Sentence First CAPTCHA
Proposal and study of a text based CAPTCHA scheme

Patrik Johansson & Robert Östlund
June 2011

Bachelor Thesis, 15 hp, C
Computer Science

Computer Engineering program
Examiner: Fredrik Bökman
Supervisor: Jonas Boustedt
Sentence First CAPTCHA
Proposal and study of a text based CAPTCHA scheme

by

Patrik Johansson & Robert Östlund

Akademin för teknik och miljö
Högskolan i Gävle

S-801 76 Gävle, Sweden

Email:
{patrik,robert}@sentencefirst.net

Abstract
A major problem on the Internet is automated computer programs abusing services intended to be used only by humans. Therefore, a method is needed to separate computers from humans. Completely Automated Public Turing Test To Tell Computers and Humans Apart, or CAPTCHA, is a term used to describe a test that is difficult for computers and easy for humans to pass and that can be generated and graded automatically. Most of the CAPTCHA schemes currently in use rely on some kind of image or audio recognition problem, making them unavailable to the visually and/or audially impaired. Additionally, visual CAPTCHAs can currently be broken with alarming high success rates. We propose a CAPTCHA scheme based purely in the text domain which we have named Sentence First CAPTCHA. The problem imposed on the users consists of classifying stochastically generated sentences by fluency and legibility and pairs of sentences by semantic coherence. This scheme was implemented and tested by means of several surveys. The answers were analysed and the results show that this could very well be a feasible CAPTCHA scheme.

Keywords: CAPTCHA, human interactive proof (HIP), natural language understanding (NLU), security
Contents

1 Introduction – Only humans allowed 1
  1.1 Aim of study .............................................. 1
  1.2 Disposition ............................................... 2

2 Background and previous work 2
  2.1 The need for Human Interactive Proof ......................... 2
  2.2 What is CAPTCHA? ........................................ 3
  2.3 Past and current CAPTCHA schemes ......................... 3
    2.3.1 OCR CAPTCHAs ....................................... 3
    2.3.2 Object recognition CAPTCHAs .......................... 4
    2.3.3 Logic puzzle CAPTCHA ................................ 5
    2.3.4 Audio captchas ........................................ 5
    2.3.5 Text based CAPTCHAs .................................. 6
  2.4 Human Paid Solving ........................................ 6

3 Our proposal: Sentence First CAPTCHA 6
  3.1 The challenge ............................................. 6
  3.2 Sentence classification ..................................... 7
  3.3 Social feedback ........................................... 7
  3.4 Sentence source ........................................... 8
    3.4.1 Markov text generation ............................... 8
    3.4.2 Source texts .......................................... 8
    3.4.3 Sentence segmentation .................................. 9
  3.5 Computer solving .......................................... 9
    3.5.1 Gap amplification .................................... 9
  3.6 Challenge generation ....................................... 10
  3.7 Reference implementation .................................. 10

4 Method 10
  4.1 Choice of method ......................................... 10
  4.2 Literature review ......................................... 10
    4.2.1 Quality of sources .................................... 10
  4.3 Work process ............................................. 11
  4.4 Surveys ................................................... 11
    4.4.1 Purpose of the surveys ............................... 11
    4.4.2 Survey design ........................................ 12
    4.4.3 The various surveys ................................... 12
    4.4.4 Differences between the surveys .................... 13

5 Results from the survey 13
  5.1 Success rates ........................................... 13
  5.2 Participants ............................................. 14

6 Discussion 14
  6.1 Representativeness ........................................ 14
  6.2 Solvability and breakability ............................... 15
  6.3 Age and success rate ..................................... 17
  6.4 Security measures ........................................ 17
  6.5 Text sources ............................................. 18
  6.6 Does Sentence First qualify as a CAPTCHA? – P as in Public 18
  6.7 Why text domain? ......................................... 18
    6.7.1 Other areas of use .................................... 19
1 Introduction – Only humans allowed

The World Wide Web is full of free services of different kinds. A common denominator for many of them is the desire that only humans should be able to access them. Automated computer programs, or bots, are constantly scouring the web, looking for registration forms to sign up for massive numbers of accounts that can be used to advertise on public forums or send spam email [1, 2]. Online polls are another target for bots – if there is no verification that the participants are human, a perpetrator can easily write a program that stuffs the ballots with bogus votes [2].

The problem was initially formulated 1996 by Moni Naor in an unpublished manuscript, along with the idea of using a kind of automated Turing test. The first known implementation of such a test was used by AltaVista in 1997, to protect the “add URL” function of their search engine from spammers [1, 2, 3].

In 2000, von Ahn et al. came up with the term CAPTCHA, which is a formalization of the problem [4, 5, 2]. Since then, many different CAPTCHA proposals and implementations have emerged, all with one common denominator: all currently known and working CAPTCHA schemes are either image or audio based (or a combination thereof [6]) – effectively locking out visually and audially impaired users, who navigate the Web using Text To Speech (TTS) and Braille terminals. Von Ahn et al. recognize the problem and suggest a need for CAPTCHAs based on text:

Images and sound alone are not sufficient: there are people who use the Web that are both visually and hearing impaired. The construction of a CAPTCHA based on a text domain such as text understanding or generation is an important open problem [7].

One proposed text domain CAPTCHA scheme is based on the ability to detect which word in a sentence has been replaced by a bogus one and another scheme is based on the ability to determine which of a pair of sentences is coherent, with one of the sentences being known and the other stochastically generated. However, these schemes both require an infinitely large private collection of texts or a way to generate infinite amounts of known good text [8].

Another proposition uses collaborative filtering algorithms to determine if subjective ratings of arbitrary objects are sufficiently similar to previous user’s ratings. This way, users are judged by their ability to rate objects approximately similarly to previous users, using nearest neighbour algorithms to enable people with tastes differing from the norm to pass. However, for such a CAPTCHA to be feasible, a way to generate infinite numbers of rateable objects is needed [9].

We propose a text domain CAPTCHA, Sentence First CAPTCHA, based on the human ability to judge a sentence by its legibility and fluency and a sentence pair by it’s semantic coherence. All sentences are stochastically generated and the “correct” answers are derived from answers from previously confirmed human users. The idea is that some of the sentences produced by the stochastic text generation are legible and fluent while some are not and that some fit together semantically while others do not, and that humans are able to classify them sufficiently consistently to have an edge over computer programs trying to do the same.

1.1 Aim of study

The purpose of this project is to implement the proposed CAPTCHA scheme and test it on human subjects to examine its feasibility. Any correlation between age and ability to complete the CAPTCHA is also explored to examine whether the scheme is accessible to people of all ages and, if not, if it could be used as a kind of age limit barrier. The following questions will be addressed:
• What are the pros and cons of the proposed CAPTCHA scheme?
• How usable is Sentence First CAPTCHA as a CAPTCHA?
• How does age affect success rate?

Due to the limited time and scope of the project course, the ability of current natural language processing algorithms to judge sentences by their legibility and fluency and sentence pairs by their coherence is not explored in depth. This is of course still important, since an important aspect of a CAPTCHA is that a human must be able to solve it better than a computer program.

1.2 Disposition

This report has the following structure:

Section 1 clarifies the objectives and purposes of this study. A description of the problem area is presented along with a problem formulation and research questions.

Section 2 explains the background and the theory that forms the basis of this report. A few past and current CAPTCHA schemes are described and analyzed.

Section 3 explains our proposed model, Sentence First CAPTCHA.

Section 4 describes the method adopted to carry out the study and the work process. It also describes the surveys that were conducted.

Section 5 and section 6 present and discuss the results from the surveys.

Section 7 describes the conclusions made and presents answers to the research questions.

Section 8 presents proposals for future work that can be made in the area along possible improvements to the proposed scheme.

2 Background and previous work

2.1 The need for Human Interactive Proof

The massive use of automated computer programs, bots, to access services that are intended to be used only by individuals is a large problem. Therefore, a method is needed to separate bots from humans. Human Interactive Proof (HIP) is a term used to describe a test that verifies that a user is, indeed, a human.

A HIP is similar to a Turing test – the test proposed by legendary computer scientist Alan Turing in which both a human and a computer try to convince a human judge that they are human [10] – in that the goal of the judge is to determine who is human and who is not. The main difference is that, since the tests must be generated and graded upon request, they have to be both generated and judged by computer programs.

The first time the problem with bots and the need for HIP was addressed was probably in 1996, in an unpublished manuscript by Moni Naor [1, 2]. In this paper, the use of some kind of computer rateable Turing test was suggested as a means of implementing HIPs, along with a few proposed sources for such tests.

Some of the services that are commonly abused by bots and thus might employ HIPs are the following:

Online polls provide web site administrators with an easy way to ask the visitors about their opinions. However, writing a program that automatically posts a web form
over and over is no big task. An example of this is the November 1999 slashdot.com poll asking which was the best graduate school in computer science. Students from CMU and MIT quickly developed programs that automatically voted for their respective schools [2].

**Free webmail** is an often-used way to send both spam and scam email. Bots register large numbers of accounts to enable the bot owners to send massive amounts of unsolicited messages. Even if the service providers actively seek out and delete accounts used for spam or scam purposes, these bots just acquire new ones and carry on with their activities [2, 11].

**Sensitive data** that is supposed to be publicly available but not automatically indexable can be protected from automatic retrieval by having users prove they are human before giving them access to the material. There are ways of telling bots to stay away from a page, but they only work on bots that actually obey them – they are useless against malicious bots [2, 12].

**Login forms** can be protected from brute force or dictionary attacks by requiring that users prove that they are human for every login attempt. Since input from a human operator is needed for every attempted login, the cost of performing such an attack is massively increased [13].

### 2.2 What is CAPTCHA?

A more specific term than HIP is CAPTCHA, Completely Automated Public Turing Test To Tell Computers and Humans Apart, introduced by von Ahn et al. [2]. A CAPTCHA is not just a test that verifies users as human; the definition explicitly states that the test should be **completely automated** and **public**. Completely automated means that the test instances should be generated automatically without any human input, whilst public means that both the data the tests are based on and the method they are generated by should be public, i.e., it should be difficult to write a program that breaks a CAPTCHA even if the test generation algorithms and data are publicly known [2].

### 2.3 Past and current CAPTCHA schemes

There are several CAPTCHA schemes and implementations, both proposed and in production. The following sections will present the most common general classes of these CAPTCHA schemes and a few implementations.

