

**The effect of an app-based self-control training on reactive aggression.**

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## **Abstract**

*Introduction:* Reactive aggression has been a complex societal problem inherent to cases such as intimate partner violence, vandalism or using a weapon. According to research aggression can be decreased and inhibited through means of self-control training. A self-control training (SCT) intervention based around the usage of an individual's non-dominant hand had shown promising results. The app HandSwitch, had been developed due to certain limitations the SCT faced.

Through means of an app the SCT could be used in a greater capacity than a clinical setting. The goal of this study was to find whether the HandSwitch app had an effect on reactive aggression.

*Methods:* The experiment (n = 136) used a between-subjects fractional factorial design with 2 components and 1 level. The participants were separated in 3 groups, which consisted of 2 app groups and 1 control group. The intervention lasted 10 days and consisted of 4 surveys. The surveys consisted of the Brief Self-Control Scale (BSCS), Brief Aggression Questionnaire (BAQ) and a Go/No-Go trial. Finally at the end 3 open questions about their perceived self-control, opinion on the intervention and improvements to the intervention were provided.

*Results:* The mean self-control increased whereas the mean aggression decreased over the span of the intervention. Based on the results of the repeated measure ANOVA the BSCS had shown significant differences between time points within the group that received 5 tasks. The Go/No-Go and BAQ had significant differences within all 3 groups. Between the groups the BSCS had shown significant differences for day 5, the Go/No-Go for day 5 and day 10 and the BAQ for the posttest. The majority of the participants thought they felt no increase in self-control and wanted to see more reminders added along with changes made to the tasks.

*Discussion:* While the results had shown a mean increase in self-control and decrease in aggression not all groups depicted a significant difference for self-control. This means that either the intervention has a fast acting influence or that there are other underlying factors. An increase in reminders and more personalization in the provided tasks may cause a difference in the statistical significance of the differences between and within the groups in terms of self-control. The results between the groups do point towards an effect of the intervention however when looking between the app groups and control group.

*Conclusion:* It is inconclusive whether the HandSwitch app intervention has had an effect on the self-control and aggression of the participants. Future research would be recommended in order to pinpoint the possible underlying factors.

## Introduction

Aggression can be defined as behavior which has the proclivity to be harmful or cause injury to another being without their intention of receiving such behavior (Blair, 2016). However, aggression is not only physical but can also manifest itself in a verbal manner, such as, bullying (Vaillancourt, et al., 2008). There are two types of aggression: proactive aggression and reactive aggression. Proactive aggression is used when the aggressor has already planned their action and is acting upon it consciously. Whereas with reactive aggression the aggressor can cause harm or injury without planning this beforehand, in other words, it is an impulsive reaction to a certain frustration or stimulus (Dodge, Lochman, Harnish, Bates & Pettit, 1997). Reactive aggression has been a complex societal problem being inherent in societal issues such as intimate partner violence (IPV) (Finkel, DeWall, Slotter, Oaten & Foshee, 2009; Hesser, et al. 2017; Ruddle, Pina & Vasquez, 2017) vandalism (Luengo, Carillo-Del-La-Peña, Otero & Romero, 1994) or using a weapon (Derefinko, DeWall, Metze, Walsch & Lynam, 2011). Indeed, reactive aggression is a problem which comes in many forms. Thus, preventing reactive aggression through means of interventions or training would alleviate the social burden of aggression.

In order to decrease reactive aggression, it is important to look into more specific factors which underlie aggression. Understanding and recognizing these factors allows one to create a tailor-made intervention to lower aggression. These factors, such as stressors which create specific situations that stimulate and elevate this type of behavior. The reason these factors are of importance is due to the fact that a stimuli or provocation can instigate an aggressive reaction from an individual, if it is perceived as a threat (Scarpa & Raine, 1997). It is important to prevent or learn to tolerate these stimuli, for example by means of interventions, in order to avoid the festering of aggression and aggressive behavior. The I<sup>3</sup> model (Denson, DeWall & Finkel, 2012) proposes three processes for aggression: instigation, impellance and inhibition. Instigation represents the effectiveness of environmental stimuli onto aggressiveness. For example, provocation (Denson, et al., 2011), such as name-calling, can be one of these triggers. This could lead to the loss of self-control which results in reactive aggression. Impellance refers to the reactivity or effectiveness of situational determinants which can further incite aggressiveness, meaning that prior history or bad experiences with the provoking party can increase the already present aggression which was caused by provocation. The two previously mentioned processes: instigation and impellance, increase the probability of aggression (Denson,

et al., 2012) whereas inhibition, the final process, reduces aggression. In this case inhibition refers to the factors which suppresses the aggression causing stimuli, such as not responding to provocative insults. Self-control can also further influence inhibition in order to increase its effect. (DeWall, Finkel & Denson, 2011). Additionally, impulsivity, risk-taking and short-sightedness seem to be characteristics of individuals with low self-control according to the general theory of crime (Pratt & Cullen, 2000). Pratt and Cullen (2000) state that low self-control has to be considered as an important predictor in criminal behavior and that low self-control does indeed increase involvement in criminal behavior. This would put self-control among other factors which could predict aggressive behavior, other factors being such as alcohol or substance abuse. Nevertheless self-control is a widely researched predictor in these cases.

Thus a potential focus for an intervention to decrease reactive aggression could lie in self-control improvement. One way to improve self-control, is by self-control training. For example, Denson, Capper, Oaten, Friese and Schofield (2011) depict reduction in aggressiveness where the participant uses their non-dominant hand to complete common tasks for 2 weeks. In these two weeks the participants were required to use their non-dominant hand between 8 am and 6 pm every day within those two weeks. The participants received tasks such as brushing their teeth, operating a computer mouse, opening a door and stirring among other day-to-day activities one would perform with their dominant hand which they had to perform with their non-dominant hand instead. This lead to reduced aggression among aggressive individuals by means of self-control training (SCT). However, while the results were promising, future research was necessary in order to understand the underlying process for control, along with the difference between trait aggression, the expression of aggression and the experience of aggression.

In order to support the users in a more adequate manner the intervention provided in a prior study (Denson, et al., 2011) was turned into an app in which the participants will both receive their tasks as well as the surveys which they will have to fill in. One of the main strengths of an app is that it allows people to make use of it in greater capacity than say a clinical or experimental setting, because the amount of participants or clients would be limited in a closed setting with physical participation and presentation (EC, 2006) Additionally, an app can also make use of persuasive features in order for the participants to make consistent and continuous use of the app. Without continuous use of the app the result of the intervention could be short-term, ultimately not helping the user in the long run. Additionally, consistent and

continuous use is important so that the participant does not miss a task which could render the intervention to be less useful in terms of the effect it has on the individual. While this app has been developed it needs further research to fully realize its benefits and identify its shortcomings and how the intervention has an effect on the participant.

The app was used by Da Silva (2019), which was received positively by the participants. The app sent 15 tasks over a period of 15 days to the participants and the differences were significant between the pre-measures and the following measures, however it was hard to draw conclusions since a control group was lacking. (Da Silva, 2019). A control group is important in order to determine whether the intervention is causing the results or whether something outside of the experiment has an effect. It was further stated that only providing 1 task a day might not be enough to realize a significant effect, a task such as opening a door or switching the lights on is not something someone does often in 1 day. Which leads to the question whether multiple tasks could cause a change, such as giving the participants multiple tasks could increase the frequency of making use of the non-dominant hand. This will be further researched in the current study.

The goal of the current study is to test whether the app based self-control training (SCT) HandSwitch can successfully lower aggression among aggressive individuals and increase their self-control. Secondly, whether multiple tasks in one day have a better effect on the decrease of aggression and increase of self-control. Multiple tasks could cause a significant effect compared to 1 task since certain tasks are not performed frequently throughout the day. And finally, whether the control group shows any of the previously mentioned effects. It is important to use the control group to further the investigation of the findings of Da Silva (2019) since no control group was used in their study. If the control group also sees changes in their aggression and self-control other factors outside of the SCT could play a role. Thus, the following is hypothesized: *1. The SCT App reduces aggression and increases self-control after the intervention compared to before the application was used within the experimental group, 2. Participants who receive 5 task in one go depict lower aggression levels and higher self-control after the intervention compared to participants whom received 1 task per day 3. The control group depicts unchanged and worse results in aggression and self-control compared to the experiment group.*

## Method

### Study design & HandSwitch app

This evaluation research was inherently a survey research with an experimental design. The experiment used a between-subjects fractional factorial design with 2 components and 1 level, namely the way of delivery, which are the tasks within the app (5 at once or 1 per day). As for the set-up, questionnaires had been used with a total of 4 survey online surveys alongside 3 groups, 2 that made use of the intervention and 1 control group. The participants were provided with tasks based on the group they were randomized in. A further elaboration of the design is depicted in Table 1. This study was part of a bigger study which also includes participants which took part in the intervention by email instead of the app. These participants were not included due to the focus of this study being on the app.

Table 1.

*Timeline of the experiment and distribution of surveys*

Day	Measurement	Group 1.1	Group 1.2	Group 2 Control
0	Day 0	Pre-measurement: BSCS and BAQ survey and Go/No- Go trial	Pre-measurement: BSCS and BAQ survey and Go/No- Go trial	Pre-measurement: BSCS and BAQ survey and Go/No- Go trial
1-5	Day 1 to day 5	5 tasks at once	1 task per day	Idle
5	Day 5	BSCS and BAQ survey, Go/No-Go trial	BSCS and BAQ survey, Go/No-Go trial	BSCS and BAQ survey, Go/No-Go trial
6-10	Day 6 to day 10	5 tasks at once	1 task per day	Idle
10	Day 10	BSCS and BAQ survey, Go/No-Go trial	BSCS and BAQ survey, Go/No-Go trial	BSCS and BAQ survey, Go/No-Go trial

11-15	Day 11 to day 15	Idle	Idle	Idle
15	Day 15	Post-measurement: BSCS and BAQ survey, Go/No-Go trial and open questions	Post-measurement: BSCS and BAQ survey, Go/No-Go trial and open questions	Post-measurement: BSCS and BAQ survey, Go/No-Go trial and open questions

