermuth 2020). Eye tracking was chosen because it is especially suited to examining reading-related processes as it provides detailed information on the time-course of processing (Rayner 1998).

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[3] The guidelines for Easy Swedish often advise writers to avoid the passive voice (e.g., LL-Center).

**Table 1.** Word-level guidelines for Easy Swedish

| Guidelines | References |
|---|---|
| undvik långa ord / välj korta ord 'avoid long words / choose short words' | LL-Center; MTM; Sundin 2007; Lundberg & Reichenberg 2008. |
| undvik obekanta ord 'avoid uncommon words' | LL-Center; MTM; Sundin 2007; Lundberg & Reichenberg 2008; Österlund 2011. |
| repetera ord i stället för att använda synonymer 'repeat words instead of using synonyms' | MTM; Sundin 2007; Lundberg & Reichenberg 2008; Österlund 2011. |

The research questions were: 1) How do word length, word frequency and word repetition influence fixation times and how do these effects differ in the target group and the control group? 2) Were the Easy Language texts comprehensible to the participants, i.e., when asked, were they able to reproduce the contents of the texts?

## 1.1 Easy Swedish: An emerging research field

Research on Easy Language is an internationally growing field, but most linguistic research has focused on the German and English languages (e.g., Chinn & Homeyard 2017; Sutherland & Isherwood 2016; Gutermuth 2020; Hansen-Schirra & Maaß 2020; Pappert & Bock 2020). Although research interest in other languages is now growing (e.g., Lindholm & Vanhatalo 2021), research on Easy Swedish remains scarce, and the focus has mainly been on written language. A meta-narrative review by Arle & Frondén (2022) showed that the conceptualization of Easy Language also differs depending on the studied material, modality, aims, and discipline. Easy Language novels have been studied from the perspectives of reading experience and pedagogical utility (e.g., Nordenstam & Olin-Scheller 2018), whereas Easy Language information texts have been examined from perspectives of accessibility (e.g., Domeij & Spetz 2014; Forsberg 2014). A few descriptive articles provide some historical and contemporary practical information on Easy Language in Sweden (Bohman 2021; O'Donnell & Ramdén 2021). Heimann Mühlenbock (2013), based on a comparison of Easy Language texts in the LäSBarT corpus of different genres with other texts, created the *SVIFT* text complexity model.

In addition to surface-level features, the model also includes vocabulary load, sentence structure, idea density, and human interest. Heimann Mühlenbock's study showed that mean word length and lemma variation index was highly relevant when separating Easy Language texts from other texts (Heimann Mühlenbock 2013: 150–151). However, the need for more research on Easy Language and the reception of Easy Language texts has been stressed both internationally and in the context of the Swedish language (e.g., Sutherland & Isherwood 2016: 297, 307–308; Moonen 2021: 393; Arle & Frondén 2022).

## 1.2 Effects of word length, frequency, and repetition on word reading

The word-level variables chosen for this study are based on Easy Language writing advice that recommend short words or advise against long words (LL-Center; MTM; Sundin 2007: 132; Österlund 2011: 11–12). Writers are also advised to use "common words" (Sundin 2007: 132; Lundberg & Reichenberg 2008: 64; Österlund 2011: 11) or to avoid "uncommon words" (LL-Center). The guidelines also include recommendations to repeat words instead of using synonyms (MTM; Sundin 2007: 124–125, 147; Lundberg & Reichenberg 2008: 74–75; Österlund 2011: 15).

Previous research demonstrates that word length and frequency influence the duration of the reader's gaze on words (Rayner 1998; 2009). Infrequent words are read with longer gaze duration than words of high frequency, even when other factors are controlled for (e.g., Inhoff & Rayner 1986; Rayner & Duffy 1986). Other studies have shown that frequency affects word recognition (Forster & Chambers 1973; Balota & Chumbley 1984; Schilling et al. 1998; Hyönä & Kaakinen 2019). Hyönä & Olson (1995) showed that both non-dyslexic and dyslexic readers have longer fixations and more regressions when reading long, low-frequency words. However, they found no significant difference between these groups in terms of the effects of word length and frequency. Similarly, a study of Easy German by Schiffl (2020; 2021) that examined effects of word frequency, word length and repetition among adult German readers with cognitive impairments and readers without impairments, found no significant difference between these groups. Joseph et al. (2009) presented stronger word length effects in gaze duration and refixation probability among children than adults. These differences were the greatest in refixation behaviour. In contrast, Tiffin-Richards & Schroeder (2015) found generally greater effects for word length and frequency for children than for adults.

Several studies have shown that the repetition of texts and words influence eye movements in reading (Rayner 1998). In a study by Hyönä & Niemi (1990), rereading a text resulted in decreased fixation duration. A similar study by Inhoff et al. (1993) showed that fixation durations decreased when passages of text were reread. Raney & Rayner (1995) demonstrated that fixation times on both high- and low-frequency words decreased when the words were encountered several times within a passage. However, this effect was more prominent for low-frequency words. All the above-mentioned studies used unimpaired readers. A study by Fajardo et al. (2014) of comprehension of Easy Language texts among students with intellectual disability showed that word length and frequency had no effect on comprehension, but that the number of coreferences (including repetition of the same noun, repetition of the word stem, and repetition of shared word steam allowing word category variation) had a significant effect on literal comprehension. Their analysis was based on reading comprehension questions to measure comprehension on the literal and inferential levels (for a further discussion of the different levels of comprehension, see e.g., Kintsch & Dijk 1978) and did not include eye-tracking measures.

