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Time to Learn

A new way of learning with the use of a smartwatch

Bachelor Thesis

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Abstract

Learning has changed over the years. People do not learn only from books anymore. Although Books are still used, other tools for learning are gaining popularity. Websites that can test the knowledge about words of another language of the user are quite common and they have improved themselves over the years.

There is however a disadvantage. The user still needs to find the time to sit down in front of the screen and focus to learn the words. With the upcoming market of smartwatches a new possibility for learning is created. A possibility that makes the user able to learn words whenever the user wants to.

The smartwatch is however a relatively new platform with a small screen and thus we had to investigate what is the best way to build an app for the smartwatch. And can an app for the smartwatch help to accelerate the memorization process of somebody who is learning the vocabulary of a second language?

The app is useful for busy people who can read and understand the language, but want to improve their vocabulary by reading articles in this language and selecting the words the user did not know. These words can be learned by the smartwatch app to improve their vocabulary. The smartwatch is a suitable solutation, because it is quickly accessible which makes it ideal for situations like waiting for and waiting in the elevator or waiting for the bus or other situations where time is lost by waiting. The user only has to twist his or her wrist to continue learning. This is the reason why it is more convenient to use than an app for the smartphone. It is much more easier to access the app on the watch than on a smartphone.

Applications that are built with the same motivation as our app are mostly built for a smartphone like an Android wallpaper. Our approach is different, because we are going to try to use a smartwatch.

Several users have used the app for five days and they provided us with results and feedback for our research.

Contents

1 Introduction

The way people learn has changed over the years. The development of information and communication technology has lead to new ways of learning. People can now find fast and really specific information on the web and learn new things using ICT tools, like laptops, iPads and other electronic devices. The traditional book is being less and less used. We can see this in high schools where students learn their languages on the laptop with a rehearsing program. These rehearsing programs should accelerate the memorization process, so the student can work more efficiently and therefore has more time for other stuff and can work more efficiently.

Accelerating the memorization process of somebody who is learning the vocabulary of a second language is not only valuable for students, but also for other people who want to learn a second language for other reasons. But even with rehearsing programs learning a second language can be a hard and time consuming thing to do. Since learning a second language is so time consuming, people often don't have enough time for it. They are busy with other important things like work and don't have the time to really learn every day. Although for these type of people it seems like they have no time to learn, in fact the time they lose for waiting for the bus, taking the elevator and walking to the car could be used more efficiently. Using these little time units is called micro learning [2]. In this thesis we are going to try to find out how we can fill these little time spots in the best way using a smartwatch.

The application for the smartwatch will be a watch face, this is the screen that the user

will see when the screen is on. We also had the option to choose for a separate app using push notifications, however push notifications in general are bad. They have a negative effect on task performance [4] and they could be perceived as annoying. The main function of the watch face is to show the time, however it also offers the user a word for which the translation can be revealed by tapping on the screen. The user will be stimulated to think of the right translation before seeing it, after revealing it the user can give the watch feedback by pressing the green ('I had it right in my head') or red button ('I had it wrong in my head'). The algorithm used for displaying words is based on the way in which people learn with flashcards. This is to speed up the memorization process, wrong words will be repeated earlier then words which the user had right in his mind.

The app for the smartwatch is part of Zeeguu ecosystem, which is a research project designed to speed & fun up vocabulary learning in a new language based on three fundamental principles: only read material the learner likes, have words everywhere with you and practice with personalized exercises. This basically means the users read articles they like, tap on the words they don't know, get "in text" translations so they can continue with their reading, and have the chance to practice them later. The words will be saved in their accounts and can be accessed at any time.

In this thesis, we introduce an app for the smartwatch called Time to Learn , so users have an complementary tool for learning their words in the Zeeguu account and thus increase the memorization process of learning a second new language. In this thesis we will research what is the best way to build such an app, therefore a user study was designed to answer the following research question:

How do users use a smartwatch application to accelerate the memorization process of somebody who is learning the vocabulary of a second language?

To answer this question, we ask and answer the following subquestions:

- How long does a session on a smartwatch take (i.e., general usage)? And how long does a learning session take on a smartwatch (i.e., only using Time to Learn app)?
- Where is the smartwatch primary used for when using the time to learn app (i.e., for looking at the time or learning words)?
- How long do users use the app daily on average?

Structure of this Thesis
The structure of the remainder of this document is the following:

In Chapter 2 (Related Work) the general research field is described and how others tried to solve this or similar problems.

In Chapter 3 (The Design) the user interface is described, explaining the choices which have been made.

In Chapter 4 (The Implementation) the code structure, algorithms and implementation choices are explained.

In chapter 5 (Usage Study) explaining the tests and a summary of the results with various diagrams.

In chapter 6 (Evaluation) a discussion about why this research was successful.

In chapter 7 (Conclusion and Future Work) conclusions about the usage results and describing possible future work.

2
Related Work

The app is built on the Zeeguu platform. Therefore this section will start by discussing Zeeguu and other applications in the Zeeguu ecosystem.

The smartwatch is a relatively new gadget and therefore the number of research studies on the use of smartwatches in learning are inexistent to the extent of our knowledge. There are however comparable approaches that use smartphones for the same purpose, that is making learning available wherever the user is which we will discuss in this chapter.

Learning new words is the main purpose of the app and thus it is important to research the best way to learn words. Especially when the user will only use micro-learning, learning during short periods of time, since the smartwatch app is a complementary tool. We close this chapter by discussing some techniques that were found during projects that investigated how to make learning new words more efficient.

2.1 Zeeguu

The smartwatch app can only be used when the user has a profile on Zeeguu. The Zeeguu platform is an ecosystem that is built around an open API which aims to improve learning words of a foreign language.

Multiple projects are part of the ecosystem: a Chrome plugin, several Android applications, an iOS application and after this project a smartwatch app can be added to the list.

2.1.1 Chrome plugin

The Chrome plugin can be installed to quickly add new words to the users profile.[6] With the plugin the user can click words the user wants to learn. By clicking the translation of that word will appear above it and by clicking the translation the word is saved to the profile of the user. When a translation does not appear to be correct, the user can change the translation.

2.1.2 Android applications

Android applications were added to the ecosystem to give the users more possibilities to use Zeeguu since Android is the most popular operating system on smartphones.[3] These applications will lead to an increase of time that the user spends on learning words. New exercises designed to improve the learning process were implemented for the applications.

2.1.3 iOS application

For iOS devices an application was made in which users could read news articles from different websites.[9] The users would read articles in the language they wanted to learn or to improve. If a word is unknown, the user could touch the word and the app would show the translation. This word could then be saved on their Zeeguu account.

2.2 Comparable research projects

D. Dearman and K.N. Truong presented a Vocabulary Wallpaper which is a language tool designed to provide quick access to vocabulary to support short session of learning.[2] This app for the smartphone shows some similarity compared to the app for the smartwatch. The app consists of a vocabulary wallpaper that can be accessed from the lock screen. This idea is similar to the idea for the smartwatch app. The conclusion of this approach showed that in four short sessions of approximately 4 hours, the participants

were able to increase the number of second language vocabulary that they could recognize and recall when using the vocabulary wallpaper.

The use of a smartwatch can help users saving time by making processes efficient and easier. D. Pradhan and N. Sujatmiko described why the use of a smartwatch is more efficient and easier compared to a smartphone.[10] An example mentioned is the number of steps that are required to use a smartphone. They described the following steps:

1. Unlocking the phone. While in pocket, a phone is typically screen-locked to avoid unwanted use. Unlocking requires several taps or slides.
2. Finding app. A person typically has number of apps that is more than one phone screen can hold and therefore apps icons are placed in multiple home-screens. Hence finding the apps required another one or two taps or slides.
3. Running the app itself. This may vary based on how easy the app?s user interface is, but it definitely needs more than just two taps.

These steps make it inconvenient to use a smartphone in situations like: driving, cycling or walking and it could even be unsafe. A smartwatch would only require an arm twist to activate the screen and some swipes (depending on the position of the app) and the watch is ready to go.

Another disadvantage could be the fact that the learner needs to carry the smartphone with him. This will create a chance of forgetting the place where the smartphone is placed. This could lead to losing time when the owner tries to find his smartphone, which is not possible when a device is worn on the wrist

2.3 The best way to study words

There are a lot of research projects about finding the most efficient way for learning new words. Due to the large number of studies, it was not possible to implement all the conclusions of each research. Those who did not make the final version of the app could be implemented in the future.

S. Thornbury described what is needed to learn a new word.[11] According to S. Thornbury knowing a word involves knowing its form and its meaning. Knowing its form means that you know whether it is a noun, a verb or a preposition etc. and how to spell it. When focussing on its meaning you not only need to know what the word means, but also what register it is used in, what category of words it belongs to: for instance: fruit, animals, plants, transport or even to groups of abstract words. And you need to know how it is used in a sentence or what chunks or collocations it can be used in.

In the app the user can see the translation of the word and the sentence in which the word appeared. However the user is not able to see whether it is a noun, a verb etc.

P. Nation came with guidelines how one should learn vocabulary in another language.[7]

1. Learn new words by using flashcards. The word is written on one side of the card and the translation on the other side. When both the word and the translation are not seen simultaneously, the connection between them will be strengthened.
2. The words should be learned in groups of fifteen to twenty words at the same time. When the words appeared to be difficult, the groups should be made smaller.
3. The learning sessions should be alternated with pauses of about one hour. In addition the sessions should be repeated after days to consolidate the words in the long-term memory. When a word appears to be learned, the time between testing this word should be gradually extended.
4. The memory process can be accelerated by saying the translations aloud.
5. A translation that is hard to remember can be more easily retrieved when it has many associations. Seeing the word in a sentence can help this process.
6. During a learning session words with similar spelling or meaning should be avoided.
7. The order in which the words are learned should change from time to time to prevent knowing the order instead of the words.
8. The context of the word helps with learning the translation.

The app uses a flashcard method which means that words that are not recognized are more rapidly repeated than words that are recognized. The words are learned in small groups of five. Since the words are placed back in the list of words when a word is learned or not, the order of words changes every time and therefore serial learning is not possible. The user is also able to see the context of the word.

J.P. Anderson and A.M. Jordan measured recall immediately after learning, after one week, after three weeks and after eight weeks.[1] The percentages of material retained were 66%, 48%, 39% and 37% respectively. These numbers indicates that new words should be repeated very soon after the words appeared for the first time. This is to prevent the word is forgotten before the word appears again.
The app registers the number of times the user knows a word. This number is used to decide at what position the word should be placed when the user indicates the word is still known. The higher the number the further the word is placed in the list and therefore the longer it will take to see that word again.

I.S.P. Nation investigated the effect of a delay between the presentation of a word and its meaning.[8] According to the researchers the learners have an opportunity to make an effort to guess the meaning. This extra effort will result in faster and longer retained learning. The guessing will only succeed if the learning could recognize the translation in the foreign word. When the learner sees a word for the first time, a simultaneous presentation of a word an its meaning is the best. After the first encounter the best way to show the word and its meaning is with a delayed presentation.
In order understand the full meaning of a word, the learner should be able to read the context of the word.
The app shows the word first without the translation which gives the user the opportunity to try to remember the translation or to do an educated guess. Then by clicking the word, the translation will appear.

3
The Design

Making an app for a smartwatch involves quite some thinking about the design. Compared to a smartphone the available display is circular and much smaller and thus designing and redesigning the layout with the time, the words, the buttons and some information components took some time. The app is a watchface and this comes with some restrictions when it comes to the different inputs the watch can receive from the user. An app that is set as a watchface can only detect touch, swipe up and swipe down. The app begins with a login screen and after entering a valid code the main screen is shown. All the decisions related to the designs of those two screens are described below.