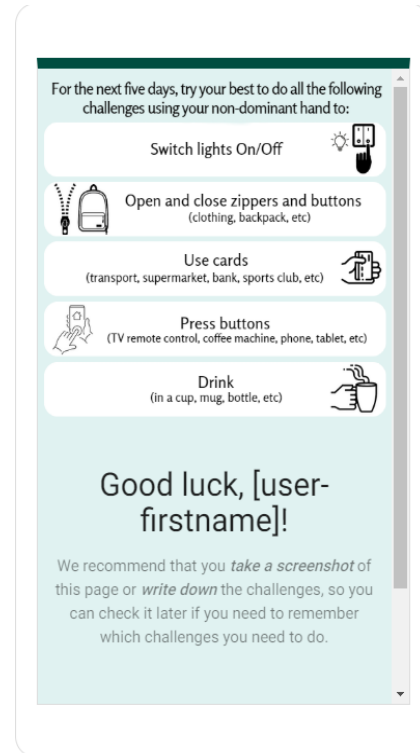
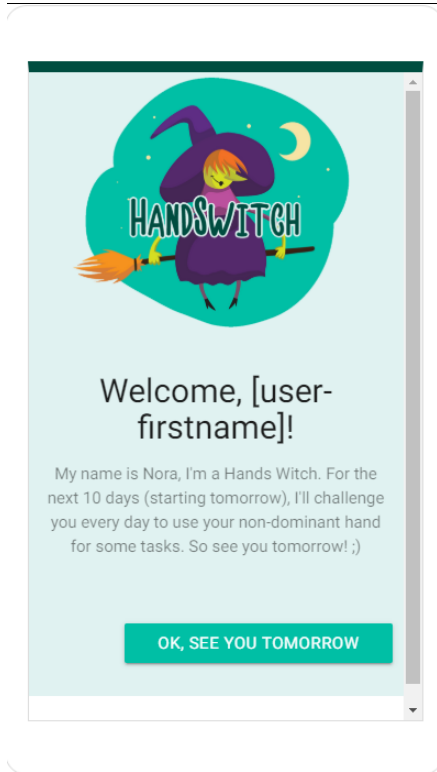
The app consists of a welcome screen (Figure 1), where the participants can give themselves a username, followed by two separate screens for each task group: one screen for when you receive 5 tasks (figure 2) and another screen if you receive 1 task (Figure 3). There are 10 tasks (see table 2) included in the app, which rank from easiest, switch lights on/off, to most difficult, writing. Thus, for the first day the 1 task group will see that their task for the day (Figure 2) is to switch lights on/off with their non-dominant hand, whereas the 5 task group sees the first 5 tasks. (Figure 2). It also consists of checkpoints, which are day 5 and day 10, these indicate that they have finished five tasks and thus have to fill in the next survey. (Figure 4) This screen will also show their progress in a timeline bar above their screen with the corresponding day. The app also includes a reminder for the users, by asking whether they have performed their task yet. For day 3 the application for instances asks whether the participant has done the task, which was using cards (Figure 5).

Table 2.

*HandSwitch tasks from easiest to most difficult to perform with your non-dominant hand.*

Task	Description
1.	Switch lights on/off
2.	Open and close zippers and buttons
3.	Use cards
4.	Press buttons
5.	Drink using a cup or a mug, bottle
6.	Open doors
7.	Pick-up and carry items

8. Use mobile phone
9. Eat
10. Write





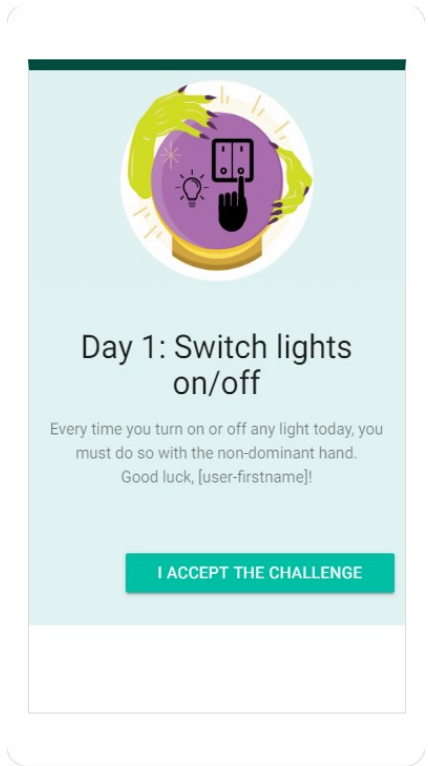


Figure 3. *1 task per day.*

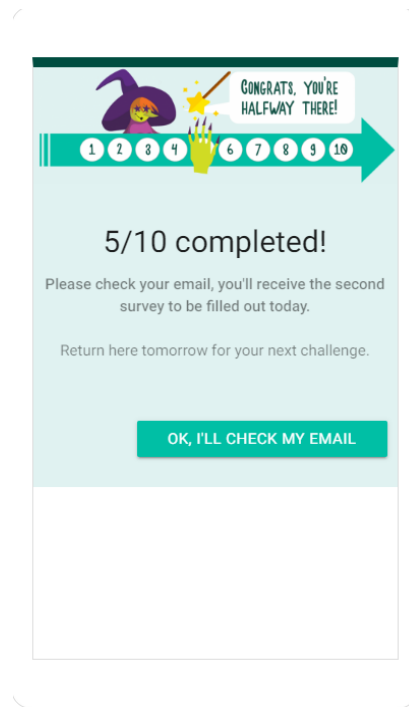


Figure 4. *Completion screen with survey*

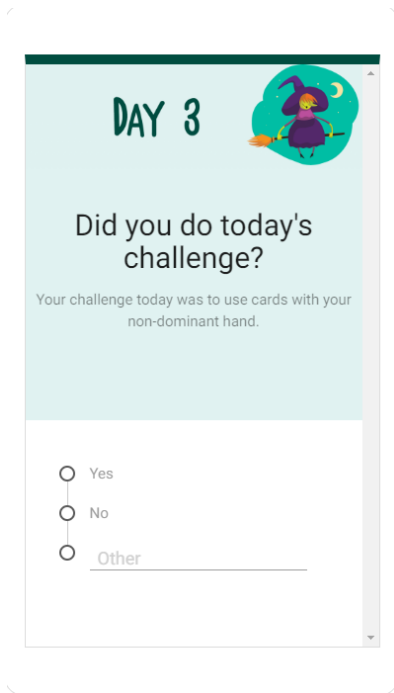


Figure 5. *Task reminder within the app.*

## **Participants**

The target group for this experiment were university students of the University of Twente. SONA was used to gather participants for this study which is a form of convenience sampling. SONA is an online test subject pool in which students can participate for various ongoing research conducted at the University of Twente. As for inclusion criteria the participant needed to be a university student and be available to receive tasks for 10 consecutive days. The participants were excluded if they are under the age of 18 and are not able to use their hands for daily activities or are ambidextrous. The final sample was composed of 136 participants (30.1% male) and were between the ages of 18 and 29 ( $M = 20.32$ ;  $SD = 1.97$ ) and finally 88.2% of the participants were right handed.

## **Materials**

### *Questionnaire items*

Three measures were used, amongst which two questionnaires, namely the Brief Aggression Questionnaire (BAQ) and Brief Self-Control Scale (BSCS) as well as Go/No-Go trial.

## **BAQ**

Denson, et al. (2011) had made use of the same scale in their comparable study, therefore the decision was made to include the BAQ in this study as well. As a measurement for aggression the 12-item BAQ questionnaire developed by Webster et al. (2014) was used. The BAQ has four sub-scales which each has 3 items totaling a validated scale of 12 items. The first sub-scale is physical aggression, the second is verbal aggression, the third anger and the fourth and final measure is hostility, thus it is aiming to measure aggression in an all-encompassing manner. Items such as “given enough provocation, I may hit another person”, “I have trouble controlling my temper”, “My friends say that I’m somewhat argumentative” and “When people are especially nice, I wonder what they want” observe aggression from various perspectives. The total results on the Likert-scale are between 12 points, which is the lowest level of aggression, to 60 points, which is the highest level of aggression. The BAQ was used in several studies regarding various forms of aggression. Such as dispositional anger (Jones & Neria, 2015), aggressive responses to moral violations (Molho, Tybur, Güler, Balliet, & Hofmann, 2017) and physical and verbal aggression (Tuvblad, et al., 2016), which means that it might also be applicable for reactive aggression. Furthermore, the current study observed lower Cronbach’s alphas ( $\alpha = .65$ ,  $\alpha = .72$ ,  $\alpha = .75$ ,  $\alpha = .77$ ) for the pretest, day 5, day 10 and posttest BAQ surveys respectively, compared to the results found by Webster, et al. (2014;  $\alpha = .82$ ). While the Cronbach’s alpha for day 5, 10 and posttest were acceptable the alpha for the pretest was rather questionable in terms of internal consistency.

## **BSCS**

For self-control the widely used 13-item BSCS developed by Tangney, Baumeister and Boone (2004) was used, which is well validated (Lindner, Nagy, & Reteldorf, 2015) The results from the Likert-scale totaling the 13 items are between 13 points, which is the lowest level of self-control, to 65 points which is the highest level of self-control. Of the 13 items 9 are asked in a negative connotation, such as “I am lazy”, while the 4 remaining questions have positive connotations regarding one’s self-control, e.g. “I refuse things that are bad for me”. Furthermore, the BSCS has been used in a wide variety of studies ranging from antisocial behavior (DeLisi & Vaughn, 2014), eating behavior (Riet, Sijtsema, Dagevos & de Bruijn, 2011), impulsivity (Carver, 2005; Vazire & Funder, 2006) and also trait and reactive aggression (Wilkowski &

Robinson, 2010) and given that one of the main focuses of the current study is reactive aggression and the questionnaire has been used for reactive aggression, antisocial behavior and impulsivity it seems to be a good fit taking these studies into account. Additionally, it was also used in the preceding and similar study by Da Silva (2019). Finally, acceptable to good Cronbach's alphas ( $\alpha = .84$ ,  $\alpha = .79$ ,  $\alpha = .86$ ,  $\alpha = .85$ ) were observed for the pretest, day 5, day 10 and posttest questionnaires respectively. The alphas are comparable to previous research with  $\alpha = .89$  (Tangney, et al., 2014) and high enough to continue, however alphas of .90 or higher are generally preferred.

### **Go/No-Go**

Finally, the Go/No-Go trial developed by Verbruggen and Logan (2008) will be used to measure self-control in another way. Namely by looking at the increase or decrease in response time compared to the self-control of the participant. In a meta-analysis of self-control measure Duckworth and Kern (2011) suggest adequate evidence was found for the validity of self-control measures such as the Go/No-Go along with that these measures should be performed multiple times to reduce error variance. The Go/No-Go trial is a motor training which is used to gain insight into and to enhance inhibition. The Go/No-go trial has been widely used in self-control research such as food evaluation between morbidly obese and normal-weight individuals (Chen, et al., 2018), smoking (Scholten, Granic, Chen, Veling and Luitjen, 2019), gambling (Challet-Bouju, Bruneau, Victorri-Vigneau and Grall-Bronnec, 2017) and alcohol consumption behavior (Qureshi, Monk, Pennington, Li and Leatherbarrow, 2017). Considering impulsiveness is connected with self-control, or lack thereof it makes the Go/No-Go trial a fitting measure to test, given that previous studies have had varying success with regards to addiction of many sorts. Finally, the participants are able to score a hit or a miss on the Go/No-Go task. Each task has 20 Gos and 5 No-Gos, meaning that 20 hits and 5 misses are the best results along with the corresponding response time for the hits.

