

**Putting the right-to-left layout to the test: Exploring appropriation and left-handed phone use
in a mirrored phone layout**

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Abstract

This study aimed to observe the appropriation of a changed phone of which use had previously stabilized. The second aim was to observe phone use among left-handed people and the need for a left-handed phone layout. This study used the Android right-to-left (RTL) function to observe this. In essence, this function mirrors the user interface. It was used as a change to the known phone layout of participants. Carroll's Model of Technology Appropriation (2004) was applied as a framework to understand the processes that guide technology use. A week-long diary study was held to observe the first week of participants using their changed phone. During the study, 26 participants (5 left-handed, 3 ambidextrous) were asked to log their experiences daily. Afterwards the participants were interviewed about their experience. It was established that the appropriation process after the first stabilizing of phone use could be considered a different process than before this first stabilization. This study defined this process as re-appropriation. This process stabilized faster than expected because it was based on previously known limitations and affordances. Besides this, re-appropriation was noted to have short-term effects as an intervention for phone use. The RTL layout was appropriate for changing the known phone, but was less effective as a left-handed mode. Left-handed participants were divided on the usefulness of a left-handed layout in general. They were observed to be adaptive in their handedness, not only in phone use. This was seen in their doubts about a left-handed mode for phones. The difference between an RTL layout and a normal layout would make it difficult for left-handed persons to use a different phone. Besides, most left-handed users are already used to the normal phone layout. The observations on re-appropriation made in this study expand on the theoretical base of appropriation. Re-appropriation possibly has interesting practical implications as an intervention strategy. This study has also filled in some of the gap in knowledge on left-handed phone use. The results of this study offer insights for future research in both the field of appropriation and the fields of left-handedness and phone use.

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Introduction

This study is inspired by the right-to-left (RTL) layout. It seems largely unknown to many phone users that some phones offer the option to completely flip the device's user interface. Almost all smartphones using an Android operating system provide option to "force" an RTL layout, hidden deep in the developer settings. This setting forces apps to effectively vertically mirror most of the layout of the phone. The mirrored phone is a big change from the non-mirrored phone. The RTL layout therefore offers the opportunity for this study to observe how change influences phone appropriation. This study aims to contribute new information to the existing knowledge on the appropriation process. Besides, the RTL layout offers the opportunity to gain insight into phone use of left-handed users. By mirroring the layout, it might become more suitable for these users. The second goal of this study is therefore to observe whether left-handed users would benefit from a change in layout. These goals will be further laid out below.

Appropriation of a changed phone

Firstly, performing a study with the RTL layout presents an opportunity to observe appropriation. When applying Carroll's Model of Technology Appropriation (MTA; Carroll, 2004), it is visible that most phone users have already worked through the appropriation process. They are aware of the affordances and limitations of the phone and have minimized exploring and experimenting. The duality of structure (Giddens, 1984, as cited in Lamsal, 2012) notes that when a technology has been appropriated, it will keep going through the process of appropriation. The technology keeps shaping and being shaped by the user (Leonardi & Barley, 2010). This shaping continues to exist, but occurs less over time. This defines the stabilized phase of "technology in use", where the phone has become a part of the daily life of the user.

By changing the phone, this stabilization is disturbed. The user will have to re-enter the process of appropriation. This study defines this appropriation of a previously stabilized technology as "re-appropriation". The disturbing of the stabilized position will encourage the interpretive flexibility

between user and phone. In this setting, re-appropriation could work as an intervention. While re-appropriating the phone, the user might start thinking critically about their previous phone use.

It will be interesting to observe re-appropriation and the changes in phone use caused by changing the phone layout. The first aim of this study is therefore to observe re-appropriation and its effects on phone use. The first research question for the following study is:

RQ 1. What does re-appropriation of a phone with an RTL layout look like over the course of the first week of use?

This question is accompanied by the following sub questions:

SQ 1.1 To what extent can re-appropriation be seen as an addition to appropriation?

SQ 1.2 How does re-appropriation relate to phone use?

The left-handed layout

Secondly, this study sees an opportunity to examine left-handed phone use with the RTL layout. When looking at phone interfaces, they seem to assume right-handedness (Garun, 2017; Nadir, 2021; Ullinger, 2018). The estimated 10.6% of people that are left-handed (Papadatou-Pastou et al., 2020) do not have a choice but to use the right-biased phone layout. This right-handed bias is present in more than just phone design. Scissors are a well known problem, but there are many lesser known problems like tutorials for guitar playing or crocheting needing to be mirrored to work for left-handed persons (Anythingleft-handed, n.d.). The left-handed part of the population has to work with many more right-biased hindrances on a daily basis. This study aims to observe whether this is also a problem in phone use.

The RTL layout effectively mirrors the normal left-to-right (LTR) layout. Everything on the right side of the screen is moved to the left, and vice versa. This “Force RTL” function is originally developed for testing bidirectional (BiDi) language layout. Internet forums and other online media platforms have interpreted the use of this function differently. Informally, the RTL function is sometimes referred to as the “left-handed mode”. The mirrored layout is seen by some left-handed users as a way to adapt their phone layout to their handedness (Obaiza, 2015; Reid, 2014).

There seems to be ample awareness of disabilities connected to hearing or sight in Android phone design (Android, n.d.). Comparatively, a subject like difference in handedness does not seem to be considered greatly. Naturally the consequences of not considering left-handed people are not comparable to excluding people living with disabilities. However, it seems logical to also consider the influence of handedness in phone design. Especially when left-handed users are already looking at the RTL layout as a solution. As Johnson and colleagues (2010) state: including people's needs and capabilities in design decisions is an important step towards inclusive experiences for all users. Being able to fit phone layouts to handedness would increase the inclusiveness of the phone. Ten percent of users would be able to adapt their experience to their actual handedness. Still, the question remains whether it is actually a desirable option. After all, most left-handed users seem to be able to work with their phone just fine.

Because of the lack of clarity on the subject, the second aim of this study is to observe left-handed phone use with the RTL layout and to observe the necessity for a left-handed layout. For this second research goal, the main question is defined as:

RQ 2. To what extent would a left-handed phone layout be of interest to left-handed users?

This question is accompanied by the following sub questions:

SQ 2.1 How do left-handed users interact with their phone?

SQ 2.2 To what extent is the RTL layout a feasible option for a left-handed layout?

Approach

The performed study consisted of a week-long diary study and a concluding interview. The participants were instructed to activate the "Force RTL" setting on their phones. Independent of handedness this would be a new layout for any of them. Participants were instructed to note their experiences with the phone in a daily diary survey. After a week, the participants were interviewed to gain deeper insight into their experiences of the past week.

The resulting data is an important step in understanding re-appropriation of a familiar but changed technology. It will help to expand the current knowledge on the subject of appropriation and

to inspire future research. Observing differences in phone use per different handedness will play a meaningful role in gaining insight into the current limitations on left-handed phone use. Depending on the outcome, this study can pave the way to encourage more left-handed people to try the RTL function, and help indicate the importance of improving the function to be used as a left-handed mode. Independent of the outcome, the data will add to the gap in current knowledge of left-handed phone interaction.

Theoretical framework

In this section the theoretical base for the study will be further explored. First a broader explanation of the RTL layout and its functioning is given. After this the chosen models for appropriation and acceptance are laid out and elaborated on. Finally handedness as a whole and handedness in phone use are explored.

Understanding the RTL layout

Before applying the RTL function to this study, its performance needs to be explored. This section will focus on obtaining a basic understanding of the function. There is hardly any documentation to be found on it. Theoretical information on the appearance of the phone in RTL layout is easier to obtain than practical information on the function. Therefore the theoretical base of the RTL function will be discussed first. Second, the inner workings of the function are explained. Lastly, a realistic view is offered on the actual functionality of the RTL function.

The paper of Ayyal Awwad and colleagues (2017) and the Google Material design page on Bidirectionality (Material Design, n.d.) give insight into the elements that are adapted in BiDi layout. The BiDi layout is what the RTL layout aims to achieve. BiDi guidelines can be broadly summarized as alignment and mirroring. Items that are influenced by alignment are aligned to the right. Numbers are the exception to this right alignment. In the category of mirroring, sliders stand out. In BiDi layout, these are horizontally mirrored except when they reflect time, like a progress bar. Some icons are also mirrored. Because icons have many small rules and hardly influence use, icons will not be expanded upon here. When comparing BiDi theory and RTL reality, many of the rules have not translated.

Why many of the BiDi rules do not translate to the practical RTL result originates from the coding. The following practical knowledge was found between coding instructions and in Android release notes (Android Developers, n.d.-a; Android Developers, n.d.-b; Harit, 2018). The RTL function takes pre-determined elements. It transforms anything it recognizes (Android Developers, n.d.-b). Many apps are not built to the exact specifications needed to successfully perform this. Most apps are not aimed at BiDi language countries, so the app designer does not pay attention to this.. It then also becomes clear why the setting is called “Force RTL”. Not all applications have been made with this option in mind, but they will often still be transformed to some degree. That is why the result is hardly ever compliant with all BiDi rules. Though not perfect, apps mirror to the extent their coding allows them to.