#### 2.3.1 OCR CAPTCHAs

The first type of CAPTCHA that was implemented – and still the most common type in use – relies on the problem for computers to perform Optical Character Recognition (OCR) on distorted images. Two OCR CAPTCHAs are EZ-Gimpy and reCAPTCHA:

**Gimpy** is an early OCR CAPTCHA that renders a number of words from a dictionary as a distorted image. To be considered human, a user has to type a given number from the set of words that are shown in the image [7]. An algorithm able to break Gimpy with a success rate of 99% has been developed [14]. Figure 1 shows a sample Gimpy challenge.

**ReCAPTCHA** (shown in Figure 2) is a free CAPTCHA scheme that takes the human effort of solving a traditional CAPTCHA and canalizes it into a useful purpose, to digitize old printed material such as books and articles, mainly from the Google Books Project and The New York Times [15, 16].

ReCAPTCHA presents a user with a challenge consisting of two distorted words, one word that needs recognition and a second “control” word for which the answer
is known. If a user gets the control word correct, the system assumes the user is human therefore gains confidence that the other word was also typed correctly. In this way reCAPTCHA also verifies the user’s answer.

ReCaptchaOCR is a tool that can break reCAPTCHA challenges [11]. It was tested on 100 randomly selected challenges from the 2008 version of reCAPTCHA and 100 randomly selected challenges from the 2009 version of reCAPTCHA and it broke the challenges with a success rate of 30% for the 2008 version and 18% for the 2009 version, taking approximately 12 seconds to break one challenge. As of 2010, ReCaptchaOCR had not been updated to break the current version of reCAPTCHA.

2.3.2 Object recognition CAPTCHAs

Object recognition CAPTCHAs rely on the human ability to detect and identify objects in images.

What’s up CAPTCHA is a proposed scheme that presents the user with a randomly rotated image [17]. The challenge consists of rotating the image to its upright orientation, a task which requires the user to detect, identify and analyse objects in the image, something considered difficult for computers. The advantages of the scheme is that it is language-independent and that it works well on mobile-devices since it does not require text input.

Asirra is an image classification HIP where every challenge consists of 12 pictures of cats and dogs. The task is to select the images that depict cats [18]. The Asirra project has a partnership with a web site with animals up for adoption, Petfinder. They provide the Asirra project with pictures of cats and dogs and every picture in a challenge has an “adopt me” link, that leads the user to the web site of the depicted animal at Petfinder, after invalidating the current challenge to prevent bots from using the link to determine the species of the animal. The number of
redirections per IP address per day is limited, preventing large scale indexing of the cat and dog images.

Asirra is considered easy for humans to solve, since, in 2007 humans passed the Asirra challenge in 99.6% of the time in under 30 seconds.

According to [19], Asirra can be defeated by computers with an accuracy of 82.7%, and a success rate of 10.3% of breaking the entire 12-image challenge. This is made possible by a two classifiers which are trained on color and texture parts of an image. The solution is completely automatic besides the process of labelling a number of example images of cats and dogs.

Notably, since it relies on a secret data set of animal images and cat or dog labels, Asirra cannot be considered a CAPTCHA.

2.3.3 Logic puzzle CAPTCHA

The logic puzzle type of CAPTCHA presents the users with a simple logic puzzle.

**Question-based CAPTCHA** is a scheme proposed by Shahreza and Shahreza [20], that combines a simple puzzle with an image classification problem. To succeed with Question-based CAPTCHA a computer or a bot must recognize phrases and shapes, parse the question and be capable of answering the question. Figure 3 depicts an example of a Question-based CAPTCHA challenge.

However, to be fully considered a CAPTCHA, Question-based CAPTCHA needs a way to generate images for the classifications. Otherwise, it depends on a private set of images.

![Figure 3: Example of Question-Based CAPTCHA (from [20])](image)

**SemCAPTCHA** is another scheme, it presents users with an image containing a random number of optically distorted names of animals, one of which is different from the other, e.g., a bird among mammals. To pass, the user must type the differing animal name [21]. Thus, it combines a logic puzzle with an OCR problem.

However, as it is based on a finite private set of animal names [21], it does not fully qualify as a CAPTCHA – if the words and classifications were public, the only difficult part of the scheme for a computer would be the OCR problem.

2.3.4 Audio captchas

Audio CAPTCHAs are generally intended as an alternative to image based CAPTCHAs for the visually impaired. There are two formats in which the CAPTCHA can be presented. The first and most common consists of spoken words or numbers that the user is asked to type. In the second format a sound is played that somehow relates to an image. Thus, the challenge is solvable by people who are either visually or audially impaired, but not both [6]. ReCAPTCHA provides the former type of challenge as an alternative to users who cannot solve OCR CAPTCHAs [15].

One major issue of audio CAPTCHAs is the distortion that is applied to the audio in order to prevent speech recognition software from solving the challenges. This increases the difficulty for humans as well as computers [22].

According to Bigham et al., Audio CAPTCHAs are more time consuming and more difficult to solve than visual CAPTCHAs [23]. Sauer et al conducted a small study that tested the usability of the reCAPTCHA audio CAPTCHA. In this study of 6 users, only 46% of the tested challenges were completed correctly [6]. In a study
carried out by Bigham in 2009, where all the audio based CAPTCHA schemes required the visually impaired participants to spend at least 30 seconds – and some over a minute – in average, it was shown that 40% never passed the audio CAPTCHAs even after three tries [23].

2.3.5 Text based CAPTCHAs

As mentioned in the introduction, a CAPTCHA scheme based on the human ability to determine which of two texts is the coherent one and a scheme based on the human ability to identify which word in a sentence that has been replaced by a bogus word have been developed and disproved [8]. To be considered CAPTCHAs, these schemes require a way to generate infinite amounts of known coherent text that cannot be identified as such computationally. As of now, there is no known text generation algorithm that can accomplish this.

Another proposed and developed scheme depends on the similarity in taste between different humans, even though their taste is only similar to a subset of other humans. The challenge consists of a number of objects to rate according to personal taste. In the same way that previous purchases can be used to predict other items a user might enjoy, the scheme uses the ratings of the first few objects in a challenge to calculate the expected ratings of the last objects, based on previous users’ ratings [9]. This scheme requires a way to generate an infinite amount of objects for the users to rate to be considered a CAPTCHA, another task without apparent solutions.

2.4 Human Paid Solving

All CAPTCHA schemes can be solved by outsourcing the task to human labour. In 2007 it was estimated that a human could earn $10 per 1,000 solved CAPTCHAs, i.e., one cent per solved CAPTCHA. In 2009 the prices had dropped to $0.5 per 1,000 solved CAPTCHAs. These jobs can be found at different “work-for-hire” sites [11].

Elson and Saul define the minimum level of security at which a CAPTCHA can be considered secure as the level where the most cost effective way of defeating it is solving it manually [18].

3 Our proposal: Sentence First CAPTCHA

We are inspired by the interesting problems related to HIP and believe much work can be done in the area. We have identified some flaws in current and earlier CAPTCHA schemes, namely lack of accessibility for visually and audially impaired and high breakability. Therefore we suggest a different approach in order to separate humans from computers. Our proposal is Sentence First CAPTCHA, a text-domain CAPTCHA which is described below.

3.1 The challenge

We propose a CAPTCHA, in which the user is asked to classify a pair of sentences according to the option that best describes them out of the following:

- Neither of the sentences is legible and fluent.
- Only the first sentence is legible and fluent.
- Only the second sentence is legible and fluent.
- Both sentences are legible and fluent but do not fit together semantically.
- Both sentences are legible and fluent and they fit together semantically.

To pass the challenge, the user must classify the sentence pair correctly.
3.2 Sentence classification

To allow for challenges to be generated using fresh sentences, we extend the classification of the sentence pair in the following way:

The sentences are either known good (legible and fluent), known bad (not legible and fluent) or unknown. The sentence pair is either known good (both sentences are good and they fit together semantically), known bad (either or both of the sentences is bad, or both sentences are good or unknown but they do not fit together semantically) or unknown. Figure 4 shows all possible combinations of classifications a sentence pair can have. To pass a challenge, the user must classify all known parts of the sentence pair correctly.

\[
\begin{align*}
AB+ & \quad A+ \quad B+ \\
A- & \quad B- \quad B+ \\
AB- & \quad A+ \quad B- \quad B+ \\
A- & \quad Bz \quad B- \quad B+ \\
ABz & \quad A- \quad Bz \quad B- \quad B+ \\
A+ & \quad Bz \quad B- \quad B+ \\
\end{align*}
\]

Figure 4: Possible classifications of sentence pair (A, B)

3.3 Social feedback

Since the scheme relies on the difficulties of computers to classify the sentences and sentence pairs, the correct classifications cannot be known without human processing. To allow for stochastically generated, initially unknown, sentences and sentence pairs to be classified as positively known the following algorithm is used:

The ratio \( R \) between good ratings and the total number of ratings is calculated and compared to a minimum concordance level \( C \), the minimum level of agreement in the ratings of a sentence or sentence pair needed for it to be considered known. If \( R > C \), the sentence or sentence pair is considered known good and if \( (1 - R) > C \) it is considered known bad. As stated in section 3.2, a sentence pair containing one or more known bad sentences is always considered known bad. Otherwise, the sentence or sentence pair is considered unknown.

To reduce the risk of sentences and sentence pairs being wrongfully classified, every sentence and sentence pair is always considered unknown if it has received fewer than \( M \) ratings.
When a challenge is passed, the classifications are saved and used for future classifications. If the challenge is failed, the classifications are discarded. Thus, only input from users that the system considers human is used when evaluating sentences and sentence pairs.

### 3.4 Sentence source

In our proposal, the sentences are generated by means of a Markov chain text generator, using literary works in the public domain as input. This kind of text generation preserves expressions and style from the original text to some degree and produces text that is statistically similar to the original [24].

#### 3.4.1 Markov text generation

A Markov process is a stochastic process whose next state depends solely on the current state and a random element. The sentence generation of Sentence First CAPTCHA is incorporated as a Markov process where each state represents an N-gram in a source text and the probabilities of all state transitions represent the relative frequencies of all N-gram occurring following the current N-gram in the source text. Figure 5 shows all N-grams and relative N-gram transition frequencies of the lyrics of the song “Happy Birthday”.