### **Open questions**

At the end of the final questionnaire the participants will be asked three open questions, the first open question asked the participants whether they had felt that their self-control had improved due to the participation in this intervention. The second open question asked for the participants

how they had experienced the app and their opinion regarding the app. The final question was about what sorts of changes they would like to see applied to the app.

### *Procedure*

The intervention was conducted over 10 days but the entire experiment along with measurements were taken over a span of 15 days because of the post-measurement. The first survey was initiated on day 0 with background information about the app and a time-line (see Table 2) on when the following surveys will need to be filled in. This was then followed up by an informed consent.

Starting with the first survey the participant were asked to fill in their email in order to for the researchers to communicate with them throughout the experiment along with providing them the results of their participation. This was followed up with a question whether the participant was participating through SONA. Following up on that five demographic questions were asked. Next the participant was required to fill in two short questionnaires, namely the BSCS and BAQ (see Appendix B) which was then followed up by the Go/No-Go trial which concluded the first survey. This was repeated in the exact same way for surveys two and three after a new question was added regarding whether the participants noticed any bugs. The surveys received an addition of adding “in the last 5 days” to the questions in order to find out whether the tasks were effective in order to carefully test the intervention effect. Thus the questions changed to “In the last 5 days I have refused things that are bad for me” instead of “I refuse things that are bad for me”. After the third survey the participant was informed that they finished the intervention and had to fill in the final BSCS and BAQ survey after 5 days and questions about how they have experienced the intervention so far.

The final survey on day 15 consisted of the fourth and final BSCS and BAQ surveys, followed up by the Go/No-Go trial and finished by three open questions.

### **Data analysis**

In order to determine normality both a histogram and a Kolmogorov-Smirnoff (K-S) test were conducted on the BSCS, Go/No-Go and BAQ variables. The K-S results were not significant for

the BSCS and BAQ, meaning the data was normally distributed. Whereas for the Go/No-Go the K-S results were significant ( $p = .000$ ).

A repeated measures ANOVA was used for the BSCS, Go/No-Go and BAQ in order to look into the exact moments which depict a significant difference within each group and to discover whether the 5 task in a day group performs better than the 1 task per day group. As well as whether the control group depicts changes in results. Based on Mauchly's test of sphericity (see Appendix C1 & C2) the Greenhouse-Geisser correction was used for all 3 groups for the BAQ scores as well as the control group for the Go/No-Go results. After the omission of the pretest results only the control group for the BAQ scores violated sphericity and required the Greenhouse-Geisser correction.

Furthermore, in order to see whether there is a significant difference between the groups and in order to compare the control group to groups 1.1 and 1.2 on one time point a One-Way ANOVA will be conducted for the BSCS, BAQ and Go/No-Go. To be able to select the correct post-hoc analysis Levene's test for equality of variances was conducted for the BSCS, BAQ and Go/No-Go. A Games-Howell post-hoc will be used for the day 5 and posttest results of the BAQ and Go/No-Go whereas a Tukey post-hoc analysis will be conducted on the rest of the results.

Finally, qualitative analyses of the answers provided by the participants in the open questions of the study were conducted. These questions will be coded based on the relevant comments made by the participants through means of inductive coding. The answers given by the participants were put in an Excel file and analyzed using a coding framework. Based on the responses sub-topics were made in order to categorize the answers through means of coding. Each question had its own coding frame along with several sub-topics. Once all answers were analyzed the questions were split in per code received in order to determine how often a single code had been attributed to an answer.

## **Results**

The goal of this study was to test whether the SCT HandSwitch was able to lower the aggression levels in individuals while conversely increasing their self-control. In order to find out whether this was successful first a general overview will be given of the results that were found. This will then be followed up by inferential analysis through means of repeated measures ANOVA and one-way ANOVA.

## Descriptive statistics BSCS, BAQ & Go/No-Go

Table 3

Means, standard deviation and ns for each measure and condition of the Brief Self-control scale (BSCS), Brief Aggression Questionnaire (BAQ) and Go/No-Go

Measure and Condition	Pretest			Day 5			Day 10			Posttest		
	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>
<b>BSCS</b>												
Total	40.92	7.57	136	41.27	7.18	136	42.29	8.16	136	42.82	7.85	136
<i>5 tasks at once</i>	41.39	8.24	33	43.09	6.36	33	44.27	8.16	33	44.33	8.30	33
<i>1 task per day</i>	42.18	8.44	34	42.74	7.61	34	43.88	8.06	34	44.03	7.65	34
Control	40.07	6.76	69	39.68	7.06	69	40.55	7.93	69	41.51	7.60	69
<b>BAQ</b>												
Total	29.99	5.58	136	27.07	6.08	136	26.75	6.34	136	26.84	6.52	136
<i>5 tasks at once</i>	30.76	5.68	33	29.12	6.18	33	28.58	5.80	33	28.36	5.74	33
<i>1 task per day</i>	29.21	4.84	34	26.59	4.11	34	24.97	5.56	34	24.59	4.98	34
Control	30.01	5.89	69	26.33	6.67	69	26.75	6.77	69	27.22	7.29	69
<b>Go/No-Go</b>												
Total	24.90	11.28	136	19.33	10.85	136	19.79	11.55	136	18.28	11.55	136
<i>5 tasks at once</i>	22.76	10.94	33	17.00	9.10	33	17.70	11.09	33	16.03	9.26	33
<i>1 task per day</i>	23.41	9.86	34	16.12	7.44	34	16.74	8.97	34	16.36	9.50	34
Control	26.69	11.95	68	22.07	12.37	68	22.32	12.45	68	20.34	13.42	68

### *Go/No-Go*

There seem to be slight differences between group 1.1, 1.2 and the control group regarding RT (see Figure 6) and accuracy (see Figure 7). While group 1.1 performs better on the pretest on RT (22.76) and accuracy (95.64%), group 1.2 seems to have better performances on the other time points (see Figure 6) whereas the control group scores a lower overall RT (22.85) while depicting the highest overall accuracy (96.42%). Comparing pretest to posttest there seems to be a decrease in RT (see Figure 6) across all 3 groups. (see Table 4)

Table 4

*Ns, RT, RTSD, Hits and Misses for the Go/No-Go by group*

Group	Time-point	RT(ms)	RTSD(ms)	Hits	Misses
App, 5 tasks	Pretest	22.76	10.94	23.91 (95.64%)	1.09 (4.36%)
	Day 5	17.00	9.10	23.76 (95.03%)	1.24 (4.97%)
	Day 10	17.70	11.09	23.94 (95.76%)	1.06 (4.24%)
	Posttest	16.03	9.26	23.64 (94.55%)	1.36 (5.45%)
1.1 (N = 33)	Total	18.37	10.10	95.24 (95.24%)	4.76 (4.76%)
	Pretest	23.41	9.86	23.35 (93.41%)	1.65 (6.59%)
App, 1 task	Day 5	16.12	7.44	23.97 (95.88%)	1.03 (4.12%)
	Day 10	16.74	8.97	24.21 (96.82%)	0.79 (3.18%)
Group 1.2 (N = 34)	Posttest	16.36	9.50	23.88 (95.53%)	1.12 (4.47%)
	Total	18.16	8.94	95.41 (95.41%)	4.59 (4.59%)
	Pretest	26.67	11.95	24.09 (96.36%)	0.91 (3.65%)
Control group	Day 5	22.07	12.37	24.07 (96.29%)	0.93 (3.71%)
	Day 10	22.32	12.45	24.29 (97.16%)	0.71 (2.84%)
Group 1.3 (N = 69)	Posttest	20.34	13.42	23.97 (95.88%)	1.03 (4.12%)
	Total	22.85	12.55	96.42 (96.42%)	3.58 (3.58%)

RT = Response Time; RTSD = Response Time Standard Deviation.

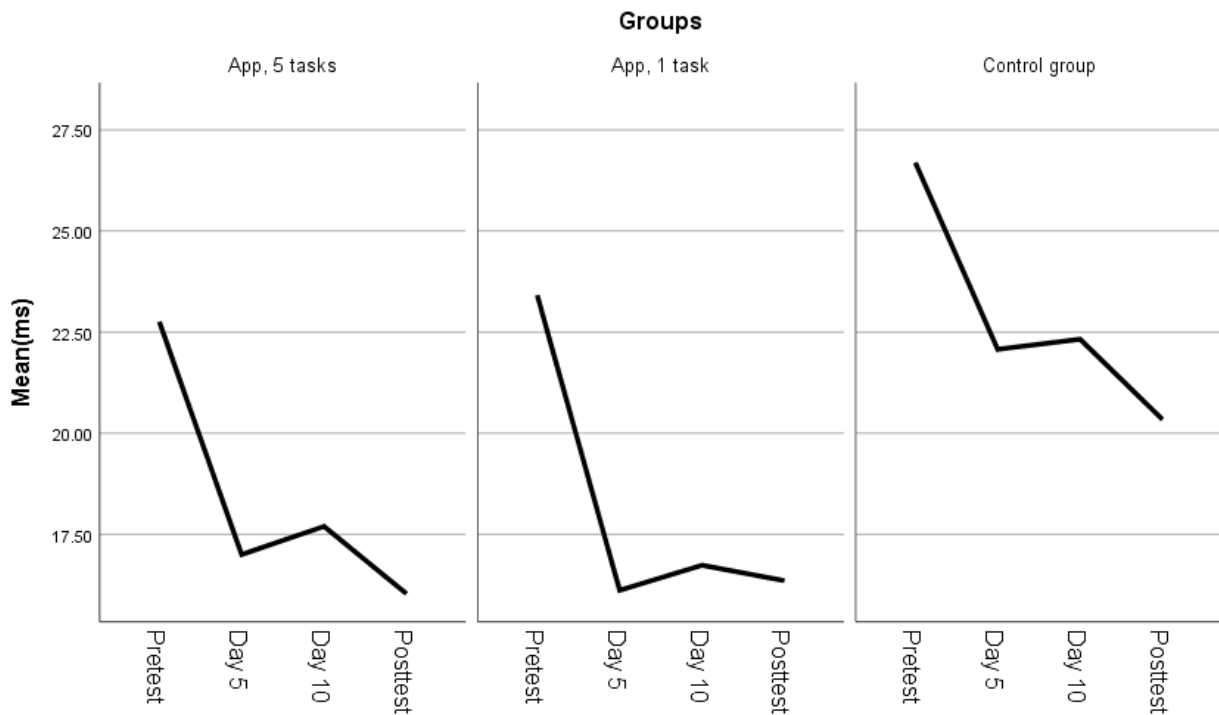




Figure 6. Average reaction speed across all 3 groups between time points.