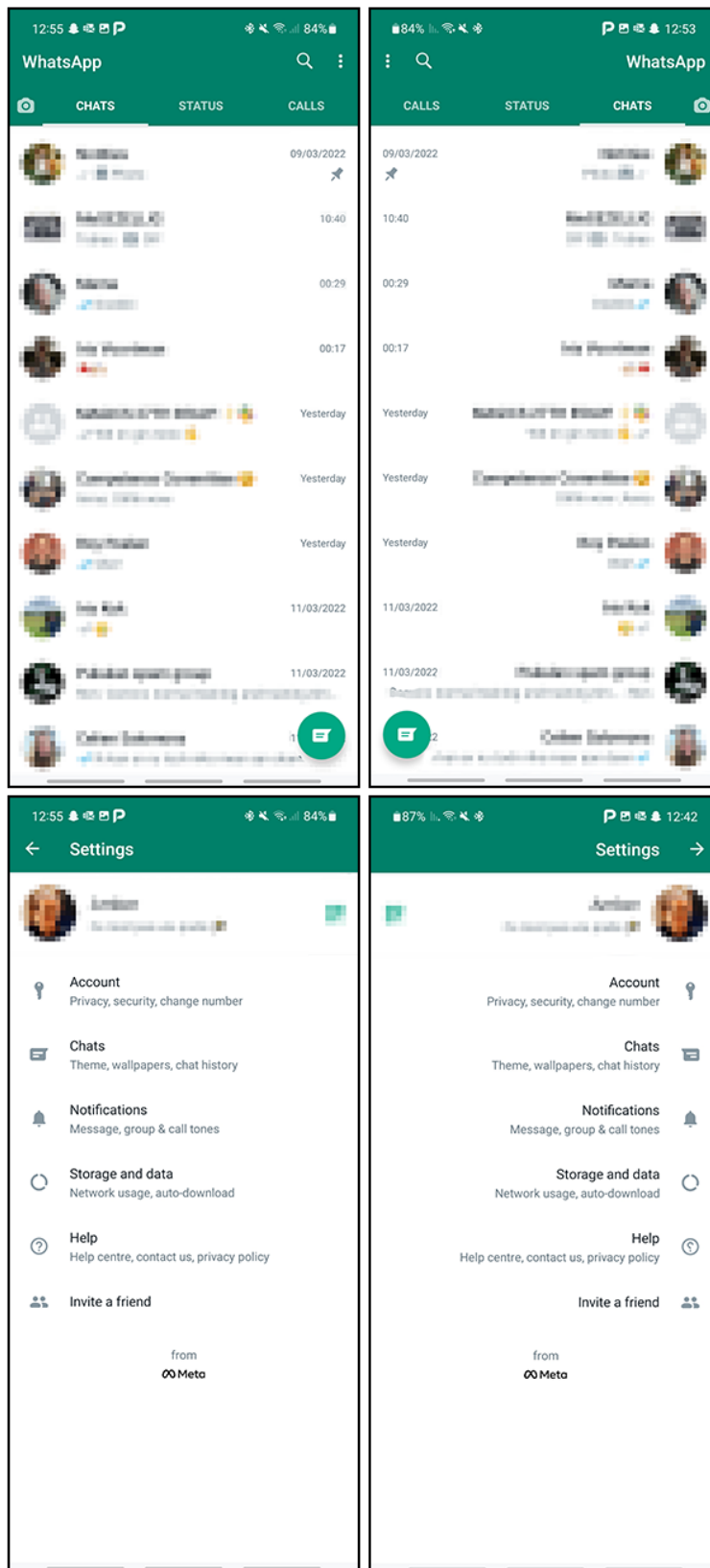
Apps have been observed by the researcher to have three different responses to the RTL function. The first kind of response consists of apps that almost perfectly mirror what is needed without creating problems (Figure 1). The second kind includes apps that mirror to different levels of success. The mirroring of these apps seems arbitrary (Figure 2). The last kind of response to activating the RTL function consists of apps that do not seem to respond at all. These observed differences in responses are based on coding and classification of elements. This influences way elements are read and converted into RTL layout (Android Developers, n.d.-b). It is difficult to predict the experiences of users, since every user will be using slightly different apps. Therefore, some users might have a more accurate and consistent experience than others when working with the function.

Previous research and RTL

No practical use of the force RTL function has been found in previous research. Discussion on RTL layout is also scarce. The few articles found look at the functionality of phone interfaces for RTL languages like Arabic (Ayyal Awwad et al., 2017; Ayyal Awwad & Slany, 2016). These articles do not mention the *Force RTL* function and rather focus on the apps that will be used in BiDi language countries as well as countries using a Latin alphabet. The first article introduces an approach for automatic detecting of localization defects in apps. The second article focuses on transforming a

Figure 1

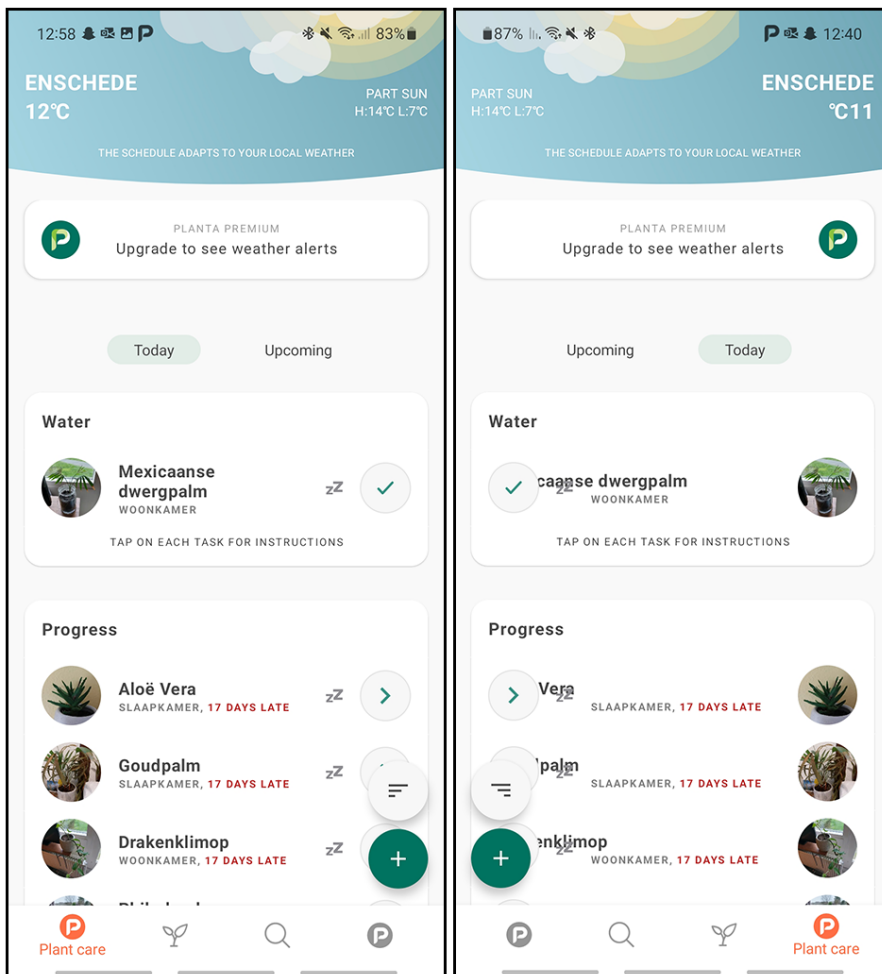
Examples of the LTR and RTL Versions of the Well-Mirrored WhatsApp App.



Note. The WhatsApp app nearly has everything correctly mirrored according to the BiDi rules.

Figure 2

Examples of the LTR and RTL Versions of the Inconsistently Mirrored Planta App.



Note. The Planta app was still usable. However, the layout was clearly not made to display properly when forced into RTL. This was the most disorderly app found by the researcher.

drawing app to the correct RTL layout, to show what is needed for a correct BiDi layout. Both focus on making apps more accessible to BiDi language users. The further lack of previous research concerning the RTL function leaves a gap in practical knowledge on actual usability. Although the RTL layout seems usable after exploration, this might differ during actual use.

Model of Technology Appropriation

In order to understand the processes that govern smartphone use and the influences a changed layout could have on it, the current study applies the Model of Technology Appropriation (MTA;

Carroll 2004). The MTA displays the path the user takes towards appropriation. This starts with the potential user finding the technology. From that moment on, the user will work towards having the technology incorporated in their day-to-day life. As visible in Figure 3, Carroll defines these steps as three levels to appropriation of a technology. These steps will be explained in the upcoming paragraphs.

Level 1

The first level starts with adoption, the user chooses to start or not to start using the new technology (Carroll, 2004). The Filter, as the first level is called in some iterations of the model, represents the different factors that influence the choice to adopt a technology (Carroll et al., 2001). These factors differ per person and circumstance (Mendoza et al., 2010). This could be factors like the perception of the technology, the user, or the context of use. This stage is not included in the MTA because it has been thoroughly examined in other literature focusing specifically on intention to use (Mendoza et al., 2010). Notable examples of literature on this stage are Rogers' Innovation Diffusion Theory (1983), and Davis' Technology Acceptance Model (1989).

Level 2

When the user decides to adopt the technology, they move on to level two (Carroll et al., 2001). The time after adopting the technology is defined as the process of appropriation. As Leonardi and Barley (2010) noted, appropriation is what happens after a technology has been adopted. This is when exploration, evaluation, and adaptation of the technology takes place (Carroll, 2004). The process of appropriation is seen as the change of technology use between the starting intention of the designer (Technology as designed) and the way it is eventually appropriated by the user (Technology in use) (Carroll, 2004). Technology in use often differs from the technology as designed, this is because technology and users influence each other.

Stating that a technology shapes and is shaped by use is a social constructivist view (Carroll et al., 2001; Leonardi & Barley, 2010). By personalizing the technology or by using it in an unexpected way, users shape the way they appropriate a technology (Carroll et al., 2001). Think of the shaving apps in the beginning of smartphone use, activating the vibrating function of the phone so the user could

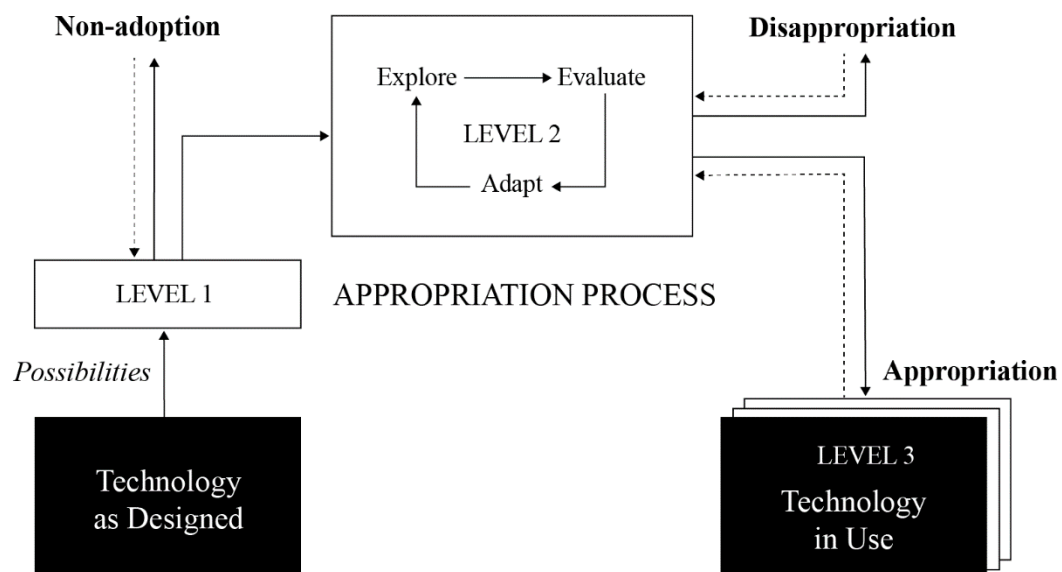
pretend to shave with their phone. The designers did not have that in mind as the purpose of the vibrating function of the phone. The technology itself also carries an intention with it, which in turn can shape the way the user appropriates it. This intention is shown in the affordances and limitations of the technology (Carroll, 2004). These prevent and encourage certain actions. A screen that is too bright could prevent a user from using their phone in the evening. Being able to check emails on a phone will make the user spend more time on it. In this way, the technology shapes the user.

Level 3

Appropriation is the third level, the integrating of the technology into daily life. At this point the technology has shifted from technology as designed to technology in use. Technology in use entails that the technology is now part of the life of the user. When having reached level 3, the user will keep going between levels 2 and 3. The technology will keep shaping and being shaped by the user. Because this process continues, appropriation is not absolute. The technology is constantly evaluated, and at any moment the user may decide to disappropriate it (Carroll, 2004).