## 1.3   Eye movements among adult readers with intellectual disabilities

Compared to good readers, disabled readers show longer average fixation durations, make more regressions, read more slowly, and make shorter saccades (Rayner 1983). Reichle et al. (2013) presented a review of studies on the eye movements of readers of different skills or ages, showing differences between skilled and non-skilled readers in fixation times, reading times, saccade length, and regressions. Non-skilled readers also tend to skip words less frequently (Joseph & Blythe 2011: 9). The perceptual span of non-skilled readers is smaller than that of proficient readers (Hyönä & Kaakinen 2019: 240; Schiffl 2021). In a study by Schiffl (2021), readers with cognitive impairments displayed reading patterns similar to those of children, i.e., longer reading times, and more numerous and shorter saccades. According to Rayner (1983), different types of dyslexia display different eye movement behaviour during reading (Rayner 1983: 167–171).

Very few studies have studied reading of Easy Language texts using eye-tracking methodology. A study by Gutermuth (2020) compared comprehension of Easy German texts, Plain Language texts, and standard language texts with different readers in the Easy Language target group, showing longer

reading times for more complex texts. Some practical reflections on conducting eye-tracking studies in the Easy Language target group has been provided: Borghardt et al. (2021) present background information and recommendations for metadata and test battery, Deilen & Schiffl (2020) provide practical advice concerning difficulties related to this specific group of readers. Like Gutermuth (2020), Deilen (2021) and Schiffl (2020; 2021) have conducted eye-tracking experiments using German-speaking readers from the Easy Language target group. Deilen (2021) focuses on compound words; Schiffl (2020; 2021) in turn examines the effects of word length, frequency and repetition, and the long-term learning effects of infrequent words.

## 2   Method

### 2.1   Participants

Eleven participants (8 women and 3 men) were recruited from a day centre for persons with intellectual disabilities (target group). As the original purpose of this study was to examine whether this type of experiment using longer texts could be conducted with this group of readers (pilot study), only a small group was recruited. All were native speakers of Swedish, living in Finland. The inclusion criteria for this group were affiliation to this specific type of institution and age between 18 and 65. No diagnosis information was collected. Due to calibration failure, eye-tracking data were only gathered from seven of the participants. The control group consisted of eight university students (6 women and 2 men), and all were native speakers of Swedish and aged between 18 and 35.

The language proficiency measure (§ 2.4) scores showed variations both between and within the groups (Table 2). This was the case for both the reading comprehension test (§ 2.4) and the decoding test (§ 2.4). One of the participants in the control group had reading difficulties – this information was only provided to the researcher in the middle of the experiment – which explains the significant variation in this group. Because the size of the control group remained smaller than expected, the data on this participant was still included in the analyses.

The study was conducted in accordance with the ethical principles of the Finnish National Board on Research Integrity, TENK (2019). Each participant gave their written consent to participation, and the Ethical Review Board of the University of Helsinki approved the study.

**Table 2.** Baseline test scores presented in mean (M) and standard deviation (SD) values per group.

|  | Target group M | Target group SD | Control group M | Control group SD |
|---|---|---|---|---|
| Text comprehension test* | 5.64 | 3.2 | 15.13 | 4.54 |
| Decoding test | 43.45 | 25.08 | 101.25 | 10.17 |

*theoretical max/min=20/0

## 2.2 Apparatus

Eye movements were recorded monocularly using EyeLink Portable Duo (SR Research, Canada) at 500 Hz sampling frequency. A chin-and-forehead rest installed 58 cm in front of the screen was used to minimise head movements. The stimuli were presented on a 17.3″ Asus ROG G752V laptop screen (refresh rate of 120 Hz, resolution 1920 × 1080).

## 2.3 Materials

Each participant silently read two informative texts comprising nine pages in total, written in Easy Swedish, on a computer screen (font: Courier New, font size: 20). The texts had been published online by the Finnish Tax Government Authority on the Inkomstregistret website[4]. Both texts were defined at the beginning as an Easy Language (*lättläst*) text. Text A contained general information on the national income register and Text B contained information on proxies for dealing with issues in the income register (Table 3).

The word frequency estimates were retrieved from the LäsBart[5] corpus of The Swedish Language Bank. Lemma frequency ratings were used.

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[4] The text materials are available at https://www.vero.fi/sv/inkomstregistret/om-oss/ inkomstregistret-lättläst/.

[5] This corpus contains Easy Language texts of different genres, and text from children's fiction, published in Sweden (Heimann Mühlenbock 2013). According to Balota et al. (2004: 494), subtitle corpus frequency estimates outperform the same type of estimates from book corpuses. However, the LäsBart frequencies were compared and found to resemble those of subtitle-based corpuses.

**Table 3.** OVIX, length, and distribution of word length, frequency, and word repetition in Text A and Text B.

|                        | Text A | Text B |
| ---------------------- | ------ | ------ |
| Length in words        | 328    | 263    |
| Word length, M         | 6.54   | 5.65   |
| Word length, min       | 1      | 1      |
| Word length, max       | 31     | 25     |
| Frequency, M           | 3.66   | 3.77   |
| Frequency, min         | 0      | 0      |
| Frequency, max         | 4.46   | 4.46   |
| Word repetition, M     | 6.05   | 6.51   |
| Word repetition, min   | 1      | 1      |
| Word repetition, max   | 22     | 22     |
| OVIX                   | 44.5   | 36     |

## 2.4  Language proficiency measures

An adapted version of the *LS Klassdiagnoser Läsförståelse I* reading comprehension test was used to assess the participants' reading comprehension. The LS Klassdiagnoser test is a diagnostic test for qualitative diagnosis of reading and writing disabilities, adapted for a Swedish-speaking context in Finland. As an adaptation of the original reading comprehension test was necessary from both an ethical and a practical perspective, only the first half of the test was used. The same adaptation was used for both groups. Thus, the participant's scores are not comparable to national scores but can nevertheless provide a comparison between groups and participants. To assess decoding while reading, the *LS Klassdiagnoser Avläsning nonsensord* readout test was used. This test is also part of the LS Klassdiagnoser diagnostic test described above.