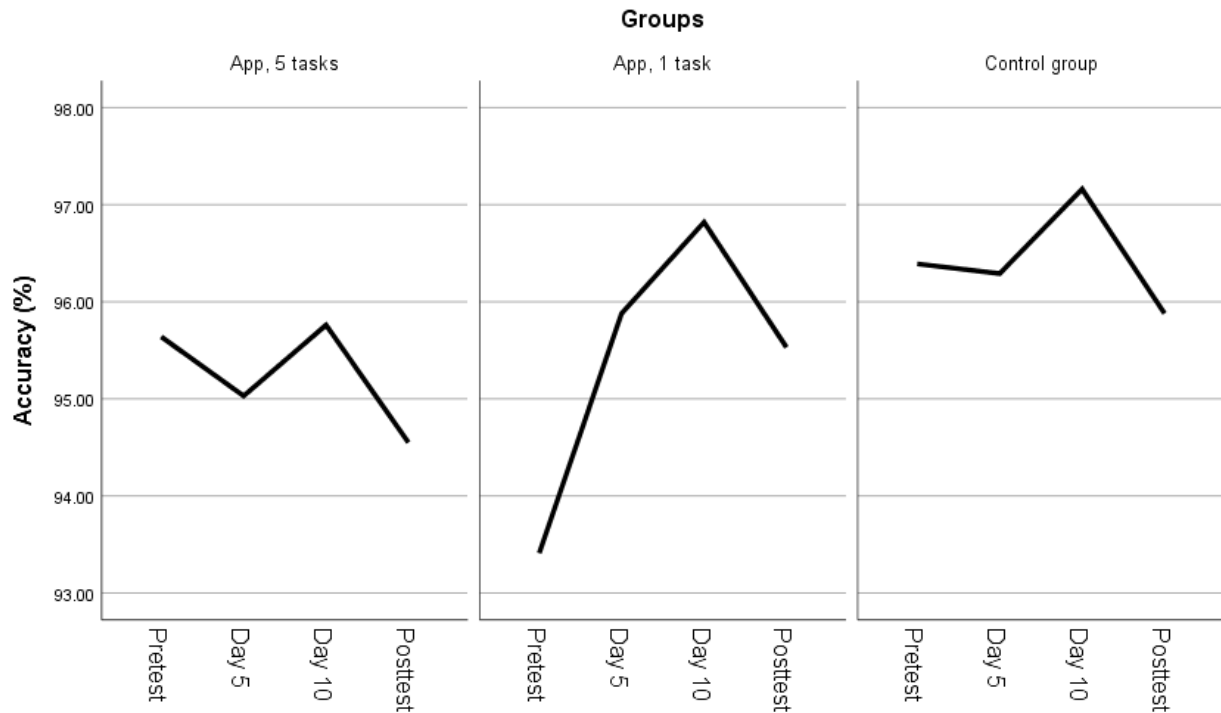


Figure 7. Average accuracy across all 3 groups between time points

### Differences within groups

A repeated measure ANOVA was conducted for every measuring moment for the BSCS, Go/No-Go and BAQ scores per group in order to determine whether the mean differed statistically significantly between time points within a group.

#### BSCS

Looking at the BSCS scores only group 1.1, the group that received 1 task per day had a statistically significant increase  $F(3,96) = 3.62, p = .016$ . With a further look into the post-hoc analysis, for the BSCS scores it seemed that only group 1.1 had a statistically significant difference which was between pretest ( $M = 41.39, SD = 8.24$ ) and posttest ( $M = 44.33, SD = 8.30, p = .046, 95\% CI [-5.84, -0.04]$ ), while there were increases between other time points outside of the difference between pretest and posttest (see Figure 8) none of these were statistically significant.

## Go/No-Go

For the Go/No-Go all 3 groups showed a statistically significant difference in their scores, with group 1.1  $F(3,96) = 7.11, p = .000$ , group 1.2  $F(3,99) = 10.27, p = .000$  and the control group  $F(2.61, 174.84) = 7.81, p = .000$ . As for the post-hoc results the Go/No-Go showed significant differences across all 3 groups, specifically every difference between the pretest and another time point was significant. A significant difference between pretest and day 5, pretest and day 10 and pretest and posttest was depicted for all 3 groups. The results differed between group 1.1 ( $p = .007$  to  $.035$ ; 95% CI [0.25, 9.87] to [1.40, 12.05]), group 1.2 ( $p = .000$  to  $.001$ ; 95% CI [2.46, 10.89] to [2.96, 11.63]) and control group ( $p = .001$  to  $.030$ ; 95% CI [0.28, 8.46] to [2.04, 10.67])

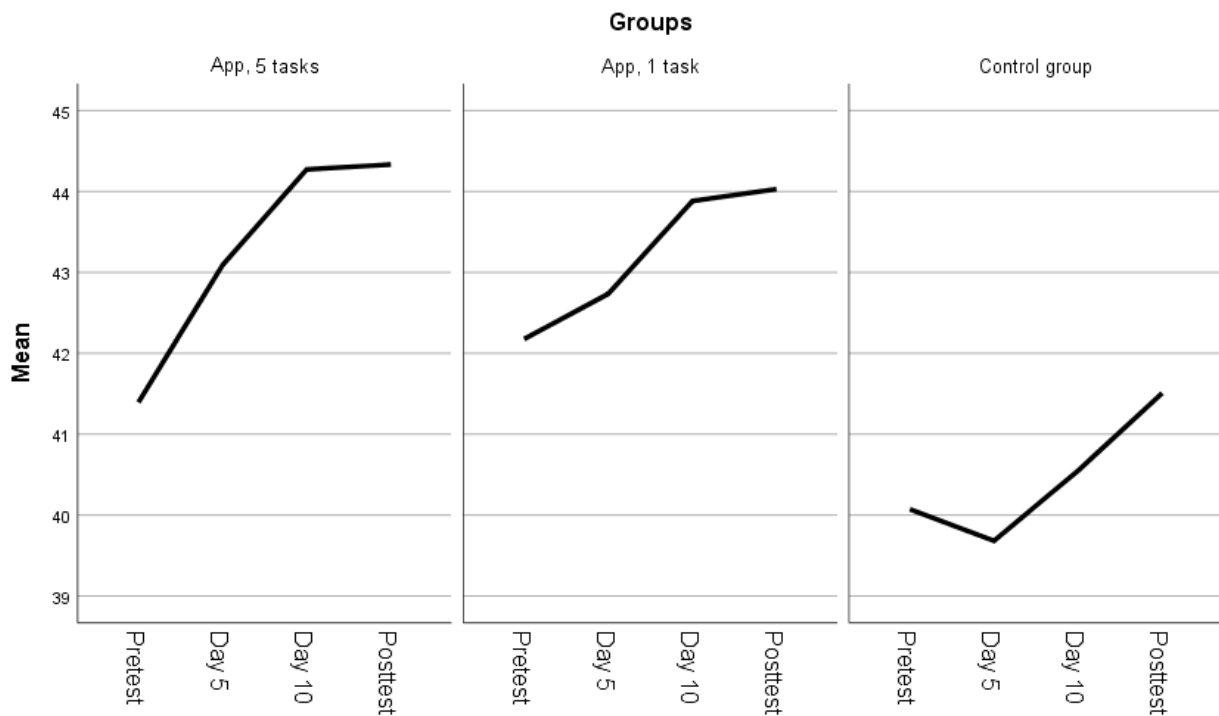


Figure 8. Average Brief Self Control Scale score over time points per group.

## BAQ

All three groups had statistically significant decreases in their BAQ scores too with  $F(2.43, 77.68) = 3.58, p = .025$  for group 1.1,  $F(2.22, 73.12) = 12.49, p = .000$  for group 1.2 and

$F(2.52, 171.65) = 14.28, p = .000$  for the control group. As for the post-hoc analysis it showed that the decrease in BAQ scores (see Figure 9) were statistically significant for all 3 groups. Specifically, group 1.1 showed that the difference between pretest ( $M = 30.76, SD = 5.68$ ) and posttest ( $M = 28.36, SD = 5.74, 95\% CI [-0.51, 3.78]$ ) was significant ( $p = .019$ ) while at other time points the score did decrease, however this was not statistically significant.

As for group 1.2 ( $p = .000$  to  $.029$ ;  $95\% CI [0.19, 5.05]$  to  $[2.01, 7.22]$ ) and the control group ( $p = .000$  to  $.003$ ;  $95\% CI [0.71, 4.86]$  to  $[1.91, 5.46]$ ). An additional significant difference between day 5 and posttest ( $p = .030, 95\% CI [0.14, 3.86]$ ) was found for group 1.2 as well.

However, to account for the potential learning effect and differences the pretest seems to depict additional analyses were conducted with the exclusion of the pretest. The BAQ only had a significant difference between day 5 and posttest for group 1.2 ( $F(2,66) = 4.83, p = .011$ ) whereas the other groups were no longer statistically significant, along with a post-hoc analysis showing that the difference between day 5 and posttest to be statistically significant ( $p = .015, 95\% CI [0.33, 3.67]$ ). As for the BSCS and Go/No-Go none of the groups were statistically significant.