3.1 Login screen

Before the user can use the app a code is needed that is used for identifying the user with the server. To get this code the app starts with a login screen. The login screen first consisted of ten buttons with the ten numbers, a clear button and a okay button. On the top of the screen there are four small rectangles for displaying the pressed numbers (see figure 3.1).

Figure 3.1: The first version of the login screen with the small numbers.

After some testing and discussions it was decided that the feedback of the pressed numbers on the top of the screen were to small and thus some rethinking was needed to come up with a new design. An idea was to make four rotating disks that was inspired from securing a travel suitcases (see figure 3.2).

Figure 3.2: The design of this lock was used as inspiration.

The advantage is that no buttons for the numbers were needed so the numbers could be place in the middle. In the middle they can be displayed in a larger font since more space is available due to the circular shape. However, the detection of swipe events were insufficient for rotating the disks and thus the idea for rotating disks was changed to improve the functionality. The positions of the numbers stayed the same, but instead of swiping an increase and decrease button was added above and below each number (see figure 3.3).

Figure 3.3: The second version of the login screen with the larger numbers.

To increase the safety of a user's account it was decided to use a code of eight digits and therefore a page indicator was placed below the decrease buttons to notify the user that the user should insert 4 digits two times. On the bottom of the screen a next button is placed to go to the next page for inserting the second 4 digits of the code or to confirm that the eight digits were inserted.

3.2 Main screen

When a valid code is inserted, the main screen becomes visible. During the project, the main screen had had different layouts. All the decisions are sorted in different categories: time, words, background, buttons, information components, option lists, profile and effects.

3.2.1 Time

An important part of the app is displaying the time, since the app will be the first thing the user will see when the watch screen turns on. This importance was not clear at the beginning of the project, therefore the first design contained the time in a small black font. The size of the font was based on the hill that was displayed on the background. With the chosen font the time fitted in the hill in the middle to increase the readability (see figure 3.4).

Figure 3.4: The first version of the main screen with the wrong ratio.

After the first discussion it was decided that the time should be displayed on 50% of the screen since the app would be use for checking the time and for learning words (see figure 3.7). The time however was not readable enough and this was solved by changing the font color to white and by changing the background (see figure 3.5). This new design worked well and therefore this became the final design for the time.

Figure 3.5: The final design of the time.

3.2.2 Words

The other important part of the app is showing the wordpairs, the word and the translation, the user wants to learn. Displaying wordpairs on a small circular screen was quite challenging which resulted in different designs for the watchface (see figure 3.6).

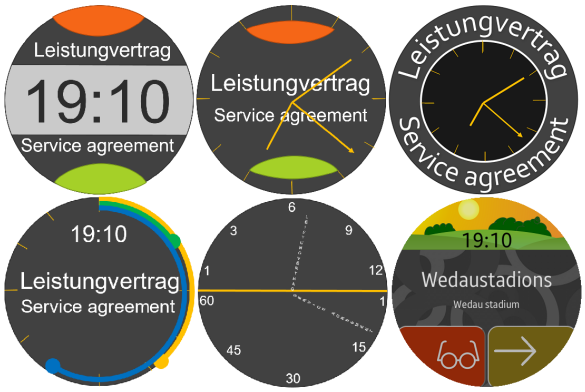


Figure 3.6: The different layouts designed for optimal usage of the circular screen.

The sixth design was chosen as the most convincing design. In the first version the wordpairs were placed in the middle of the screen (see figure 3.4) with a white font. Due to the circular shape there is more space available in the middle of the screen and

therefore the wordpairs can be in a larger font. The color white was chosen to have a maximum contrast with the background since the background mostly consists of dark colors. The words have a larger font than the translations to have a clear distinction between the two types and later on the smaller font was selected to make sure that there is enough space to display the translations. Since the translations are placed lower than the words, less space is available. When only 50% of the screen was available for the wordpairs after the first discussion, the wordpairs were placed just below the middle where the space lost is minimal (see figure 3.7).

Figure 3.7: The second version of the time display uses 50% of the screen for showing the time.

3.2.3 Background

The app consists of two parts, one for the time and one for the wordpairs. Both parts have different backgrounds. The background for the wordpairs was selected in the beginning of the project and did not change. The background consists of different dark grayish colors and with the white colored wordpairs the user should not have any problems reading the wordpairs.

At first the idea for the background of the time was that it should support the current time. Therefore four different backgrounds were designed for the morning, afternoon, evening and night (see figure 3.8).

Figure 3.8: The first designs for the background of the time.

The space for the time then changed to 50% of the screen and therefore the backgrounds were unusable because of the old dimensions of the images. Instead of changing the images to the new dimensions this moment was used to think again about the background of the time. The different images for the different types of the day had to be saved on the watch. This storage issue was solved by using one image. The new background consisted of the sun, the moon and a transition between blue and black. This background rotated around it's center which makes it possible to support the current time with the positions of the sun and the moon (see figure 3.9).

Figure 3.9: The rotating background image of the time.

Due to the rotation a sunset and sunrise could be seen on the watch. To emphasize the sunset and sunrise a landscape was added to make, for example, the sun appear from the horizon with a sunset. The used colors for the landscape were different from the colors in the rotating background and hence a new background with the sun and moon was designed to match the landscape (see figure 3.10). The landscape worked well with the

rotating background and therefore two other landscapes were designed from which the user can choose (see figure 3.11).

Figure 3.10: Version 5 of the main screen with a new background and a landscape.

Figure 3.11: The designs of the other two landscapes the user could choose from.

3.2.4 Buttons

As mentioned before swipe detection was insufficient so it was decided that the app should only use touch events. To navigate through the app with only touch events it seemed logical to use buttons. With the time on top of the screen and the wordpairs in the middle there was unused space in the bottom for the buttons. In the first design the user should be able to reveal the translation of the shown word or to go to the next wordpair. This resulted in two buttons, a red one with glasses on it and one with an arrow to the right (see figure 3.4). Glasses were chosen for revealing because it could refer to looking something up and that matches with revealing the translation. Since the app is displayed on a small screen, the buttons should not be to small and thus almost all the available

space in the bottom was used for the buttons to ensure that there was enough space for the user to press a button. Different tests showed that the buttons could be made smaller. This was a favorable conclusion since after testing it was decided that only 50% will be used for the wordpairs (see figure 3.7). The design of the buttons was not really pleasing and needed some rethinking. The first modification was erasing the reveal button. Instead of the button the user could touch the word to reveal the translation. The 'next' button was widened so it covered the bottom of the screen (see figure 3.5). During development more options were implemented and therefore a new button was made next to the 'next' button. The settings button gave access to these options (see figure 3.12). The curves on the buttons as can be seen in the first design were replaced with right angles to create a modern feeling.

Figure 3.12: Version 4 with the new 'settings' button.

The app was tested and more attention was paid to improve the order in which the wordpairs are shown. This process should become smarter by the use of a knowledge estimator that would estimate what the next word should be to maximize the learning process. This estimation could only be made when the server could receive feedback of every single word. It is therefore necessary that the user should give feedback after every word. The design of the app was adapted to this new idea by changing the 'next' button to a 'reveal' button (see figure 3.10). When the user pressed this button the translation appeared and the 'reveal' button changed in three different buttons: a 'wrong' button, a 'menu' button and a 'right' button (see figure 3.13).

Figure 3.13: The mandatory feedback page displayed after revealing a word.

This new design forced the user to give feedback after every word. This feedback could be used to optimize the order of the words. The first design of the buttons were a cross and a checkmark to let the user know what to press when a word was not know or was known. Later on a book and a graduation cap were used for the same purpose but the feedback to the user would be less harsh with the new design (see figure 3.14).

Figure 3.14: The mandatory feedback page with the redesigned buttons

3.2.5 Information components

Besides the time the app also shows the date. The date was added later when the design of the time was completed. In the first design the date had his own small icon on top of the screen (see figure 3.5). This icon was partly covered by a Tizen icon for the swipe down menu. Therefore the icon for the date was moved downwards near the time (see figure 3.10). During a discussion it was mentioned that it would be nice to be able to see the temperature and the weather type on the watchface. After some research a free api* was found that could provide the app with this information. In the beginning of the implementation the temperature was placed to the left of the date and the weather type was placed to the right of the date. This was barely readable and it did not fit in the realized design hence a new icon was designed that contained the date, temperature, weather type and an open area in the middle for the Tizen icon for the swipe down menu (see figure 3.15).

Figure 3.15: Version 6, the final design

3.2.6 Option lists

The app has access to two different option lists: the settings which can be reached by double tapping on the time and the menu that can be reached by tapping in the middle of the translation. This was different in one of the first designs. When the app was able to show the words with the translation, the user should have an option to tell the app that a word had a wrong translation or that a word was learned and thus in both cases it should

not reappear again. Due to the small screen it was not convenient to add more buttons for each of these options to the watchface and therefore the idea came to make a menu with these extra options. Besides these options the user should be able to reverse the order in which the wordpairs were asked (when the words were displayed from German to English, the words would be displayed from English to German after the button was pressed), to insert the number of words that the user wanted to learn and to log out of the app. All these options were reachable for the user by a 'menu' button in the bottom. The 'next' button was replaced by two buttons, the 'menu' and the 'next' button (see figure 3.12). When the 'menu' button was clicked a menu would appear with the 'trash' button and the 'I learned it' button (see figure 3.16).

Figure 3.16: The design of the menu in version 4.

In the bottom the user could close the menu or open the settings. By pressing the 'settings' button the user would open the settings page with the buttons for reverse, number of words and log out (see figure 3.17).

Figure 3.17: The design of the settings in version 4.

After some discussions the overall opinion was that the 'menu' button should not be this large on the watchface since the menu would give complementary options which were not part of the main function of the app. Therefore the button should not cover half of the bottom and a solution was to split the menu and the settings to two different pages that the user could reach independently. The user could reach the menu by tapping in the middle of the translation (see figure 3.13) and the settings could be reach by double tapping on the time since this space was hardly used. The double tap was necessary because tapping the time would change the background. The menu and the settings both had a black transparent background for a long time. This was inspired from the transparent and blurred swipe down menu from a well-known OS. Unfortunately the blur effect was not a success, but the transparency remained.

During testing the text in the buttons were hard to read and the buttons of the main page were visible through the buttons on the bottom. Therefore it was decided that the menu and the settings page should have a background. For the background the same image was used as the background of the wordpairs to preserve the unity of the design. A lot of translations depends on the context of the word. Hence the user should be able to see the context of the word and this option was added to the menu page (see figure 3.18).

Figure 3.18: The new design of the menu in version 6.

Later on the idea was abandoned of letting the user choose how many words the user wants to learn and instead came the 'profile' button as the latest addition to the settings page (see figure 3.19).

Figure 3.19: The new design of the settings in version 6.

3.2.7 Profile

One of the latest addition to the app was the implementation of a profile page where the user could see the four medals that could be earned by using the app (see figure 3.20). The four categories are: words learned, total time, longest session and longest streak.

Figure 3.20: The profile page in which the user can find the latest earned achievements.

This page was inspired from a presentation where gamification was mentioned. The idea was that when users could earn medals, users would be more willing to use the app. When the user presses the 'I learned it' button, the number of 'words learned' will increase and after 10 new learned words, a popup will appear with a motivating message to continue. The total time the user used the app is also registered. When this time is the same as one of the pre-determined minutes a popup appears (see figure version 6 popup.png). With longest session the time is measured that the user uses the app continuously and with the longest streak the number of days is registered in which the app is used daily. One day of not using the app resets the longest streak.