## 2.5  Pre-questionnaire

Prior to testing, the participants answered an open-ended pre-questionnaire that tested for possible previous knowledge of the content of the texts (Appendix B).
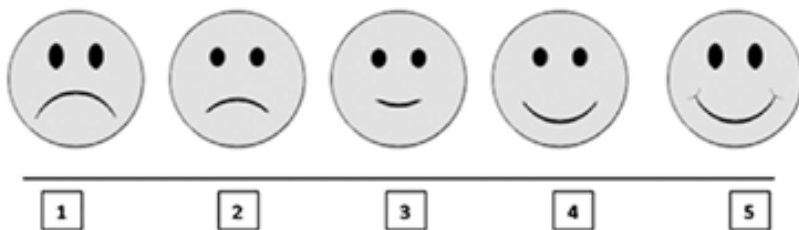
**Figure 1.** Evaluation scale

## 2.6   Text comprehension and evaluation tasks

After reading each text, the participants answered an open-ended free recall text comprehension question ("What do you remember of what you just read?", see Gutermuth 2020). This question format was chosen due to difficulties related to intellectual disabilities that might arise when working with this group of readers (for a further discussion, see e. g., Fajardo et al. 2014; Sutherland & Isherwood 2016; Gutermuth 2020). The questions were answered orally and recorded. The answers were marked down in the ethnographic material consisting of field notes on the participants' answers. The participants also evaluated how difficult and how interesting they found the text ("How difficult/interesting do you think the text was, on a scale of 1–5?").

A picture of a 1–5 scale was used to facilitate communication concerning both questions (see Figure 1). These evaluations were included in the ethnographic material.

## 2.7   Procedure

Testing took place in a room at the hosting institution (target group) and in the eye-tracking lab of the university (control group). The participants were tested individually and instructed orally following the same scheme. They were informed that the purpose of the research was to scrutinise Easy Language texts and that they were about to read two such texts. Each participant signed an informed consent form before experimentation. Subsequently, the eye-tracker was set up and each participant was calibrated using a three-point

calibration screen. They were instructed to "Read as well as you can, so that you understand.", and were informed that the experiment consisted of two texts divided onto several pages each. Reading time was not restricted – the participants were allowed to read at their own pace. Advancement in the text was moderated by the researcher. The participants were instructed to inform the researcher when they had finished reading a page, and the researcher then changed the page. This procedure was chosen to allow the participants to fully concentrate on the reading task and not be distracted by technical and motor challenges. Returning to a previous page was not possible. Prior to the experiment, a practice trial was run, consisting of two text pages and a short break that was used to clarify the task if needed. Half of the participants read Text B first. Those who failed the calibration process (§ 2.1) read both the texts in one word document on the 14″ screen of a laptop computer (Yoga 530-14IKB). The researcher moderated advancement in the text. All the participants answered the follow-up question, also those whose eye-tracking data we could not include due to calibration failure.

## 2.8    Qualitative analysis

The answers to the follow-up recall question were transcribed and analysed using qualitative content analysis (e. g., Graneheim et al. 2017; Krippendorff 2019). The approach was inductive, consisting of only a concrete analysis of the manifest content, with a low abstraction level and a low interpretation degree (Graneheim et al. 2017: 30–31). The answers were then analysed using an adapted version of the coding scheme used by Gutermuth (2020: 154). In this scheme, the content of the recall was given a number (0, 0.5, 1) according to the information included (see Table 4). Although the free recall question answers provide limited information about the participants' text comprehension, the term comprehension is used when referring to the free recall coding scheme results (cf. Gutermuth 2020).

## 2.9    Statistical analysis

Eye-tracking data were analysed by linear mixed-effects models (LMM) using the *lme4* package (Bates et al. 2015) in the R statistical software (RStudio version 1.4.1103; R Core Team 2020). The dependent variables (the different eye movement measures: dwell time, first run dwell time, and regression path duration, see § 3.1 for a detailed description of the measures) were log-

**Table 4.** Comprehension rates of the free recall coding scheme (for comparison, see Gutermuth 2020: 154).

| Code | Comprehension | Evaluation Criteria |
| --- | --- | --- |
| 1 | Good overall comprehension | Reproduction of the main content, reproduction of relevant information. |
| 0.5 | Partial comprehension | Reproduction of some relevant details but no reproduction of the main content. |
| 0 | Poor or no comprehension | No reproduction of the main content or relevant information. |

transformed before the analyses. The target group (dummy coded: control group as baseline) and word length (centred), frequency (centred), and repetition were added to the models as fixed effects variables, one at a time. Due to the high correlation between word length and frequency ($r = -0.72$), these were separated into different models. Random intercepts for participants and words were included in the random part of the models.

Observations exceeding three standard deviations from the grand mean were excluded from the analyses. This resulted in the exclusion of 1.92% of data for dwell time, 1.85% for the first run dwell time, and 1.3% of the regression path duration. A statistical significance of .05 was indicated by values of [$t$ or $z$] > 1.96 (Baayen 2008). For the sake of brevity, only significant effects are reported in the text. The final models are reported in Appendix A Tables 1–3. The dataset and the analysis code are available at https://osf.io/dcjgk/.[6]

## 3 Results

### 3.1 Pre-processing of data

Three different reading measures were computed for all the words in the texts from the eye movement data: dwell time, first run dwell time, and the regression path duration. Dwell time is the summed duration of all the fixations landing on a word. First run dwell time is the summed duration of fixations landing on the word during its first-pass reading. Regression path duration is the summed duration of fixations calculated from when the word is first fixated

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[6] Last updated 2023-01-31.

on until the time the reader moves on to the next word. These measures were chosen because they provide information on the different stages of processing. The first run dwell time informs us of initial processing, whereas the dwell time and the regression path duration provide information on later processing, such as integrating the word meaning into the sentence context (Rayner 1998; 2009).