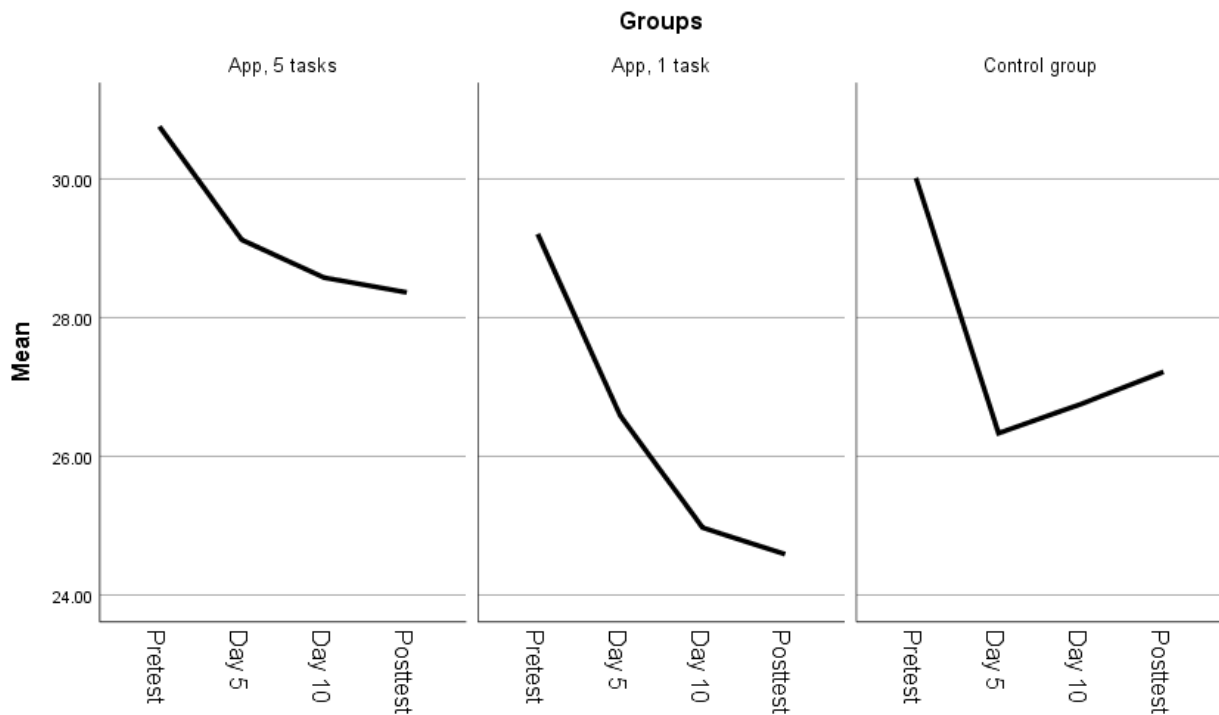


Figure 9. Average Brief Aggression Questionnaire score over time points per group.

## Differences between groups

In order to compare the groups on one time point a one-way ANOVA was necessary to conduct. Additionally, the control group could also be compared to the two app groups using this method.

### *BSCS*

A significant difference between groups on day 5 and day 10 for the BSCS was determined by one-way ANOVA (see Table 5) meaning that between all 3 groups the differences on day 5 and 10 were statistically significant. However, the post-hoc analysis resulted in no significant comparisons.

Table 5  
*One-way ANOVA on BSCS scores F-score and significance.*

	<i>F</i>	<i>p</i>
Pretest	0.97	.384
Day 5	3.60	.030*
Day 10	3.30	.040*
Posttest	2.01	.138

### *Go/No-Go*

As for the Go/No-Go day 5 and day 10 were also found to be significant (see Table 6). The post-hoc analysis reported a significantly ( $p = .009$ ) lower RT ( $M = 16.12$ ) for group 1.2 compared to the control group ( $M = 22.07$ ,  $MD = -5.96$ , 95% CI  $[-10.64, -1.27]$ ) on day 5. The other comparisons were not significant.

Table 6  
*One-way ANOVA on Go/No-Go scores F-score and significance.*

	<i>F</i>	<i>p</i>
Pretest	1.77	.175
Day 5	4.67	.011*
Day 10	3.50	.033*
Posttest	2.16	.120

## BAQ

Finally, for the BAQ only the posttest seemed to be significant (see Table 7). As for the post-hoc analysis the BAQ scores had one significant comparison for the posttest, namely participants in group 1.1 reported a significantly ( $p = .015$ ) higher BAQ score ( $M = 28.36$ ) compared to participants in group 1.2 ( $M = 24.59$ ,  $MD = 3.78$ , 95% CI [0.62, 6.93]), the other comparisons were not significant.

Table 7  
*One-way ANOVA on BAQ scores F-score and significance.*

	<i>F</i>	<i>p</i>
Pretest	0.65	.526
Day 5	2.55	.082
Day 10	2.78	.066
Posttest	3.14	.047*

## Qualitative results

Aside from the collected quantitative data the participants were also asked three open questions regarding the intervention. The answers to these questions are important in order to find factors that were not accounted for that could have had an impact on the results of the study.

### *Question 1. Self-control improvement*

The first question which the participants got to answer was whether they felt that their self-control improved by participating in this intervention. For the first question (see Appendix C1), the majority of the app users indicated that they felt that the intervention had no effect on their self-control whereas their individual BSCS scores differed widely from pretest to posttest. For example, one participant mentioned that they did not feel that their self-control improved whereas the BSCS score difference between pretest and posttest was 11 points. They stated: “*For me not so much because my self-control is quite good, and I did not experience any changes in that. Also I forgot a lot of times to actually do the hand-switching, so that might be a reason.*” The group of participants who answered ineffective to the first question did see an increase in BSCS scores between pretest and posttest as shown in table 5 ( $M = 1.08$ ) with a large range ( $R = 29$ ) indicating that while the participant was not of the impression that their self-control

increased, their BSCS score did show an increase when comparing posttest to pretest. Generally, the consensus was that the group that felt that the intervention was ineffective was not able to notice the difference in self-control or the participant accounted the change to other factors outside of the intervention, whereas the participants who were unsure or thought the intervention was effective did indeed see a positive difference in BSCS score.

### *Question 2. Opinions*

The second question asked the participants to give their opinions regarding the intervention (see appendix C2). There were a wide variety of opinions given on the intervention. While the most predominant answers were regarding bugs and three participants also further elaborated that they experienced additional issues with their iPhones. Several other interesting opinions were given as well. For instance, participants had mixed opinions about the amount of tasks they had received, while one participant with 1 task a day asked for more the other participant with 5 tasks per day asked for less. Another prevalent opinion was that the participants would like to see more reminders, whereas some participants were of the opinion that the reminders were adequate. Furthermore, comments were made regarding elements of the app or tasks being unclear, which was however overruled by the amount of participants indicating the app was easy to understand and had the right amount of information.

### *Question 3. Changes participants would like to see made to the intervention.*

Finally, the participants were asked what sorts of changes (see Appendix C3) they would like to see made to the intervention. The most prevalent and important answer was that the participants wanted more reminders. Another important and prevalent comment made was that they found certain tasks either too difficult *“I would change some hand-switch tasks. Some of them seem to be really unrealistic for me to carry out.”* or the participant did not have an opportunity to perform a task in a natural manner *“As a university student, I use my laptop for everything. Therefore, using my non-dominant hand for writing did not happen. Maybe come up with another challenge since I believe many students will feel the same way. In terms of difficulty, it would have been perfect though.”*. As a final important answer, different questionnaires were requested with more relevance to the tasks performed *“Maybe, I would ask*

*different questions- more specific questions to the tasks” or an additional questionnaire “Maybe questions about frustration.”.*

## **Discussion**

In this study the goal was to find out whether an app based SCT could successfully lower aggression and increase self-control among aggressive individuals along with three hypotheses, namely that the intervention would increase the self-control and decrease the aggression level of the participants. Secondly, that people who were shown five tasks at once would have a higher increase in self-control and a lower level of aggression compared to the group who received one task a day and finally that the results of the control group did not change.

### *Effectiveness of the intervention*

Within every group there seemed to be an increase in BSCS scores, a faster response time and a decrease in aggression. The increase in self-control was however only significant for the group that received 5 tasks in a day. As for the decrease in aggression there was a significant difference across every group. The significant difference for the group that received 5 tasks was in line with previous research by Da Silva (2019). With the addition of the control group it was also possible to see whether an outside factor played a role in the results. There were no clear indications that an outside factor had an influence based on the results of the control group. While the expectation was that the control group would show no changes in their results the group was able to improve their self-control and lower their aggression, however the results were quite lower compared to the experiment group. Taking previous studies into account which were able to find a relationship between self-control and aggression (Chen, et al., 2019; Denson, et al., 2011) as well as another study (DeSteno, Lim, Duong & Condon, 2018) which adapted the task from Denson, et al. (2011) was able to find a relationship between meditation and anger as well it seems that the results are somewhat in line with previous research. However, the difference between the pretest and following measures did show a big change in results. This could be attributed to a learning effect, meaning that the participants got exposed to new information and through means of getting used to the intervention the results also changed. Another alternative way of looking at the change could be to attribute this to the speed at which the intervention has an effect on the participant, in this case it taking effect immediately. The results when omitting the pretest only depict a significant difference in aggression for the group that received 1 task per day whereas all

other groups had no significant results, including the difference in self-control. Thus, this begs the question whether the intervention is able to show quicker results among the participants than anticipated or whether there was in fact a learning effect. Based on the results however, it does seem that the intervention is effective, but would require further research in order to look further into the differences observed between the pretest and other measures.

### *Self-control explained by Go/No-Go*

The Go/No-Go was used as an additional measure for self-control. The initial results comparing the pretest to the rest of the intervention seemed to depict significant changes across the response time, the changes between day 5 and pretest were rather inconclusive. A big drop-off in response time was observed between pretest and day 5, which was not replicated in the following trial results. Previous studies which used Go/No-Go were able to successfully find results which depicted Go/No-Go to have an effect on inhibition (Los, 2013; Schulz, et al., 2007) however their results did not have a comparable big difference between the pretest and the following time points. Which means that another factor could have influenced the results to lead to this big difference, either through the means of the intervention having a rapid effect, a learning effect or other factors.

Another possible cause for this difference could be attributed to whether the participants took the trial on their phones or by using a computer and whether there were cases where both were used for different time points. Using a phone would cause different reaction times due to only having to tap your finger onto the screen, whereas using a laptop could decrease the response time due to the use of a touchpad or a mouse as well as the overall responsiveness of the device used. A final alternative possibility would be that the intervention takes quick effect on the participant, which could clarify the rapid increase in response time. Possible avenues for future research could be to create separate groups which take the trial by phone, and another by computer. Additionally, in order to further understand whether a learning effect is indeed taking place having an additional group which is part of a longer intervention could show possible differences in long-term. Nevertheless, the results shown by the Go/No-Go seem to have some semblance with previous studies, however careful conclusions need to be made regarding the effectiveness of the intervention on the Go/No-Go results and possible external reasons such as a



learning effect or the manner in which the participant took the trial needs to be further researched in future studies.

### *Reminders*

One of the most forthcoming suggestions and comments from the participants were regarding the addition of more reminders for tasks. The need for reminders could have caused unnecessary frustration for the participants due to forgetfulness and not being able to take their time doing the task or answering the questionnaires. Reminders are persuasive features which can draw the attention of the participant in a positive way in order to convince them to keep making use of the app. This can help in achievements of goals and successful completions of tasks and are even able to enhance behavior change interventions (Fry, & Neff, 2009; Oduor, Alahäivälä, & Oinas-Kukkonen, 2017). Therefore, it is an important piece of feedback to receive from the participants because this can further elevate the intervention to more effectivity. The addition of more reminders could cause changes to the results too. Fry and Neff (2009) found increased effectiveness in health behavior interventions when reminders were used alongside personal contact. Thus, an increase in reminders might cause a significant change in the observed results for the intervention in future research.