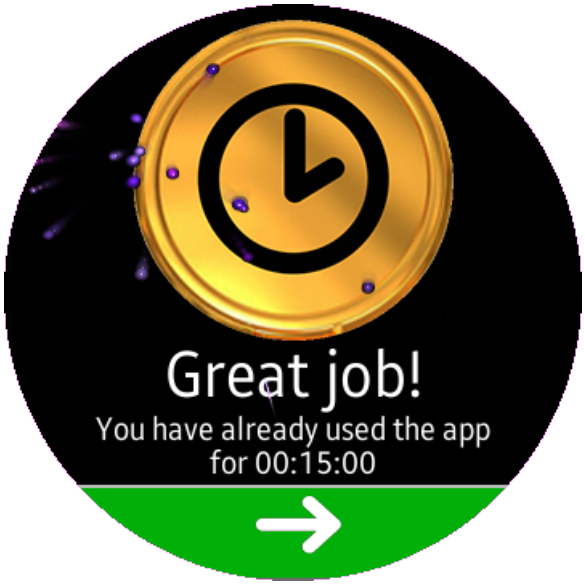


Figure 3.21: The design of the popup screen when the user improved an achievement.

3.2.8 Effects

To improve the experience of the app some effects were added: to give feedback after a button was pressed, to give information (why an option was not available or why a medal was earned) or to beautify a popup. Because of the small screen the user could think the wrong button was pressed and therefore the user should get feedback about which button was pressed. The most important buttons in the app are the buttons used for indicating whether a word was known or not. When one of these buttons is pressed a green or red image appears depending on if right or wrong is pressed. This image stays on the display for a few milliseconds before it fades out. In the app several popups are added to give the user feedback when an option is not available. The design of the popup is based on the first design of the option lists. The popup has a black transparent background with white text on it. The popup could appear when: there is no connection with the internet, when a wrong code is inserted, when the user has too few words, when there are too few words left on the watch or when a user earned a new medal. The popup that appears when a new medal is earned is beatified by some fireworks.

4
The Implementation

In this part the implementation choices are described. In this project writing the code was one of the biggest challenges. The code has been changed a lot during the process. One of the reasons was to increase readability, but also because of design changes and new features which had to be implemented. The code is written in JavaScript in combination with HTML 5, this means it is a web-based application. The code is build with a framework called require.js, this makes it possible to have multiple files (modules) in javascript, this to increase readability and structure. In the following sections, we will zoom in some interesting and important decisions and choices related to the implementation.

4.1 Flash card algorithm

For presenting the words we used a certain algorithm. This algorithm will make sure users will learn faster and it's based on the flashcard method. The algorithm works in such a way that words which are answered wrongly will be faster repeated than words which were answered correctly. As explained in the design the user can indicate whether he had the answer wrong or right in his head. If the user had it wrong the word will be repeated after five more words, when the user had it right in his head the word will be repeated depending on the number of times the user had it correct. The word will be

$timesCorrect * 5$ positions moved in case the user had it right in his head. In figure 4.1 this process is shown.

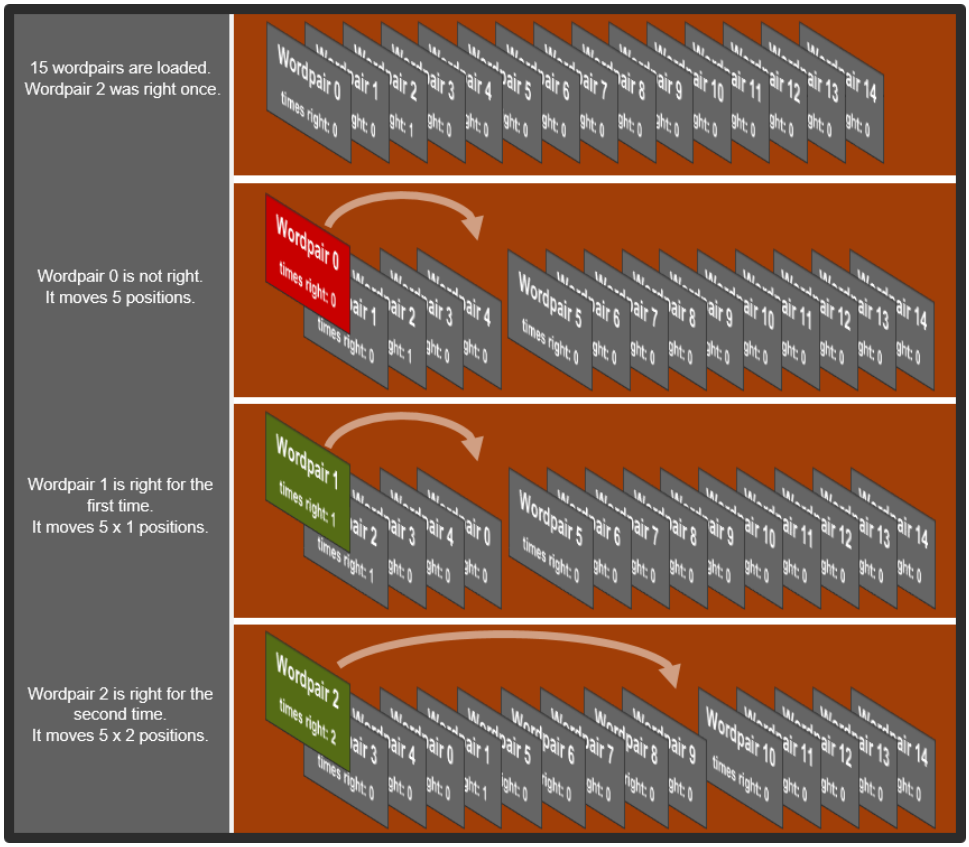


Figure 4.1: An example Flashcard simulation

In listing 1 the code involved is shown, every time the users taps wrong or right the function $updateWordPair$ is called, if the user had it right the number of times correct will be increased. After that the current word will be moved in the array. This happens by first adding the word some positions further and then deleting the current word (i.e., deleting element zero in the array). If the user taps wrong the current progression will be reset (i.e, timesCorrect becomes zero again), and the word will be moved five positions to the right (see figure 4.1). This means the word will be repeated reasonably fast. Because the first element of the array is always shown on the screen, the next word will be drawn on the screen, since the previous first element is deleted. In $userData.js$ everything related to the user is implemented, so this is the place where words can be found. A wordPair is characterized with the following attributes: word, translation, id, context and number of times correct. Getting the word pairs from the server is explained in the next section.

```
1      updateWordPair: function(wordIsRight) {
2        if (wordIsRight) {
3          wordPair[0].timesCorrect++;
4          wordPair.splice(wordPair[0].timesCorrect *
       NUMBER_OF_FLASHCARDS, 0, wordPair[0]);
5        } else {
6          wordPair[0].timesCorrect = 0;
7          wordPair.splice(NUMBER_OF_FLASHCARDS, 0, wordPair[0]);
8        }
9        wordPair.splice(0, 1);
10     },
```

Listing 1: flashcard implemenation in userData.js

4.2 Getting new words from the server

~~In t~~→The module **`session.js`** ML ►*please format everywhere the module names as I did here. sure, if you talked about modules before, make sure to move the command definition earlier*◄ ~~the~~→declares function XYZNAME which ~~words are~~ fetches words from the server. This session ML ►*who's this session?* ◄ is created in the main.js.

The code ~~which login gives~~→provided by login ML ►*what's loing here? a function? a module? not clear!*◄ (either entered by the user or loaded from the userData) will be used in session.js to get the words for the user. The session can get new words with this unique code. ML ►*The code is required to be submitted with every request to the server. For everything, not only for getting new words!*◄ This code ~~is generated once a new account is created and~~ ML ►*you're making assumptions about the server. this is not eactly true so don't talk about it.*◄ can be found in the account when logged in the browser. The code contains eight digits. When a session is created, the first thing to look at is whether there are ~~currently~~ any words on the watch. ML ►*too big and boring a blog of text here. Structure a bit:* ◄ There are two situations:

- If there are ~~any words on the watch~~ we can set the status ML ►*which status?*◄ to 'success',
- in case there are no words on the watch yet: the watch has to communicate with the server and get the words with the endpoint 'bookmarks_to_study'. This endpoint will return the words which are currently the most important to study for that particular user. In the implementation we made the choice to get fifty words in case the user has no internet connection for longer periods of time. The session can return different states: if the words are successfully fetched from the server the state will be 'success' as described earlier, if the code is invalid the state will

be 'wrong session number', in case of no internet connection the state will be 'no connection'. There is one exception, but this will not happen very often this is when there are too few words in the account of the user. One of these states will be returned to the main module and the main module will give this state through to the login module, in the login the user can then be informed by a popup that will inform the user about a specific situation.

If the state ML ►*state of what?*◄ was 'success' the user will get in the main screen where the words are presented.

ML ►*this is clearly a new idea. thus new paragraph!!*◄ The login module is not the only place where the watch tries to get new words~~, it~~→This also happens when the user is already logged in and a screen on event occurred (i.e., user makes arm twist to look at time). The new words will then be added to the current wordlist on a screen off event (i.e., user makes again a arm twist to indicate he is not looking anymore), adding words at this point is to prevent any conflicts: adding words to a list which the user is currently doing stuff with. New words will only be added if the list is smaller than fifty words. The list can become smaller if the user has marked a couple of words as 'learned it' or as 'wrong translation' ML ►*THis sentence should start this paragraph. The story would be beter if it flows like this: - it is not sufficient to load words only on login, the user might learn words, and we need to fetch new ones - after evaluating several scenarios, it was decided that the best moment for this would be a "screen on" event. - adding the new words is on "screen off"*◄.

ML ►*new idea. background story. new paragraph.*◄ When writing the code the initial preference was to get words and add them at the same time on a screen off event, since the user won't be using the application at that moment and it would really feel as everything happens in the background. Unfortunately this didn't work the watch gets in a sort of sleep ~~modus~~→mode and won't be able to communicate with server anymore. The GET request wasn't executed so it was impossible to do this on a screen off event.

Sync vs. Async Calls ML ►*For a bit of more structure it's nicer to add a new paragraph here!*◄

When the watch tries to get new words from the server, this happens asynchronously to prevent the watch from getting slow.

Implementing this asynchronously ~~was huge~~→resulted in considerable speedup ~~in the end~~, because when the user is able to ~~get~~→accumulate a ~~lot~~→large number of words in his account (e.g., some user had already 10000 words) the endpoint will be ~~really~~→very slow~~,~~→One of the main reasons for slowness is that ~~since~~ the list of words is not already sorted based on importance on the server server side.