Every word in the text was assigned an area of interest (AOI). Due to calibration issues, in some of the gaze measurements, the fixations were positioned slightly off the rows and were systematically moved to the right row. In some cases, the calibration had drifted to the right. In cases where it was completely clear how the calibration had drifted, fixations were systematically moved to the left so that the first fixation was on the first word. However, the words affected by this drift or obscurity were removed from the data before the word-level analysis was conducted. Accurate field notes were made on the drifting, so that the drifted fixations could be later moved to the right line.

## 3.2    Effects of word length, frequency, and repetition

As expected, longer words attracted longer fixation durations. In addition, the effect of word length was more prominent in the target group. The effect of word length was observed in all three fixation measures: dwell time ($\beta = 0.29$, 95% CI [0.26, 0.32], $t = 19.41$), first run dwell time ($\beta = 0.18$, 95% CI [0.14, 0.21], $t = 10.84$), and regression path duration ($\beta = 0.20$, 95% CI [0.15, 0.25], $t = 8.03$). An interaction between group and word length was observed in all three measures: dwell time ($\beta = 0.09$, 95% CI [0.06, 0.12], $t = 5.77$), first run dwell time ($\beta = 0.07$, 95% CI [0.04, 0.11], $t = 4.48$), and regression path duration ($\beta = 0.16$, 95% CI [0.10, 0.22], $t = 5.12$). This means that the word length effect was greater in the target group than in the control group (see Figure 2).

The models with lemma frequency as a predictor showed that as the frequency of a word increased, the duration of the gaze on the word decreased. This effect was more prominent in the target group than in the control group. The effect of lemma frequency was revealed for dwell time ($\beta = -0.25$, 95% CI [$-0.29$, $-0.21$], $t = -12.14$), first run dwell time ($\beta = -0.15$, 95% CI [$-0.19$, $-0.11$], $t = -8.01$), and regression path duration ($\beta = -0.15$, 95% CI [$-0.21$, $-0.10$], $t = -5.47$). An interaction between group and frequency was observed in all three measures: dwell time ($\beta = -0.07$, 95% CI [$-0.10$, $-0.04$], $t = -4.50$), first run dwell time ($\beta = -0.06$, 95% CI [$-0.09$, $-0.02$],
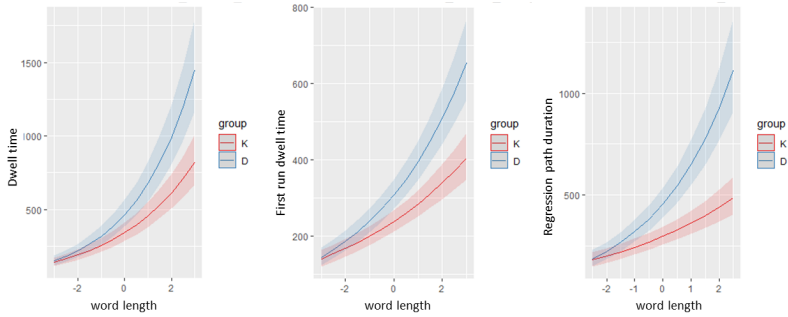
**Figure 2.** Effects of word length and interactions between group and word length for dwell time, first run dwell time, and regression path duration (D=target group, K=control group)
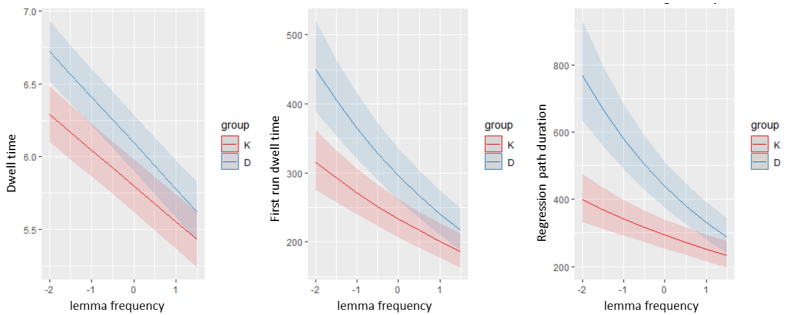


**Figure 3.** Effects of lemma frequency and interactions between group and frequency for dwell time, first run dwell time, and regression path duration (D=target group, K=control group)
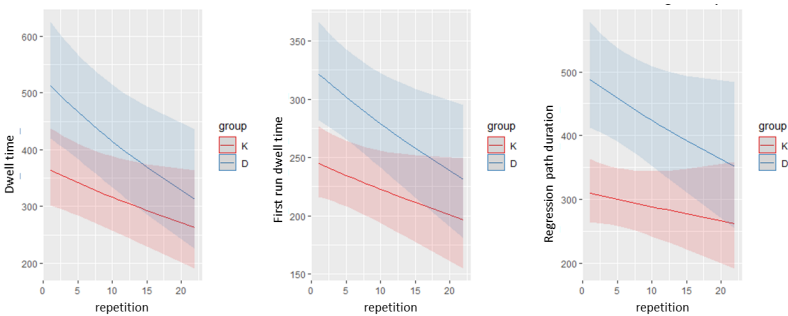


**Figure 4.** Effects of word repetition and interactions between group and repetition for dwell time, first run dwell time, and regression path duration (D=target group, K=control group)

$t = -3.37$), and regression path duration ($\beta = -0.13$, 95% CI [$-0.19, -0.07$], $t = -4.03$). This means that the effects of lemma frequency were greater in the target group (see Figure 3).