When generating a sentence, a random state is chosen as starting point and all its words are added to a buffer string. A new state is then chosen randomly, weighted by the frequencies of the possible following states and the last word of the new state is added to the buffer string. The process of choosing a new state and concatenating the last word to the buffer is repeated until the chosen state is an end of file (EOF) marker or a maximum number of words has been reached.

By adding up the N-gram frequencies from several source texts, sentences combining expressions from multiple texts can be generated.

![Figure 5: The song “Happy Birthday” represented as a set of N-grams](image)

#### 3.4.2 Source texts

Public domain literary works were used as source texts for this project due to the ready availability and lack of copyright requirements. To generate the sentences used in the surveys, the following works were used:
• Lewis Carroll’s *Alice’s adventures in Wonderland*
• Sir Arthur Conan Doyle’s *The Adventures of Sherlock Holmes*
• Jane Austen’s *Pride and Prejudice*

### 3.4.3 Sentence segmentation

Since the proposed CAPTCHA is based on the classification of sentences and pairs of sentences, the generated text must be separated into sentences. This is no straight forward task since many types of punctuation can be used in several ways. The problem of deciding where sentences end and begin is called “sentence boundary disambiguation” [25].

In the beginning, a naïve regular expression was used to detect sentence boundaries. After a while it proved insufficient and was replaced with a Perl script that accounts for quotation marks, parentheses, honorifics and abbreviations [26].

### 3.5 Computer solving

The fluency of a text is traditionally of relatively little significance to the area of Natural Language Understanding (NLU), since most NLU tasks are oriented towards extracting information expressed in natural language rather than information about the language itself [24].

Systems that can successfully distinguish between machine translated and human translated text have been implemented [27]; however, that a text is machine translated does not in itself mean that it would not be considered legible and fluent by a human judge.

#### 3.5.1 Gap amplification

Since a single Sentence First CAPTCHA challenge only has five possible options, the success rate of completely random guesses would be 20% at best (with all parts known), and even larger when any parts are unknown. However, as long as the human success rate is higher than the computer ditto, \( m \) and \( k < m \) can be chosen so that if a user must pass more than \( k \) out of \( m \) different challenges to be considered human, the success rates for the combined challenge can be adjusted arbitrarily. The cost of this success rate gap amplification is that users must complete more challenges, making the CAPTCHA more obtrusive and time consuming [2].

If the human success rate for single challenges is \( \beta \), the success rate for exactly \( k \) out of \( m \) challenges is, according to binomial probability:

\[
\binom{m}{k} \beta^k (1 - \beta)^{m-k}
\]

The success rate for more than \( k \) out of \( m \) challenges is thus:

\[
\sum_{i=k+1}^{m} \binom{m}{i} \beta^i (1 - \beta)^{m-i}
\]

Given a human success rate \( \beta \) and computer success rate \( \eta \), maximizing the security level while minimizing the number of needed challenges is a matter of finding the smallest \( m \) and \( k \) for which the following expression is true, with a minimum acceptable human success rate \( B \) and maximum acceptable computer success rate \( E \):

\[
\left\{ \begin{array}{l}
\sum_{i=k+1}^{m} \binom{m}{i} \beta^i (1 - \beta)^{m-i} \geq B \\
\sum_{i=k+1}^{m} \binom{m}{i} \eta^i (1 - \eta)^{m-i} \leq E 
\end{array} \right.
\]
3.6 Challenge generation

Since the system contains both known and unknown sentences and the challenges are repeated serially, the combined challenge can be generated in a way that optimizes security while still allowing for some unknown elements to gain ratings. For example, by deciding that all challenges should contain at least one known sentence, at least two (for a known good sentence) or three (for a known bad sentence) options are always known to be incorrect, allowing for a maximum possible success rate of 60% when guessing randomly, and lower for challenges containing more known parts. To receive even more ratings, completely unknown sentence pairs that do not count towards the minimum number of solved challenges can be inserted in a challenge set.

Additionally, the known sentences and sentence pairs must be chosen so that the correct answers are evenly distributed. Otherwise, an automatic solver that knows the most common correct answer gains an edge.

3.7 Reference implementation

A reference implementation of Sentence First CAPTCHA was created and a public demo is available online, at http://sentencefirst.net/challenge/. A screenshot is available in Appendix F.

4 Method

4.1 Choice of method

As our study was aimed at gathering data that our proposed CAPTCHA scheme could be applied to, we deemed a series of quantitative surveys the most applicable data collection method. Biggam expresses it like this:

Experimental research tends to be the domain of the scientist, where he attempts to test an hypothesis (i.e. a theory) through some type of experiment. He will first try to define the problem that he is looking at; next, he will formulate his hypothesis; and finally, he will implement his experiment to test whether or not his hypothesis was correct [28].

In our research, the proposal was the hypothesis and surveys were used to collect data that could be analysed to examine the feasibility of the proposal. Along with the experimental research we also conducted a literature review.

4.2 Literature review

To obtain the necessary background knowledge in the HIP area, a literature review was conducted. The main sources were articles from computer scientific databases. Many articles were collected from esteemed databases such as ACM Digital Library and IEEE Xplore. The Information retrieval was based on keywords such as: “CAPTCHA”, “Human Interactive Proof” etc. In addition to the systematic article search we also conducted a manual search of information from the reference lists from the respective articles to find other relevant articles.

4.2.1 Quality of sources

Doing the literature review, it was important to verify the credibility of the sources. However, we decided to trust that the resources available from scientific or academic libraries had been evaluated by researchers and publishers and are therefore accepted within the scientific community.
4.3 Work process

In the initial phase of the project a time plan was made, to allow for the parts to be carried out in the time frame of the capstone course. When the schedule was set, the literature review was initiated. The Markov chain sentence generation algorithm was then implemented. When the sentence generation was satisfactory, the process of designing the surveys began, using sentences generated by the algorithm as a basis. After the first sets of surveys had been handed out, a web survey was designed and implemented. When all survey answers were received, the answers were analysed and the participants were tested as if their answers had been to an actual CAPTCHA implementation. When we had received all the survey answers we started to analyse the data, we made charts and plots of interesting results and summarized the data into tables. Throughout the project, this report was written in parallel. Figure 6 shows the progress of the work as a flow chart.

We co-operated in the execution of every part of the project and the work effort was equal.

![Figure 6: Flow chart of work progress](image)

4.4 Surveys

To gather human response data, a quantitative study was performed, using three different surveys.

4.4.1 Purpose of the surveys

The main purpose of the study was to examine whether humans classify the fluency and legibility of sentences and sentence pairs consistently enough for the classifications to be usable as basis for a CAPTCHA scheme. It also examines how difficult humans perceive
this type of challenge and how willing they would be to face this kind of challenge when filling an online form. Some factors like age, gender and previous CAPTCHA experience are also collected, to be used in the later analysis. To allow for quick and easy participation, the surveys consisted of pre-printed questions and fields where the participants could fill in the answers [29].

The survey answers are treated as challenge answers from verified humans and are put into the database of the reference implementation, thus providing the system with a small training set of known (see section 3.2) sentences and sentence pairs.

4.4.2 Survey design

The main layout of the surveys is as follows:

- Questions about the participant:
  - Age
  - Gender
  - Previous encounters with OCR CAPTCHAs, along with a screenshot of a reCAPTCHA challenge.

- A number of sentence pairs for the participants to classify, as if they were Sentence First CAPTCHA challenges as described in section 3. Some were taken directly from the source texts (expected good) and some are generated from the source texts (unknown).

- Questions about the participant’s reactions and thoughts about the survey.
  - Clarity and difficulty of understanding the instructions.
  - Perceived difficulty of classifying the sentences and sentence pairs.
  - Whether the participant would be willing to be subjected to a test based around classifying sentences instead of an OCR CAPTCHA.

The first few sentence pairs were taken directly from the source texts. The purpose of this was to allow the participants to get accustomed to the concept before being presented with utter gibberish.

To encourage people to participate in the survey, prices donated from Mackmyra Svensk Whisky and cinema gift cards donated by Högskolan i Gävle were given out in a lottery amongst those of the participants who left their contact information.

4.4.3 The various surveys

The first survey was handed out to faculty members at Högskolan i Gävle. This survey consists of 6 sentence pairs in Swedish and 23 in English. It can be found in Appendix A. The number of sentence pairs was limited to reduce the time needed to complete the survey and reduce the risk of the participants getting tired and losing focus towards the end of the survey.

The second survey was handed out to a class of elementary school pupils in the eighth grade at a Swedish school and can be found in Appendix B. This was intended to make it more clear whether any correlation between age and concordance existed. This survey was even more limited in size than the first; since it was handed out during class the time was highly limited. Therefore, it consisted of 6 sentence pairs in Swedish and 13 in English. Some sentences were kept from the first survey and some were replaced, due to punctuation errors stemming from the shortcomings of the sentence segmentation algorithm that was initially used.
The third survey was a publicly available online survey available via social networks such as Facebook and Twitter. At the cost of subject control, this allowed for larger numbers of answers to be collected easily and at low cost. The web survey consisted of 20 sentence pairs, all in English, and was presented as a web page using a PHP/MySQL back-end. The answers from the web survey were immediately available for analysis from the database. Screenshots of the web survey can be found in Appendix C.

### 4.4.4 Differences between the surveys

The paper surveys consisted of sentence pairs in both Swedish and English, while the online survey only consisted of sentence pairs in English. The main reason for excluding the Swedish sentences is that it was supposed to be as short and unobtrusive as possible, while still providing as much data as possible.

### 5 Results from the survey

This section presents the results from the survey, together with our analysis. The sentence pairs used in the surveys can be found in Appendix D and the answers can be found in Appendix E. We received 22 answers from the first paper survey, 24 answers from the second and 72 answers from the web survey.

#### 5.1 Success rates

Correct answers were calculated according to the algorithm described in section 3.3, with minimum concordance levels of 80%, 85%, 90% and 95%. For each participant, the number of completed challenges (as per the rules described in section 3.2) was calculated. The ratio of this number to the number of challenges with at least one known part is then considered to be the success rate.