ML ►put this paragraph before the previous one. tell the story chronologically◄ In the first implementation when it was implemented synchronously, therefore the user could have some delay before being able to interact with the watch. It was first implemented in this way to prevent conflicts, user cannot do something with a list while words are being added. This is now solved by getting the new wordPairs on a screen on (see listing 2) and add them later on a screen off (see listing 3).

```
1   function getNewWordPairs(newWords, currentWords) {
2     if (currentWords.length === 0) {
3       return newWords;
4     } else {
5       for (var j=0; j<currentWords.length; j++) {
6         for (var i=0; i<newWords.length; i++) {
7           if (currentWords[j].id === newWords[i].id) {
8             newWords.splice(i, 1);
9             break;
10          }
11        }
12      }
13    }
14    return newWords;
15  }
```

Listing 2: getting new wordPairs in session.js

```
1     addWords: function(numberOfWords, newWords) {
2       wordPair = wordPair.concat(newWords);
3       wordPair = wordPair.slice(0, numberOfWords);
4     },
```

Listing 3: adding new words to wordPair in userData.js

4.3 Usage Tracking

4.3.1 Events

Events are implemented to give the knowledge estimator information which can be used to analyze the knowledge of the user. The knowledge estimator is on the server side implemented. This means we had to decide at what point we should send the events. Because the knowledge estimator decided what the next word is going to be for the user, the events should be send when the user taps wrong or right. This is the moment the user will be presented with a new word. The knowledge estimator can receive the following events: reveal, right, wrong, wrong translation, I learned it, showContext, screenOn and

screenOff. ML ►*just as there is a command for formatting modules, it would be good to have a command and a rule for formatting event names. I propose* `eventName`*. Finally, it would be nice to have a list here, and a short description of the event names*◄

4.3.2 Clicktracking

ML ►*this should be two words: Click Tracking. Or better yet, touch tracking. Although I'm not sure it makes sense to talk too much about it given that we don't actually have any data about it :)*◄ The clicktracker is designed for ~~research~~→usability purposes ML ►*all the project is for research :)* ◄. Its purpose is to track where the user clicks/taps, so the coordinates are saved. Not only the click position is saved, also the click type (e.g., user taps on reveal). For some functions this can be really interesting like the right button; the user can tap on the button itself or on the green space above the button. Both actions result in the same thing. In the future we could change the design based on these results to give the user a better experience. To conclude the clicktracker is not implemented as ~~an extra~~→a user-facing feature ~~function for the user~~, it is purely for ~~research~~→telemetry purposes.

4.4 Changing the watchface and sending and saving

ML ►*sending and saving what??*◄

Sending and saving the clicks and events was a ~~big~~ challenge in this project. ~~This is the result of~~ The user ~~being~~→is able to change the watch face at every moment, ~~which~~→and this will result in losing data. ~~Because the user is able to go to a different watch face at any moment~~ ML ►*you just said this in the prev sentence!*◄ ~~clicks and~~→user interaction events should be saved to the storage of the watch immediately. We do this by saving it ML ►*it????*◄ to the local storage. This is implemented in the same way as saving to the local storage in a web browser. A click and event are immediately pushed to the storage after they occurred. ML ►*you kind of said this a few sentences before!* ◄

ML ►*new paragraph!*◄ The clicks in the storage are sent ML ►*sent where?*◄ on a screen-on event asynchronously, so it won't influence the speed of the application and it happens in the background. ML ►*mention the endpoint?* ◄When the clicks are successfully sent to the server, the server will return 'OK', if the watch then receives this message the clicks in the storage can be freed, they are now at the server. The events in the storage are sent on 'right' and 'wrong' as previously explained to inform the knowledge estimator. Just as with the clicks the events are deleted from the storage if they successfully have been arrived on the server side.

ML ►*new par*◄ Losing data with changing the watch face not only happens with clicks and events, it also happens when the user reverses the way the words are asked (e.g., English - Dutch to Dutch - English) and with changing the background.

The login code is being saved the first time and used for automatic login after a watch face change.

4.5 Drawing the user interface

The user interface is drawn every second on the screen, this happens in gui.js in the draw function which is public (shown in listing 4). The main module has an function which calls this function in GUI every second (shown in listing 5). The screen is thus updated every second. Time and profile ML ►*what's profile?*◄ are also being refreshed in the draw function, in the future it would be nice to have these in a different function to make sure the function only draws.

ML ►*I'm looking at the draw functin. it looks really bad that the last two lines of code are not in their own function! they should be abstracted in a function called weather.rotateBackground(). otherwise the code is at two levels of abstraction at the same time!* ◄

```
1     draw: function() {
2       profile.refresh();
3       time.refresh();
4       time.draw();
5       time.drawDate();
6       battery.draw();
7       weather.draw();
8
9       var totalMinutes = time.getHours()*60 + time.getMinutes()*1;
10      background.rotate(weather.getSunrise(), weather.getSunset(),
    totalMinutes);
11    },
```

Listing 4: draw function in gui.js

```
1   function updateScreenEverySecond() {
2     gui.draw();
3     setTimeout(updateScreenEverySecond, 1000);
4   }
```

Listing 5: updateScreenEverySecond function in main.js

5
Usage Study

After the implementation the app was ready to enter the test phase. The results of the test period should give answers to the following two questions: is the app used during short intervals (this would indicate that the users used the app for micro-learning) and is the app designed properly (e.g., are all the options found during the test period).

The test period consisted of four parts:

1. All participants started with making an account on Zeeguu and used Zeeguu Reader for reading. During this usage, the platform ~~in which they~~ saved ~~several~~ words they ~~wanted to learn.~~→did not understand.
2. The participant received the smartwatch with the app as a watchface and basic instructions about how to use the app.
3. The participant used the app for four days in a row.
4. After four days the participants handed in the smartwatch and they filled in a questionnaire about the test period and how they experienced the app.

During the test period the smartwatch kept track of the usage by using telemetry. All the buttons and touch areas for the existing options had different events attached to ~~it~~→them so when a button or area was pressed, an event would be ~~made and~~ sent to the server. The events and their definitions are shown in table 5.1.

Table 5.1: Events

Type	Definition
screenOn	~~When~~ the screen lightens up.
reveal	~~When~~ the user wants to see the translation and presses the 'reveal' button or area.
right	~~When~~ the user knows the translation and presses the 'right' button or area.
wrong	~~When~~ the user does not know the translation and presses the 'wrong' or area.
wrongTranslation	~~When~~ the user thinks the translation is incorrect and presses the 'wrong translation' button in them menu.
learnedIt	~~When~~ the user thinks the word is learned and presses the 'I learned it' button in the menu.
showContext	~~When~~ the user wants to see the context of the word and presses the 'show context' button in the menu.
reverse	~~When~~ the user wants to learn the other way around and presses the 'reverse' button in settings.
screenOff	~~When~~ the screen turns off (automatically, after a timeout).

~~In the implementation was mentioned that we use a clicktracker to track where the user taps (i.e., click type and position). With this extra data a heat map could be made that would reveal the most used positions for the different options. However an object was sent to the server while the server expected a string due to miscommunication and therefore the data was unfortunately unusable.~~ ML *►sorry, but this is not scientifically relevant.◄*

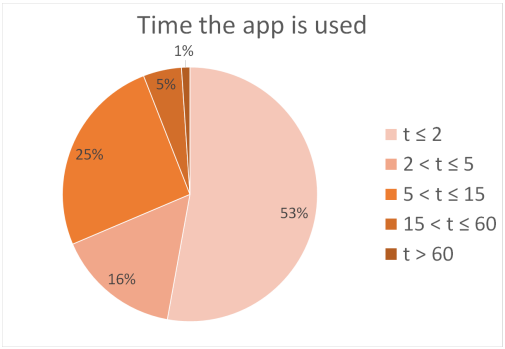
5.1 Usage results

After all the participants finished their test period all the events per user were collected from the server and analyzed. For answering the research questions and for giving a clear overview about how the app was used during the test period, the following diagrams were made per user:

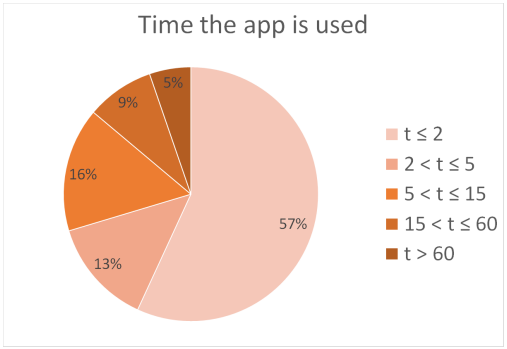
- **A circle diagram ~~about~~→presenting** ML *►also, it's not circle diagram. it's pie chart diagram◄* **the overall usage of the smartwatch in seconds (see fig. 5.1 and 5.2).** ~~The diagram about the overall usage~~→This diagram was created by collecting all the time intervals between a 'screenOn' and a 'screenOff' event. This data was then sorted into five different intervals:

- time ≤ 2
- $2 <$ time ≤ 5
- $5 <$ time ≤ 15
- $15 <$ time ≤ 60
- time > 60

The first interval was chosen, ~~because~~→assumig that checking the time or other arm movements would not take more than two seconds. When the duration is longer than two seconds the user probably does more than only checking the time. The user could check the time, but because a word is shown too, the user might reveal that word by pressing 'reveal' and then the user might also give feedback by pressing 'right' or 'wrong'. These actions for one word would take not more than five seconds. Summarized, these could be learning sessions that were not intended to be a learning session. Then comes the intended learning sessions but for a really short time and the sessions that took a bit longer. As mentioned before the learning app will probably only be used for short sessions and thus sessions longer that one minute will probably hardly occur.

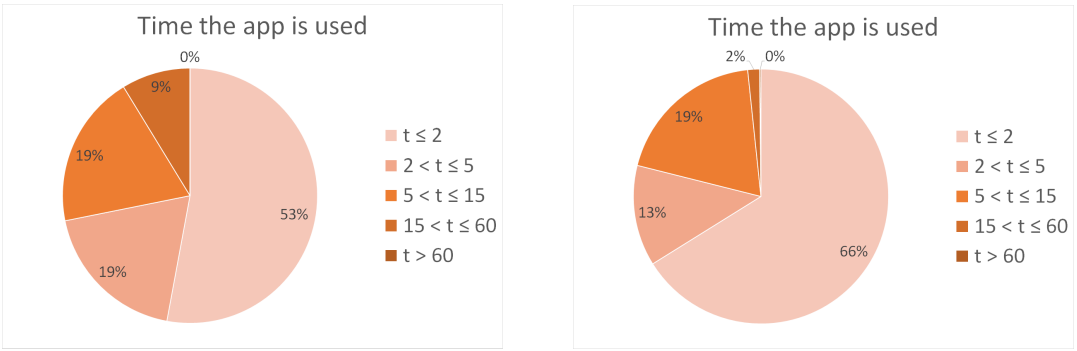


(a) ~~Testperson~~→User 1 ML ▶*testperson is not a single word in english. Fix elsewhere too pls.*◀



(b) Testperson 2

Figure 5.1: General usage testpersons 1 and 2



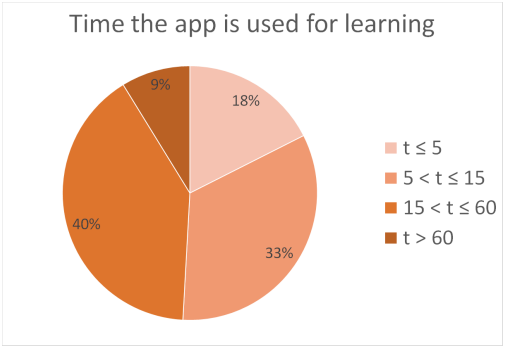
(a) Testperson 3

(b) Testperson 4

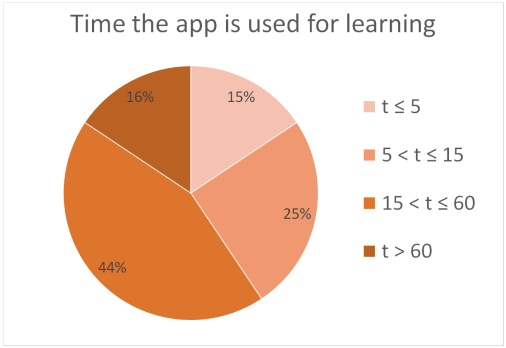
Figure 5.2: General usage testpersons 3 and 4

- **A circle diagram about the duration of the learning sessions on the app in seconds (see fig. 5.3 and 5.4.).** The durations of the learning sessions were found by using an algorithm (see listing 6). This algorithm first sorted out all the 'screenOn' events that were immediately followed by a 'screenOff' event. A user that used the app for learning and not for checking the time would use at least one option the app provides for learning new words before the screen would turn off. Therefore the combinations of a 'screenOn' and 'screenOff' events were seen as not learning sessions and these pairs were erased from the list of events. ML ▶*add a footnote, that there is possibly some noise here as a user might have left the word and translation on the screen and see them displayed nevertheless*◀ In the remaining events the time was measured between a 'screenOn' and a 'screenOff' event and afterwards the data was sorted into four intervals:
  - time ≤ 5
  - $5 <$ time ≤ 15
  - $15 <$ time ≤ 60
  - time > 60

  The app will presumably be used for micro learning. Therefore the number of sessions will probably decrease exponentially when the duration increases. This is the reason why the length of the intervals increases faster than a linear growth.