Figure 3

Model of Technology Appropriation (Adapted from Carroll, 2004)



The duality between user and technology will stabilize over time (Giddens, 1984, as cited in Lamsal, 2012). Mendoza and colleagues (2010) observed 14 participants' appropriation of EndNote, a bibliographic software package. During the study they noted the unpredictable stabilization time while they observed different influences that strengthen and weaken the intention for long-term use. Around seven to eight weeks into the twenty-week study the use of the technology started to stabilize. The stabilization times will differ per technology, but stabilization will happen when the user continues using the technology. Orlikowski (1992) states in the context of organizations, there is no need for a technology to be constantly reconstructed. Reconstruction takes conscious effort, stabilization reduces this effort by reducing reconstruction.

Re-appropriation and intervention

By changing the layout, the stabilized process of appropriation is disturbed. This is defined by this paper as re-appropriation: the user entering the process of appropriation again after the initial stabilizing of the technology use. It is a re-entry into level 2 of the MTA. This was first described by Mendoza and colleagues (2010). In their study, an ongoing training program was available for the participants to continue developing their EndNote skills. This appeared to be a facilitating condition for re-appropriation. After stabilization of use, participants came back to the trainings to learn more about the software. Other research in the context of organizations, mentions that re-appropriation occurs in short bursts after the initial stabilizing of the technology (Tyre & Orlikowski, 1994). No further research on re-appropriation was encountered.

This study is interested in the possible effect of re-appropriation on phone use. Taking a practical view, the affordances and limitations of the phone are already known. The user has to consider fewer factors compared to the original process. This leads to the expectation that the steps of re-appropriation will likely differ from the main appropriation process of the phone.

Intervention. During the COVID-19 pandemic, many people have been pushed out of their usual rhythm and many had to re-evaluate their daily behavior. The pandemic encouraged employees working from home to think about the application of working from home outside of the pandemic. For

example, they liked that working from home affords them autonomy (RIVM Corona Gedragsonite, 2021). The “COVID-intervention” caused re-evaluation and change. This result may also apply to re-appropriation.

Continuing in a state of no reconstruction for too long can be perceived as negative (Orlikowski, 1992). In the case of phone use, the use of this technology has been relatively stable for a long time. When standing still, the user may lose the capability to think critically about their phone use. Re-evaluation is needed from time to time, and might be triggered by re-appropriation. When the balanced duality that has been formed over time is broken by a change, the user may have to re-evaluate their previous phone use. This study will observe whether intervention can be a result from re-appropriation.

The Technology Acceptance Model

As explained before, the MTA does not give much context on the intention to use a technology. Since this is an important part to accepting a technology, the Technology Acceptance Model (TAM) will be applied (Davis, 1989). The model shows how users base their intention to use a technology on perceived ease of use and perceived usefulness (Davis, 1989). This acceptance of a technology is especially relevant during level 1 of the MTA, the adoption phase. However, it remains to be important throughout the use of the technology, as it also applicable to the acceptance of change.

Davis defines perceived usefulness as the question whether a technology is expected to improve performance. Perceived ease of use is defined as how complicated the use of the technology is regarded. Davis found perceived usefulness to be a stronger predictor than perceived ease of use. He states that users are willing to undergo some discomfort if the technology is useful. It is expected that users of the mirrored phone will have more difficulties with ease of use than with usefulness, as the affordances and limitations of the phone remain the same.

Left-handedness

To help in understanding left-handed phone users, general statistics on left-handedness have to be reviewed. This is followed by the pressure on left-handed people in a right-handed world. Left-handed solutions and the adaptability of left-handed persons is also discussed. The section then

continues by establishing a theoretical base on left-handedness and phone use. Finally, the chosen method of determining handedness is presented.

Around 10.6% of people are left-handed world-wide, according to Papadatou-Pastou and colleagues (2020). The actual statistics of handedness are difficult to be certain of, due to lack of measurement and influence of culture on perceived handedness. Measured handedness has been observed to be more skewed in high-conformity societies (e.g. Kushner, 2013; Lien et al., 2015; Xu & Zheng, 2017), indicating cultural pressure against left-handedness (Papadatou-Pastou et al., 2020). Gender influences handedness, with men being more likely to be left-handed than women (Buser et al., 2021). Age has also been suggested to moderate the numbers, with younger people more often being left-handed (e.g. De Kovel et al., 2019; Jung & Jung, 2009; Porac, 1993). In these statistics, a trend of pressure on left-handed persons to conform to the right handed world becomes visible.

These pressures felt-by left handed people have been decreasing in some areas. This increased tolerance is why younger people are more often found to be left-handed. Pressure to conform to right-handed behavior due to cultural or religious reasons has relaxed in the previous century (Porac, 2016). In a survey among 650 young adults, Porac and colleagues (1986) found that 52 of the 73 left-handed participants experienced a pressure to switch to the right. They found that more pressure to switch was seen in older participants, indicating a decrease in pressure over time. With growing tolerance, it is likely that this has become even less over the years. Still, left-handed people may feel pressured to switch to the common right-handed pattern in movements like eating and writing (Porac, 2016; Porac et al., 1986).

A right-handed world

Even with less pressure to change to using their right hand, the world surrounding the left-handed people is often oriented towards right-handedness. Left-handed people experience some challenges in this right-handed world. This right-handed bias is still found in many objects, for example, scissors, can openers, and bread knives (Anythingleft-handed, n.d.; McFadden, 2017). Besides, everyday circumstances are made more difficult because of this bias. In a supermarket, the cash register is often

made for right-handed cashiers. Online tutorials on guitar playing or crocheting are often using their hands the other way around. Many left-handed people have grown used to these inconveniences, but as the webshop Anythingleft-handed states:

Whilst us left-handers are pretty adaptable - finding ways to make standard right-handed tools work for us, why should we have to suffer the resulting discomfort and poor performance? (n.d., homepage)

There are solutions, specialized designs for left-handed people. The acceptance of these objects seems low. Basak and Roy (2019) tested the possibilities to adapt a desktop computer to left-handed use. Though difficult to find, the settings to switch mouse button functions are there. When they asked 8 left-handed people about it, two had tried this before, but none were ultimately interested in switching. When asked, they stated that they did not want to re-invest the time it had taken to get used to right-handed mouse use. The two who tried switching stated that they had grown accustomed to normal use. Besides, they shared their interface with family, or had to use other computers in a normal way, which would be confusing. These sentiments could also be applicable to left-handed phone solutions. That is why this study questions the necessity of a left-handed layout.

An unwillingness to use left-specific products would be explained by the adaptability of the left-handed person. A higher handedness adaptability is seen in left-handed persons compared to right-handed persons. This is visible in many handedness studies (Hoffmann et al., 1997; Przybyla et al., 2011). Hoffmann (1997), for example, performed an experiment in which he let different groups perform a different movement task. The groups consisted 8-16 participants, each with an equal amount of left- and right-handed participants. The tasks differed in content and difficulty. He concluded that left-handed and right-handed participants do not perform differently when using their preferred hand. It also did not matter when the task consisted of ballistic arm movements. However, when needing visual aid in the task and using their non-preferred hand, the left-handed participants performed better than the right-handed participants. This result was also reproduced in the context of computer mouses

(Hoffmann et al., 1997). Now that some light has been shed on the context of left-handedness, this section continues by looking specifically at phone use by left-handed people.

Left-handedness and phone use

Upcoming, previous research is looked at to better understand left-handed phone use and to investigate if there is a need for a left-handed option in phone use. The suitability of the normal layout for left-handed users is examined. After this, it is laid out whether non-dominant hand is a problem for left-handed users. Finally, the actual hand use of left-handed phone users is explored. These paragraphs will provide context on phone use and left-handedness.

To start, it is explored what hand left-handed persons use to interact with their phone. It has been observed that handedness influences in which hand a phone is held. Mostly it is held in the left hand when left-handed and vice versa (Alshahrani et al., 2021; Arif, 2012; Seidman et al., 2013). However, like in other behavior, in phone use there is conformity toward right-handed use visible in left-handed users (Alshahrani et al., 2021; Inkpen et al., 2006; Silfverberg et al., 2000). These findings suggest that, even if the UI is more focused on right-handed users, some left-handed users will still use their dominant hand to perform tasks.

This raises the question whether it would be a problem for left-handed users to interact with their phone using their non-preferred hand. In their study, Aşçı and Rızvanoğlu (2014) compare left- and right-handed phone interaction. An eight-person study was performed to observe the usability of a grocery app. The four right-handed participants performed faster and more accurate when a target was located at the lower-right part of the screen. The other way around, the left-handed participants were faster and more accurate. They observed that in phone use there seems to be no difference in general speed and accuracy per handedness when the participant is using their preferred hand. This was also noted in other studies, and is comparable to general handedness (Hoffmann, 1997; Hoffmann et al., 1997; Perry & Hourcade, 2008; Przybyla et al., 2011). This indicates that phone users will always have spaces that are more difficult to reach, their location depending on handedness.

It is still unclear if the design makes hard-to-reach spaces are more inconvenient for left-handed users. This paragraph will therefore touch on the suitability of the normal layout for left-handed use. According to some internet articles, phone interfaces seem to be aimed at the right-handed majority (Garun, 2017; Nadir, 2021; Ullinger, 2018). However, it is hard to find evidence for this in existing literature. Research states that the most difficult to reach target for right-handed users is the top-left of a phone. Easiest to reach are targets in the middle and upper-right of the screen (Ng et al., 2014; Trudeau et al., 2012). Mirroring these outcomes would logically give the left-handed results. However, those relatively old studies examined smaller phones than the current phone sizes. Besides, Hooper (2017) more recently found that people shift the way they hold their device constantly. Because screens have increased in size, the users are switching between different positions and one- and two-handed use, all depending on the situation. These developments likely influence the areas that were previously defined as hard to reach. To conclude, recent research is not able to provide the tools to gain insight into the suitability of the normal phone layout for left-handed use.

To conclude, left-handed phone use remains difficult to assess. With many elements of their regular phone use still unknown or unclear, it is difficult to define expectations. It is possible that there will be a noticeable difference in appropriation of the mirrored phone compared to the right-handed participants. This due to left-handed persons being more adaptable. Additionally, according to the literature, the RTL layout might support the left-handed users in working faster and more accurate. However, an absence of information on usability for left-handed users does not exclude that they are able to work with the normal layout without complications.

Measuring handedness

To conclude this section on left-handedness, this part focusses on determining what constitutes a left-handed person. In the measurement of handedness lies a methodological divide. Although often simplified, handedness is not a binary attribute that is easily divided into left- and right-handedness (Hardyck & Petrinovich, 1977). As Papadatou-Pastou and colleagues (2013) observed, percentages of hand preference differ per method used. The greatest difference in results was seen when only asking

participants to indicate the hand they use to write. This mostly mislabels left-handed participants writing with their right hand (Papadatou-Pastou et al., 2013). To measure handedness in this proposed study, the Edinburgh Handedness Inventory (EHI) will be used. This method includes ambidextrous outcomes (Oldfield, 1971). It is also the measure used most often in the past years (Papadatou-Pastou, 2020). The EHI consists of 10 questions and results in a laterality index, indicating hand preference (Oldfield, 1971). Results of the Edinburgh Handedness Inventory are like a bimodal scale. Participants are mostly classified as right- or left-handed but there are also participants treading the middle area. These participants are ambidextrous, or both-handed.