Increasing the minimum concordance generally increases the human success rate. This is because the sentence pairs with deviant classifications are less likely to reach the minimum concordance level and thus be used to identify wrong answers. This reduction in discriminating sentence pairs introduces noise in the results, as a single wrongful answer carries a greater impact. This is noticeable in Figure 7(d), where most participants fall in the $> 90\%$ range, but some appear in lower ranges than for the lower concordance levels. Figure 7 shows the distribution of average success rates for the different minimum concordance levels.

The success rates of the younger participants are more evenly spread out across the spectrum than those of the older participants for all concordance levels but the highest. Figure 8 shows the success rate distribution with the participants aged less than 20 separate from those aged 20 or more.

As the number of sentences and sentence pairs that can be used as discriminators decreases, so does the number of incorrect answers. Thus, the probability of guessing non-wrong answers by chance increases. The average success rates when randomly classifying the sentence pairs with at least one known element at minimum concordance levels 80%, 85%, 90% and 95% in the challenge sets of the two paper surveys and the web survey are listed in Table 1.

As can be seen in the table, the random success rates are greater than 50% for most minimum concordance levels and challenge sets. In light of this, human success rates for a challenge based on the classification of single sentences, based on the survey participants’ classifications of the separate sentences were calculated for minimum concordance levels of 80% and 85%, as shown in Figure 9. With minimum concordance levels of 90% and 95%, only 12 and 5 sentences respectively had sufficiently concordant ratings to be considered known, so those levels were left out.
Figure 7: Success rates for different minimum concordance levels

<table>
<thead>
<tr>
<th>C</th>
<th>P1</th>
<th>P2</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.80</td>
<td>43%</td>
<td>60%</td>
<td>56%</td>
</tr>
<tr>
<td>0.85</td>
<td>48%</td>
<td>63%</td>
<td>62%</td>
</tr>
<tr>
<td>0.90</td>
<td>60%</td>
<td>76%</td>
<td>72%</td>
</tr>
<tr>
<td>0.95</td>
<td>67%</td>
<td>80%</td>
<td>80%</td>
</tr>
</tbody>
</table>

Table 1: Random success rates, by minimum concordance and question set

5.2 Participants

Figure 10 shows the age distribution of the survey participants. As can be seen, most of the participants are of age 20-29. This is because most of the survey answers came from the web survey. Since it was primarily publicized through social networks, “friends of friends” had the highest probability of seeing it and participating and were thus more likely to participate. As of now, the difference in success rate distributions for participants with different genders and previous CAPTCHA experiences has not been analysed.

6 Discussion

6.1 Representativeness

In this study, we used surveys and a web survey to collect data to which the proposed CAPTCHA scheme could be applied, to provide indications about whether it could be practically useful.

Using a web survey for data collection, we cannot expect the participants to be representative of the whole world [30]. However, it is reasonable to argue that, to some degree, they are representable of the set of people who regularly encounter CAPTCHAs.
Figure 8: Success rates for different minimum concordance levels, ages less than 20 separate

\[ C = 0.8 \]

\[ C = 0.85 \]

\[ C = 0.9 \]

\[ C = 0.95 \]

\( \text{Figure 8: Success rates for different minimum concordance levels, ages less than 20 separate} \)

– i.e., we believe that people with social media presence are more likely to encounter CAPTCHAs than the general population, since the use of social media requires some degree of web literacy.

The intention of our study was never to be able to make claims about general human success rates, but rather a means of examining the feasibility of our proposed CAPTCHA scheme. Therefore, the calculations and predictions in the following sections are intended as indications rather than absolute truths about the usability of Sentence First CAPTCHA applicable to humanity as a whole.

6.2 Solvability and breakability

As noted in section 5.1, the success rates increase with higher minimum concordance levels, at the cost of a reduced growth rate of the challenge set, due to the decreased number of possible discriminators.

As our challenge set in the study consists solely of the sentences and sentence pairs the survey participants agree on, the number of discriminators decrease with the higher concordance levels, resulting in an increase in random guess success rates. This problem would be somewhat alleviated in an environment where the challenges are actually generated as described in section 3.6, since the sentences and sentence pairs used in actual challenges would be chosen based on their previous classifications.

At 85% minimum concordance, 80% of the participants had a success rate greater than 80%, which is the highest possible success rate of a completely random guess (i.e., the cases where only one alternative is positively incorrect). Since some sentence pairs are classified in a way that renders more than one answer incorrect, the success rate when guessing at random would be even lower, and thus the difference between human and random success rates would be larger.

As mentioned in section 3.5.1, any gap between human and computer success rates
can be amplified by repeating the challenge serially. For most concordance values, the human success rates – for both the proposed sentence pair classification scheme and for the improvised scheme based on the classification of single sentences described in section 5.1 – were above 80% for more than 80% of the participants.

In the following, we assume a 50% computer success rate ($\eta$) – as would be the case if a computer was guessing randomly when classifying single sentences, and comparable with the 20%-80% span of possible success rates when classifying a sentence pair with at least one known part – and a human success rate ($\beta$) of 80% for 80% of the users:

$$\begin{cases} 
\beta = 0.8 \\
\eta = 0.5
\end{cases}$$

By evaluating the expression for the success rate of a serially repeated challenge in section 3.5.1 with different $m$ and $k$ for both the human and computer success rates, the success rates of combined challenges were calculated, as shown in Table 2. By having users complete 10 out of 16 challenges to be considered human, 80% of the humans would be considered human in 92% of the cases and a computer guessing randomly
would be considered non-human 91% of the cases.

<table>
<thead>
<tr>
<th>m</th>
<th>k</th>
<th>$\beta_{m,k}$ (%)</th>
<th>$\eta_{m,k}$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>6</td>
<td>87.91</td>
<td>15.74</td>
</tr>
<tr>
<td>12</td>
<td>7</td>
<td>92.74</td>
<td>17.68</td>
</tr>
<tr>
<td>13</td>
<td>8</td>
<td>90.09</td>
<td>11.97</td>
</tr>
<tr>
<td>14</td>
<td>9</td>
<td>87.02</td>
<td>7.92</td>
</tr>
<tr>
<td>15</td>
<td>10</td>
<td>83.58</td>
<td>5.13</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>91.83</td>
<td>9.23</td>
</tr>
</tbody>
</table>

Table 2: Amplified success rates for $\beta = 0.8, \eta = 0.5$

Any CAPTCHA is a trade-off between usability and security – the more secure a CAPTCHA is, the less user friendly it gets [6]. To be practically useful, a CAPTCHA cannot be too obtrusive and time consuming [2].

As mentioned in section 2.3.4, several studies have been carried out where the human success rates when solving current audio CAPTCHAs were lower than 60%, and the challenges still required up to a minute of time to complete. Considering those results, having to classify 16 sentences or sentence pairs may actually be less time consuming and obtrusive if 80% of the users pass 92% of the time.

Additionally, as Sentence First CAPTCHA is completely based in the text domain, it is equally accessible to both visually and audially impaired (see section 6.7).

6.3 Age and success rate

As noted in section 5.1, the success rate distribution is generally more spread out for the youngest group of participant than for the other age groups. However, many of the participants in the youngest group still have success rates higher than 80%. This indicates that Sentence First CAPTCHA may be less suitable when protecting services or resources intended to be accessible by younger users – and possibly users with less fluency in English, including people with cognitive disabilities – but not enough to be effectively used as an age limit barrier. Nevertheless, for very young people, which are not literate or have not developed a good semantical understanding, we are positive that Sentence First CAPTCHA can be used as a barrier.

6.4 Security measures

If Sentence First CAPTCHA were to be used in a production environment, it could easily be accompanied by a few simple measures to improve the security:

- Sentences and sentence pairs should be removed from the set used for generating discriminating challenges when they have been used as such a certain number of times to prevent large scale indexing of sentence pair classifications.

- A limit to the number of challenge responses submitted from a host within a certain time frame, possibly combined with IP blocking, to counter parallel brute force attacks.

- Assuming humans cannot read, parse and classify a sentence pair in less than a few seconds, a minimum time between challenge generation and response would hardly be noticed by human users but could severely increase the cost of serial brute force attacks.
6.5 Text sources

During and after doing the surveys we received some comments about the source texts. Many participants recognized that the original text partially came from *Alice’s adventures in Wonderland* and they wondered why we chose literature containing difficult language and strange expressions. As stated in section 3.4.2, the main reason for using the texts we used was availability.

We understand that different authors write different texts, with different styles in terms of expression and language. People perceive texts differently in terms of various difficulties. These thing are hard to take into account when generating sentences. A solution to this might be to have a larger dataset of source texts. We have raised this subject in section Future work.

Since the text generation algorithm retains some of the authorial style of the input texts, it follows that humans who react in certain ways to the works of certain authors react similarly to text generated from the same works. With a sufficiently large dataset, a nearest neighbour algorithm may account for diverse tastes and understandings of specific authorial styles better.

6.6 Does Sentence First qualify as a CAPTCHA? – P as in Public

The public criteria is one that breaks several CAPTCHA proposals, due to the need of an ever growing set of challenges [9, 8]. In the case of Sentence First, the source texts do not need to be kept secret, since the generated texts are not in the source texts. Even if a sentence straight from a published work would be used in a challenge there is no guarantee that previous users have classified it as legible and fluent, although the probability would of course be a lot higher.

Godfrey dismissed an imagined CAPTCHA based on distinguishing between coherent and incoherent text because of the difficulty of generating known good texts that cannot be classified as such computationally [8]. However, by using answers from previous users to determine whether a sentence is good or bad, the need for a replenishable source of known good text is worked around – the process of generating random sentences and having users classify them is essentially a way of generating known good sentences by means of brute force.

If one considers also the answers from users – and thus all sentence and sentence pair classifications – part of the dataset, Sentence First CAPTCHA should not be considered a CAPTCHA. However, keeping the answers secret is key in any social feedback (e.g. [17]) or collaborative filtering (e.g. [9]) CAPTCHA. Otherwise, a perpetrator could use the same – publicly known – algorithm as the CAPTCHA on the data to calculate the “correct” answers. Thus, we do not consider keeping the answers secret a problem.

To summarize, we believe that Sentence First CAPTCHA can indeed be considered a CAPTCHA.

6.7 Why text domain?

As stated in the introduction, audio and image based CAPTCHA schemes discriminate against the visually and audially impaired. Since a text domain CAPTCHA doesn’t rely on a single sense, it can be presented through any medium through which written language can be expressed – it could even be used by people who are both visually and audially impaired using Braille terminals with little or no modification. Additionally, it is equally useful in a text based web browser, e.g., for terminal mode Linux users.