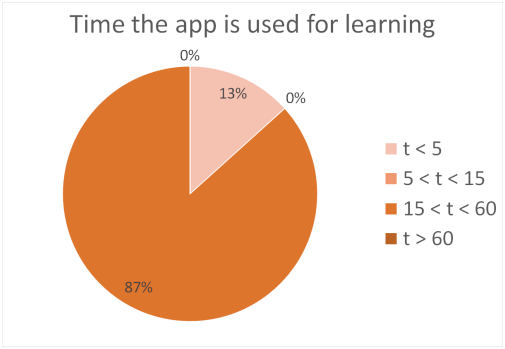


(a) Testperson 1

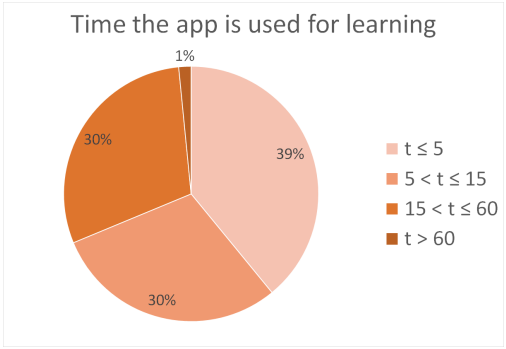


(b) Testperson 2

Figure 5.3: Learning sessions time testpersons 1 and 2



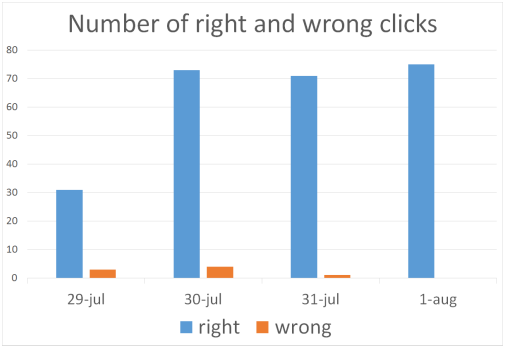
(a) Testperson 3



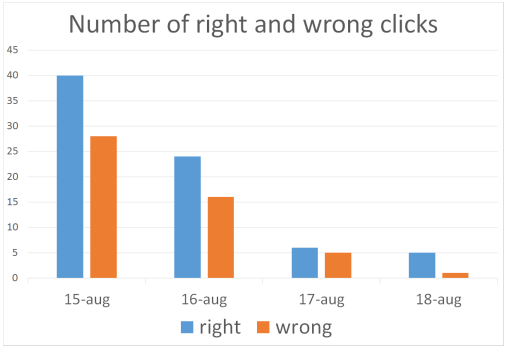
(b) Testperson 4

Figure 5.4: Learning sessions time testpersons 3 and 4

- **A bar chart about the number of times a user pressed 'right' and 'wrong' (see fig. 5.5 and 5.2.4).** For each day the app was used the number of 'right' and 'wrong' events were counted and plotted in a bar chart.

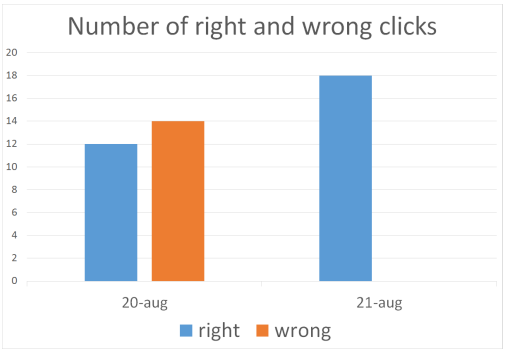


(a) Testperson 1

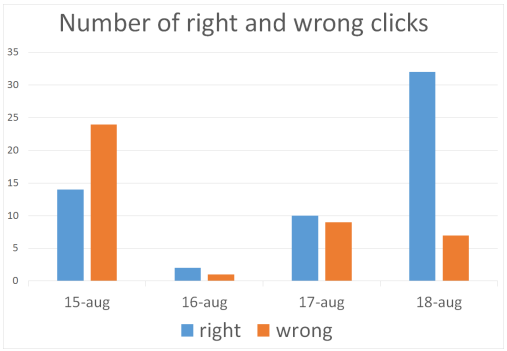


(b) Testperson 2

Figure 5.5: Number of right and wrong clicks for testpersons 1 and 2



(a) Testperson 3



(b) Testperson 4

Figure 5.6: Number of right and wrong clicks for testpersons 3 and 4

- **A table with the average reaction time between a 'reveal' and a 'right' or 'wrong' and the time the app was used (see tables 5.2, 5.3, 5.4 and 5.5).** ML *►can we make the right to be green. like in the app?◄* ML *►Also, average is meaningless for non-normally distributed distributions. If you can't prove you have a normal distribution, and you probably can't, then you have to use median instead of average! Worst case scenario, keep them both, but average alone is not allowed.◄* The reaction time is the time it took the user to press 'right' or 'wrong' after 'reveal' was pressed. The average was calculated for each single day and for the whole period of four days. Besides the average time the total time is mentioned too. This indicates for how long the user used the app during the four days of testing.

Table 5.2: Testperson 1 average reaction time and total usage time

Date	**Average**	**Time**
29-07-2016	00:00:02	00:08:39
30-07-2016	00:00:13	00:13:10
31-07-2016	00:00:01	00:45:43
01-08-2016	00:00:36	00:37:07
Average	00:00:07	00:26:10
Total		01:44:39

Table 5.3: Testperson 2 average reaction time and total usage time

Date	**Average**	**Time**
15-08-2016	00:00:08	00:19:45
16-08-2016	00:00:02	02:15:03
17-08-2016	00:00:02	00:36:00
18-08-2016	00:00:02	00:01:00
Average	00:00:05	00:47:57
Total		02:35:48

Table 5.4: Testperson 3 average reaction time and total usage time

Date	**Average**	**Time**
21-08-2016	00:04:20	00:18:21
22-08-2016	00:00:04	00:02:23
Average	00:02:12	00:10:22
Total		00:20:44

Table 5.5: Testperson 4 average reaction time and total usage time

Date	**Average**	**Time**
16-08-2016	00:03:54	00:37:23
17-08-2016	00:00:03	04:05:46
18-08-2016	00:12:34	00:28:02
19-08-2016	00:02:30	00:13:41
Average	00:04:45	01:21:13
Total		05:24:52

```
1  var USER_CODE = 73140814;
2  var ENDPOINT = "https://zeeguu.unibe.ch/get_smartwatch_events";
3  var events;
4  var numberOfOccurrences;
5
6  function length(obj) {
7    return Object.keys(obj).length;
8  }
9
10 function getEvents() {
11   var xhr = new XMLHttpRequest();
12   xhr.open('GET', ENDPOINT + "?session=" + USER_CODE, false);
13   xhr.onload = function () {
14     events = JSON.parse(this.responseText);
15   };
16   xhr.send();
17 }
18
19 function removeDuplicates() {
20   var count = 0;
21   for (var i=0; i+1 < length(events); i++) {
22     if (events[i].event === events[i+1].event && events[i].time ===
     events[i+1].time && events[i].bookmark_id === events[i+1].
     bookmark_id) {
23       events.splice(i, 1);
24       i--;
25       count++;
26     }
27   }
28   console.log("number of duplicates: " + count);
29 }
30
31 function removeScreenOnFollowedByScreenOff() {
32   var count = 0;
33   for (var i=0; i+1 < length(events); i++) {
34     if (events[i].event === "screenOn" && events[i+1].event === "
     screenOff") {
35       events.splice(i, 2);
36       i--;
37       count++;
38     }
39   }
40   console.log("number of screenOn followed immediately by screenOff
     removed: " + count);
41 }
42
43 function getDateObject(timeString) {
44   year = timeString.substr(0, 4);
```

```
45    month = timeString.substr(5, 2);
46    day = timeString.substr(8, 2);
47    hours = timeString.substr(11, 2);
48    minutes = timeString.substr(14, 2);
49    seconds = timeString.substr(17, 2);
50
51    return new Date(year, month, day, hours, minutes, seconds, 0);
52  }
53
54  function countDifferentSessionLengths() {
55    var count = 0;
56    var screenOn = -1, screenOff = -1;
57    var timeScreenOn, timeScreenOff, difference;
58    var t5 = 0, t15 = 0, t60 = 0, t_other = 0;
59
60
61    for (var i=0; i+1 < length(events); i++) {
62      if (events[i].event === "screenOn") {
63        screenOn = i;
64      } else if (events[i].event === "screenOff" && screenOn !== -1) {
65        screenOff = i;
66
67        timeScreenOn = getDateObject(events[screenOn].time);
68        timeScreenOff = getDateObject(events[screenOff].time);
69        difference = (timeScreenOff - timeScreenOn)/1000;
70
71        if (difference <= 5) {
72          t5++;
73        } else if (difference <= 15) {
74          t15++;
75        } else if (difference <= 60) {
76          t60++;
77        } else {
78          // > 60
79          t_other++;
80        }
81
82        //reset
83        screenOn = -1;
84        screenOff = -1;
85      }
86    }
87    console.log("t <= 5: " + t5);
88    console.log("5 < t <= 15: " + t15);
89    console.log("15 < t <= 60: " + t60);
90    console.log("t > 60: " + t_other);
91  }
92
93  getEvents();
```

```
94 console.log("total number of events: " + length(events));
95 removeDuplicates();
96 console.log("total number of events after removing duplicates: " +
       length(events));
97 removeScreenOnFollowedByScreenOff();
98 countDifferentSessionLengths();
```

Listing 6: script to get different session lengths

ML ►*This code does not belong here. Move it to an appendix!*◄

5.2 Evaluating usage results

ML ►*Please merge this sectio nwith the previous one. Basically, I want all the discussion about an image to stay together. It makes no sense to describe the visualisations first, and then discuss them later.*◄

5.2.1 General usage

The graph about the overall usage of the smartwatch ~~tells something about~~→provides insight into thegeneral behavior of the smartwatch users ~~related to a smartwatch~~. ~~From the graphs it can be seen~~→The graphs show ML ►*shorter is better!*◄ that most of the time (53% till 66%) the smartwatch is used less than three seconds ML ►*I'm confused, I thought it was 2 seconds!*◄. This can be related to checking the time which could mean that the ratio between checking the time and learning words is roughly 50 to 50. This is in a well agreement with the design where 50% of the screen is used for the time and the other 50% for learning words.
The graphs also shows that a session on the smartwatch rarely lasts for more than 60 seconds. ~~Apparently~~ the smartwatch is not suitable or convenient enough to be constantly used for a long period. If the smartwatch is used for a session that lasts a couple of minutes then this will not be longer than fifteen seconds in most cases. ML ►*this makes no sense*◄

5.2.2 Learning sessions

The graph about the learning sessions shows a different distribution when it comes to the duration of the sessions. When the smartwatch is used to learn words, the session last for 5 till 60 seconds most of the time where the interval of 15 till 60 seconds is often the

largest. Sessions that are used for learning and that last for more than 60 seconds are still a small percentage of all the sessions. In the graph from testperson 3 the distribution is a little bit skewed, this is probably due to a lack of results. This user didn't use the watch as often as the other users.