With the theoretical framework in place, this paper will continue by explaining the approach to the study.

Method

In this section the method for obtaining data on the posed research questions will be described. First, it will shortly touch on the general design. After this, the participants and their selection are discussed. This is followed by the procedure of data collection. Finally, this section will conclude with the methods of data analysis.

For the study, participants were recruited to have the RTL layout active on their own phone for a week. The study consisted of three parts: an introductory conversation and questionnaire, a week-long diary study, and a concluding interview. A qualitative approach in the shape of a diary study was chosen. A qualitative study gives insight into the specific experiences of the participants instead of generalizing.

Participants

The participants were selected on handedness, whether they own an Android device, and proficiency in the English language. More left-handed participants were needed than would take part in the study organically. This made it necessary to actively recruit for left-handed participants. Owning and using an Android device was necessary because the RTL layout would otherwise not be available. Already using the device ensures the participant is already used to the normal LTR layout. Finally, sufficient proficiency in the English or Dutch language was required to be able to participate actively

in the study. The participants needed to be able to understand exercises and to communicate their thoughts verbally and in writing.

To obtain sufficient data, 20-30 participants were required (Boddy, 2016; Dworkin, 2012). They were recruited through the BMS test subject pool of the University of Twente and through recruitment by the researcher. None of the participants had worked with the RTL function before this study. A total of 26 participants have participated in the study. The average age of the participants was 21.3. In Table 1 more of their sociodemographic characteristics are detailed.

Most participants filled out all seven diary entries. Four times only one entry was missing, and on two occasions the participant filled it out in the morning instead of the evening before. Two outliers were missing more than one diary entry. One participant only started diary entries on day 5 and did not write entry 7. The other did not have anything to say after day 2, so only wrote the first, second, and seventh entry.

All participants participated in the concluding interview. The interview was in all but one occasions held on day 7 or 8 of the study. One exception was held on day 10 due to external problems.

Procedure

The diary study was accompanied by an introductory questionnaire and a concluding one-on-one interview. In this section these methods are further explained. The full study was performed in either English or Dutch, depending on the participant. The diary study prompts were in English, but the participants were free to answer in either English or Dutch. Anonymity was established by having the participants choose a pseudonym for themselves under which their data would be collected.

For feasibility purposes the starting moments of the 26 participants were staggered. This way, the beginning and end parts would not all take place on the same day. Together, the three parts of the study took seven days per participant to complete. The concluding interview was held on the participants' seventh or eighth day. In total, three weeks around May 2022 were spent on collecting data.

Intake and questionnaire

Part one of the study started with a one-on-one intake. Although the prerequisites are shown clearly to aspiring participants, this moment was used to confirm they met the requirements. After being approved, participants received a briefing on the experiment and other practical information. In total this took about 15 minutes per participant.

Table 1

Sociodemographic Characteristics of Participants

Variable	n	%
Gender	26	100
Male	17	65.4
Female	9	34.6
Nationality	26	100
Dutch	18	69.2
German	5	19.2
English	1	3.8
Polish	1	3.8
Romanian	1	3.8
Indicated handedness	26	100
Right-handed	18	69.2
Left-handed	7	26.9
Ambidextrous	1	3.8
EHI result	26	100
Right-handed	18	69.2
Left-handed	5	19.2
Ambidextrous	3	11.5

After this, part one continued. Some information needed to be collected before the diary study would start. To obtain this, the participant was asked some introductory questions (see Appendix A). They were asked for details about the participant's phone and phone usage behavior, including handedness during phone use. These focused on normal phone use, outside of the study. The answers to these questions were written down. To determine normal hand use, the participant was asked to take some time to think of the hand(s) they use to interact with their phone. Lastly, a questionnaire was used to collect the remaining required data. The questionnaire determined some basic characteristics (age, gender, primary language, self-indicated handedness). Besides these questions, it contained the 10-point Edinburgh Handedness Inventory (EHI; Oldfield, 1971).

The EHI was used to accurately determine the participant's handedness. When filling out the EHI, the participants were encouraged to act out the behavior mentioned in the question to be able to answer accurately (Oldfield, 1971). A list of the questions can be found in Appendix A.

Diary study

The second part of the study consisted of a diary study. The participants had to be repeatedly observed to see the development of the acceptance and appropriation of using an RTL layout. A diary study was chosen to collect this data. With limited resources, this would be the most feasible way to observe use of the RTL layout in its first week. The setup of the study followed advice of articles found describing diary studies (Janssens et al., 2018; Salazar, 2016). Diary studies entail that participants are requested to note their experiences over the course of a set period of time. It was expected that the collected data would reflect the daily changes in the participants' actions or thoughts concerning the RTL layout.

The goal of the diary study was to capture experiences of acceptance and appropriation during daily phone use. It was also aimed at finding the drivers behind choices and feelings. The responses would be used to find references to acceptance and appropriation. Besides, the responses assisted in determining the value of the RTL layout. Participants used their own phones during the study. Activating the RTL mode marked the start of the week-long diary study. They were not specifically

told to keep the RTL layout activated until the end. Only on the last day the participants were asked to not switch back until after the concluding interview.

It was decided to have one retroactive assessment moment per day. This would provide enough information on the experiences of the day. Every evening around 8:00pm, participants were expected to enter their experiences. Other than this, they were encouraged to go about their normal lives. To ensure the participant remembered to write an entry, they were reminded via text message every day at 8:00pm. Writing the daily entries was done on their own phones via an online link. With the assistance of prompts the participants were asked to detail their experiences (e.g. “Describe how you experienced using the mirrored layout today”, “Have you noticed a change in your phone usage behavior?”). Full prompts can be found in Appendix B.

Concluding interview

A semi-structured one-on-one interview was held to further discuss the experiences participants had with the new layout. The interview attempted to capture their general experience, to find a conclusion to the experiences of the week. Questions were aimed at finding references to appropriation and usefulness. Furthermore, the way participants’ handedness related to their experience was also discussed. The topic list can be found in Table 2. The questions also held in account the participant’s diary entries.

These concluding interviews lasted around 25 minutes. Participants were allowed to choose to have the interview in person or via online meeting. In either setting it was ensured that there were no distractions. The interviews were recorded and transcribed.

Data analysis

To prepare data for analysis, the introduction questions, diary entries, and the concluding interview were collected into one document per participant. These documents were then imported into ATLAS.ti for the coding process. A preliminary coding scheme (Table 3) was made, based on the theory and on some categories that were noted during the interviews. This coding scheme was expanded in an inductive manner during the coding of the documents.

The rest of the coding process depended on thematic analysis. For thematic analysis the framework by Braun and Clarke (2006) was applied. Two rounds of coding were performed. The first round consisted of exploration and initial coding. The second to observe and correct the accuracy of the codes, to look for themes and categories, and to prepare the codes for reliability testing.

For reliability testing the Krippendorff Alpha index of agreement was used. This is the measure available within ATLAS.ti. The Krippendorff Alpha is used in ATLAS.ti because it corrects for limitations found in Cohen's Kappa (Cohen, 1960; Friese, 2020; Krippendorff et al., 2015). The coefficient α_c represents to what extent different coders can distinguish codes within a semantic domain (ATLAS.ti, 2020). For this study it was determined that $\alpha_c \geq 0.70$ would be seen as an acceptable reliability coefficient.

Two rounds of reliability testing were needed to achieve acceptable reliability. The first round showed the need for better description of the codes, which presented itself in seven code groups with low reliability. The code "adaptations to phone use" in code group "phone use" proved to be overlapping with other codes and was vague in description. For these reasons it was removed from testing. The second round of testing proved successful enough to continue. The final coding scheme and reliability of the second round are shown in Table 4. After reliability testing the coding was finalized. The results were collected and written down in the results section.

Table 2*Topic List of the Concluding Interview.*

Topic	Example
Past week	How did you experience the past week?
Appropriation of the RTL function	If you were to divide the week into stages, what would it look like?
RTL function	What did you think of the mirrored mode?
Usefulness	Do you think the mirrored mode could be useful?
Emotions / attitude	How would you describe your attitude to the mirrored function over the course of this week?
Phone use experiences	Did the mirrored mode influence the way you usually use your phone?
Task speed	Did you notice a change in task speed over the past week?
Multitasking	How did you think your multitasking was going compared to before?
Phone use time	Did the mirrored layout influence the time spent on your phone?
Handedness	Do you feel like your handedness influenced the way you used your phone?
Handedness change	Did you notice a change in with which hand you were using your phone?
Left-handed use	Do you feel like the layout has added value for left-handed users?
Intervention	Is there anything from this experience you will take with you after this experience?

Table 3*Preliminary Coding Scheme*

Code	Expected definition
Acceptance	
Usability / ease of use	Participant comments on the ease of use of the layout.
Usefulness	Participant notes how useful the mirrored layout is or could be.
Adaptation	Participant notes changes made to phone use to accommodate for the mirrored layout.
Avoidance behavior	Participant avoids using the phone.
Emotion	
Positive emotion	Participant expresses a positive emotion.
Negative emotion	Participant expresses a negative emotion.
Handedness	Participant mentions something about hands used during phone use.
Logic	Participant comments on the design choices of the RTL layout.
Phone use	Participant talks about phone use; use time, task speed, multitasking.
Usefulness outgroup	Participant notes that the mirrored layout could be useful for a group they themselves do not belong to.