Compared to images, a text string is easier to store in a database and requires less storage space and bandwidth. It also takes less computing cost when generating and grading a challenge.

Unlike most image based CAPTCHA schemes, a text based CAPTCHA has to rely on language understanding in some way. Thus, Sentence First CAPTCHA may
discriminate against people with insufficient lingual proficiency.

6.7.1 Other areas of use

Sentence First CAPTCHA may be useful in other areas, not only as a CAPTCHA.

- Sentence First CAPTCHA may be used as a language learning tool, by having users complete challenges to verify their perception of written texts.
- Additionally, Sentence First CAPTCHA may be useful as a text validation tool, e.g. by inserting texts that need to be verified as fluent, legible and coherent in the challenge sets.

7 Conclusions

We have proposed Sentence First CAPTCHA, a text domain CAPTCHA which presents the user to a set of sentence pairs.

7.1 Pros and cons of the proposed CAPTCHA scheme

7.1.1 Pros

- As it is completely text based, Sentence First CAPTCHA does not discriminate against any sensory disabilities and can be presented through any medium through which written language can be expressed.
- If Sentence First CAPTCHA proves to be acceptably secure and reasonably usable it solves the open problem of constructing a text domain CAPTCHA as stipulated in [2].
- Unlike the audio CAPTCHAs currently in use, which rely on a difficult challenge that even humans have a hard time solving, Sentence First CAPTCHA consists of challenges that can be repeated serially to produce a combined challenge with a arbitrarily high human success while remaing difficult for bots to break.
- If Sentence First CAPTCHA was to be used extensively to protect real resources, it would force malicious CAPTCHA breaking program developers to aid in the fluency and semantic coherency recognizing abilities of NLU algorithms, just like the current OCR based CAPTCHAs have stimulated the development of advanced OCR software.

7.1.2 Cons

- Due to Sentence First CAPTCHA being a multiple-choice question CAPTCHA by design, a computer guessing randomly has a relatively high success rate. This can be alleviated by repeating the challenge serially.
- ... which introduces the possible problem of Sentence First CAPTCHA having to present a relatively high number of challenges to be reasonably secure, requiring users to spend more time solving it.

7.2 How usable is Sentence First CAPTCHA as a CAPTCHA?

The results of our study imply that Sentence First CAPTCHA may provide higher human success rates than current CAPTCHA schemes accessible by visually impaired users. It would also work on Braille terminals since it is based in the text domain, making it accessible to both visually and audially impaired users – unlike any CAPTCHA scheme currently in use.
We have shown that the human edge over a randomly guessing computer can be amplified through serial repetition, at the cost of the larger number of challenges increasing the time needed to solve the CAPTCHA and making it more obtrusive. However, the scope of this study does not allow for further examination of the computer success rates, especially when employing NLU algorithms to analyze the sentences and sentence pairs, but we are confident humans have an edge.

7.3 How does age affect success rate?

The success rates among the participants aged 13-19 are more evenly distributed than the ones of the rest of the participants. However, a large portion of the group still had sufficiently high success rates to be considered human in most cases.

Thus, we conclude that Sentence First CAPTCHA might be more difficult for younger users to solve. However, it cannot reliably be used as an age barrier, except for really young ages.

8 Future work

For Sentence First CAPTCHA to be used as a CAPTCHA in a production environment, some additional research may be needed. Our suggestions for future work are:

**Interface optimization:** For Sentence First CAPTCHA to be truly accessible to the visually and audially impaired, the challenge presentation has to be optimized for, and tested with, Text To Speech (TTS) and braille terminals.

**Collaborative filtering:** With a large answer set, users with similar but eccentric tastes or understandings of language might appear as clusters, allowing for the use of collaborative filtering algorithms to determine if users are human even when their classifications deviate from the norm.

**Source text influence:** Any impact the choice of source texts – and possibly combinations of several source texts – has on the concordance in classifications should be examined.

**User contributed text:** Another possible source of texts may be user-contributed comments and forum posts, which are sometimes poorly written, grammatically questionable and contain internet slang or “text talk.” Since they are human-written but not necessarily fluent and coherent, they may be more difficult for computers to classify.

**Combination:** By combining the collaborative filtering approach above with the text source suggestions, one might be able to create a CAPTCHA that allows users with widely different lingual preferences and tastes pass by accounting for the widely different language styles used in the different source texts.

**Larger scale study:** To produce statistically significant results, a larger scale study with truly randomized samples should be carried out.

**Observational study:** Another possible approach to examine the feasibility of Sentence First CAPTCHA is to perform a study where participants are observed while classifying sentences. In this kind of study, the participants' reactions to the sentence pair classification task can be observed and any problems or confusions that arise may be discovered and addressed.
Acknowledgements

We would like to thank everyone who participated in our surveys, without whom the study would never could have been carried out. Many thanks go to David Sundgren for the help with statistics and probabilities he provided. We would also like to thank Högskolan i Gävle and Mackmyra Whiskey for providing us with prizes for our lottery. Last but not least, a special thank you goes to our supervisor Jonas Boustedt for pushing us, guiding us and offering valuable advice.
References


Appendix A: Paper Survey 1 – Faculty members at Högskolan i Gävle
Enkät

Ibland behöver man kunna skilja på människor och datorer automatiskt. Till exempel då man ska registrera ett konto på någon websida. För att skilja människor och datorer åt används ett slags test som kallas CAPTCHA. Ofta består dessa av en bild föreställandes en förvrängd text som användaren ska skriva in för att bevisa att den är en människa.

Optisk CAPTCHA

Vi utreder ett alternativt sätt att skilja datorer och människor åt, som bygger på läsförståelse och språkkänsla. Den här enkäten handlar i stora drag om att vi vill ha hjälp med att bedöma ett antal meningar som presenteras parvis. För varje meningspar vill vi att du markerar vilket eller vilka av följande påståenden är sanna:

- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

Om ingen av meningarna är begriplig och välformulerad markerar du inget alternativ.


Den första delen av enkäten består av meningspar på svenska och den andra består av meningar på engelska. I slutet av varje del finns det ett par frågor där du får berätta vad du tyckte om delen.

Viktigt att komma ihåg är att det är du som bestämmer vilka meningar du tycker är läsliga och vilka meningspar som är sammanhängande—det finns inget rätt eller fel!

Exempelmeningar

Nedan följer några exempel på meningar som vi som gjort enkäten bedömt och fyllt i.

0. Var är du?

Den lilla stugan, vägrade hon att tala med far och mor, utan han gick fram i nästan oavbruten rad.
- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

0. Pojken var så skulle vilja locka jägarna, så pass kunnig simmare.

Det är svårt att i timtal bredvid dem, att ge också i dem.
- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

Exempelmeningar

Nedan följer några exempel på meningar som vi som gjort enkäten bedömt och fyllt i.

0. Karlen väntade nu, tills vargarna var aldeles inpå släden.

Då välte han det stora karet ner på isen, sprang själv efter och kröp in under det.
- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.
Meningar på svenska

1. Med detsamma stötte han spjutet ner i vattnet.
När han lyfte det, följde en lång, präktig ål med upp ur djupet.
- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

2. Det var inte utan, att den har varit rubbad!
Det kommer inga jägare hit till snären.
- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

3. Himlen var inte längre blå, utan den såg ut att kunna bli något duktigt av den.
Men han fann ingen där, och nu såg studenten de lösa bladen i handskriften virvla ut genom fönstret.
- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

Han springer framåt den trikkanfattade allén, över de små broarna, upp igenom blomsteranläggningarna, in genom porten.
- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

5. Sedan drog de sig lugna.
Medan husbondefolket talade om, ingenting emot.
- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

6. Därmed bröto upp i sin kosa som om han ensam hemma i Bergslagerna, som kommo och i ett par kamrater.
Ön är en pöl med en älvstrand och strax därpå såg, när det har kommit vandrande för att de majestätsk ut på denna kväll.
- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

Frågor

1. Hur upplevde du meningarna?
- lätt att bedöma □——□——□——□——□ svåra att bedöma

2. Egna tankar, åsikter och synpunkter:
Meningar på engelska

1. The first witness was the Hatter.
   He came in with a teacup in one hand and a piece of bread and butter in the other.
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

2. Down, down, down!
   Would the fall never come to an end?
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

3. He took me for his housemaid!
   said Alice, as she ran off.
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

4. Just then Alice ran across the Duchess (who was now out of prison).
   Nobody moved.
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

5. It is a long tail, certainly, said Alice, but I haven’t been invited yet.
   Please would you tell me, please, said Alice, because I’m not myself, you see—being so many
   different sizes in a day is very confusing.
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

6. Then the Queen left off, quite out of breath, and walked away with Alice.
   The Queen!
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

7. I must be growing small again.
   I quite forgot you didn’t like cats.
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

8. Edwin and Morcar, the Earls of Mercia and Northumbria – Ugh!
   Not at all, said Alice.
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.
9. There was exactly one a-piece, all round.
Suddenly their eyes chanced to fall upon Alice, as she ran off.

10. Suddenly their eyes chanced to fall upon Alice, as she was small enough to get through was more hopeless than ever.
She caught the flamingo and tucked it away under her arm, that it might not escape again.

11. She ate a little bit and said anxiously to herself, Which way?
Her first idea was that she had somehow fallen into the sea.

12. She tucked her arm affectionately into Alice's.
You may go, said the King.

13. Edwin and Morcar, the Earls of Mercia and Northumbria – Ugh!
Not at all, said Alice.

14. I haven't the slightest idea, said the Dodo, the best way to explain it is to do it.
This question the Dodo could not answer without a great deal too far off to trouble myself about you.

15. I must be on the look-out for serpents, night and day!
I've tried banks, and I've tried hedges, the Pigeon went on, but those serpents!

16. She said it to the garden, and the White Rabbit cried out Silence in the other, saying, in a solemn tone, Why, Mary Ann!
I haven't been invited yet.
17. All persons more than a rat-hole; she knelt down and cried.
Not like cats.

- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

18. The Fish-Footman began by producing from under his arm a great deal too far off to trouble myself about you.
–Who s to go with Edgar Atheling to meet William and offer him the crown.

- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

19. Exactly so, said the Duchess?
Let s go on with the Dormouse.

- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

20. She took the way through the legs of tiny golden key was quite forgetting that beautiful garden–how is the wood.
said her eye; but they would go, as she would bend about and she had lost.

- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

21. Hush!
She was just as she should frighten them, on one end of the Mouse was talking familiarly with its full effect and then at last!

- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

22. It was dead leaves that it continued the first at the Dodo, finding that, said Alice heard yet?
It is you are; and she tried the number of mushroom (she had never left off.

- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

23. She stretched her head pressing against it a little glass.
Who is to-day!

- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

Frågor

1. Hur upplevde du meningarna?
lätta att bedöma □□□□□ svåra att bedöma

2. Egna tankar, åsikter och synpunkter:
Allmänna frågor

1. Hur tydliga och lättförståeliga var instruktionerna?
   □ lätt ——— □ □ □ □ □ svårt

2. Hur gammal är du?
   □ 0-12
   □ 13-19
   □ 20-29
   □ 30-39
   □ 40-49
   □ 50-59
   □ 60-

3. Kön?
   □ Man
   □ Kvinna

4. Har du stött på en CAPTCHA på Internet någon gång?
   □ Ja, många gånger
   □ Ja, någon gång
   □ Nej, aldrig

5. Skulle du kunna tänka dig att bedöma meningsspar som i enkäten istället för att fylla i en CAPTCHA när du registrerar dig på en sida på Internet?
   □ aldrig ——— ——— ——— ——— ——— □ absolut
Appendix B: Paper Survey 2 – Elementary school pupils
Enkät

Ibland behöver man kunna skilja på människor och datorer automatiskt. Till exempel då man ska registrera ett konto på någon websida. För att skilja människor och datorer åt används ett slags test som kallas CAPTCHA. Ofta består dessa av en bild föreställandes en förvrängd text som användaren ska skriva in för att bevisa att den är en människa.

Optisk CAPTCHA

Vi utreder ett alternativt sätt att skilja datorer och människor åt, som bygger på läsförståelse och språkkänsla. Den här enkäten handlar i stora drag om att vi vill ha hjälp med att bedöma ett antal meningar som presenteras parvis. För varje meningspar vill vi att du markerar vilket eller vilka av följande påståenden är sanna:

- Första meningen är begriplig och välformulerad.
- Andra meningen är begriplig och välformulerad.
- Meningarna är sammanhängande som en följd.

Om ingen av meningarna är begriplig och välformulerad markerar du inget alternativ.

Om du stöter på ett ord du inte förstår, försök att lista ut vad det betyder i sammanhanget eller, om det inte går, bedöma meningen efter magkänslan!

Den första delen av enkäten handlar av meningar på svenska och den andra av meningar på engelska. I slutet av varje del finns det ett par frågor där du får berätta vad du tyckte om enkäten.

Viktigt att komma ihåg är att det är du som bestämmer vilka meningar du tycker är läsliga och vilka meningspar som är sammanhängande; det finns inget rätt eller fel!

Exempelmeningar

Nedan följer några exempel på meningar som vi som gjort enkäten bedömde och fyllt i.

0. Karlen väntade nu, tills vargarna var aldeles in på släden. Då valte han det stora karet ner på isen, sprang själv efter och kröp in under det.
  ☒ Första meningen är begriplig och välformulerad.
  ☒ Andra meningen är begriplig och välformulerad.
  ☐ Meningarna är sammanhängande som en följd.

0. Var är du? Den lilla stugan, vägrade hon att tala med far och mor, utan han gick fram i nästan oavbruten rad.
  ☒ Första meningen är begriplig och välformulerad.
  ☐ Andra meningen är begriplig och välformulerad.
  ☐ Meningarna är sammanhängande som en följd.

0. Pojken var så skulle vilja locka jågarna, så pass kunnig simmare. Det är svårt att i timtal bredvid dem, att ge också i dem.
  ☐ Första meningen är begriplig och välformulerad.
  ☐ Andra meningen är begriplig och välformulerad.
  ☐ Meningarna är sammanhängande som en följd.
Meningar på svenska

   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

2. Man kan räka ut för dimma mitt på sommaren, och om hösten kan man säga att det knappt är möjligt att undgå den. Vad Nils Holgersson beträffar, så hade han haft bra nog väder, så länge som han var kvar i Lappland, men vildgässet hunno knappt röra ut, att de nu foro in i Jämtland, förrän dimmorna tättade omkring honom, så att han inte kunde se något av landet.
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

3. Får vi se, får vi se?
   Vi led svart av hunger, och en gång gick vi opp i rämmen här på skäret och sökte efter mat.
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

5. Se nu kommer jag till det fattiga fjällfolket och tyckte, att jag var kväll skulle läsa predikan eller inte. Och han talade, stillades hans gråt, och detta var gjort, som fanns till hands och passade det på de blanka kopparkärlen under taket.
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

6. Människorna, ställde sig svarta, den, att släcka branden skulle hamna på sin börn. Snarare tyckte så att det för dem voro riktigt skulle bli sjuk, tänkte pojen hade de började oförskräckt.
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

Frågor

1. Hur upplevde du meningarna?
   □ lätt att bedöma □□□□□ □ svåra att bedöma

2. Egna tankar, åsikter och synpunkter:
   __________________________________________
   __________________________________________
   __________________________________________
Meningar på engelska

1. The first witness was the Hatter.
He came in with a teacup in one hand and a piece of bread and butter in the other.
☐ Första meningen är begriplig och välformulerad.
☐ Andra meningen är begriplig och välformulerad.
☐ Meningarna är sammanhängande som en följd.

2. Down, down, down!
Would the fall never come to an end?
☐ Första meningen är begriplig och välformulerad.
☐ Andra meningen är begriplig och välformulerad.
☐ Meningarna är sammanhängande som en följd.

3. You bring Mrs. Oakshott here and I'll answer her, but what have you ever known of self-denial and dependence?
When have you been prevented by want of money from going wherever you chose, or procuring anything you had a particularly malignant boot-slitting specimen of the London slavey.
☐ Första meningen är begriplig och välformulerad.
☐ Andra meningen är begriplig och välformulerad.
☐ Meningarna är sammanhängande som en följd.

4. It is a long tail, certainly, said Alice, but I haven't been invited yet.
Please would you tell me, please, said Alice, because I'm not myself, you see–being so many different sizes in a day is very confusing.
☐ Första meningen är begriplig och välformulerad.
☐ Andra meningen är begriplig och välformulerad.
☐ Meningarna är sammanhängande som en följd.

5. Her prudent mother, occupied by the same cause from confiding in my cousin; and that there would be no chance of a train back.
I should be very glad to see them; anything was a welcome relief to him at once to the rooms which we are to be deduced from it.
☐ Första meningen är begriplig och välformulerad.
☐ Andra meningen är begriplig och välformulerad.
☐ Meningarna är sammanhängande som en följd.

6. There was exactly one a-piece, all round.
Suddenly their eyes chanced to fall upon Alice, as she ran off.
☐ Första meningen är begriplig och välformulerad.
☐ Andra meningen är begriplig och välformulerad.
☐ Meningarna är sammanhängande som en följd.

7. Suddenly their eyes chanced to fall upon Alice, as she was small enough to get through was more hopeless than ever.
She caught the flamingo and tucked it away under her arm, that it might not escape again.
☐ Första meningen är begriplig och välformulerad.
☐ Andra meningen är begriplig och välformulerad.
☐ Meningarna är sammanhängande som en följd.

8. She ate a little bit and said anxiously to herself, Which way?
Her first idea was that she had somehow fallen into the sea.
☐ Första meningen är begriplig och välformulerad.
☐ Andra meningen är begriplig och välformulerad.
☐ Meningarna är sammanhängande som en följd.
9. She tucked her arm affectionately into Alice's.
   You may go, said the King.
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

10. No man of common humanity, no man who had behaved with such forbearance and liberality towards him.
   And there are several of them you see uncommonly pretty.
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

11. She wished, she feared that the master of the house heard with real sorrow that they were very unfit to have the happiest memories in the world.
   “You will excuse this mask,” continued our strange visitor.
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

12. If you received it on a Bible.
   Oh, don't bring it into court!
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

13. He made her an offer in this very room, and she refused him.
   The consequence of it is, that Lady Lucas will have a regular prison bath; and I think, if you saw him, you would agree with Lady Lucas.
   □ Första meningen är begriplig och välformulerad.
   □ Andra meningen är begriplig och välformulerad.
   □ Meningarna är sammanhängande som en följd.

Frågor

1. Hur upplevde du meningarna?
   lätt att bedöma □ — □ — □ — □ svåra att bedöma

2. Ega tankar, åsikter och synpunkter:
Allmänna Frågor

1. Hur tydliga och lättförståeliga var instruktionerna?
   □ lätt □——□——□——□—— □ svårt

2. Kän?
   □ Man
   □ Kvinnan

3. Har du stött på en CAPTCHA på Internet någon gång?
   □ Ja, många gånger
   □ Ja, någon gång
   □ Nej, aldrig

4. Skulle du kunna tänka dig att bedöma meningspar som i enkäten istället för att fylla i en CAPTCHA när du registrerar dig på en sida på Internet?
   □ aldrig □——□——□——□—— □ absolut
Appendix C: Web survey screenshots

Välkommen!

Denna enkät är en del av vårt examensarbete i datavetenskap, där vi utreder om läsförståelse och språkkänsla kan utnyttjas för att skilja människor från datorer.


Tack för din medverkan! / Robert och Patrik

---

Frågor om dig

Din ålder?
- 0-12
- 13-19
- 20-29
- 30-39
- 40-49
- 50-59
- 60+

Ditt kön?
- Man
- Kvinna

E-post

---

Kort om CAPTCHA

Ibland behöver man kunna skilja på människor och datorer automatiskt. Till exempel då man ska registrera ett konto på någon webbsida. För att skilja människor och datorer åt används ett slags test som kallas CAPTCHA. Ofta består dessa av en bild forestallandes en förvånad text som användaren ska skriva in för att bevisa att den är en människa.

---

Har du stött på en CAPTCHA någon gång?
- Ja, många gånger
- Ja, någon gång
- Nej, aldrig

---

38
Nu börjar det...

Den här enkäten handlar i stora drag om att vi vill ha hjälp med att bedöma ett antal meningar som presenteras parvis.