Word repetition affected only some measures. As the number of repetitions of the word within the text increased, the duration of the gaze on the word decreased. However, the repetition effect was only significant for dwell time ($\beta = -0.02$, 95% CI [$-0.03, -0.00$], $t = -2.1$), not for first run dwell time or regression path duration. An interaction between group and repetition was also only observed during dwell time ($\beta = -0.01$, 95% CI [$-0.01, -0.00$], $t = -2.76$). Hence, the greater effect in the target group was only observed in the dwell time fixations, the other two reading measures showed similar effects in both groups (see Figure 4).

In addition, the readers in the target group read more slowly overall, as indicated by an effect of group in all measures (Appendix A). A complete presentation of the model results can be found in Appendix A.

### 3.3   "This was not exactly easy to read"

The free recall question comprehension rates were considerably low in the target group; this was the case for both texts (Table 5). None of the participants in this group were able to reproduce the main content of the texts, even when they had some previous knowledge of the text subject. Although three of the participants gave an accurate description of a proxy in the pre-questionnaire, they were unable to reproduce the content of the text on proxies (Text B). One of them could reproduce fragments of the content (Transcript 2). In contrast, the control group participants were able to reproduce the main content and recalled relevant information (Table 5).

As shown in § 2.1, although the decoding and reading comprehension test results showed variance both between the participants in the target group and between the groups, the results of these tests had no apparent connection to the results of the free recall task in the target group. The participants who scored better in the baseline tests did not necessarily reproduce more, or more accurate information from the texts.

How difficult the texts were rated by the participants also had no apparent connection to the results of the free recall task (Table 5). The texts were rated as slightly more difficult in the target group, but also as more interesting. Seven in the target group and five in the control group rated the text they read first as more difficult. One of the participants commented that the texts contained

**Table 5.** Results of follow-up questions provided in mean (M) and standard deviation (SD) values for each text in the target group and in the control group.

| TEXT A | Target group M | Target group SD | Control group M | Control group SD |
|---|---|---|---|---|
| Prequestionnaire | 0 | 0 | 0.81 | 0.35 |
| Comprehension* | 0.19 | 0.24 | 0.94 | 0.17 |
| Difficulty rating | 3.43 | 1.05 | 2.13 | 1.27 |
| Interest rating | 3.71 | 0.88 | 3 | 0.71 |
| **TEXT B** | | | | |
| Prequestionnaire | 0.38 | 0.48 | 0.88 | 0.33 |
| Comprehension* | 0.06 | 0.17 | 1 | 0 |
| Difficulty rating | 3.08 | 0.61 | 2.44 | 0.77 |
| Interest rating | 3.71 | 0.88 | 2.57 | 0.86 |

* 0=poor or no comprehension, 0.5=partial comprehension, 1=good overall comprehension

difficult words, and another stated: "This was not exactly easy to read". The highest interest ratings were received from the participants with the lowest comprehension rates, except for one from the target group, who recalled partial information from Text A.

Most participants recalled some details but no other content of the texts. For example, one of them recalled the words *proxy*, *private persons* and *company*, but did not recall the connection between these or the roles of these in the text (Transcript 1). Another participant recalled only the name *FPA*,[7] the words registration and wage information, and the abbreviation *LL*, which was part of the name *LL-Center* mentioned at the beginning of the text. A third participant recalled that the texts contained information about money ("it's about money"), paying bills, and "having access to" something but did not recall to what. Five participants recalled the name *FPA*.

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[7] Folkpensionsanstalten (Kela) is The Social Insurance Institution of Finland. This name is probably familiar to many in the Easy Language target group as it provides social security coverage for Finnish residents and offers social security benefits such as family benefits, health insurance, rehabilitation, basic unemployment security, basic social assistance, and disability benefits. (https://www.fpa.fi/)

(1)     PARTICIPANT 2. R=researcher, P=participant.
    01    R:    Vad kommer du ihåg från det som du just läste?
             'What do you remember of what you just read?'
    02    P:    (.) om (.) det där (.) fullmakt och sånt (...) till privater personer
             och (.) företag och (...)
             '(.) of (.) that (.) proxy and such (...) for private persons and
             (.) company and (...)
    03    R:    mm (...)
    04    P:    Sen var där nån länk också.
             'Then there was a link too.'

Five of the participants were able to recall some relevant details of the content. Three answers contained accurate information on proxies following the free recall question on Text B. One explained that it was dealing with things "instead of someone", another recalled that the text contained information on "if you want to give a proxy to someone". Three participants recalled partial information from Text A. One seemed to comprehend one of the aims of the income register: that the income information is gathered without the employees having to take measures. Another recalled, "they can see there what your wage is and whatnot".

(2)     PARTICIPANT 8. R=researcher, P=participant.
    01    R:    Vad kommer du ihåg av det som du just läste? (.)
             'What do you remember of what you just read?'
    02    P:    Jo det var så att man sku ge dehär fullmakt åt en annan som
             har någo ärende att man kan hjälpa nån annan med fullmakter
             å dehär inkomster å dehär för fullmakt skaffar man också för
             någo sånt förstod jag [...]
             'Yes, it was so that you would give this proxy to another who
             has to take care of something that you can help someone else
             with proxies and this income and that for proxy you also get or
             something like that I understood'
    10    P:    (?)  någo, va någo om dehär förvaltningsregister eller dehär
             någo FPA o dehä me Januari 2021 som man sen sku börja me
             att lämna in dehä me re re register å löner å de som hjälper att
             andra kan göra sina ärenden dehär me pension och löner de får
             man via såna här löneregister å så får man fara på FPA å på någo
             info (?) löneregister, någo sånt förstod jag med det här nu.