Table 4*Final Coding Scheme and Krippendorff's Alpha Index.*

Code category	α_{binary}	Codes per code category	Definition
Approach behavior	0.79	Active exploration	Participant is actively exploring their phone without needing to do so
		Passive exploration	Participant is using phone normally, waiting to encounter problems

Code category	α_{binary}	Codes per code category	Definition
		Avoidance behavior	Participant is actively avoiding using their phone
Appropriation	0.79	Having to get used to	Participant realizes the need to get used to the new layout
		Getting used to	Participant is making progress, but is aware there is still ground to gain
		Gotten used to	Participant states to have gotten used to the layout
Handedness	0.98	Pre-study	Participant references their "normal" handedness during phone use
		Different	Participant notes a (possible) change in hands used during phone use
		Same	Participant states the hands used during phone use are the same as pre-study
Phone usage	0.94	Focus	Participant notes a difference in level of focus needed to perform tasks on their phone
		Multitasking	Participant references their ability to multitask during the study
		Task speed	Participant references the time it took them to perform tasks on their phone
		Phone time	Participant references the time they spent on their phone
		Phone time pre-study	Participant notes time spent on their phone before participating in the study

Code category	α_{binary}	Codes per code category	Definition
Muscle memory	0.88	Muscle memory	Participant mentions their muscles automatically performing actions
Negative	0.88	Negative sentiment	Participant expresses a negative emotion, opinion, or experience, with exception of the other codes in the category
		Confusion	Participant expresses confusion or something being confusing
		Frustration	Participant expresses frustration, this further includes sentiments like annoyance and anger
		Illogical	Participant notes that the mirrored layout includes design choices that are perceived as unnecessary or illogical
Neutral	0.80	Neutral sentiment	Participant expresses a neutral emotion, opinion, or experience
Positive	0.90	Positive sentiment	Participant expresses a positive emotion, opinion, or experience, with exception of the other codes in the category
		Happy going back	Participant expresses to think positively of returning to the "normal" layout
		Influence on phone use	Participant notes that the mirrored layout had an influence on their phone use that they perceive as positive

Code category	c_{binary}	Codes per code category	Definition
Post-study resolutions	1.00	Post-study resolutions	Participant states to take something they found out through the study with them after it ends.
Useful	0.92	Usefulness	Participant makes a statement about the added value of the mirrored layout
		Usefulness outgroup	Participant states the mirrored layout may be useful for a group they do not personally belong to

Results

In this section the results of the study are summarized. First it will describe the usability of RTL and the resulting sentiments. Secondly different parts of the re-appropriation process are described. The third section describes the influences the mirrored phone had on phone use and the adaptations made to phone use are laid out. After that, results considering left-handed participants and their phone use are shown. Additionally, the section describes perceived usefulness of an adapted layout for left-handed users. The final section shows the perceived usefulness of the mirrored layout for others.

RTL during use

This first section describes the practical experiences of using the RTL layout. The layout mostly worked as expected, with some exceptions. The problems and errors that were experienced are briefly noted to better illustrate what participants were working with. After that, the sentiments regarding the changed phone are described.

Practical use

In general, the RTL layout was usable for the participants. Errors were noted in a university timetable app, a tv streaming service, and an audio drama player. All of these apps had a function that

became unusable. Participants experiencing this found ways to work around these issues, either via the app itself or by using a browser version of the app. Apart from that, some minor problems were encountered in specific apps. These problems were less severe than the errors mentioned above. The minor problems included illogical placements and movements. For example, a news site indicated to swipe right for the next category when the user actually needed to swipe left to achieve this.

The bidirectional nature of the languages the RTL layout is made for resulted in some punctuation being placed in illogical places. Some participants were bothered by the way this influenced readability. These issues were most noted in the Instagram app, where this logic caused descriptions and comments to become confusing to read. Another notable illogical consequence of the BiDi layout was that clocks and countdowns were sometimes mirrored to a seconds-minutes-hours format. This occurred in some calendar, alarm, and timer apps. In certain calendar apps the days were also mirrored to a Sunday-Monday layout.

Sentiments

The layout had a shocking effect on participants when they were first faced with it. This shock lasted a few hours to two days at most. Negative sentiments were most often seen in the beginning of the week. Positive sentiments were more evenly distributed. The following paragraphs will describe these sentiments.

Negative sentiments. The largest part amount of negative sentiments were feelings of frustration, which was identifiable over 23 different participants. Confusion was also a notable part with instances over 20 participants. These negative sentiments often came down to the mirrored layout being unknown. Frustration and confusion came when it did not behave as expected. Finally 21 of the participants indicated the layout to be illogical. Illogical meant that some layout choices within the mirroring function were perceived to strange and unnecessary.

Muscle memory played a part in this. The participants were used to blindly being able to navigate. The illogical and unpredictable layout often caused them to keep making mistakes, which resulted in disliking the layout. Nina noted this on day two: “I had the tendency to tap at the screen in

the places that I was used to with the ‘normal’ layout so I struggled quite a lot, which was kinda frustrating” (diary entry, day 2).

Over time the negative sentiments seemed to decrease. This development was visible in Eren’s third diary entry: “Today nothing special happened. It still feels weird and inconvenient, but I am slowly adapting to it”. The negative sentiments seemed to decrease with the participant getting used to their phone. The larger part of the negative sentiments were therefore mainly noted during the first few days of the study. Less negativity did not result in more positivity, instead the sentiments of the participant would get more neutral over time.

Neutral sentiments. The noted neutral sentiments mostly occurred after the negative sentiments had passed. They came down to the feeling that it does not really matter eventually. This meant that they learned to cope or did not feel any irritation any more, they thought their phone was “fine”. Most sentiments came down to indifference. Like Sose stated in her fifth diary entry:

Today I only remembered once, that my display is mirrored. And that was just because a friend was confused when looking at my screen. I think my usage became very automatic and unconscious in the last few days. That is why I didn't have many emotions during today's use.

These neutral sentiments sometimes were sometimes mentioned in combination with the timeframe of the study. When asking Tom what he thought of going back to the normal layout, he stated “Yeah I do find it nice, because I have a neutral view, but that’s because I knew it would end. I like that I will be able to use my easy phone layout again” (concluding interview). Similarly, when asking Pino about her attitude throughout the week, she said: “Kind of positive, I was not very frustrated or negative about it, but that might also be because I knew there was an end to it” (concluding interview). These quotes indicate that participants seem to think that the timeframe played a role in their neutral feelings.

Positive sentiments. Many of the noted positive sentiments were related to the mirrored layout being interesting or funny. It was seen as interesting because they did not know the function existed on their phone. Positive sentiments originating from not enjoying the layout were also noted. The idea of

it not being as bad as expected was noted in 8 participants. The positive sentiment of almost being able to switch back to the LTR layout was even noted in 12 participants.

Sometimes participants liked certain interaction aspects of the mirrored layout. This mostly came down to buttons being in a more convenient place. For a participant with bigger hands, buttons being on the other side makes them easier to reach. This as opposed to the buttons being close to the palm, making the bend for the thumb harder. As Sky said “I think definitely in this case for me it made sense because certain features were normally closer or too close to my right thumb, then now I can actually reach it normally” (concluding interview). Sometimes it was noted that the button being further away made the buttons less risky to be accidentally pressed, which was noted as something positive. Marie notes this in her second diary entry: “For certain apps having the buttons away from my dominant hand is quite convenient. TikTok is a good example of this as I now follow and like less people by accident”.

Two participants did not express any positive sentiment, two others expressed only the positive sentiment of almost “getting to go back” to the LTR layout. The absence of positive sentiments among these participants did not mean they necessarily felt negatively about the layout. They generally had a more neutral attitude towards their phone and were less affected by the change.

Finding the layout as a whole enjoyable was limited to the four participants that did not switch back the layout at the end of the study. This is described more in the continued appropriation section later.

Re-appropriation

This section discusses the appropriation behaviors shown during the re-appropriation process. First, approaches to re-appropriation are discussed. These are followed by the different avoidance behaviors of participants. After that, it is described how re-appropriation slowed down and started to stabilize. Finally, this section describes the switching back to the normal layout, and the four participants that did not switch back yet.

Approaches to re-appropriation

From the first diary entries on there was an immediate difference visible in re-appropriation behavior among participants. Approach behavior is defined as the way the participants explore the changed phone and try to get used to it. The first approach behavior noted is active exploration. This approach consisted of the participant purposefully going through their phone to observe and experience the changes. Three participants chose this approach. Because of their exploring, their phone time was higher during this phase than it normally would have been. As Mary stated during the concluding interview:

That first day, I opened every app, to see how it looks in the mirrored mode. So I opened apps that I normally hardly use and then I thought “oh it’s kind of funny”. So I think that first day, I really used my phone more than I normally would.

After exploring, the participants switched to a more passive approach. Mary was the only one to switch to avoidance behavior after having explored the layout, this will be discussed in the next section.

The second approach was passive exploration. Participants showing passive exploration approaches did not approach the layout differently than they would have if it had just been another day of LTR phone use. The approach was mostly to wait until something did not work as planned. At that point they could address the issue and proceed from there. As Justin described it during the concluding interview: "Trial and error mostly, so just doing it and if it doesn't work then you try something else, and if that works, then that's what you do". Eventually every participant came to a passive exploration.

Avoidance behavior during re-appropriation

Avoidance behavior is defined as participants using their phone less because they do not want to work with their phone. Two distinctions can be made, active and passive avoidance behavior.

Active avoidance behavior. This behavior was distinguished by participants actively choosing not to use their phone more than absolutely necessary. Seven participants showing avoidance behavior stated their phone to be very frustrating. Nina stated “The first few days I didn’t grab my phone as often,

because it was frustrating and also kind of tiring because you need to be way more focused while using it” (concluding interview). Two of the participants also found their phone to be weird-looking, deterring them from using it.

Two participants started using their phones with a passive approach, but grew annoyed. From day three on Xi started actively avoiding using his phone by performing necessary functions on his laptop. He states he normally gets used to changes really quickly and had expected that to happen with this layout, too. When it did not get better after the first days, he started avoiding his phone for a few days. Baleron was the only one that stopped actively avoiding the layout and then seemed to return to it. After letting go of his avoidance behavior around day three, it took him about a day or two to find a new way of handling his phone. He decided to focus on finishing his tasks as fast as possible so he would not have to spend more time on his phone than necessary. More of his situation will be discussed later, in the section on changed hand use.

Between the time span of a few hours to about two days after beginning the avoidance behavior, the participants gave up on their efforts to actively avoid using their phone. Looking back on trying to avoid using his phone, Anakin noted during the concluding interview that this had not been an effective approach.

I think you just have to use it. I think when I actively tried to avoid it I got more upset by it or more annoyed by it, because I was not used to it and I was constantly on the wrong side.

There was no specific reason for why they stopped actively avoiding their phone. Some got more used to their phone after unlocking it a few times. Other participants started using their phone because they needed to. Often it was a combination of these reasons. This is visible in June’s diary entry of day 3: “Because I had to communicate with people I used WhatsApp the most out of the apps and I think the time I’ve spent on my phone became the usual amount of time I spend without mirrored mode”. After giving up on avoiding the mirrored layout, all participants went on to take a passive approach to exploring and getting used to the layout.

Passive avoidance behavior. When looking at the time participants spent on their phones, eight participants explicitly noted that they spent less time on their phone than they usually would. Of those eight, five were participants that had showed active avoidance behavior previously. Participants generally noticed that they found less joy in scrolling social media, or that they tried to finish tasks as fast as possible. As June said about her decreased social media use during the concluding interview: “It was less addictive”. This passive avoidance behavior did not seem to be premeditated, but seemed to merely happen. When they noticed the change it had often already happened. It seems their automatic phone use was disturbed, causing actions to take more effort. They seemed to respond to this by performing these actions less.

The more the participants got used to the RTL layout, the less this passive avoidance seemed to occur. In the end all but one participant noted to have gotten back to their normal phone usage time. The phone use of the participant who could not get used to his phone, Xi, remained lower than usual during the entire study. This indicates that he kept passively avoiding his phone until the end of the study.

Stabilization of re-appropriation

One of the things that stands out when looking at the results is the relative ease of the re-appropriation process. It was expected that stabilization would not be observed due to the relatively short timeframe of the study. However, this was not the case. Because of this it was possible to observe the beginnings of stabilization.