### *The provided tasks*

The participants provided comments regarding not being able to perform tasks as well as finding tasks impossible or difficult to perform. Another comment made by participants was also that they either wanted less tasks, coming from participants in the group that received 5 tasks in a row, or that they wanted more tasks, coming from participants in the group that received 1 task per day. Since some participants admitted that they did not do certain tasks because of the difficulty or not having the occasion to perform the task, such as writing with their non-dominant hand due to only working by computer, it becomes evident that not all tasks were performed and that this might have an effect on the results because people did not perform the tasks as requested. On one hand it could cause frustration among participants due to finding a task impossible to perform while on the other hand not performing a task because it does not fit them. Taking both the participants who wanted less or more tasks as well as participants who did not perform or found tasks impossible certain actions can be taken to mediate these problems. One would be to allow the participants to pick the amount of tasks they want to receive so that the

amount does not cause unnecessary frustration, and also allows the participant to be aware of what to expect of the intervention through a choice made by them. Another would be to test omit certain tasks and include different ones. For example, if the sample group consists of mostly university students it would be a possibility to substitute writing for using a computer mouse with their non-dominant hand.

### *Differences within the experiment group*

The experiment group consisted of a group that received 5 tasks in a day and a group that received 1 task a day. It was important to look at the differences between these two groups due to the results acquired in the previous study by Da Silva (2019). The 5 task group had outperformed the 1 task group and the same result was expected for this study. However, this was not entirely the case. The 5 task in a day group was able to depict significant differences across all measures whereas the 1 task per day group did not, but the aggression level based on the BAQ results were lower for the 1 task per day group. One reason for this could be that the participants that received 5 tasks in a day had difficulties looking up the tasks throughout the day, which was also indicated in the open questions at the end. This could have caused unnecessary frustration when the participants were not able to navigate the app in a satisfactory manner. While the representation of the group that had difficulties finding their tasks were not of significant proportion, it is still a worthwhile reason to consider. Secondly, the group that received 1 task per day did not receive tasks which they perform frequently throughout the day until the last three days. One of these tasks consisted of writing, which participants also admitted to not carrying out due to not having the occasion or situation to write something or due to it being too difficult to perform. This could also have had an effect on the difference between both groups since the 5 task in a day group had to perform these in succession to each other. The dissatisfaction of the tasks along with not being able to navigate the app in a satisfactory manner could have had an unforeseeable effect. Although it is not apparent what could have caused these differences in aggression certain factors do come to mind. Further research would be required to determine whether this was a one-off case or whether the aforementioned factors could have had an influence on the aggression level as well as unfound factors which might have had an influence too.

### **Recommendations**

Although the results for the group that received 5 tasks in day were statistically significant there were some questions raised. In order to further research possible factors which may underlie the reasons for certain results to not be significant or factors which may influence the intervention future research is recommended, and certain recommendations do come in mind.

First of all, while ANOVA analysis was suitable for the current study due to a low amount of missing cases a mixed linear model would also be a good fit. This was not used in the current study due to lack of knowledge regarding this model along with its interpretations. Furthermore, since there was no missing data and the time between measurement moments were the same ANOVA was a good and efficient fit due to the present research knowledge.

Secondly, a more balanced sample size could benefit the results of the study as well. According to Ridder, Lensvelt-Mulders, Finkenauer, Stok & Baumeister (2011) improving self-control may depict a stronger result in male compared to female. In this study 77.9% of the participants were female, which could have had an impact on the results. Furthermore, de Ridder, et al. (2011) also indicate that people with stronger impulses, specifically males, could benefit more from a higher self-control as well. Additionally, the majority of studies which use self-control scale had equal gender distribution (Ridder, et al., 2011). Meaning that a more equally distributed gender ratio is recommended for future studies.

Thirdly, a practical recommendation would be to

Finally, for practical use the additions of reminders would be advisable along with additional research regarding persuasive features. While this study has touched upon this subject briefly, more in-depth research into persuasive features along with usage of reminders might prove to be useful. As an addition to reminders rewards or achievements could also enhance the success rate of the app and performance of the tasks (Oduor, Alahäivälä, & Oinas-Kukkonen, 2017).

## **Limitations**

This study has some limitations which future research would want to circumvent. The first limitation is that the bugs which the participants have experienced could have caused additional frustrations and thus influenced the results. The way frustrations can influence self-control is due to experiencing a negative stimuli or scenario (Scarpa & Raine, 1997). Which can in turn also cause aggression if self-control is lowered as a result of this frustration.

Secondly, the BAQ scores for the pretest were higher by a large margin compared to the other time points. The reasons for this is not yet certain, one potential factor could be the Cronbach's alpha for the pretest ( $\alpha = .65$ ), which was not as high ( $\alpha = .82$ ) as reported by Webster, et al. (2014). Taking into account the very low Cronbach's alpha for the pretest along with the very high scores for the pretest in regards to the BSCS, BAQ and Go/No-Go something could have gone wrong in terms of testing here. This could have had an influence onto the results and further reliability analysis could be required.

Another limitation would be sample group used, in this study university students were used as participants who have a wide variety of self-control as well as low to no aggression (Mahmood & Kakamad, 2018), whereas a more aggressive group might be able to show vastly different results when provided with the same intervention and in the same trend a less self-controlled group as well. Therefore, having participants for which the intervention is intended to be used as target group, namely aggressive individuals such as (ex)convicts for assault or individuals with anger management issues, could be more accurate in terms of results. The reason students were chosen as sample group was due to making the evaluation more efficient due to students being a large and readily available group for studies.

## **Conclusions**

The results of this study were able to answer the hypotheses. Based on previous research two groups were made within the experiment group, one group received 5 tasks in a day while the other received 1. The group that received 5 tasks per day showed significant results, namely a significant increase in self-control, a significant increase in response time as well as significant decrease in aggression. This means that the intervention did indeed have an effect as well as the 5 task per day group showing significant results over the 1 task per day group. Furthermore, the control group did indeed see some changes in aggression and self-control, however the results were much lower compared to the experiment group. However, the results did raise some questions. The results for the pretest measure were vastly different compared to the following measures, indicating that something happened during the pretest. This could be based on a learning effect given that the control group also depicted such a difference or be attributed to the intervention and that it has a fast acting nature in terms of results. Additionally, while the results

were not significant, the 1 task per day group also depicted a lower level of aggression after the intervention compared to the 5 task in a day group. This calls for future research in order to look into the factors which may cause this vast difference in results across measures. A longitudinal study would be recommended in order to get a view on the results along with the difference that occurred between pretest and the following measures. This will also enable the researchers to find out whether the results persist over time as well as make the intervention feel less artificial compared to an experimental design. Furthermore, it would also allow the researchers to get closer to causal explanations of the observed results. All in all, the intervention did have an effect on self-control and aggression as depicted by the results of the group that received 5 tasks in a day. Meaning hypothesis 1. *1. The SCT App reduces aggression and increases self-control after the intervention compared to before the application was used within the experimental group* can be accepted. However, although the 5 task in a day group did have higher self-control the 1 task per day group did depict a lower level of aggression at the end of the intervention. Which leads to the rejection of hypothesis 2. *2. Participants who receive 5 task in one go depict lower aggression levels and higher self-control after the intervention compared to participants whom received 1 task per day.* Finally, while the results of the control group were comparably worse than the experiment group changes were present in self-control and aggression, leading to the rejection of hypothesis 3. *3. The control group depicts unchanged and worse results in aggression and self-control compared to the experiment group*

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10.1111/j.1467-6494.2009.00607.x

## Appendices

### A. The app

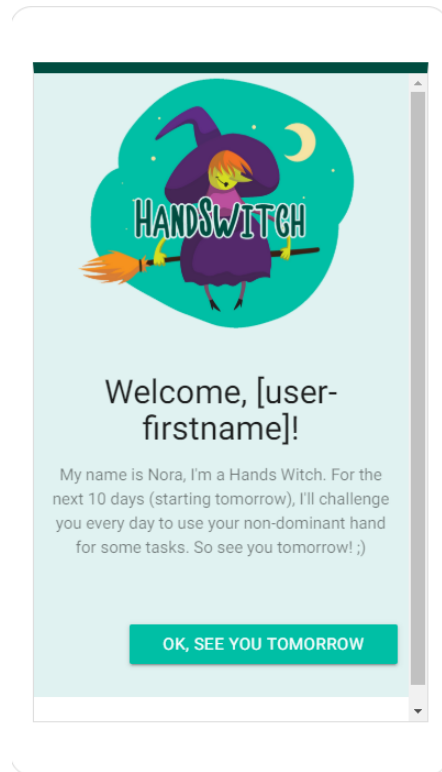


Figure A1. *The introduction screen*

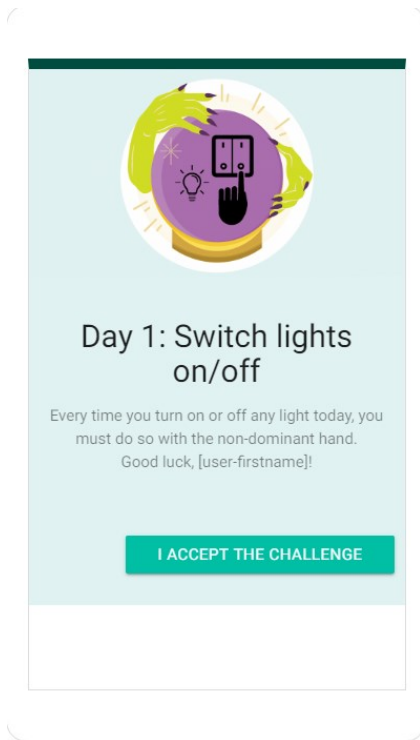


Figure A2.1 Day 1 for 5 tasks in a row group 1.1

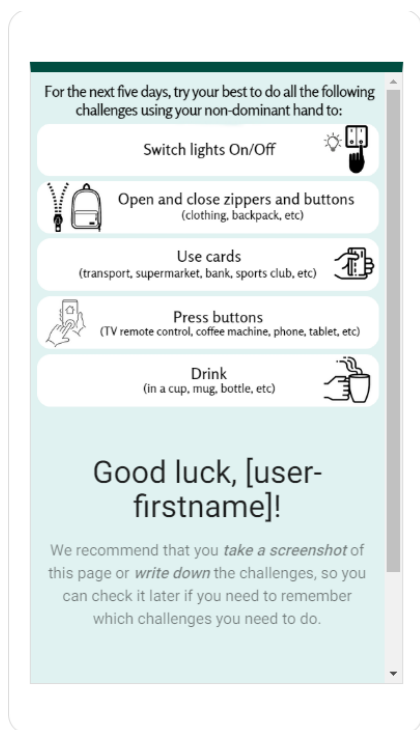


Figure A2.2 Day 1 for 1 task per day group 1.2

That's great! Which one(s) you did?