'(?) something, it was something about this administration register or this FPA and in January 2021 that you then start to hand in this with the re- re- register and wages and it then helps others take care of their affairs with pensions and wages that you get through these wage registers and then you can go to FPA and some info (?) wage register, something like that I understood of this now'

The participants who read the papers in one word document did not perform better on the free recall task, with the exception of one, who was able to reproduce some relevant details from both texts. This participant explained that a proxy can be given to another person who has to deal with some matter (Transcript 2). However, the main point of the text – how to use proxies when handling matters in the electronic income register, was not reproduced. A similar answer was given regarding Text A, showing that the participant had understood that the text had something to do with wages and a register and that the register collects information on wages, but apparently did not fully understand the content. The participant also noted some relevant details: "FPA" and the date, January 2021.

## 4    Discussion

The purpose of the present study was to investigate the effects of word length, frequency and repetition on eye movements, and whether these differed in the target group and the control group. Another aim was to examine reading comprehension by asking the participants what they recalled of the texts. The results showed significantly greater word length and frequency effects and poor comprehension rates in the target group.

The eye-tracking results and statistical analysis showed significant word length and frequency effects for all measures. That is, high frequency words and short words were read faster than low frequency and long words. These results are in line with previous eye-tracking research (Rayner 1998; 2009). The effects were also significantly more prominent in the target group. This provides new knowledge about the Easy Language group: long and infrequent words seemed to have a greater effect on the processing time of the readers in this group than on that of the non-impaired readers: the longer and more infrequent the word, the longer the fixations. These results differ from those of the eye-tracking study of Finnish language texts by Hyönä & Olson (1995), which showed similar effects of word length and frequency on non-dyslexic

and dyslexic readers. Similarly, an eye-tracking study by Schiffl (2020; 2021) demonstrated no greater word length, frequency, or word repetition effects among readers with cognitive impairments than among other readers. However, the number of participants was greater in the German study ($n = 30$), and the group definition was slightly different ("readers with cognitive impairments"). The differences could also derive from dissimilarities between, for example, the levels of text complexity in the Swedish and German texts used in the experiments, or from the fact that Schiffl used sentences instead of texts. The results of this study are yet in line with previous research showing generally greater effects of word length and frequency for children compared to adults (Tiffin-Richards & Schroeder 2015). Similar to the present study, Tiffany and Schroeder used reader-appropriate frequency estimates.

The results regarding word repetition were not as clear. The repetition effect was only significant for the dwell time measure. Moreover, the greater effect in the target group was only observed in the dwell time fixations. The more prominent word length, frequency, and (partial) repetition effects in the target group indicate that infrequent words, long words, and words that are repeated less often within the text can cause greater difficulties in processing words for members of this group of readers. It is thus likely that these characteristics cause more reading problems in this group of readers. This adds validity to the Easy Language guidelines, which state that writers should use frequent and short words and repeat words instead of using synonyms.

Nevertheless, as the sample of this study was quite small, and the inclusion criteria included affiliation with the day centre for people with intellectual disabilities and certain diagnoses were not accessed, the results are not generalizable to readers with intellectual disabilities in general. Furthermore, the Easy Language target group is a heterogeneous group of readers with different needs, qualifications and reading abilities, with variations even in diagnoses (e.g., Heimann Mühlenbock 2013: 18–19; Forsberg 2014: 33, 39–40; Arle & Frondén 2022). The target group also displayed longer fixation times overall, which is in line with previous findings regarding English language texts, that have shown that disabled readers, compared to good readers, had longer average fixation durations (Rayner 1983; Reichle et al. 2013). The baseline test scores for both reading comprehension and decoding varied both between the groups and within the target group, which is also in line with previous research (e.g., Schiffl 2020). This underpins the expressed heterogeneity of the Easy Language target group (for a further discussion, see Arle & Frondén 2022).

The application of eye-tracking methodology in this subgroup of the Easy Language target group was rather complicated. As described in § 2, the experimental design underwent several adaptations in order to meet the needs and difficulties of the readers in the target group. For example, the instructions and the reading task had to be very simple, so that they were not too difficult for the readers to comprehend. We also noticed that the readers seemed to be afraid of underperforming and eager to meet the researchers' expectations. Consequently, designing and implementing the experiment without creating a sense of failure among the participants was important, and resulted in the simple experiment design described in § 2. Despite this, calibration issues were experienced, resulting in loss of data. These experiences are in line with those in previous eye-tracking studies that included readers with disabilities (see e. g., Gutermuth 2020).

The free recall task showed poor comprehension rates in the target group. The low rates indicate that these texts were too difficult for the readers in the target group. The longer fixation times on long, infrequent, and partly less repeated words reflect problems in comprehending individual words. Despite this, although Text A contained slightly longer words and less frequent words in mean values (Table 5), the comprehension rates were slightly higher than those for Text B (Table 5). Even though this difference was not statistically significant, this finding indicates that text comprehension is also influenced by factors other than word frequency and word length, such as the syntactic and semantic complexity of the text, or the familiarity of the topic discussed in the text. The details remembered by the readers in the target group also did not have a clear connection to either frequency, word length or repetition. This study revealed significant effects of word length and frequency on fixations while reading, and some effect for word repetition. The study by Fajardo et al. (2014) showing no effect for word length and frequency on comprehension but significant effects for the number of coreferences on literal comprehension, studied reading comprehension on both the literal and inferential levels. However, as the present study only studied reading fixations and free recall response, it did not examine the effects of word length, frequency, and repetition on different levels of comprehension. Furthermore, this study included only repetition of the same noun in the analysis and excluded repetition of the word stem and shared word steam allowing word category variation (cf. Fajardo et al. 2014). Inclusion of the latter two would possibly have resulted in greater effects for repetition.