All but one of the participants got generally used to the layout in the end. This is seen in the sentiments and in phone use, as mentioned before. With participants indicating to be used to the layout by day four on average, participants continue to experience minor issues up until the end of the study. Some still had occasional issues with tapping the wrong button or still not being able to deal with certain apps in the mirrored layout. These final steps of making the technology part of daily life seem to be the steps that take the longest.

Switching back

Having gotten this far into re-appropriation of the changed phone did not mean that the participants intended to keep using it. Four participants indicated that the idea of it being temporary helped in working with the layout or helped being able to finish the week. Xi is the main example for finishing the week just to finish the week. His last diary entry expanded on this:

The last whole day in this layout gave me something to look forward to. I notice I can't get used to the mirroring, especially because it has not been done consistently. If it would have taken much longer, I would have quit sooner. (Xi, diary entry, day 7)

Though some participants had thought about switching back before the end of the study, but eventually no participants ended up doing so. When they finished the concluding interview, all but four participants happily returned to the LTR layout.

Continued appropriation. Four participants decided to keep the layout switched for at least a while longer. Left-handed Adriaan explains that he never expected a left-handed function to be beneficial, because you learn to use your right hand anyway. He wanted to keep the setting on for at least a while longer to observe whether it is actually nice to use. Thomas states that it might be similar to when he switched to using a left-handed mouse at one point, and that it took some time to get used to that. He wants to further explore whether this is something similar.

Another participant not switching back the setting was an ambidextrous participant, Georg. He described his experience as great. He states some things are easier, and that he thinks he will leave it in the mirrored mode. He was very impressed with the adaptive power of his brain. Besides, he appreciated having to think more consciously about his phone use. For a self-described left-hander, he states that it feels better to use his left hand while using his phone.

Finally right-handed participant Sky also decided to keep the layout switched a bit longer. He likes the idea that he is training his left hand to participate in phone use. As he states:

Because especially with typing and things like that, it's like, yeah I'm very right dominant, but I can see that if I were to use my left hand properly on the keyboard I would be much faster in writing messages. (Sky, concluding interview)

In this quote it becomes visible that he uses the RTL layout as a tool to achieve increased left-handed efficiency.

Differences in phone use

This section discusses the influence of the changed phone on phone use. This starts with the passive influences the RTL layout had on phone use. Continuing, it moves on to discuss active adaptations to phone use that were made by participants as a response to the changed layout. Influences relating to changes in hand use during phone use will be discussed separately afterwards.

Passive influences on phone use

The RTL layout had a practical influence on several aspects of phone use. Phone time went down for some participants due to the decrease of immersion or the increase in annoyance when interacting with the phone. This will be elaborated on in the adaptations to phone use section. Multitasking was also influenced in six cases, because participants had to focus on their phone use and could not perform other tasks simultaneously. Three participants noted that they started to focus on one task at a time because of this. Some participants stated they were more focused on their phone because they did not want to make mistakes. Lastly, task speed went down for all participants. This was partly due to the readability of the right-aligned text with its uncommon punctuation placement. All these effects decreased over time, as participants got used to their changed phone.

The relocation of items resulted in muscle memory mistakes, which influenced multitasking and task speed greatly. Participants discovered how often they operate on muscle memory when it started to work against them. This made it necessary to “re-train” muscle memory, as Georg called it during his concluding interview. Extra attention was needed, especially in the beginning, to prevent their hand from automatically performing actions wrong. Problems regarding muscle memory were

often specifically expressed by using the WhatsApp communications app as example. Several participants noted to accidentally use less emojis in their messages because of muscle memory.

Because the smileys were all mirrored as well. When I wanted to send a smiley I would accidentally press stickers and I would send a sticker and ... [makes an annoyed noise]. Those first three days I have been really annoyed by my phone. (Mary, concluding interview)

Many other accounts of pressing wrong buttons or swiping the wrong way were collected among the participants. It did get easier over time. In addition to statements made by participants, this can also be confirmed by looking at task speed. Self-indicated task speed had gone down in the beginning of the week for most. In the end, twenty of the participants indicated to be “back to normal”, or back to at least at 90% (self-indicated) of their previous speed. One right-handed user, Baleron, increased his task speed compared to normal use, this will be expanded on in the changes in hands used section in a few paragraphs.

Two participants noted that they appreciated that the layout made them spend less time on their phone. Sose, for example, was demotivated from performing meaningless actions on her phone because of the RTL layout. As a result, she felt that she had more free time to spend on other things. Mary experienced a similar feeling. She adds that she normally spends a lot of time scrolling TikTok in bed, but that she did not feel like doing that with the mirrored layout. Though both participants noted their phone use to be mostly back to normal by the end, they had both not yet reverted to their previous social media use.

Four participants noted that they appreciated the increased deliberation that was needed to navigate their phone. It made them more aware of their actions. John describes it as follows:

Well the best thing about the layout I think, it has not directly to do with the layout, but more indirectly the fact that I've gotten more deliberate in my phone use and taking things a little slower. Because obviously muscle memory is a big advantage, because you don't have to think

about everything you do. But then again, that's also the disadvantage that you don't think about what you're doing. (concluding interview)

Though Sose appreciated this as well, she was more realistic in her views: “The mirrored layout is a good option for people who want to use their phone more consciously. But I would say after some time of usage you are not that conscious anymore”. This quote shows an expectation that the effects on deliberation are only temporary.

Changes in hands used

The mirrored layout was observed to have some influence on the hands participants used their phone with. Though most changes were seen in right-handed participants, some change was also seen in ambidextrous participants. Among the left-handed participants no changes were observed. The changes in hands used while interacting with the RTL layout were generally not too extreme. Mostly, it was seen as participants used their left hand incidentally in tasks like scrolling or tapping. Furthermore, the left hand was used in combination with the right hand. The participants started noticing changes at different points in the study. Though it was mostly noticed about halfway, some noticed it as early as day one, some only on the last day. All changes will be further described below.

Right-handed participants. An active attempt to increase left-handed use was noted in six right-handed participants. Three of them ended up using their left hand more than they did with the normal layout. The other three trying to actively use their left hand more discontinued their attempts. This was explained to either be due to the feeling that the left hand did not add value, or due to the left-handed use feeling unnatural. When asked if he had tried, Oscar stated: “Yeah, I did, a little bit. But it didn't feel better to use my left hand in this mirrored mode than using my right hand” (concluding interview).

Baleron was mentioned earlier when talking about task speed and avoidance behavior. In purposefully increasing his both-handed use, he noticed that his left thumb did not have any muscle memory. This resulted in the thumb being unbiased in use. He compared this to his right thumb, that still had the tendency to fall back into previous familiar patterns. He states that he intends to keep using

his phone in this manner. His fifth diary entry reads: “The layout seems almost natural now I started using both hands. I feel like it’s more efficient, yet, I have to focus fully on my phone to make it work. [...] Using both hands became almost a necessity” (Baleron, diary entry, day 5).

Six participants noted a passive increase in their left-handed phone use. This implies that there was no active effort into using the left hand more. For example, Hooi mentioned the change in passing: “Using the mirrored layout is going well, however, some buttons are in different places and I’m using a different hand than usual” (diary entry, day 5). When she was asked whether she felt it was necessary to use her other hand she stated: “Yeah I don’t know, it went kind of automatically, but I did think it was more useful” (Hooi, concluding interview). Two participants tried to explain why they thought this increase in left-handed use happened. Marie started using her left hand more as support. To explain this, she stated that with the increased distance to the buttons, she would risk her phone if she did not use her left hand as support. Sose explained her change in hand use by giving the example of Instagram, where the stories move RTL. When reaching over to move to the next story she blocks the story with her hand, so changing hands was the solution.

Three of the participants that noticed a change in hands mentioned that they retroactively think they used to use the other hand a bit already, because the switch was too easy. For example, Pino stated during the introduction interview that she never uses her left hand. Soon, she corrected herself: “I also notice that I can switch between hands (thumbs) quite easily and that probably I already used my left hand with the original layout but I didn’t notice it as much” (Pino, diary entry, day 5). Whether this is correct or not, all of them still used their left hand more than before.

From the data it was sometimes unclear whether increased left-handed use was single-handed or in combination with the right hand. Both were described as “I use my left hand more”. This was often possible to clear up with help from the context, but some unclarity remains within the data.

Ambidextrous participants. The three ambidextrous participants can be split into two sides. Two of them actively tried using their left hand more. Eren described his attempt in his third diary entry: “I still use both hands equally, but sometimes when I have more time to complete a task, I give myself

the time to use more the left hand”. They both ended up abandoning the attempt due to either the left-handed use not having added value, or the habit of using the right hand being too strong. The other participant, Georg, ended up passively using his left hand more. He found it felt more natural for his self-indicated left-handedness.

Left-handed phone use

This section focuses on the left-handed users, their phone use, and the necessity of a left-handed phone layout. Notably, there were no female left-handed or ambidextrous participants. This can largely be explained by the gendered nature of left-handedness. As noted before, men are more likely to be left-handed than women (Buser et al., 2021). Since no great differences were visible between right-handed male and female participants, it is not expected to have influenced left-handed results greatly.

Before the study, all of the five left-handed participants indicated to use their left hand at different levels during phone use. Thomas often uses both hands at the same time besides his left-handed phone use. Xi indicated to use his right hand more often, he notes his right-handed phone use is one of the only things he does not necessarily prefer to use his left hand for.

I don't really notice a difference between my left and right hand during phone use, but I do notice with other things that left is definitely my dominant hand. For example, when you hold a pen with your wrong hand you notice it's not good, but with my phone it doesn't really matter which hand. (Xi, concluding interview)

There is a notable difference per left-handed phone user in how they have appropriated their normal phone. Regardless of that, left-handed users are all used to their chosen way of using their phone, just like right-handed users. During the introductory interview, they did not express the need for a different layout.

Xi, Thomas, and Adriaan all started talking about computer mice during the concluding interview. Though not about phone use, this gives some more insight into the experiences of left-handed persons in a right-handed world. Xi does not like using the left-handed computer mice. Adriaan states that he learned using them with his right hand and that is why he uses them that way. He states that in

general it is a bit more difficult to learn using right-oriented objects, “but you have to, because there is no alternative”. Thomas did not appreciate left-handed options until he started using a left-handed mouse, now he wonders what other options would help him. To conclude and to bring the topic back to phone use, this quote from Adriaan:

That is why I thought a left-handed function, what’s the point. Only it now actually seems to be nicer to work with. So considering that, I did not expect to want more optimized products or services, but it has, it could be beneficial. (concluding interview)

Left-handed re-appropriation

There were not many left-handed participants. Comparing their re-appropriation process to that of the other participants therefore does not give much insight. All left-handed participants ended up getting used to the layout on day 4 or 5, except for Xi, who did not get used to the layout. Besides the two who ended up continuing the re-appropriation process, the others did not note any lasting changes in their phone use. Of the five left-handed participants, none ended up noticing a change in the hands they used to work with their phone during the study. John, a participant who uses both hands during phone use, came closest to a change. He stated he used his left hand more because there are more buttons on the left side, but since he already used two hands, this is seen as normal use.