5.2.3 Right and wrong

~~If we look at all the graphs, it is easily seen~~→The graphs show that right is more often pressed than wrong. This might come as a surprise, since learning new words should start with more wrong then right. In the graph of testperson 1 (see fig. 5.5) this is shown extreme, this user had a German background and was learning german. This might be a possible explanation for the ~~absurd~~ ML ►*absurd :)))*◄ high number of right clicks. In the graph of testperson 2 (see fig. 5.5), a decrease in usage is seen. At 17 August~~us~~ ML ►*everywhere else!*◄ the battery of the watch ~~it's battery~~ was depleted, so therefore usage was less. At 18 Augustus usage was less since it was not a full day of usage, the user handed in the watch at noon. In the graph of testperson 3 (see fig. 5.2.4) it can be seen that the watch is unfortunately only used for 2 days, there is however a clear learning curve which can ~~only~~ be observed in the graphs of testperson 1 and 4.

5.2.4 Reaction time reveal to right/wrong

The average reaction time between a 'reveal' and a 'right' or 'wrong' differs per user. The first two participants had nearly the same reaction time which is quite fast compared to the other participants. A fast reaction could mean that they are fast learners and they do not have to spend a lot of time to learn the translation. This thought is confirmed by the bar chart where the two participants with a high reaction time had pressed 'right' more often than 'wrong'.
The other two participants had a much longer reaction time in comparison with the first two reaction times. It could be that these users needed more time to learn a new word and therefore they required more time to learn the translation of a certain word. In the bar chart of the testperson 4 (see fig.) it can be seen that in the first day 'wrong' is pressed more than 'right' what could indicate that the user was confronted with some hard-to-learn words. ML ►*How can you have an average of 4 minutes??? :))) See the observation I've made earlier about the median!*◄

5.3 Questionnaires results

ML ▶*mention the appendix here!*◀ In order to get even more feedback from the user it was decided to let them answer a questionnaire after their test period. The purpose was to get specific information about the app which cannot be obtained by only using the events. Although the test group was really small, it only consisted of four persons, we can still learn from it. The questionnaire was divided into two sections, questions related to:

- general information about the user (i.e., what kind of users do we have)
- the usage of the smartwatch app.

In the sections below the results are summarized and evaluated, the questionnaire can be found in appendix B and the answers of the users in appendix C.

5.3.1 General information about the user

All four of the users were relatively young, the youngest person was 22 and the oldest 34. It can thus be concluded that the test group was quite young. This could mean that they prefer certain ways of learning which fits the generation.

ML ▶*newline*◀ ~~What also~~ →It was interesting to see ~~was~~ that people don't invest much time in learning new words (see question XX from the questionnaire). This could simply mean that they don't have much time, or that they just hate learning new words for long periods of time. Either case using the smartwatch app helps them invest more time in learning new words using micro learning.

For the people who already were learning, the most frequent method was by reading texts in the other language. This would suggest that using the Zeeguu ecosystem (as explained in related work) ML ▶*Before I forget: Please use this quotation [5] in the related work when you talk about the Zeeguu API*◀ in combination with the smartwatch is way that people who are enthusiastic about learning a new language would like.

5.3.2 Smartwatch app usage

In general the reactions to the design were positive, the context function might need a larger font, but this will also result in more words being removed from the list, since the context won't fit on the screen. There were also some complains about not being able to find all the features the app offers. This was due to not having instructed some of the testers properly, but also because some features might not be very logical to find. The

settings for example could be find by double tapping the time. This may not be the most convenient place for the user. A solution would be to have a sort of short instruction manual in the app itself, or to make some small button on the screen for settings.

ML ►*new*◄ There were two interesting features mentioned that people would like to have in app. The first one was a pronunciation function, this however is hard to implement, because the Samsung Gear S2 does not have a speaker built in. ~~Another~~→The second feature ~~which was mentioned~~ was "I don't want to learn this word", one way of doing this would be to combine "wrong translation" and "I don't want to learn this word" to "trash", in either way the word has to be removed. The disadvantage would be less specific user feedback.

The users used the app exactly how we hoped they would, they used it mostly when they had to wait for something. This is exactly what micro learning is all about, the small wait moments will now be filled.

6
Conclusion and Future Work

6.1 Conclusion

THIS IS STILL IN PROGRESS.

How do users use a smartwatch application to accelerate the memorization process of somebody who is learning the vocabulary of a second language?
The users that use a smartwatch application to learn new words mostly use micro learning in order to learn new words. The sessions that last for 5 till 60 seconds occur most of the time.

- How long takes a session on a smartwatch (i.e., general usage)? And how long does a learning session take on a smartwatch (i.e., only using time to learn app)?
- Where is the smartwatch primary for used when using the time to learn app (i.e., for looking at the time or learning words)?
- How long do they use the app?

In this project we tried to give the user the best possible experience to make learning as efficient and fun as possible.

6.2 Future work

As far as we know this is the first time a smartwatch app was made for learning ~~words~~→vocabulary. In this project we tried to give the user the best possible experience to make learning as efficient and fun as possible. Naturally there are still some interesting features that can be implemented to improve the functionality of the app. Some examples are:

- **Improvements on the server side**
  Several events are sent to the server when the app is used. These events were used for the test results. However these events could also be used to personalize the learning process. Every user has a different learning curve that plots the time it takes before a word will be forgotten. It is therefore important that a learning app shows that word again, before the user forgets the translation. A ~~new~~→recent research project developed at the RUG tried to calculate this curve in order to maximize the efficiency of a learning app ML ►*would be nice to insert citation here :)*◄. The algorithm for the learning curve could be implemented on the server side where it could use the events to estimate the learning curve for all users. The algorithm will send a word to the watch that the user should learn according to his learning curve. The downside of this approach for the used smartwatch model will be that the watch should constantly be connected to the internet to keep the learning curve up-to-date. The connection is also important for receiving new words from the server. There are smartwatch models that support 3G and therefore keeping a connection with the internet should not be a problem for these models. ✓

- **Knowing the form of the word**
  In the 'Related Work' chapter some techniques are mentioned which could improve the time it takes to learn new words. One of these techniques was categorizing the words into different forms, like: verbs, nouns or prepositions etc. so it is clear for the learner in which situation the word should be used. We are still unsure whether there is a database with the form for different words. If it exists, the app could show this form for every word although it will be hard to find space on the small screen.

- **Pronunciation of a word**
  After the test period almost all the users would like to have a pronunciation function. The smartwatch model we used did not have speakers, so this function would not work for this model. However, there are models which do have speakers and there are databases available with the pronunciation of a lot of words in different languages which means that this idea could be implemented in a later version of the app.

- **Pronounce the word aloud**
  Another way to improve learning is to say the translation aloud. It can be read in the 'Related Work' chapter that pronouncing a word aloud helps the saving process in the brains. The smartwatch model we used has a build-in microphone like many more models. This makes it possible to check if the user says something. This function could even be improved by verifying if the word is pronounced the right way.
- **Avoid interference with words of similar spelling or meaning**
  Words with a similar spelling or meaning should not be shown one after another in order to prevent confusion. This would require an algorithm and a database that decides whether two words have a similar spelling and whether these words have a similar meaning.
- **Improve first encounter of word**
  The method for showing new words on the app can be improved by showing the word and the translation simultaneously if it is the first time the user sees that word. After the first time the word and the translation can be shown in the same manner the app is showing the words in the latest version.
  Since knowing the context of a certain word is important for the learning process, the 'reveal' button could be split in two with left the option to show the context and right the option to reveal the translation. The user will then be able to make an educated guess when reading the context of the word. In the latest version this is not possible since the option 'show context' is only available when the translation is already revealed.

A

Test Cases

Test cases

Test Scenario	Test Case	Pre-conditions	Test Step	Test Data	Post-conditions	Expected Result	Actual Result	Pass/Fail
Check login functionality without code in storage.	Check response on entering valid code.	1. The app 'timeToLearn' must be installed. 2. The user tries to log in for the first time. No code is saved in storage. 3. 'timeToLearn' is the current watch face. 4. The watch is connected to the internet.	1. The user enters the first four digits using the 'plus' and 'minus' buttons. 2. The user presses next. 3. The users enters the last four digits using the 'plus' and 'minus' buttons. 4. The user presses next.	Code: 61015763	1. The code is saved to the localStorage. 2. The words of the account are loaded with the code. And saved to the localStorage. 3. The mainPage becomes visible.	Login must be successful, the user is prompted with the main screen.	See expected result.	☑
	Check response on entering invalid code.	1. The app 'timeToLearn' must be installed. 2. The user tries to log in for the first time. No code is saved in storage. 3. 'timeToLearn' is the current watch face. 4. The watch is connected to the internet	1. The user enters the first four digits using the 'plus' and 'minus' buttons. 2. The user presses next. 3. The users enters the last four digits using the 'plus' and 'minus' buttons. 4. The user presses next. 5. The user presses the screen when the popup appears.	Code: 00000000	1. The entered code will be erased. 2. The login screen will be shown again.	A popup appears telling the user the code is wrong. When the popup is pressed, the user is back to login.	See expected result.	☑
	Check response if there is no connection with the internet.	1. The app 'timeToLearn' must be installed. 2. The user tries to log in for the first time. No code is saved in storage. 3. 'timeToLearn' is the current watch face. 4. The watch is not connected to the internet.	1. The user enters the first four digits using the 'plus' and 'minus' buttons. 2. The user presses next. 3. The users enters the last four digits using the 'plus' and 'minus' buttons. 4. The user presses next. 5. The user presses the screen when the popup appears.	Code: 61015763 (Any code can be entered here)	1. The entered code will be erased. 2. The login screen will be shown again.	A popup appears telling the user there is no connection to the internet. When the popup is pressed, the user is back to login.	See expected result.	☑
	Check response if the user has to few words in his account	1. The app 'timeToLearn' must be installed. 2. The user tries to log in for the first time. No code is saved in storage. 3. 'timeToLearn' is the current watch face. 4. The user has less than five words in his account	1. The user enters the first four digits using the 'plus' and 'minus' buttons. 2. The user presses next. 3. The users enters the last four digits using the 'plus' and 'minus' buttons. 4. The user presses next. 5. The user presses the screen when the popup appears.	Account with less than 5 words saved.	1. The entered code will be erased. 2. The login screen will be shown again.	A popup appears telling the user there are too few words in his account. When the popup is pressed, the user is back to login.	See expected result.	☑
Check login functionality with code in storage.	Check response after restart with code in storage.	1. The app 'timeToLearn' must be installed. 2. 'timeToLearn' is the current watch face. 3. The user has to be logged in at least once, so a code is saved. 4. The watch is currently off.	The user holds the power button.	None	1. The mainPage is loaded. 2. The userData is loaded.	The watch goes on, the watch face is loaded and the user will be in main screen where the user sees the last seen word.	See expected result.	☑