The answers to the recall question show that the readers in the target group mostly remembered irrelevant details. Some details were relevant, but very few of the readers recalled any of the main content. The answers did not reflect a deeper integration of information or comprehension of the texts and what this information could be used for. However, the free recall answers provide merely an indication about their comprehension (e.g., Gutermuth 2020: 151–152). Based on the answers of the participants in the examples (1–2), it is difficult to determine whether the lack of information in the answer was due to poor comprehension, issues related to expression difficulties, or other factors. Nevertheless, as this study did not examine further cognitive and language processing, and no neuropsychological test battery was included in the baseline test (cf. Gutermuth 2020; Pappert & Bock 2020; Schiffl 2020; Borghardt et al. 2021), this issue was not investigated any further. However, the robust effect of word frequency on eye fixation times indicated that the readers were indeed processing the meaning of the words in the text, and not simply gazing at the text mindlessly (see e.g., Reichle et al. 2010). One of the participants in the target group who read the texts without the eye-tracking camera read the text aloud. This participant read every word correctly but was later unable to reproduce the content of the texts.

The reading strategies fostered by the instructions before reading (to read as well as they could) might also have generated different reading strategies – and thereby the free recall question responses – than in a real-life situation, in which public authority texts are probably read for a purpose that derives from an actual problem or situation. The reading and production context of public authority texts usually have specific aims for both producer and reader (e.g., Forsberg 2014). In this case, the reading strategy was perhaps not equal to those in real-life situations and might thereby have had negative effects on the recall task. However, in terms of the participants' disabilities, this procedure was chosen to keep the experiment as simple as possible, and the free recall procedure provides yet an indication of poor comprehension in the target group.

The large impact of the word length and frequency effects in the target group supports the guidelines' recommendation that writers should use shorter and more frequent words. The higher fixation times indicated that the readers struggled with these word characteristics.

## 5    Limitations of the study and future research

Other practical details that differed from natural reading situations (e. g., the layout of the original texts) in addition to those described previously, were bigger font size and line spacing, and the way in which the text was presented on several pages in the eye-tracking experiment. In a real-life situation, the original texts would be presented on a web page as linear texts. The focus of this study was three specific word-level characteristics: word length, frequency, and repetition. The study contained no multimodal aspects, although the recommendation to add pictures that support the text is included in the Easy Swedish guidelines (e. g., LL-Center; MTM), and the use of pictures could affect reading comprehension. However, the original format of the chosen text also contained no pictures. From a perspective of readability and comprehensibility, it should also be noted that many factors interact and that a great range of different aspects affect the level of readability and comprehensibility (for a further discussion, see e. g., Wengelin 2011; 2015).

The small sample of this study is perhaps its greatest limitation. The small number of participants in both in the target group and the control group, in combination with the calibration problems mentioned in § 3.1, resulted in a small data size. As recalibration noticeably led to increased stress among the participants, this was not an option. Despite this, the LMM analyses generated significant effects, which strongly demonstrates the examined word-level effects (word length, frequency, and repetition) in this group. However, future studies should examine these effects with a larger group of readers.

Word length was calculated in terms of numbers of letters; this could also have been calculated in number of syllables or morphemes (cf. e. g., Hyönä & Pollatsek 1998). Future studies could add these. For frequency estimates, lemma frequencies were used. However, as morpheme frequency can also affect word identification (Reichle & Perfetti 2003), it may also be beneficial to study morpheme frequency effects among disabled readers. A study by Valtasalmi (2022) examined lexical knowledge of adults with intellectual disabilities. The results of the study showed that despite high frequency of the words included in the task possibly contributed to correct responses, these readers also knew low-frequency words if the words were familiar from "everyday language" (Valtasalmi 2022). As this study used some of the Easy Language writing guidelines as its basis, and the formulation of "common words" was understood as *frequent* words, the aspect of individual familiarity was ignored. However, this aspect affects processing (i. e., words

that are familiar to a certain reader are processed faster) and familiarity is not always linked to frequency, as a word that is familiar to one reader may be unfamiliar to another (Gernsbacher 1984: 275–277). This aspect could perhaps be included in a future study. In future studies, reading comprehension could also be examined at different levels of comprehension to further examine the effect of Easy Language and the validity of the related guidelines (see e.g., Kintsch & Dijk 1978; Kintsch 1994; Fajardo et al. 2014). Future studies could also be designed to reflect more of the ordinary reading strategies used when reading public authority information, for example, answering a specific question that influences the reader's everyday life. Instead of being instructed to read as well as they can so that they understand, the readers could be given a practical question to answer or a practical problem to solve (e.g., "you have to apply for a subsidy" or "you are going to vote in a public election, how should you do this?"). However, this may complicate the experiment and the instructions too much for some readers in the target group. Future studies could also examine the competencies that influence the reading abilities of this group of readers. A text analysis of the studied texts, as well as a comparison of Easy Language authority texts in different countries, was also excluded from this study, and would be a welcome focus in future linguistic research.

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# Appendix A    Final models