- Switch lights on/off
- Open/close zippers and buttons
- Use cards
- Press buttons
- Drink
- Other \_\_\_\_\_

Figure A3.1 Day 3 reminder 5 task in a row group 1.1

**DAY 3**

Did you do at least one of the challenges today?

Hi, [user-firstname]! Just to remember, your challenges were to switch lights, open and close zippers/buttons, use cards, press buttons, and drink using your non-dominant hand.

- Yes
- No
- Other \_\_\_\_\_

Figure A3.2 Did you do your task? If yes, which task?

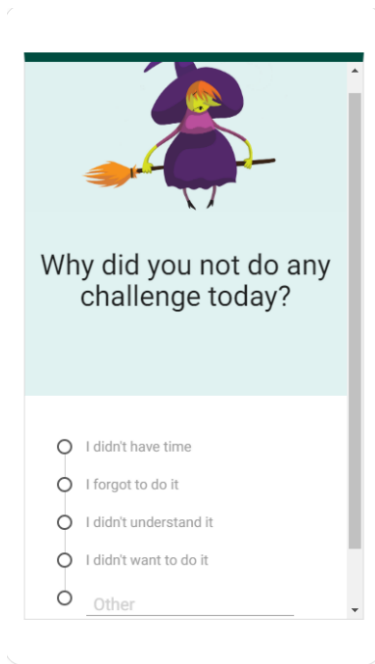


Figure A3.3 *Did you do your task? If no, why not?*

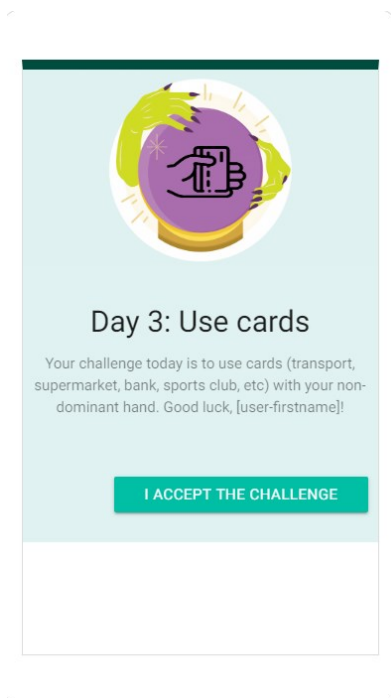


Figure A4 *Day 3 for 1 task per day group 1.2*

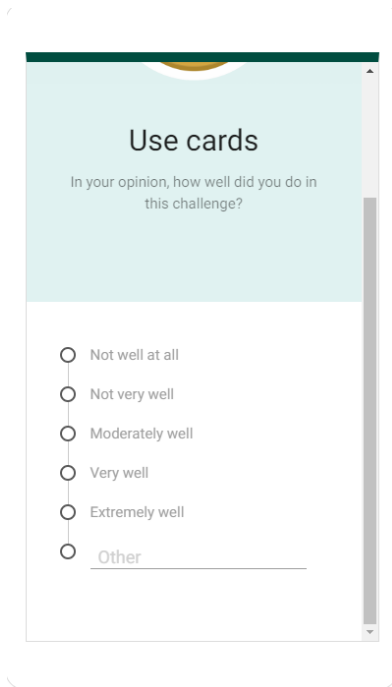


Figure A5.1 *How well did you do?*

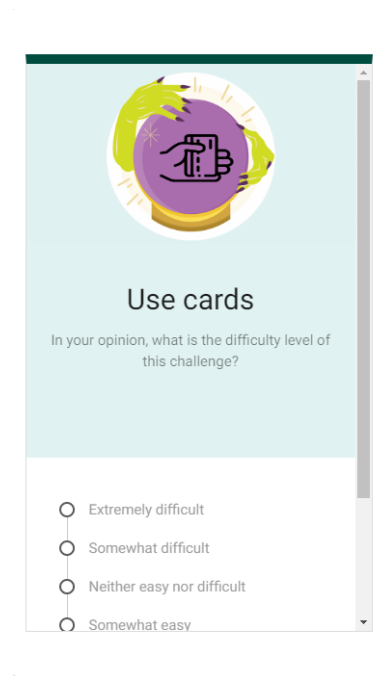


Figure A5.2 *How difficult was the task?*

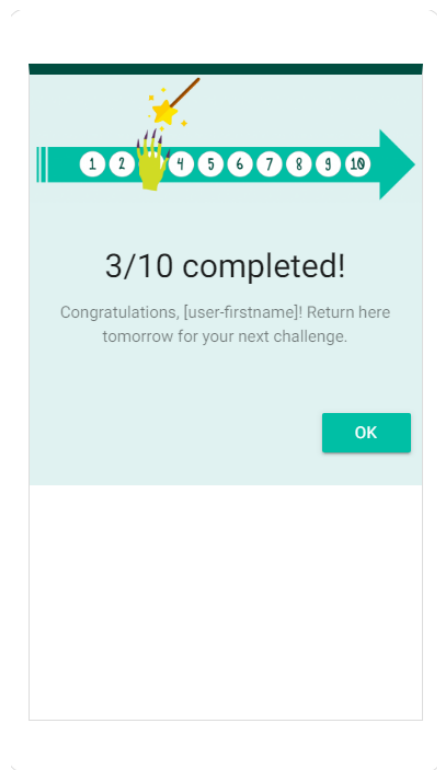


Figure A6. *Completion screen*



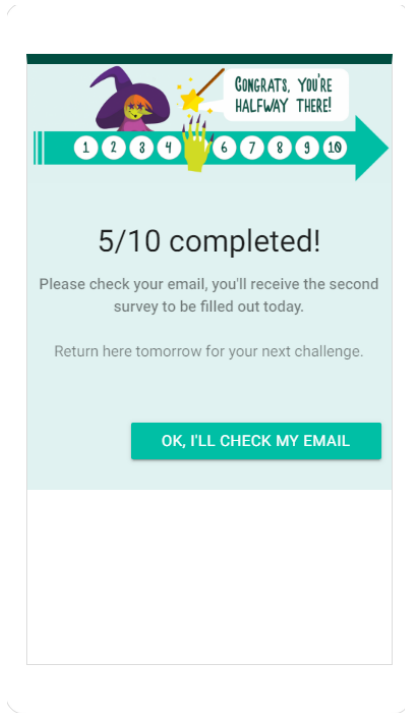


Figure A7. Completion screen on survey day.

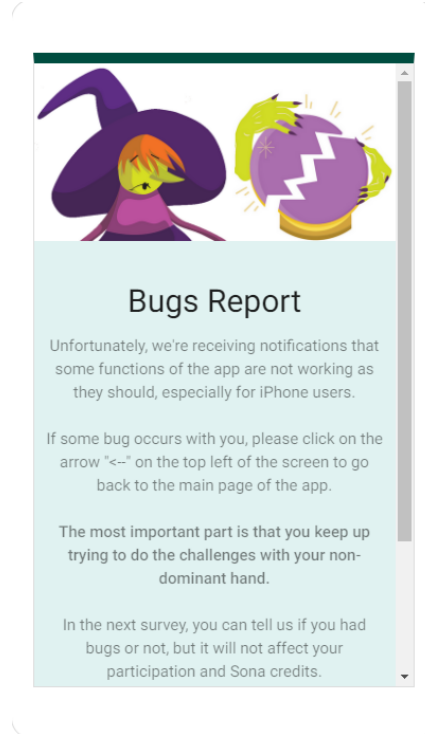


Figure A8. Bug report screen.

## B. Brief Aggression Questionnaire & Brief Self Control Scale

Table B1.

### *Brief Aggression Questionnaire (BAQ) Subscales and Items*

The BAQ uses a 5-point Likert scale from 1 (extremely uncharacteristic of me) to 5 (extremely characteristic of me).

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#### Physical aggression

1. Given enough provocation, I may hit another person
2. If I have to resort to violence to protect my rights, I will.
3. There are people who pushed me so far that we came to blows

#### Anger

4. I am an even-tempered person.
5. Sometimes I fly off the handle for no good reason.
6. I have trouble controlling my temper.

#### Verbal aggression

7. I tell my friends openly when I disagree with them.
8. When people annoy me, I may tell them what I think of them.
9. My friends say that I'm somewhat argumentative.

#### Hostility

10. Other people always seem to get the breaks.
  11. I sometimes feel that people are laughing at me behind my back.
  12. When people are especially nice, I wonder what they want.
-

Table B2.

*Brief Self Control Scale (BSCS) items.*

The BSCS uses a 5-point Likert scale from 1 (Not at all) to 5 (Extremely).

- 
1. I am good at resisting temptation
  2. I have a hard time breaking bad habits
  3. I am lazy.
  4. I say inappropriate things.
  5. I do certain things that are bad for me, if they are fun.
  6. I wish I had more self-discipline.
  7. Pleasure and fun sometimes keep me from getting work done
  8. I have trouble concentrating
  9. I am able to work effectively toward long-term goals
  10. Sometimes I can't stop myself from doing something, even if I know it is wrong.
  11. I often act without thinking through all the alternatives.
  12. I refuse things that are bad for me
  13. People would say that I have iron self-discipline.
-

### C. Assumptions data analysis

Table C1

*Mauchly's test of sphericity.*

<u>Measure</u>	<u><i>p</i></u>
BAQ	
Group 1.1	.011*
Group 1.2	.009*
Control group	.001*
Go/No-Go	
Control group	.007*