Test Scenario	Test Case	Pre-conditions	Test Step	Test Data	Post-conditions	Expected Result	Actual Result	Pass/Fail
	Check response after changing watch face with code in storage	1. The app 'timeToLearn' must be installed. 2. 'timeToLearn' is the current watch face. 3. The user has to be logged in at least once, so a code is saved.	1. The user changes the wathface by pressing and holding the screen. 2. The user selects a different watch face. 3. The users presses and holds the screen again. 4. The user selects the 'timeToLearn' app as his watch face	None	1. The mainPage is loaded. 2. The userData is loaded.	The app used for the watch face will be changed to some other app and then changed back to the 'timeToLearn' app. The user will be in the main screen where user sees the last seen word.	See expected result.	☑
check background functionalty	Check response on tapping on the time.	The main page is shown.	Tap on the time.	None	The index of the array where all landscapes are saved is increased by one.	The landscape of the background of the time changes to another landscape	See expected result.	☑
	Check response on double tapping on the time.	The main page is shown.	Double tap on the time.	None	The settings layer is set to visible.	Over the main page the settings page is shown.	See expected result.	☑
	Check response when changing the watchface	The main page is shown.	1. Tap on the time to change background. 2. Hold screen to change the watch face. 3. Change back to timeToLearn watch face.	None	Background number is increased and saved to localStorage.	Background is the same as before changing the watch face.	See expected result.	☑
check settings functionality	Check response on tapping on "reverse".	1. User is on the main page.	1. Double tap on the time. 2. Tap the button with the text "reverse". 3. Tap the word. 4. Tap on the left or on the right of the word to get another word.	None	The variable "reverse" in userData is changed.	The translation of the previous shown word is shown instead of the word. After tapping the translation, the previous shown word is shown below the translation. All words after are shown in reversed order.	See expected result.	☑
	Check if reverse state is the same after changing watchface.	User is on the main page	1. Double tap on the time. 2. Tap the button with the text "reverse". 3. Change the watch face	None	The variable "reverse" in userData is changed and saved to local storage.	After changing the watch face and switching back to TimeToLearn app, the order of the words is the same as before.	See expected result.	☑
	Check response on tapping "profile"	The main page is shown.	1. Double tap on the time. 2. Tap the button with the text "profile".	None	The visibility of profilePage is set to visible.	The profile page is shown with on the top a banner with "profile", in the middle a grey space with the medal for "words learned" is shown together with the number of words you have learned. On the bottom there is a back button to leave the profile page. On the side there are two buttons to navigate through the medals.	See expected result.	☑
	Check response on tapping "log out"	The main page is shown.	1. Double tap on the time. 2. Tap the button with the text "log out".	None	The localStorage is erased and the login screen visibility is set to visible.	After "log out" is clicked, the settings page disappears and the login screen is visible again.	See expected result.	☑
	Check response on tapping on the settings page.	The main page is shown.	1. Double tap on the time. 2. Tap the screen anywhere besides the other buttons.	None	The visibility of the settings page is set to hidden and thus the main page is visible again.	By tapping anywhere besides the other buttons, the settings page fades out and thus the main page is visible again.	See expected result.	☑

Test Scenario	Test Case	Pre-conditions	Test Step	Test Data	Post-conditions	Expected Result	Actual Result	Pass/Fail
	Check response on tapping on the back button in settings.	The main page is shown.	1. Double tap on the time. 2. Tap the button with the back arrow on it.	None	The visibility of the settings page is set to hidden and thus the main page is visible again.	By pressing the button, the settings page fades out and thus the main page is visible again.	See expected result.	☑
	Check response after an screen off.	The main page is shown.	1. Double tap on the time. 2. Wait for the watch screen to switch off. 3. After a screen off press the power button to turn on the screen.	None	The visibility of the settings page is set to hidden when the screen of the watch turns off and thus the main page is visible again when the watch is switched on.	When the screen turns on. The main page is visible.	See expected result.	☑
check reveal functionality	Check response on tapping on the word.	The main page is shown with a word or some words visible just below the middle, an open space and a orange button with glasses on the bottom of the screen.	Tap on the shown word(s).	None	The revealed page is set to visible. This page consists of the word(s), the translation and three other buttons: wrong, menu, right	Below the previous shown word(s) the translation appears. On the left and on the right a red and green area appears to indicate that this space detects taps too. On the bottom three buttons appear. From left to right: wrong (pressed when the user did not know the translation), menu (for extra options related to the words) and right (pressed when the user did know the translation).	See expected result.	☑
	Check response on tapping the button with the glasses icon.	The main page is shown with a word or some words visible just below the middle, an open space and a orange button with glasses on the bottom of the screen.	Tap on the orange button with the glasses on it.	None	The revealed page is set to visible. This page consists of the word(s), the translation and three other buttons: wrong, menu, right	Below the previous shown word(s) the translation appears. On the left and on the right a red and green area appears to indicate that this space detects taps too. On the bottom three buttons appears. From left to right: wrong (pressed when the user did not know the translation), menu (for extra options related to the words) and right (pressed when the user did know the translation).	See expected result.	☑
	Check response on tapping the wrong space.	The main page is shown with a word or some words and its translation under it. Left and right there is a red and a green area and below there are three buttons: red, orange and green.	Tap on the left side of the screen, on the red area.	None	By tapping the wrong space an event is sent to the server if there is a connection. If not the event is saved so it can be sent when there is a connection. The word is placed 5 steps further in the wordPair so it appears again after 5 words.	After clicking the wrong space a red image appears with an open book to notify the user about the clicked space. This image fades out and a new word appears on the main page.	See expected result.	☑
	Check response on tapping the wrong button.	The main page is shown with a word or some words and its translation under it. Left and right there is a red and a green area and below there are three buttons: red, orange and green.	Tap on the left red button on the bottom of the screen.	None	By tapping the wrong button an event is sent to the server if there is a connection. If not the event is saved so it can be sent when there is a connection. The word is placed 5 steps further in the wordPair so it appears again after 5 words.	After clicking the wrong button a red image appears with an open book to notify the user about the clicked space. This image fades out and a new word appears on the main page.	See expected result.	☑

Test Scenario	Test Case	Pre-conditions	Test Step	Test Data	Post-conditions	Expected Result	Actual Result	Pass/Fail
check feedback functionality	Check response on tapping the right space.	The main page is shown with a word or some words and its translation under it. Left and right there is a red and a green area and below there are three buttons: red, orange and green.	Tap on the right side of the screen, on the green area.	None	By tapping the right space an event is sent to the server if there is a connection. If not the event is saved so it can be sent when there is a connection. The word is placed 5 steps further after the first encounter in the wordPair so it appears again after 5 words. If the word is right again it will be placed 10 positions further in the wordPair.	After clicking the right space a green image appears with a graduation cap to notify the user about the clicked space. This image fades out and a new word appears on the main page.	See expected result.	☑
	Check response on tapping the right button.	The main page is shown with a word or some words and its translation under it. Left and right there is a red and a green area and below there are three buttons: red, orange and green.	Tap on the right green button on the bottom of the screen.	None	By tapping the right button an event is sent to the server if there is a connection. If not the event is saved so it can be sent when there is a connection. The word is placed 5 steps further after the first encounter in the wordPair so it appears again after 5 words. If the word is right again it will be placed 10 positions further in the wordPair.	After clicking the right button a green image appears with a graduation cap to notify the user about the clicked space. This image fades out and a new word appears on the main page.	See expected result.	☑
check menu functionality	Check response on tapping the menu space.	The main page is shown with a word or some words and its translation under it. Left and right there is a red and a green area and below there are three buttons: red, orange and green.	Tap in the middle of the space were the words are displayed.	None	The visibility of the menu page is set to visible.	After tapping the space the menu appears with three buttons "wrong translation", "I learned it" and "show context". On the bottom of the screen the back button is displayed.	See expected result.	☑
	Check response on pressing the menu button.	The main page is shown with a word or some words and its translation under it. Left and right there is a red and a green area and below there are three buttons: red, orange and green.	Tap on the middle orange button on the bottom of the screen.	None	The visibility of the menu page is set to visible.	After tapping the space the menu appears with three buttons "wrong translation", "I learned it" and "show context". On the bottom of the screen the back button is displayed.	See expected result.	☑
	Check response on pressing the "wrong translation" button.	The menu page is shown with three buttons "wrong translation", "I learned it" and "show context". On the bottom of the screen the back button is displayed.	Press the button with the text "wrong translation".	None	An event is sent to the server (when there is a connection), notifying the server that the current displayed word has to be erased. The word pair is always deleted from the local storage. The menu page visibility is set to hidden so the main page can be seen again.	After pressing the button the menu fades out and the main page is visible again. On the word space a red image appears with a trash can to notify the user about his or her action. When the image fades out a new word is on the main page.	See expected result.	☑
	Check response on pressing the "I learned it" button	The menu page is shown with three buttons "wrong translation", "I learned it" and "show context". On the bottom of the screen the back button is displayed.	Press the button with the text "I learned it".	None	An event is sent to the server (when there is a connection), notifying the server that the current displayed word should not be returned to the watch. The word pair is always deleted from the local storage. The menu page visibility is set to hidden so the main page can be seen again.	After pressing the button the menu fades out and the main page is visible again. On the word space a green image appears with a graduation gap to notify the user about his or her action. When the image fades out a new word is on the main page.	See expected result.	☑

Test Scenario	Test Case	Pre-conditions	Test Step	Test Data	Post-conditions	Expected Result	Actual Result	Pass/Fail
	Check response on pressing the "show context" button	The menu page is shown with three buttons "wrong translation", "I learned it" and "show context". On the bottom of the screen the back button is displayed.	1. Press the button with the text "show context". 2. Tap on the context in the word space.	None	The visibility of the menu page is set to hidden and a canvas becomes visible in which the sentence is printed in which the word was found. This canvas lies on top of the word space. After tapping the canvas the word is shown again.	The menu page fades out and the context appears on the same place were the words are normally displayed. After tapping the context, the context disappears and the word becomes visible again.	See expected result.	☑
	Check response on tapping on the menu page.	The menu page is shown with three buttons "wrong translation", "I learned it" and "show context". On the bottom of the screen the back button is displayed.	Tap the screen anywhere besides the other buttons.	None	The visibility of the menu page is set to hidden and thus the main page is visible again.	The menu page fades out and thus the main page is visible again.	See expected result.	☑
	Check response on tapping on the back button in menu.	The menu page is shown with three buttons "wrong translation", "I learned it" and "show context". On the bottom of the screen the back button is displayed.	Tap the button with the back arrow on it.	None	The visibility of the menu page is set to hidden and thus the main page is visible again.	The menu page fades out and thus the main page is visible again.	See expected result.	☑
	Check response after an screen off.	The menu page is shown with three buttons "wrong translation", "I learned it" and "show context". On the bottom of the screen the back button is displayed.	1. Wait for the watch screen to switch off or do a arm twist. 2. After a screen off press the power button or do a arm twist to turn on the screen.	None	The visibility of the menu page is set to hidden when the screen of the watch turns off and thus the main page is visible again when the watch is switched on.	The main page is visible.	See expected result.	☑
check profile functionality	Check response after pressing the left button.	The profile page is shown.	Tap the button on the left of the screen.	None	The medalPos is lowered by one. If the medalPos is zero, it will become four. And the medal is drawn on the screen.	The page icon number is updated, the previous medal is shown.	See expected result.	☑
	Check response after pressing the right button	The profile page is shown.	Tap the button the right of the screen	None	The medalPos is increased by one. If the medalPos is four, it will become zero. And the medal is drawn on the screen.	The page icon number is updated, the next medal is shown.	See expected result.	☑
	Check response after pressing the back button	The profile page is shown.	Tap the button on the bottom of the screen with the back arrow on it.	None	The visibility of the profile page is set to hidden.	The profile page fades out and the main page appears again.	See expected result.	☑
	Check response after an screen off.	The profile page is shown with two buttons on the side of the screen, a medal with information in the middle and a back button on the bottom.	1. Wait for the watch screen to switch off. 2. After a screen off press the power button to turn on the screen.	None	The visibility of the profile page is set to hidden when the screen of the watch turns off and thus the main page is visible again when the watch is switched on.	The main page is visible.	See expected result.	☑
check mainpage functionality	Check if the temperature is correct.	The main page is shown.	1. Check the current temperature at your current location. 2. Check the displayed temperature on the watch.	Temperature at the current location.	With an api the location is determined and with the location the temperature is loaded from another api.	The correct temperature is displayed on the top of the screen.	See expected result.	☑
	Check if the weather type is correct.	The main page is shown.	1. Check the current weather type at your current location. 2. Check the displayed weather type on the watch.	Weather type at the current location.	With an api the location is determined and with the location the weather type is loaded from another api.	The correct weather type is displayed on the top of the screen.	See expected result.	☑