Perceived usefulness

The five left-handed participants were divided on the usefulness of the mirrored phone. Some left-handed participants saw the benefits of it. According to them the layout fit them better. It felt more natural, like it was supposed to be this way. Adriaan appreciated the changed swiping direction, something he has always found to be more difficult as a left-handed user. He states that the general ergonomics of the mirrored layout feel better. Thomas also stated that this layout seemed better for his left-handed use.

Just like most right-handed participants, three left-handers did not think the LTR layout was a suitable layout for them. “I don’t think it’s made for left-handers” (John, concluding interview). Mies even perceived the layout to be less beneficial to left-handed users “I have said it a few times already,

but I mainly use my left hand, and the mirroring did not make it easier. Many important things were now on the right-hand side” (concluding interview).

The choice for left-handed people lies between adapting to the right-handed way, or to adopt left-handed solutions. However, the problem with left-handed solutions is that these are not the standard. Xi noted on this:

Maybe when you start you can teach yourself to use it mirrored, but that will also have disadvantages I think. You would have to use that mode all the time, while you can just use every phone the same way now. (concluding interview)

This last problem was not only voiced by left-handers. Both ambidextrous and right-handed users have also noted this generalizability as a problem. Right-handed Sjottel added the following when asked if the RTL layout was useful: “Maybe, but actually I don’t think so. Because when you’re using other people’s phone then... Often it’s just the best to use the standard, because then you can work with everything” (concluding interview).

Another problem Xi touched upon in his quote was something also mentioned by John and Thomas. Many left-handed users have already gotten used to the normal LTR layout. This makes it less attractive to adapt to the mirrored layout, because the normal layout is already perceived as normal. As John said during the concluding interview:

I don't think that the mirrored layout presents an advantage for left-handers. Maybe if you get your first phone and immediately change the layout to mirrored, maybe in that case. But if you're like me and you've used one layout for ten years nearly and then switch, I think that creates more challenges than benefits.

Having observed both the more positive and more negative opinions, it is difficult to conclude whether a left-handed layout is necessary. Generally, the left-handed user does not seem to experience problems. Even the participants continuing their experience with the RTL layout are fine with using the

normal layout. It is like some right-handed users noted, if this was the standard, they could get used to it.

Perceived usefulness outgroup

All participants were asked if they thought the RTL layout could be useful in daily life. Between all answers, Oscar had the most bold opinion with the following statement:

I was going to say maybe when someone's, like, left hand is disabled or right hand is disabled, you can switch the modes depending on that. But it wouldn't make sense, because you have to get used to two new things then. And it doesn't aid you in you left hand or right hand more, at least in my experience. (concluding interview)

Some participants shared this opinion, but most differed slightly. Though not useful for themselves, these participants did note it was likely useful for a different group or a different situation. The other target populations that were coined were: left-handed people (when participants were not left-handed themselves), people with a BiDi language background, children, and disabled people. A few participants also stated, like John earlier, that it would be useful if it was this way from their first phone experience. This last thought does suggest that they think it is only useful when they are not aware of a better option.

Discussion

After having observed the results from the study, this section will now expand on these results. Afterwards, theoretical and practical implications are discussed. This is followed by limitations and suggestions for future research. Finally, this paper ends with a conclusion.

Re-appropriation

As expected, the re-appropriation process differed from a normal appropriation process. As Mendoza and colleagues (2010) hinted to, re-appropriation seems to take the current knowledge and tries to expand it. The participants largely kept exploration, evaluation, and adaptation to a minimum. Furthermore, it took only a few days for the technology to start to stabilize. Often not even considering approaching the layout differently than the normal one, the participants seemed to rely on previous

knowledge. As anticipated, this seems to be based on the functionality, expectations, and limitations staying the same. This approach appears restrictive, since the user is not fully open to learn how this changed technology compares to the previous one.

In previous research on behavior when using a new technology, this kind of behavior was also seen. The paradox of the active user (PAU) is defined as users preferring actions that are less efficient than recommended actions (Carroll & Rosson, 1987; Fu & Gray, 2004). It is a paradox because it shows users will not invest time in learning the possibilities of a technology, even when it saves them time later. The PAU is made up of two biases (Carroll & Rosson, 1987). Firstly, the production bias, users to want results as soon as possible. Secondly, the assimilation bias, users try to base their use on prior experiences. These two biases are seen in the approaches of the participants. In their passive approaches they were observed to be waiting for problems to occur, basing their use on previous knowledge. They did this instead of taking the time to learn what to expect. An active approach to their changed phone would in theory have helped participants understand their phone faster. Changes would be more generalizable, and therefore re-appropriation more efficient.

In practice, the active approach did not seem to help much. Participants actively exploring the new layout did not necessarily show signs of more efficient re-appropriation. Since the layout was perceived as inconsistent, what was learned could not be generalized. Besides, the ingrained muscle memory was one of the observed obstacles during the study. Active exploration did not help the participants overcome this obstacle. The actions and intentions of the participants still match the PAU despite this, because participants were unaware of active exploration not helping in more efficient use.

Habits and muscle memory

Muscle memory was one of the factors that made the layout difficult to get used to. Participants indicated that this slowed them down, it caused them to press wrong buttons, and to swipe in wrong directions. Participants had to slow down to not make mistakes, resulting in lower task speed. When they tried to perform a task quickly or without thinking, their actions became more based on muscle

memory and failed more often. The impact of muscle memory and habit on re-appropriation was not something that was expected, therefore some further research on the topic will be discussed.

During further exploration of previous studies, Kohler's (1964) documentation on the studies more commonly known as the Innsbruck Goggle Experiments stood out. The basic idea of their studies reflected the current one. In these studies, participants were given mirroring glasses to wear. These glasses mirrored visual input. Though not related to technology, the idea of having something familiar mirrored is magnified in their studies. One of the results those experiments encountered was the amount of habits a person relies on (Kohler, 1964). About this, Kohler stated: "Nothing is more burdensome and sapping of energy (and hence effectively unpleasant) than rehabilitation. Then only do we notice what habit is, and to what extent we consist of many and strong habits" (1964, p. 138). He notes that habits change at different paces. Similar to the current study, it was observed that when participants quickly had to reach for something their hand would still go wrong (Kohler, 1964). For example, when suddenly having to catch a ball with mirrored glasses, their arms would still move to where the ball visually appears. This would still happen when the same person is already quite used to the mirrored world. Habits are what makes getting used to change difficult, without them right being left and left being right should hardly even be a problem (Kohler, 1964).

It was implicitly expected that left-handed participants would be better at appropriating the "left-handed mode". Why this was not necessarily the case can also be explained with muscle memory. Most participants did not change anything to the hands they were using to interact with their phone in the RTL layout. Because of this, all participants equally had to work against their muscle memory to appropriate the change. According to previous research (Hoffmann, 1997; Hoffmann et al., 1997; Przybyla et al., 2011), the left-handed users would have had an advantage if they had used their non-preferred hand. One right-handed participant stated that it was easier to tap the correct things with his left hand, because that hand was not bothered by previous muscle memory.

Intervention

In the context of re-appropriation, this paper stated in the theoretical framework that the changed layout could possibly be seen as an intervention. A change to interrupt effortless use, to make users more aware of their normal phone use. It was expected that long term changes would not be observed, and this seems to be correct. Short-term behavioral changes because of the layout have been observed. Some participants liked that it made them spend less time on their phone. A higher focus on tasks made a few participants more aware of what they spent their time on. Resolutions were even made by some to use their left hand more, to be able to work even more productively in the normal LTR layout.

Left-handed solutions

With the limited amount of left-handed participants, some insight into experiences of left-handed phone users is still achieved. Different opinions, approaches, and results were found within the five participants. The observations align with several points from the theoretical framework on left-handed persons in a right-handed world, this will be expanded on in this section.

There are two points in particular that need to be discussed together. The idea that the RTL layout felt more like how phone use is supposed to be for left-handed users, and the statements from left-handed participants that they do not use left-handed alternatives. This plays into what the left-handed participants in the study of Basak and Roy (2019) said, about not intending to use a left-handed mouse setting. Apparently left-handed options would not necessarily make their interactions with the world around them better. When encountering the right-handed version, left-handed users will still experience problems. It therefore seems that adaptation is necessary to interact with the right-handed world, because left-handed options will not always be available. The adaptiveness of left-handed users seems to be another reason why adapted products are not always used. Left-handed people seem to find a way to make right-handed objects work. In the case of the phone to the extent that changing it would seem unnecessary.

Basak and Roy (2019) decided at the end of their study that the solution was to make an easily accessible button to switch mouse sides. This would solve issues with other computers or family

members sharing the computer. Besides, because of the easy switch it hardly takes any effort. This would be a possibility for phones, too, if a mirrored layout would be perceived as necessary. Currently it takes some time to switch the layout. The user activates developer mode, waits for it to load, finds the “Force RTL” setting and activates it. Even after this effort, some apps take a long time to switch. With the differences between layouts as one of the big observed problems, an easy switch might solve situations in which users are faced with a different phone.

Acceptance and switching back

Directly after the concluding interview, the RTL layout was contently switched back by most of the participants. They continued to prefer the LTR layout throughout the study. This happened even when the use of their changed phone had largely stabilized. This section looks closer into acceptance and discusses the different influences on this temporary acceptance.

As Davis already stated in 1989, usefulness is a more influential factor for behavioral intention than ease of use. Changing the layout of the phone did generally not make it less functional, but it did make the phone harder to use. With ease of use at a low point during the first few days, the participants were still using their phone. Not that it was not tried to stop using it, as seen in the results.

The absence of switching back can partially be explained by the TAM. When applying the TAM, this study acknowledges that there are two different evaluations of usefulness. On the one hand the usefulness of the phone itself, on the other hand the mirrored layout that has been activated through the settings. Looking at the results, users still intended to use their phone mainly because of the usefulness of the phone, not because of the usefulness of the layout. The functionality that the phone offers is worth having a more uncomfortable experience (Davis, 1989). Since the intention to use the phone remains equal, the next paragraph looks towards the acceptance of the RTL layout.

Though in the beginning very low according to some participants, ease of use of the RTL layout increased as time went by. This was faster than was expected by many of the participants. Most claimed to be back to, or close to, their regular task speed by the end. During the concluding interview some even admitted that if this was the new standard, they could live with it. They said this despite preferring

the normal layout. So, by the end both RTL layout usefulness and ease of use were at an acceptable level. However, this does not cover participants' continued use when they still prefer the old layout. The continued use in the beginning of the study is also mostly unexplained by the TAM, since there would be a low intention to use at that point according to the model.

Voluntary use

Because the participants used the RTL layout for a study, this likely influenced intention to use. To be able to explore this further, a different model has to be considered for support. The Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003) will be looked at in this case. Venkatesh and colleagues explored different technology acceptance models to construct their UTAUT model. In their model that is based on these sources, social influence and its moderator voluntary use are included. These factors help in exploring the results of this study on the social level.