För varje meningsspar vill vi att du markerar vilket av följande påståenden som är sant:

- Den första meningen är begriplig och välformulerad.
- Den andra meningen är begriplig och välformulerad.
- Båda meningarna är begripliga och välformulerade.
- Meningarna är sammankopplade som en följd.
- Ingen av meningarna är begriplig och välformulerad.

Om du stöter på ett ord du inte förstår, försök att lista ut vad det betyder i sammanhanget eller om det inte går, bedöm meningen efter magikanslan!

Meningspar 1

The first witness was the Hatter.

He came in with a teacup in one hand and a piece of bread and butter in the other.

- Den första meningen är begriplig och välformulerad.
- Den andra meningen är begriplig och välformulerad.
- Båda meningarna är begripliga och välformulerade.
- Meningarna är sammankopplade som en följd.
- Ingen av meningarna är begriplig och välformulerad.

Avslutande frågor

Hur tydliga och lättförståeliga var instruktionerna?

Tydliga och lätt att förstå — ○ — ○ — ○ — ○ — ○

Tydliga och svåra att förstå

Hur upplevde du meningarna?

Lätta att bedöma — ○ — ○ — ○ — ○ — ○

Svåra att bedöma

Skulle du kunna tänka dig att bedöma ett antal meningsspar som i denna enkät istället för att fylla i en traditionell CAPTCHA när du registrerar dig på en sida på Internet?

Aldrig — ○ — ○ — ○ — ○ — ○ — Absolut

Sida: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

Kontakt info@eniekansla.net

39
# Appendix D: Sentences

Table 3: Sentences used in surveys

<table>
<thead>
<tr>
<th>Pair</th>
<th>Sentences</th>
</tr>
</thead>
</table>
| 1    | The first witness was the Hatter.  
He came in with a teacup in one hand and a piece of bread and butter in the other. |
| 2    | Down, down, down!  
Would the fall never come to an end? |
| 3    | You bring Mrs. Oakshott here and I’ll answer her, but what have you ever known of self-denial and dependence?  
When have you been prevented by want of money from going wherever you chose, or procuring anything you had a particularly malignant boot-slitting specimen of the London slavey |
| 4    | It is a long tail, certainly, said Alice, but I haven’t been invited yet.  
Please would you tell me, please, said Alice, because I m not myself, you see–being so many different sizes in a day is very confusing. |
| 5    | Her prudent mother, occupied by the same cause from confiding in my cousin; and that there would be no chance of a train back.  
I should be very glad to see them; anything was a welcome relief to him at once to the rooms which we are to be deduced from it. |
| 6    | There was exactly one a-piece, all round.  
Suddenly their eyes chanced to fall upon Alice, as she ran off. |
| 7    | Suddenly their eyes chanced to fall upon Alice, as she was small enough to get through was more hopeless than ever.  
She caught the flamingo and tucked it away under her arm, that it might not escape again. |
| 8    | She ate a little bit and said anxiously to herself, Which way?  
Her first idea was that she had somehow fallen into the sea. |
| 9    | She tucked her arm affectionately into Alice’s.  
You may go, said the King. |
| 10   | No man of common humanity, no man who had behaved with such forbearance and liberality towards him.  
And there are several of them you see uncommonly pretty. |
| 11   | She wished, she feared that the master of the house heard with real sorrow that they were very unfit to have the happiest memories in the world.  
“You will excuse this mask,” continued our strange visitor. |
| 12   | If you received it on a Bible.  
Oh, don’t bring it into court! |
| 13   | He made her an offer in this very room, and she refused him.  
The consequence of it is, that Lady Lucas will have a regular prison bath; and I think, if you saw him, you would agree with Lady Lucas. |
| 14   | He took me for his housemaid!  
said Alice, as she ran off. |
| 15   | Just then Alice ran across the Duchess (who was now out of prison).  
Nobody moved. |
| 16   | It is a long tail, certainly, said Alice, but I haven’t been invited yet.  
Please would you tell me, please, said Alice, because I m not myself, you see–being so many different sizes in a day is very confusing. |

Continued on next page
<table>
<thead>
<tr>
<th>Pair</th>
<th>Sentences</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Then the Queen left off, quite out of breath, and walked away with Alice. The Queen!</td>
</tr>
<tr>
<td>18</td>
<td>I must be growing small again.</td>
</tr>
<tr>
<td></td>
<td>I quite forgot you didn’t like cats.</td>
</tr>
<tr>
<td>19</td>
<td>Edwin and Morcar, the Earls of Mercia and Northumbria – Ugh!</td>
</tr>
<tr>
<td></td>
<td>Not at all, said Alice.</td>
</tr>
<tr>
<td>20</td>
<td>Suddenly their eyes chanced to fall upon Alice, as she was small enough to get through was more hopeless than ever.</td>
</tr>
<tr>
<td></td>
<td>She caught the flamingo and tucked it away under her arm, that it might not escape again.</td>
</tr>
<tr>
<td>21</td>
<td>She ate a little bit and said anxiously to herself, Which way?</td>
</tr>
<tr>
<td></td>
<td>Her first idea was that she had somehow fallen into the sea.</td>
</tr>
<tr>
<td>22</td>
<td>I haven’t the slightest idea, said the Dodo, the best way to explain it is to do it.</td>
</tr>
<tr>
<td></td>
<td>This question the Dodo could not answer without a great deal too far off to trouble myself about you.</td>
</tr>
<tr>
<td>23</td>
<td>I must be on the look-out for serpents, night and day!</td>
</tr>
<tr>
<td></td>
<td>I’ve tried banks, and I’ve tried hedges, the Pigeon went on, but those serpents!</td>
</tr>
<tr>
<td>24</td>
<td>She said it to the garden, and the White Rabbit cried out Silence in the other, saying, in a solemn tone, Why, Mary Ann!</td>
</tr>
<tr>
<td></td>
<td>I haven’t been invited yet.</td>
</tr>
<tr>
<td>25</td>
<td>All persons more than a rat-hole; she knelt down and cried.</td>
</tr>
<tr>
<td></td>
<td>Not like cats.</td>
</tr>
<tr>
<td>26</td>
<td>The Fish-Footman began by producing from under his arm a great deal too far off to trouble myself about you.</td>
</tr>
<tr>
<td></td>
<td>–Who’s to go with Edgar Atheling to meet William and offer him the crown.</td>
</tr>
<tr>
<td>27</td>
<td>Exactly so, said the Duchess?</td>
</tr>
<tr>
<td></td>
<td>Let’s go on with the Dormouse.</td>
</tr>
<tr>
<td>28</td>
<td>She took the way through the legs of tiny golden key was quite forgetting that beautiful garden–how is the wood.</td>
</tr>
<tr>
<td></td>
<td>said her eye; but they would go, as she would bend about and she had lost.</td>
</tr>
<tr>
<td>29</td>
<td>Hush!</td>
</tr>
<tr>
<td></td>
<td>She was just as she should frighten them, on one end of the Mouse was talking familiarly with its full effect and then at last!</td>
</tr>
<tr>
<td>30</td>
<td>It was dead leaves that it continued the first at the Dodo, finding that, said Alice heard yet?</td>
</tr>
<tr>
<td></td>
<td>It is you are; and she tried the number of mushroom (she had never left off.</td>
</tr>
<tr>
<td>31</td>
<td>She stretched her head pressing against it a little glass.</td>
</tr>
<tr>
<td></td>
<td>Who is to-day!</td>
</tr>
</tbody>
</table>
Appendix E: Survey answers

Table 4: Answer key

<table>
<thead>
<tr>
<th>Answer</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Neither of the sentences is legible and fluent.</td>
</tr>
<tr>
<td>1</td>
<td>Only the first sentence is legible and fluent.</td>
</tr>
<tr>
<td>2</td>
<td>Only the second sentence is legible and fluent.</td>
</tr>
<tr>
<td>3</td>
<td>Both sentences are legible and fluent but do not fit together semantically.</td>
</tr>
<tr>
<td>4</td>
<td>Both sentences are legible and fluent and they fit together semantically.</td>
</tr>
</tbody>
</table>

Table 5: Paper survey 2 answers

<table>
<thead>
<tr>
<th>Age</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>13−19</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>13−19</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>13−19</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>13−19</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
### Table 6: Paper survey 1 answers