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Table C2

*Mauchly's test of sphericity with omission of pretest scores.*

<u>Measure</u>	<u><i>p</i></u>
BAQ	
Control group	.049*

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### D. Go/No-Go Figures

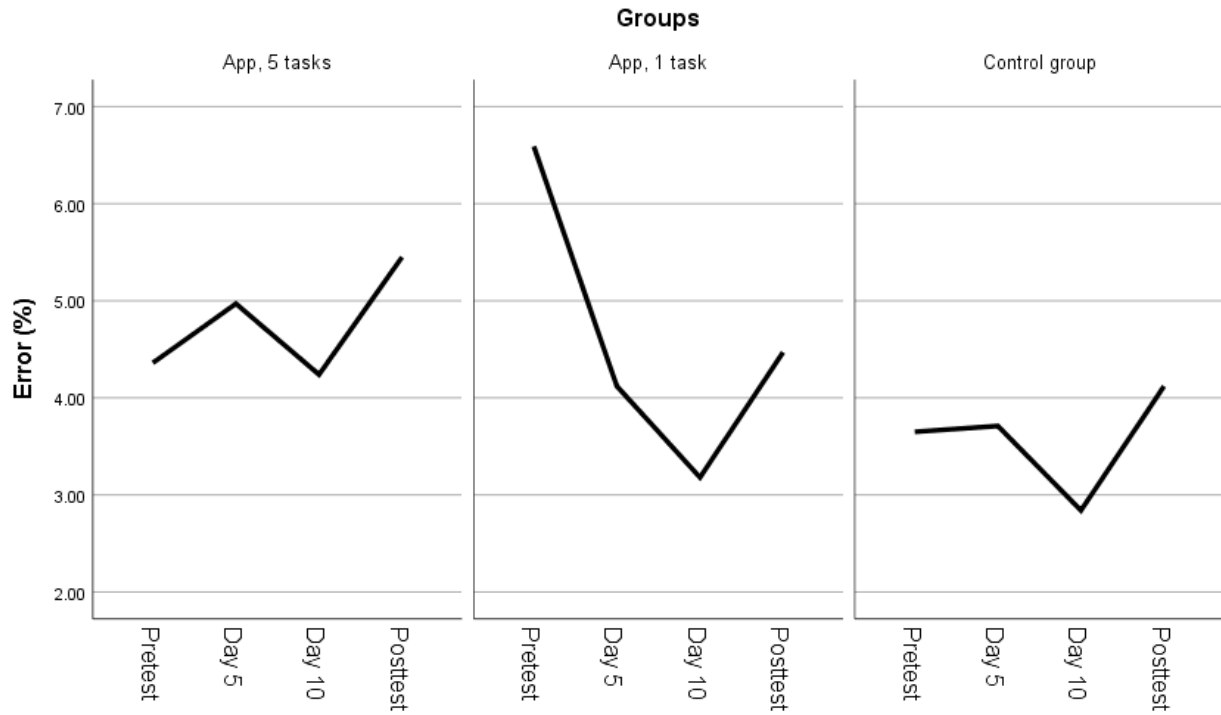


Figure D1. Error percentage comparison across all 3 groups between time-points.

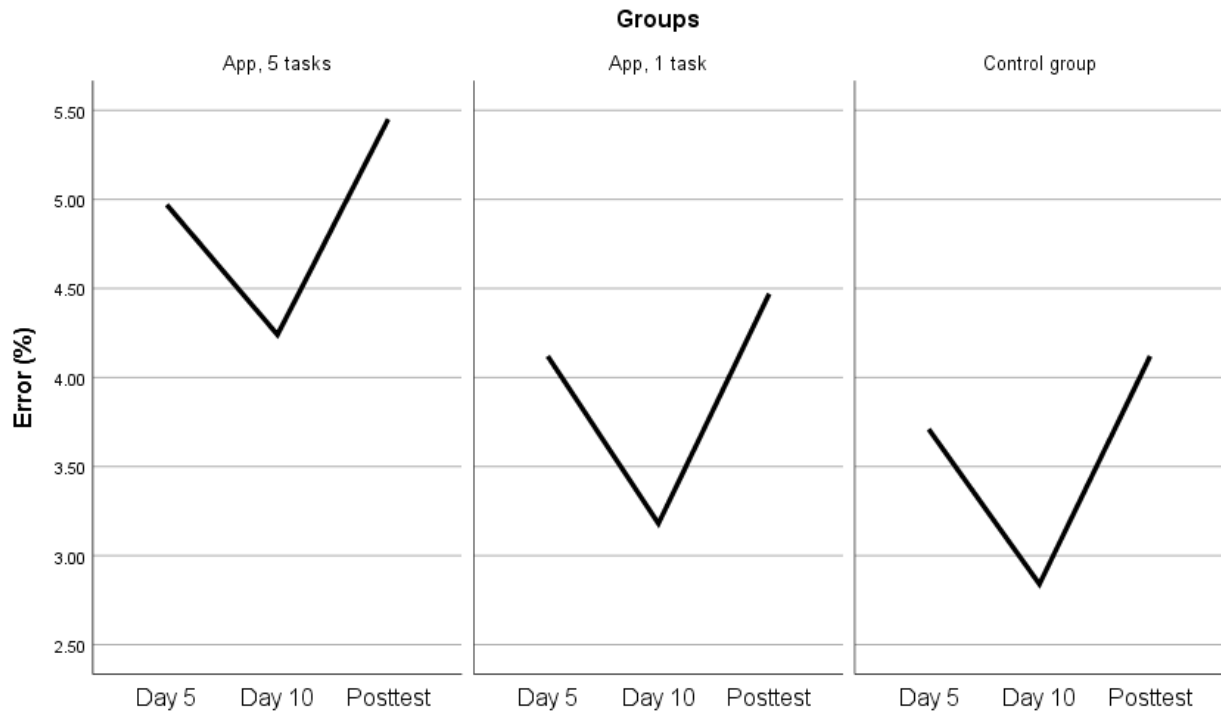


Figure D2. Error percentage comparison across all 3 groups between time-points excluding T1.

## E. Qualitative results

Table E1

*Qualitative results regarding the effectivity of the intervention on their self-control (n = 68)*

Code	Definition	M <sup>a</sup>	R <sup>b</sup>	Example quote
Ineffective(N = 37)	Certain that the intervention did not have an effect on their self-control	1.08	29	“I don’t think that the intervention has helped me to improve my self-control in general, at least I did not notice it yet.”
Effective (N= 22)	Certain that the intervention had an effect on their self-control	4.86	23	“I think it did help, because I had to control and constantly remind myself of using my non-dominant hand. I also partially adapted this self-control to other parts in my life.”
Maybe (N = 7)	Uncertain whether the intervention had an effect on their self-control	3.29	10	“For the certain things i had to do with my left hand i hand to think more before doing them, so maybe? But i did not feel like it effected how i did other things”
Unknown (N = 1)	Not related to the question	-	-	

Blank (N = 1)      Empty                      -                      -  
answer

---

<sup>a</sup> Mean BSCS score increase over all participants between pretest to posttest

<sup>b</sup> Range of BSCS score differences from minimum to maximum between pretest and posttest



Table E2

*Qualitative results regarding the opinions of the participants on the intervention (n = 68)<sup>a</sup>*

Code	Definition	Example quote
Bugs (N = 31)	The participant experienced bugs while using the application which had an adverse effect on their experience	“The bugs kept me from answering the question honestly, because I could not choose many options”
Easy to understand/right amount of information (N = 26)	The application was easy to understand and/or contained the right amount of information to make use of it for this intervention	“The app was easy to use and quite self-explanatory.”
Appealing design (N = 13)	The design of the application was appealing	“I liked the simple design”
Positive (without explanation) (N = 11)	The participant’s opinion was succinct and positive about the application without anything specific	“I like the App. Creative and innovative”
Reminders (N = 10)	Positive opinion about the reminders sent by the application regarding the task	“I like the app, because she sends push-up messages, so you can't forget to fill out the survey”
Not enough reminders (N = 9)	Negative opinion about the reminders sent by the application regarding the task	“but it would be nice if you get reminding notifications during the day. It was difficult to forget about the intervention.”
Worked as it should/no bugs (N = 9)	The application worked as intended without the occurrence of bugs	“No bugs. Everything worked well.”

Elements/tasks were unclear (N = 5)	Elements of the application or the manner in which the tasks were supposed to carry out were unclear to the participant	“In the beginning I didn’t realize that we have to sign up for every day so I was kind of confused why there are always two „pictures“ of the day.”
Not able to easily look up tasks (N = 4)	The participants were not able to look up their tasks in a satisfactory manner	“but it would be useful to have a look on the challenges without making a screenshot.”
Fun to use (N = 4)	The app was fun and enjoyable to use for the participant	“The app was really nice in general. It was fun working with it.“
Did not work well for iPhones (N = 3)	The application was not working as intended on iPhones	“The App itself has a good overview but continuing after clicking an answer sometimes is buggy on my iOS version.”
Design can be improved (N = 2)	The design of the application could be improved in terms of functionality or aesthetic	“The only thing that I can think of that can be improved is the accept the challenge Button below the Tasks, because you have to scroll down in order to see it I regularly forgott to press the button.”
Five tasks at once was too much (N = 1)	The participants found the amount of tasks which they were assigned to, too much.	“I would also prefer only getting one challenge a day, getting five at once made it harder to remember them”
Personalization (N = 1)	The participant liked the personalization of the application	“Besides I really liked that the app was personalised and addressed one directly and I liked the witch.”

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<sup>a</sup>Participants were allowed to voice their opinion on multiple matters, resulting in a higher projected *n* than total *n*.

Table E3

*Qualitative results regarding the changes the participants would apply to the intervention (n = 68) <sup>a</sup>*

Code	Definition	Example quote
Nothing/don't know (N = 19)	The participants did not want to change anything or had nothing to add	"I would not change anything"
Add reminders (N = 14)	The participants wanted additional reminders added	"App sends reminders to use the non-dominant hand"
Dislike/change task(s) (N = 13)	Certain tasks were disliked and/or were requested changed for future use of the application	"I liked the intervention, but maybe there could've been a bigger variety of tasks."
Changes to questionnaires / go/no-go task/study design (N = 10)	The participants wanted to see changes or additions to the provided questionnaires, the go/no-go task and study design such as new questions, tasks or design	"Maybe questions about frustration."
Fix the bugs in the app (N = 7)	The participants wanted the bugs they encountered to be fixed	"I would just try to make the app work better."
Only one task per day instead of five at once (N = 3)	The participants found five tasks at once too much and wanted to receive one task per day instead	"Only one challenge a day"
Too easy to 'cheat'/add validation (N = 2)	The participants had concerns regarding 'cheating' such as not	"Maybe that you kind of havr to prove that you did some things, not everything, but e.g. the writing with

	carrying out the task and/or validation on how to prove whether the participant did or did not carry out the task along with suggestions on how to tackle these problems	your left hand so you know you have to do it to show it to someone and not lie to yourself and others about having done the task.”
More than one task per day (or more than one day per task) (N = 2)	The participants wanted to receive more than one task per day or carry out a single task more than once in a day.	“I think it would be best to do multiple tasks over multiple days to get used to them and for example using credit cards could be then happening more often than once.”
More explanation of the goal of the intervention (N = 2)	The participants wanted more explanation regarding the intervention and what we wanted to achieve such as an explanation as to why they were supposed to use their non-dominant hand.	“I would improve the instructions because first it was very unclear to me why I have to use my non-dominant hand in relationship to my self-control (now I see the connection)”
Make each task visible in the app during usage (N = 1)	The participant wanted the received tasks to be visible at all times	“Make the tasks for the day viewable”

<sup>a</sup>Participants were allowed to voice their opinion on multiple matters, resulting in a higher projected *n* than actual *n*.