Subjective norm or social influence concerns a person trying to behave according to (perceived) social pressure (Venkatesh et al., 2003). Venkatesh and colleagues (2003) noted in their exploration of other models that social influence is only significant when the use of a technology is mandatory. This is confirmed in their testing of the UTAUT model. Voluntariness is not a binary factor, but a scale between voluntary and mandatory conditions as Moore and Benbasat (1991) noted. It has been observed that voluntariness has a negative influence on behavioral intention (Karahanna et al., 1999; Venkatesh et al., 2003). In the current study neither participation nor continuous use of the RTL layout was mandatory. Still, the participants would likely have felt some pressure to keep the layout changed until the end of the study.

Timeframe

Finally, the week-long reference period was also perceived to have an influence on participants' emotions and their not switching back throughout the week. Because they did not have a goal in this study besides maybe finishing the study, they seemed to be waiting for it to end. Maister (1985) states, "uncertain waits are longer than known, finite waits" (p. 5). He gives the example of a waiting room. When a patient is told there is a 30 minute delay, they will be able to relax and accept this. When the

patient is told the doctor will be there as soon as possible, they cannot settle down due to the anticipation. The finite expectation helps in accepting the time in between (Maister, 1985). In the current study, for example, two participants stated that they thought it was funny when something went wrong, but that they would have seen this differently if they did not know it would end in a few days. They were better able to accept their situation because it had an end.

This idea, combined with the pressure of the participants being part of a study, is enough to explain the continued use where the TAM could not. This is confirmation that the lack of explanation was not due to some unexplained mystery, but instead a result of the narrow scope of the TAM.

Usefulness of the RTL layout for an outgroup

An attitude of relocating usefulness from themselves to a different group was seen among participants. The mirrored layout is not useful for the participant, but maybe for left-handed people (when the participant was not left-handed), disabled people, younger people, or people from BiDi language countries. Looking at existing research, a comparison can be made to the Third Person Effect (TPE). The TPE (Conners, 2005; Davison, 1983; Sun et al., 2008) explores how people believe media messages do not have an effect on themselves (first-person), but do have an effect on other people (third-person). The “not me but maybe other people” idea that the participants brought forth fits with this idea. Right-handed phone users do not think they need a mirrored layout, but apparently think others might need it. In the meantime, the others also think it might be useful for someone else but them. The participants were often not aware of the needs of the other group. Like the overestimation of media messages’ effect on others seen by the TPE, the responses of the participants seem to indicate an overestimation of the problems encountered by the others during phone use.

Taking a different approach, there is the possibility that participants were trying to soften their opinion that the RTL layout was not useful for themselves by thinking of other uses for the layout. Because of their unawareness of the needs of the other group, participants could not fully exclude the possibility that the layout could be useful for the others. Even if its usefulness may seem unlikely to them.

Theoretical implications

The main model that was applied in this paper was Carroll's MTA (2004). The MTA offered an understanding of the path the user takes in appropriating a technology. This study observed differences in the re-appropriation of a technology as compared to the original process of appropriation. Looking at the results, separately defining this process as re-appropriation seems to be fitting. Re-appropriation is a relatively fast process. The user seems to be base re-appropriation on the previously known limitations and affordances of the technology. The observations made in this study build on existing appropriation knowledge, while adding a layer that is not yet present in the theoretical base.

Furthermore it has been observed that re-appropriation can act as an intervention. An intervention could make users re-evaluate their stabilized use, making users more aware of their habits. Most of the noted effects were already disappearing towards the end of the study. More research is needed to observe if some intervention results would persist into longer re-appropriation or into the return to the original form of the technology.

This study considered acceptance to observe why participants choose to continue using their mirrored phone. Upon reflection the scope of the chosen TAM (Davis, 1989) was too compact to observe all factors influencing behavioral intention in re-appropriation. Part of the UTAUT (Venkatesh et al., 2003) was therefore applied to explain social influence and voluntary use. Because the use of the RTL layout was for the study, users likely felt some pressure to finish the week. After the factor of social influence fell away, users switched back. Though they had accepted the RTL layout, it was not perceived to be better than the normal LTR layout. In following research the UTAUT would be a better model to work with, since it includes more factors to explain intention.

Practical implications

If interventions resulting from re-appropriation would be observed to persist over time, re-appropriation could be used as an intervention. For example, in phone use the RTL layout could be applied to deter users from using their phone too much. Phone use would then be associated with the less positively perceived RTL layout.

Having observed the issues the mirrored layout would face, some recommendations can be made. The biggest issue arising from the current research is that a specialized left-handed layout would make using other phones more difficult. If a left-handed layout would be developed, it would have to be available on every phone. It would also have to be easy to switch between a right- and left-handed layout. Another issue that arose was that left-handed phone users are already used to their phone because of years of use. A left-handed layout would therefore not necessarily be appreciated by long-time phone users.

The RTL layout in its current state would not be recommended as a left-handed mode. Though it did sometimes improve parts of the experience of a participant, for many participants the illogical and inconsistent layout continued to bother them. Still, the basic idea of a left-handed mode is already partially present in the RTL function. In the basics, to convert the RTL to a left-handed mode it should refrain from switching text, progress bars, sliders, and time. These were the elements observed by participants to be the most frustrating and confusing in the RTL layout.

Android apps have much freedom in design. This freedom is what stands in the way of a smoothly functioning RTL or left-handed mode. The function recognizes elements in apps and has a predetermined way of changing them to form the RTL layout (Android Developers, n.d.-a; Android Developers, n.d.-b; Harit, 2018). The app will not transform correctly when app designers use these elements incorrectly, or not use them at all. Improving support for the RTL function starts at the design level of Android apps. This is difficult to influence and would come down to educating developers. However, because of the freedom of app layout there will always be apps that do not take mirroring into account. The fixed layout of iPhones and their apps would likely make for an easier platform to successfully implement a mirrored mode on.

Limitations and future research

The concept of re-appropriation could be interesting to look into further, to expand the knowledge on appropriation after the initial technology stabilization. The timeframe of a week limited the data that could be collected on intervention. A longer study on re-appropriation with a goal, like

decreasing phone use in participants, could give new insights into tolerance of the changed technology. Maybe participants would be accepting of the layout for a longer period of time when it helps them in the long run. Re-appropriation and intervention would also benefit from research on the return to the previously appropriated technology. This would show whether the intervention carries over or is immediately undone.

This study observed only five left-handed users, and all were students. The data from this study is a small insight into left-handed phone use and the necessity for a left-handed layout. To get a broader impression of left-handed phone use and its problems, more left-handed users from different age groups and socioeconomic backgrounds should be observed.

The hands used during phone use and the changes to it were self-indicated measures, there was room for error. Phone users seem not too aware of the hands they use to interact with their phone. For example, this was visible in participants who stated that they likely already used their left hand before the study, because the change did not feel like a change. The self-indication causes some uncertainty to the accuracy of the measures of changed handedness. For future research it might be more effective to ask participants to pay attention to their hand use some time prior to the study, or to measure or log it more directly during the study. Furthermore, phone use with only the left hand was sometimes difficult to differentiate from using the left hand more in combination with the right hand. Both increased left- and both-handed use is mostly described as “I was using my left hand more”. This was a complication that was only noticed when starting the analysis. At the time of the concluding interview, the researcher had not considered the dual meaning of the phrase. This occurred in a few participants, often the context helped in determining what the participant meant.

The deductive approach to the study caused both the diary study prompts and the concluding interview topics to be unspecific. The participants often found they had less to say in their diary entries after the use started to stabilize, the prompts could play into this. The concluding interview would benefit from current knowledge to be able to go deeper into the topics. In future research, an inductive

approach based on the gained knowledge from the current study would be encouraged to make the study more focused.

Conclusion

This study has observed re-appropriation of a changed phone after initial appropriation. The re-appropriation of the phone after stabilization can be seen as a different process than the first-time appropriation that happens before stabilization. Besides this, re-appropriation offers opportunities to act as a short-term intervention. The re-appropriation process has resulted in short-term changes in behavior. These results are a stepping stone for further research into re-appropriation and intervention by re-appropriation.

Furthermore, this study has contributed to the current gap in knowledge on left-handed phone interaction. Left-handed users are observed to be adaptive. The participants did not indicate to be in need of specific left-handed solutions prior to the study. Afterwards, some left-handed participants found the mirrored layout to feel like a more natural layout for left-handed use. Resulting from observing the left-handed participants it is noted that a left-handed layout is not seen as necessary, though it is sometimes welcomed.

These results can be used as a reference for future studies in the field of appropriation. It has also contributed data to the left-handed field, with insights into left-handed phone use.

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Appendix A

Intake questions

Verbal questions

- What brand of phone do you use?
- Phone language setting
- Any special details about the phone that may interfere with "normal" use? (e.g. a part of the screen does not work, something is broken, activated accessibility settings or other special settings)
- Did you have to get used to your current phone? How long did that take? Why not?
- How much time do you spend on your phone per day? How do you feel about this?
- What hand(s) do you use when interacting with your phone? Does it differ per action? And why do you think this is? Please elaborate.
- What do you think about your phone's layout and its compatibility to your favored hand(s)?

Questionnaire

- Gender - (Male; Female; Non-binary / third gender; Prefer not to say)
- Age - Number entry field
- Main language - (Dutch; English; German; Other (please specify))
- Are you left- or right-handed? - (Left; Both; Right)

Edinburgh Handedness Index (Oldfield, 1971)

“The following questions will help determine your handedness. Select which hand you use per action. If you need to, act out the behavior to see what you normally do.”

- Writing - (Always left; Mostly left; Mostly right; Always right)
- Drawing - (Always left; Mostly left; Mostly right; Always right)
- Throwing - (Always left; Mostly left; Mostly right; Always right)
- Scissors - (Always left; Mostly left; Mostly right; Always right)
- Toothbrush - (Always left; Mostly left; Mostly right; Always right)

- Knife without fork - (Always left; Mostly left; Mostly right; Always right)
- Spoon - (Always left; Mostly left; Mostly right; Always right)
- Broom (top hand) - (Always left; Mostly left; Mostly right; Always right)
- Lighting a match - (Always left; Mostly left; Mostly right; Always right)
- Opening the lid of a box - (Always left; Mostly left; Mostly right; Always right)

Appendix B

Diary study prompts

- A. Describe how you experienced using the mirrored layout today (i.e. emotions, experiences, notable occurrences). Why was this the case? Try to elaborate.
- B. Have you noticed a change in your phone usage behavior while using your phone (i.e. time spent on phone, problem solving behavior, experimentation, hands used, emotions)? Why? Or why not? Try to elaborate.
- C. How was today compared to the previous days of working with this layout? Was it better or worse, or maybe a bit of both? Try to elaborate.
- D. Do you have notes that did not fit into the other boxes?
- E. I have had to disable the left-to-right setting today
(If yes) Why and for how long did you disable the setting?