| Age   | 1 | 2 | 6 | 7 | 8 | 9 | 14 | 15 | 16 | 17 | 18 | 19 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|-------|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 40–49 | 4 | 0 | 2 | 2 | 3 | 3 | 4 | 3 | 1 | 1 | 0 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 0 | 0 | 0 |
| 30–39 | 4 | 4 | 1 | 2 | 1 | 4 | 4 | 2 | 2 | 1 | 2 | 2 | 1 | 4 | 2 | 2 | 2 | 0 | 0 | 0 | 0 |
| 40–49 | 4 | 4 | 3 | 0 | 3 | 4 | 4 | 3 | 1 | 2 | 3 | 3 | 1 | 1 | 2 | 0 | 2 | 3 | 0 | 0 | 0 | 1 |
| 30–39 | 4 | 4 | 3 | 2 | 3 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 2 | 4 | 0 | 1 | 0 | 2 |
| 30–39 | 4 | 4 | 3 | 2 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 1 | 4 | 3 | 2 | 2 | 4 | 0 | 1 | 0 | 1 |
| 60+   | 4 | 4 | 3 | 2 | 3 | 3 | 4 | 4 | 2 | 1 | 2 | 3 | 1 | 3 | 2 | 2 | 0 | 3 | 0 | 1 | 0 | 1 |
| 50–59 | 4 | 3 | 0 | 2 | 3 | 3 | 1 | 2 | 0 | 4 | 2 | 3 | 1 | 3 | 2 | 2 | 2 | 0 | 0 | 1 | 0 |
| 50–59 | 4 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20–29 | 4 | 4 | 0 | 0 | 2 | 2 | 4 | 4 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 0 | 1 | 0 |
| 40–49 | 4 | 4 | 2 | 2 | 3 | 2 | 4 | 2 | 2 | 0 | 2 | 2 | 1 | 4 | 2 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| 30–39 | 2 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 1 | 1 | 2 | 3 | 3 | 4 | 3 | 3 | 4 | 4 | 0 | 4 | 3 | 4 |
| 20–29 | 4 | 4 | 2 | 2 | 3 | 2 | 4 | 3 | 2 | 1 | 3 | 3 | 1 | 1 | 2 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| 50–59 | 4 | 4 | 0 | 0 | 2 | 2 | 4 | 4 | 4 | 2 | 4 | 0 | 0 | 2 | 2 | 2 | 4 | 4 | 1 | 1 | 3 |
| 60+   | 4 | 4 | 4 | 2 | 4 | 4 | 0 | 4 | 4 | 4 | 3 | 1 | 4 | 4 | 0 | 2 | 4 | 0 | 0 | 0 | 4 |
| 30–39 | 3 | 4 | 2 | 2 | 3 | 4 | 4 | 2 | 2 | 1 | 3 | 3 | 4 | 4 | 2 | 2 | 2 | 3 | 0 | 0 | 0 |
| 50–59 | 4 | 4 | 2 | 2 | 3 | 4 | 0 | 0 | 2 | 2 | 1 | 1 | 0 | 4 | 2 | 2 | 4 | 0 | 0 | 0 | 4 |
| 20–29 | 4 | 4 | 0 | 3 | 3 | 3 | 4 | 2 | 0 | 1 | 3 | 2 | 0 | 1 | 2 | 0 | 0 | 3 | 0 | 0 | 0 |
| 60+   | 4 | 4 | 2 | 2 | 3 | 2 | 4 | 2 | 0 | 4 | 4 | 3 | 0 | 1 | 2 | 2 | 0 | 3 | 0 | 0 | 0 |
| 50–59 | 4 | 4 | 2 | 3 | 4 | 3 | 4 | 4 | 4 | 3 | 3 | 1 | 4 | 4 | 3 | 2 | 4 | 0 | 0 | 0 | 2 |
| 60+   | 2 | 3 | 0 | 2 | 3 | 3 | 4 | 2 | 0 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2 | 4 | 0 | 0 | 0 |
| 40–49 | 4 | 4 | 0 | 2 | 3 | 2 | 4 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2 | 3 | 0 | 1 | 0 | 0 |
| 60+   | 4 | 4 | 2 | 3 | 3 | 3 | 4 | 3 | 0 | 1 | 3 | 2 | 1 | 0 | 2 | 0 | 2 | 4 | 0 | 0 | 0 | 1 |
Table 7: Web survey answers

| Age   | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 15 | 17 | 23 | 25 | 27 | 30 | 31 |
|-------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 20 – 29 | 3  | 4  | 1  | 3  | 0  | 3  | 3  | 2  | 2  | 2  | 3  | 1  | 3  | 4  | 4  | 2  | 3  | 0  | 0  | 0  |
| 30 – 39 | 3  | 3  | 0  | 3  | 2  | 3  | 2  | 1  | 2  | 3  | 1  | 4  | 4  | 3  | 2  | 2  | 0  | 0  | 0  | 0  |
| 30 – 39 | 4  | 2  | 1  | 2  | 0  | 3  | 2  | 3  | 3  | 0  | 0  | 2  | 1  | 4  | 0  | 4  | 0  | 0  | 0  | 0  |
| 13 – 19 | 4  | 4  | 1  | 2  | 0  | 3  | 2  | 3  | 3  | 0  | 0  | 4  | 4  | 4  | 2  | 1  | 4  | 2  | 2  | 0  |
| 20 – 29 | 4  | 4  | 1  | 2  | 0  | 3  | 0  | 3  | 3  | 2  | 2  | 3  | 3  | 3  | 2  | 4  | 2  | 3  | 0  | 0  |
| 20 – 29 | 4  | 2  | 1  | 2  | 0  | 3  | 3  | 3  | 3  | 0  | 2  | 2  | 4  | 3  | 1  | 4  | 2  | 1  | 0  | 4  |
| 20 – 29 | 3  | 4  | 1  | 3  | 0  | 3  | 2  | 3  | 3  | 0  | 3  | 2  | 1  | 4  | 4  | 4  | 0  | 3  | 0  | 0  |
| 20 – 29 | 3  | 4  | 0  | 3  | 2  | 2  | 3  | 4  | 3  | 2  | 3  | 3  | 4  | 3  | 3  | 3  | 3  | 3  | 1  | 4  |
| 20 – 29 | 0  | 2  | 3  | 2  | 3  | 2  | 2  | 2  | 2  | 4  | 3  | 1  | 3  | 3  | 3  | 2  | 3  | 3  | 3  | 3  |
| 20 – 29 | 3  | 4  | 1  | 2  | 0  | 3  | 2  | 3  | 2  | 0  | 2  | 3  | 1  | 3  | 2  | 1  | 0  | 0  | 0  | 1  |
| 20 – 29 | 3  | 3  | 1  | 3  | 1  | 3  | 2  | 3  | 3  | 1  | 2  | 2  | 1  | 3  | 3  | 3  | 2  | 2  | 0  | 0  |
| 20 – 29 | 4  | 4  | 1  | 3  | 0  | 2  | 2  | 3  | 2  | 3  | 3  | 2  | 3  | 1  | 1  | 4  | 2  | 3  | 0  | 0  |
| 20 – 29 | 3  | 4  | 0  | 2  | 0  | 2  | 2  | 3  | 3  | 0  | 2  | 3  | 1  | 2  | 1  | 4  | 3  | 2  | 0  | 0  |
| 20 – 29 | 3  | 4  | 2  | 3  | 0  | 2  | 1  | 2  | 3  | 0  | 2  | 3  | 4  | 2  | 3  | 4  | 2  | 4  | 0  | 0  |
| 20 – 29 | 4  | 4  | 1  | 2  | 1  | 2  | 0  | 3  | 3  | 2  | 2  | 3  | 3  | 3  | 4  | 0  | 4  | 0  | 0  | 0  |
| 20 – 29 | 3  | 2  | 4  | 3  | 0  | 3  | 2  | 2  | 3  | 1  | 2  | 2  | 4  | 1  | 3  | 4  | 0  | 3  | 0  | 0  |
| 20 – 29 | 3  | 3  | 1  | 2  | 0  | 3  | 3  | 3  | 3  | 3  | 1  | 2  | 3  | 2  | 3  | 1  | 2  | 3  | 0  | 0  |
| 20 – 29 | 3  | 4  | 1  | 2  | 0  | 3  | 0  | 3  | 2  | 2  | 2  | 0  | 4  | 2  | 3  | 1  | 2  | 3  | 0  | 0  |
| 20 – 29 | 4  | 4  | 1  | 4  | 0  | 3  | 2  | 3  | 4  | 0  | 0  | 0  | 4  | 4  | 4  | 0  | 4  | 0  | 0  | 0  |
| 20 – 29 | 2  | 4  | 1  | 0  | 0  | 0  | 0  | 2  | 2  | 0  | 0  | 0  | 3  | 2  | 3  | 0  | 0  | 0  | 0  | 0  |
| 20 – 29 | 0  | 4  | 3  | 0  | 0  | 0  | 2  | 1  | 0  | 0  | 0  | 3  | 3  | 3  | 4  | 0  | 2  | 3  | 0  | 0  |
| 20 – 29 | 1  | 3  | 0  | 3  | 1  | 2  | 3  | 3  | 3  | 2  | 3  | 2  | 3  | 3  | 1  | 3  | 0  | 1  | 2  | 1  |
| 40 – 49 | 3  | 3  | 0  | 0  | 0  | 0  | 2  | 3  | 3  | 0  | 0  | 2  | 1  | 3  | 3  | 0  | 2  | 3  | 0  | 0  |
| 20 – 29 | 2  | 2  | 1  | 2  | 0  | 3  | 3  | 3  | 4  | 4  | 4  | 3  | 4  | 4  | 4  | 3  | 4  | 1  | 1  | 1  |

Continued on next page
<table>
<thead>
<tr>
<th>Age</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>15</th>
<th>17</th>
<th>23</th>
<th>25</th>
<th>27</th>
<th>30</th>
<th>31</th>
</tr>
</thead>
<tbody>
<tr>
<td>50−59</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40−49</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>30−39</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20−29</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10−19</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0−09</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10−19</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0−09</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10−19</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0−09</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10−19</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0−09</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Continued on next page
<table>
<thead>
<tr>
<th>Age</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>15</th>
<th>17</th>
<th>23</th>
<th>25</th>
<th>27</th>
<th>30</th>
<th>31</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 – 29</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>20 – 29</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 – 29</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>30 – 39</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 – 29</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>50 – 59</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>20 – 29</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 – 29</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 – 29</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 – 29</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 – 29</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 – 29</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 – 29</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>20 – 29</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40 – 49</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>30 – 39</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 – 29</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 – 29</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>20 – 29</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20 – 29</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>40 – 49</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>30 – 39</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>20 – 29</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Appendix F: Implementation screenshot

Excuse me, but are you human?

All persons more than a rat-hole; she knelt down and cried.

Not like cats.

- Neither of the sentences is legible and fluent.
- Only the first sentence is legible and fluent.
- Only the second sentence is legible and fluent.
- Both sentences are legible and fluent but do not fit together semantically.
- Both sentences are legible and fluent and they fit together semantically.

It is a long tail, certainly, said Alice, but I haven't been invited yet.

Please would you tell me, please, said Alice, because I'm not myself, you see—being so many different sizes in a day is very confusing.

- Neither of the sentences is legible and fluent.
- Only the first sentence is legible and fluent.
- Only the second sentence is legible and fluent.
- Both sentences are legible and fluent but do not fit together semantically.
- Both sentences are legible and fluent and they fit together semantically.

She stretched her head pressing against it a little glass.

Who is to-day?

- Neither of the sentences is legible and fluent.
- Only the first sentence is legible and fluent.
- Only the second sentence is legible and fluent.
- Both sentences are legible and fluent but do not fit together semantically.
- Both sentences are legible and fluent and they fit together semantically.

No man of common humanity, no man who had behaved with such forbearance and liberality towards him.

And there are several of them you see uncommonly pretty.

- Neither of the sentences is legible and fluent.
- Only the first sentence is legible and fluent.
- Only the second sentence is legible and fluent.
- Both sentences are legible and fluent but do not fit together semantically.
- Both sentences are legible and fluent and they fit together semantically.