## A.1    Models' outputs with lemma frequency as predictor

| | Dwell time | | | | First run dwell time | | | | Regression path duration | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Predictors | Estimates | CI | p | Predictors | Estimates | CI | p | Predictors | Estimates | CI | p |
| (Intercept) | 5.80 | 5.62…5.98 | < 0.001 | (Intercept) | 5.45 | 5.34…5.57 | < 0.001 | (Intercept) | 5.68 | 5.54…5.83 | < 0.001 |
| Group [D] | 0.29 | 0.04…0.55 | 0.025 | Group [D] | 0.24 | 0.07…0.40 | 0.005 | Group [D] | 0.40 | 0.19…0.61 | < 0.001 |
| Lemma frequency | −0.25 | −0.29…−0.21 | < 0.001 | Lemma frequency | −0.15 | −0.19…−0.11 | < 0.001 | Lemma frequency | −0.15 | −0.21…−0.10 | < 0.001 |
| Group [D] × lemma frequency | −0.07 | −0.10…−0.04 | < 0.001 | Group [D] × lemma frequency | −0.06 | −0.09…−0.02 | < 0.001 | Group [D] × lemma frequency | −0.13 | −0.19…−0.07 | < 0.001 |
| | Random Effects | | | | Random Effects | | | | Random Effects | | |
| $\sigma^2$ | 0.34 | | | $\sigma^2$ | 0.29 | | | $\sigma^2$ | 0.48 | | |
| τ00 Word | 0.06 | | | τ00 Word | 0.04 | | | τ00 Word | 0.04 | | |
| τ00 Participant | 0.06 | | | τ00 Participant | 0.03 | | | τ00 Participant | 0.04 | | |
| ICC | 0.27 | | | ICC | 0.19 | | | ICC | 0.14 | | |
| N Participant | 15 | | | N Participant | 15 | | | N Participant | 15 | | |
| N Word | 231 | | | N Word | 230 | | | N Word | 210 | | |
| Observations | 5895 | | | Observations | 4100 | | | Observations | 1991 | | |
| Marginal $R^2$ / Conditional $R^2$ | 0.173 / 0.394 | | | Marginal $R^2$ / Conditional $R^2$ | 0.111 / 0.277 | | | Marginal $R^2$ / Conditional $R^2$ | 0.131 / 0.257 | | |

## A.2    Models' outputs with word length as predictor

| | Dwell time | | | | First run dwell time | | | | Regression path duration | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Predictors | Estimates | CI | p | Predictors | Estimates | CI | p | Predictors | Estimates | CI | p |
| (Intercept) | 5.83 | 5.65…6.01 | < 0.001 | (Intercept) | 5.47 | 5.36…5.59 | < 0.001 | (Intercept) | 5.69 | 5.54…5.84 | < 0.001 |
| Group [D] | 0.31 | 0.04…0.57 | 0.023 | Group [D] | 0.23 | 0.09…0.42 | 0.001 | Group [D] | 0.43 | 0.21…0.64 | < 0.001 |
| Word length | 0.29 | 0.26…0.32 | < 0.001 | Word length | 0.18 | 0.14…0.21 | < 0.001 | Word length | 0.20 | 0.15…0.25 | < 0.001 |
| Group [D] × word length | 0.09 | 0.06…0.12 | < 0.001 | Group [D] × word length | 0.07 | 0.04…0.11 | < 0.001 | Group [D] × word length | 0.16 | 0.10…0.22 | < 0.001 |
| | Random Effects | | | | Random Effects | | | | Random Effects | | |
| $\sigma^2$ | 0.34 | | | $\sigma^2$ | 0.30 | | | $\sigma^2$ | 0.48 | | |
| τ00 Word | 0.02 | | | τ00 Word | 0.03 | | | τ00 Word | 0.02 | | |
| τ00 Participant | 0.07 | | | τ00 Participant | 0.03 | | | τ00 Participant | 0.04 | | |
| ICC | 0.21 | | | ICC | 0.15 | | | ICC | 0.12 | | |
| N Participant | 15 | | | N Participant | 15 | | | N Participant | 5 | | |
| N Word | 245 | | | N Word | 244 | | | N Word | 221 | | |
| Observations | 6332 | | | Observations | 4471 | | | Observations | 2104 | | |
| Marginal $R^2$ / Conditional $R^2$ | 0.231 / 0.396 | | | Marginal $R^2$ / Conditional $R^2$ | 0.143 / 0.273 | | | Marginal $R^2$ / Conditional $R^2$ | 0.178 / 0.276 | | |

## A.3    Models' outputs with repetition as predictor

| | Dwell time | | | | First run dwell time | | | | Regression path duration | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Predictors | Estimates | CI | p | Predictors | Estimates | CI | p | Predictors | Estimates | CI | p |
| (Intercept) | 5.91 | 5.72…6.10 | < 0.001 | (Intercept) | 5.51 | 5.38…5.64 | < 0.001 | (Intercept) | 5.74 | 5.54…5.83 | < 0.001 |
| Group [D] | 0.35 | 0.09…0.61 | 0.008 | Group [D] | 0.28 | 0.11…0.45 | 0.001 | Group [D] | 0.46 | 0.19…0.61 | < 0.001 |
| Repetition | −0.02 | −0.03…−0.00 | < 0.035 | Repetition | −0.01 | −0.02…−0.00 | < 0.072 | Repetition | −0.01 | −0.02…−0.01 | < 0.316 |
| Group [D] × repetition | −0.01 | −0.01…−0.00 | < 0.006 | Group [D] × repetition | −0.01 | −0.01…−0.00 | < 0.111 | Group [D] × repetition | −0.01 | −0.02…−0.00 | < 0.206 |
| | Random Effects | | | | Random Effects | | | | Random Effects | | |
| $\sigma^2$ | 0.34 | | | $\sigma^2$ | 0.30 | | | $\sigma^2$ | 0.48 | | |
| τ00 Word | 0.14 | | | τ00 Word | 0.07 | | | τ00 Word | 0.10 | | |
| τ00 Participant | 0.06 | | | τ00 Participant | 0.03 | | | τ00 Participant | 0.04 | | |
| ICC | 0.37 | | | ICC | 0.25 | | | ICC | 0.23 | | |
| N Participant | 15 | | | N Participant | 15 | | | N Participant | 15 | | |
| N Word | 245 | | | N Word | 244 | | | N Word | 221 | | |
| Observations | 6332 | | | Observations | 4471 | | | Observations | 2104 | | |
| Marginal $R^2$ / Conditional $R^2$ | 0.057 / 0.405 | | | Marginal $R^2$ / Conditional $R^2$ | 0.047 / 0.285 | | | Marginal $R^2$ / Conditional $R^2$ | 0.069 / 0.280 | | |

## Appendix B    Open-ended pre-questionnaire

1. Vad är inkomstregistret? ['What is the income register?']

2. Vad är en fullmakt? ['What is a proxy?']

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