Test Scenario	Test Case	Pre-conditions	Test Step	Test Data	Post-conditions	Expected Result	Actual Result	Pass/Fail
	Check if the date is correct.	The main page is shown.	1. Check the current date at your current location. 2. Check the displayed date on the watch.	Date at the current location.	With a function provided by tizen the date is loaded from the OS.	The correct date is displayed on the top of the screen.	See expected result.	☑
	Check if the time is correct.	The main page is shown.	1. Check the current time at your current location. 2. Check the displayed time on the watch.	Time at the current location.	With a function provided by tizen the time is loaded from the OS.	The time is displayed on the upper part of the screen.	See expected result.	☑
check popup functionality	Check if a popup appears when there are too few words left.	The main page is shown.	1. Tap the shown word to reveal the translation. 2. Tap the button in the middle on the bottom of the screen. 3. Press the button "wrong translation" or "I learned it". 4. Repeat this action until a popup appears.	None	In the app there should be at least the same amount of words as there are flashcards. When this amount is reached, a popup on top of the word space becomes visible.	The popup appears on top of the word space which disappears after 3 seconds.	See expected result.	☑
	Check if a popup appears when the learning streak is increased	The app is used for one day.	1. Use the app the next day. 2. Wait until the popup appears. 3. Close the popup by pressing the button on the bottom of the screen.	None	The date when the app is used, is saved to the local storage. When the app is used on another day, the date is compared to the saved date and if the difference is one day, the streak is increased. The popup canvas is not visible anymore.	A popup is shown with a medal (with glasses), the current learning streak and fireworks. The popup fades out when the button is pressed and the main page is visible.	See expected result.	☑
	Check if a popup appears when a new achievement is accomplished for learning session	The app is used for some minutes.	1. Use the app until the popup appears without the screen going off. 2. Close the popup by pressing the button on the bottom of the screen.	None	Longest session time is updated and saved to localStorage. The popup canvas is not visible anymore.	In the profile page the longest session will be updated.	See expected result.	☑
	Check if a popup appears when a new achievement is accomplished for total time	The app is used for some minutes.	1. Use the app at least 15 minutes 2. Close the popup by pressing the button on the bottom of the screen	None	The popup canvas is not visible anymore.	Popup is shown on the screen and can be closed with the button	See expected result.	☑
	Check if a popup appears when a new achievement is accomplished for words learned	No words are currently learned	1. Tap the menu button on the revealedPage 2. Tap 'I learned it' button. 3. Close the popup by pressing the button on the bottom of the screen	None	wordsLearned is updated and saved to the localStorage. The popup canvas is not visible anymore.	Popup is shown on the screen with the message 'you learned your first word!'. In profile words learned is now 1.	See expected result.	☑

B
Questionnaire

The questionnaire asked the following questions to the participants:

B.1 General information

1. What is your age?
2. How many times a day are you checking the time?
3. If you are learning new words, how much time do you spend daily on learning?
4. What is your native language?
5. In which language have you learned the words on the app?
6. What is your current language level in this language that you are learning?
    - A1 - Beginner. Can recognize and use simple phrases.
    - A2 - Elementary. Using simple words, can describe his or her surroundings and communicate immediate needs.
    - B1 - Intermediate. Can understand the main points of clear standard speech. Can narrate an event, an experience or a dream.

- B2 - Upper Intermediate. Can speak in a clear, detailed way on a number of subjects; express an opinion on current affairs, giving the advantages and disadvantages of the various options.
- C1 - Advanced. Can use the language effectively and fluently in a social, professional or academic context.
- C2 - Master. Can express him or herself precisely in a spontaneous, fluent way, conveying finer shades of meaning precisely.

7. For how many years have you been studying this language?
8. How much time do/did you spend daily on learning before the app?
9. How much words do/did you learn daily?
10. In what way are you learning the language? (multiple choices)
    - I'm not learning it yet, but I will.
    - Reading texts in the other language.
    - Using a textbook.
    - Talking/chatting with other people speaking the foreign language.
    - Apps for the smartphone.
    - Other:...

B.2 Questions after using the smartwatch app

1. What do you think about the design? (e.g., Were the buttons large enough, was the text readable etc.)
2. Was it clear how the app should be used? If not, why?
3. Some people did not use all of the features: show context, I learned it, wrong translation, reverse and profile. If you also didn't, could you let us know why?
4. What didn't you like about the app?
5. Which features did you miss that would have been useful?
6. Which features did you like?
7. What did you think about the medals with the achievements in the app?

8. When did you use the app the most? (e.g., waiting for the bus)
9. When you didn't know a word, did you reveal the translation instantly or did you take time to think about the answer?
10. Did you sometimes press right when you actually didn't really know the word? If so, what was the reason?
11. What score would you give the TimeToLearn app from 1 to 10?
12. Would you recommend the TimeToLearn app to your friends?
    - Yes
    - No

C

Questionnaire answers

In this appendix the answers of the users are included, in the user study we used numbers to separate the users. The same numbers are used here to separate the user.

C.1 General information

1. What is your age?
   (i) 24
   (ii) 22
   (iii) 26
   (iv) 34
2. How many times a day are you checking the time?
   (i) It depends if I am waiting or not. Moreover, I do it subconsciously. I would say: About 10-15 times
   (ii) 24 approximately
   (iii) 7

(iv) 10

3. If you are learning new words, how much time do you spend daily on learning?
   (i) Once a day, maybe 10 minutes
   (ii) 1 hour
   (iii) 10 min
   (iv) not much...
4. What is your native language?
   (i) Dutch
   (ii) Dutch
   (iii) Romanian
   (iv) Romanian
5. In which language have you learned the words on the app?
   (i) German
   (ii) German
   (iii) Danish
   (iv) German
6. What is your current language level in this language that you are learning?
   (i) C2
   (ii) B1
   (iii) A2
   (iv) B1
7. For how many years have you been studying this language?
   (i) The first time having it in school was 13 years ago
   (ii) 6 (only at school)
   (iii) 1
   (iv) 3
8. How much time do/did you spend daily on learning before the app?

(i) None

(ii) none

(iii) Almost at all

(iv) not learning daily...

9. How much words do/did you learn daily?

(i) I picked about 5-6 words a day

(ii) none

(iii) Around 14

(iv) i didn't put time aside daily...

10. In what way are you learning the language? (multiple choices)

(i)
- Reading texts in the other language
- Talking/chatting with other people speaking the foreign language.

(ii) I am not learning it yet, but I will.

(iii)
- Reading texts in the other language
- Using a textbook
- Talking/chatting with other people speaking the foreign language.

(iv) Reading texts in the other language.

C.2 Questions after using the smartwatch app

1. What do you think about the design? (e.g., Were the buttons large enough, was the text readable etc.)

(i) The design was great!

(ii) The design was alright, it was excellently readable.

(iii) The design was overall ok, it is simple and easy to use. You need to get closer to read the word in the sentence but that's an extra function.

(iv) context was not large enough i was missing an "i don't want to learn this word" option.

2. Was it clear how the app should be used? If not, why?

   (i) It didn't come naturally to me that there were more options in the app, like "I have learned the word". So I got the same words over and over, that I already knew.

   (ii) It was clear from the instructions which I obtained from Niels, but to do it myself I think it would be confusing

   (iii) Yes, it was quite clear. I was not sure when the words will be removed from the list and that's why I used the function 'I know the word, don't show it again'

   (iv) clear for me

3. Some people did not use all of the features: show context, I learned it, wrong translation, reverse and profile. If you also didn't, could you let us know why?

   (i) Because I didn't know the app had these features. A small tutorial might have done the job? Or a message "You haven't used all features of this app. Did you know that... "

   (ii) I only used these features once. I have no specific reason why I didn't use them, I forgot they existed sometimes and other times I just wanted a quick check if the translation I had in mind was correct.

   (iii) I didn't use wrong translation because I was not sure about the translation, and didn't have time to check the word in another dictionary. It's still a very new language for me

   (iv) reverse is not easy to find not always clear if a translation is wrong...

4. What didn't you like about the app?

   (i) The translations weren't always correct in the context, as I sometimes already knew what it meant. It does have a option to choose a different translation, but a person learning a new language wouldn't know the exact word. That's just a problem with translation sites though and not the app itself. During testing the app screen froze like 2-3 times and sometimes reacted a bit slow.

   (ii) None.

   (iii) The fact that I was not sure if it is the right translation and also, that I couldn't hear the pronunciation

   (iv) nothing

5. Which features did you miss that would have been useful?

(i) As explained earlier: A feature to encourage you to fully use the app or a small tutorial, as I was new to the app.

(ii) Maybe some feature to learn the pronunciation as well.

(iii) pronunciation

(iv) i would like to be able to see the context before the answer, maybe the context would help me remember the answer

6. Which features did you like?

(i) Achievements and the general looks

(ii) The context feature is really helpful in my opinion although I didn't use it much.

(iii) The 'show the word in the context' button

(iv) like being able to learn vocabulary in elevators

7. What did you think about the medals with the achievements in the app?

(i) Great!

(ii) I did not pay much attention to this.

(iii) Were fun at the beginning but would not be so interesting on long term

(iv) Yes (I liked it)

8. When did you use the app the most? (e.g., waiting for the bus)

(i) Waiting, before going to sleep and out of boredom

(ii) When I was doing nothing at all or waiting, mostly in the evenings while watching tv and so on.

(iii) Waiting for the green light while biking

(iv) when waiting for people, or things (e.g. elevator)

9. When you didn't know a word, did you reveal the translation instantly or did you take time to think about the answer?

(i) Most of the time instantly. I was impatient and curious to know what it meant.

(ii) sometimes I accidentally hit reveal translation but mostly I tried to think about the correct translation.

(iii) Waited few seconds but not very long

(iv) i would reveal the answer if i didn't know the word

10. Did you sometimes press right when you actually didn't really know the word? If so, what was the reason?

    (i) No, perhaps a miss click

    (ii) Yes sometimes, only by accident.

    (iii) Seldom, and if so, because I believe the word it's not so important

    (iv) maybe... so i can feel good about myself

11. What score would you give the TimeToLearn app from 1 to 10?

    (i) No, perhaps a miss click

    (ii) 9

    (iii) 7 (maybe develop it for smartphones, I don't like having a watch, would like to have also pronunciation and a very accurate translation)

    (iv) 8/10

12. Would you recommend the TimeToLearn app to your friends?

    (i) Yes

    (ii) Yes

    (iii) Yes

    (iv) Yes

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