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Improving Subjective Well-Being Through a Personalized Digital Best Possible Self Intervention

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Abstract

Increasing Subjective Well-Being (SWB) has beneficial outcomes in many ways, e.g. being more healthy and working more productively. The Best Possible Self (BPS) intervention can increase SWB; however, to maximize it's effect it should match individual's needs and preferences. The effect of personality-adapted persuasive strategies on SWB was examined in a digital BPS environment in a longitudinal study. Of 57 participants that started, 46 participants completed 3 trials, conducted weekly, where they had to fill out SWB questionnaires and carry out a BPS activity. No significant differences were found between groups. Over all participants, SWB increased significantly during a trial, but not over trials. For examining sustaining effect, a supplementary analysis of SWB at a three-week follow-up was conducted. No significant difference between groups was found. In a supplementary analysis, however, significant differences in motivation were found between groups. This study therefore suggests other researchers should investigate persuasive strategies based on personality further, and look into these strategies to be used as digital coaches that keep motivation high for improving SWB.

Contents

1 Introduction

Subjective Well-Being (SWB), defined as people's overall evaluations of their lives and their emotional experiences [Busseri and Sadava, 2011, Diener et al., 2017, Dolan et al., 2008, Nonnenmacher and Friedrichs, 2013], has gained more and more interest since the first review of SWB in 1984 [Diener, 1984], with in 2015 alone 14,000 publications that mentioned SWB [Diener et al., 2017]. SWB is sometimes used interchangeably with the term 'happiness', however, this is a loose term with ambiguous meaning and is therefore avoided here and in most scientific literature [Diener et al., 2017]. SWB is studied in many disciplines, like psychology, philosophy, public policy, sociology, and economics [Das et al., 2020, Diener et al., 2017]. In this study, the emphasis will be on individual SWB (in contrast to mean SWB of an entire population, like in public policy).

SWB is an umbrella term that refers to a cognitive (or evaluative) and an affective (or emotional) dimension [Das et al., 2020], where the cognitive dimension is depicted by Life Satisfaction (LS) and the affective dimension is depicted by Positive Affect (PA) and Negative Affect (NA) [Azizan and Mahmud, 2018, Busseri and Sadava, 2011, Solanes et al., 2021]. Higher SWB is indicated by higher LS and PA, and lower NA [Heintzelman and Tay, 2018]. The three dimensions are separable when factor-analyzed and have separable determinants and correlates, for instance, PA seems to be influenced by social relationships, NA by internal conflicts, and LS by health and income [Busseri and Sadava, 2011, Diener et al., 2017, Solanes et al., 2021]. SWB focuses on the subjective feeling and thinking states of well-being [Dolan et al., 2008], known as the hedonic view of well-being, in contrast to the eudaimonic view where well-being is seen as an external assessment of whether an individual possesses desirable qualities [Das et al., 2020].

Having higher SWB has many beneficial outcomes, such as being more healthy, living longer, having more supportive social relationships, and working more productively [Busseri and Sadava, 2011, Diener et al., 2017, Solanes et al., 2021]. Therefore, it is considered as both an important personal and societal goal to increase SWB [Busseri and Sadava, 2011]. It was claimed for some time that SWB was almost entirely dependent on genes and that it could not be changed by situations or circumstances in the long term, due to people's adaptation to them. However, now, it is believed that on average the heritability of SWB is 40%, leaving 60% dependent on the environment, and it is proven that interventions can increase SWB [Diener et al., 2017].

For interventions to have sustaining effect, authors emphasize attention should be given to the person-activity fit: to which extent the type and format of the intervention match an individual's needs and preferences [Diener et al., 2017, Layous et al., 2013, Loveday et al., 2018, McCrae, 2011]. The activity must be fitted to achieve a way of sustaining interest and to remain fresh, meaningful and positive for a person [McCrae, 2011]. [Manthey et al., 2016] states that providing personalized

instructions and feedback in a digital environment might increase the effectiveness of interventions.

Although researchers study the effectiveness of digital interventions for increasing SWB with promising results [Heintzelman et al., 2020, Manthey et al., 2016, Renner et al., 2014, Seear and Vella-Brodrick, 2013], there is still a lack of empirical studies that try to understand interventions via technology and the characteristics of individuals that might influence the effectiveness [Koydemir et al., 2021]. Furthermore, although personalization is thought to be an important aspect in the Human Computer Interaction community, for instance in persuasive technologies [Alqahtani et al., 2022, Orji et al., 2017], to the author's knowledge, no studies have been conducted on the effect of personalizing a digital SWB intervention and thereby enhancing the person-activity fit. To this end, this study examined if a personalized digital intervention improves SWB more than a general digital intervention. To investigate this, a digital intervention method based on the literature on SWB was developed, which was then adapted according to personality.

The next section describes the intervention that was used in this study, the personality adaptations that were implemented, and some related work on SWB. Then, the method and results will be described. Last, the discussion explains study limitations and directions for future research.

2 Related Work

Thousands of publications on SWB appear yearly [Diener et al., 2017]. To get an overview of all the available information, for this study, a systematic review was conducted of SWB reviews (instead of primary studies), which can be found in Appendix F. After this review, more information was gained on the intervention method via snowballing, and some literature was found on personality adaptation. All relevant related work was combined in this section.

In the following subsections and the remainder of this study, SWB is assumed to be the umbrella term for the separable components LS, PA, and NA [Azizan and Mahmud, 2018, Das et al., 2020, Diener et al., 2017, Solanes et al., 2021], however, there is much debate on the definition and components of SWB [Charlemagne-Badal et al., 2015, Schimmack, 2006]. A review was conducted by [Busseri and Sadava, 2011] on the structure of SWB, which is explained in the systematic review in Appendix F and in the box below.

Different Models of SWB

In their review on the structure of SWB, [Busseri and Sadava, 2011] describe five models that are used throughout the literature. They explain the implications of using each model regarding measurement, analysis and interpretation, and integration and synthesis in studies on SWB. Four of the five models are depicted in Figure 1. In the fifth model, SWB is seen as an integrated system of distinct configurations of LS, PA, and NA, where the structure of SWB may vary between individuals, and even within individuals over time.

Subfigure (a) illustrates the model where SWB is the term for a research domain, where the three components should be treated separately, and hence could be studied separately. In the model of Subfigure (b), SWB is seen as an underlying latent factor that is the cause of changes in its indicators LS, PA, and inverse NA, whereas in Subfigure (c), SWB is a latent composite variable that is produced by combination of the causal indicators LS, PA, and inverse NA (note the difference with (b), where SWB is not caused by its indicators, but the other way around). Using model (b) and (c), all components should be taken into account and can not be studied separately. In the model of Subfigure (d), SWB is the term for a causal system where LS is the outcome of relative contributions of PA and NA. Using this model, apart from studying all components, LS could be studied separately as the main variable of interest for SWB.

[Busseri and Sadava, 2011] stresses that researchers should not adopt one of the models and an analytic approach without any justification of the implications of these choices. For this study, model (a) is chosen since it is the structure that is most common among other researchers, and consequently, this study can be integrated with the existing literature. Researchers are encouraged to study the differences between the models in the future, for example, by analyzing the data of this study using each model and comparing the results regarding SWB.
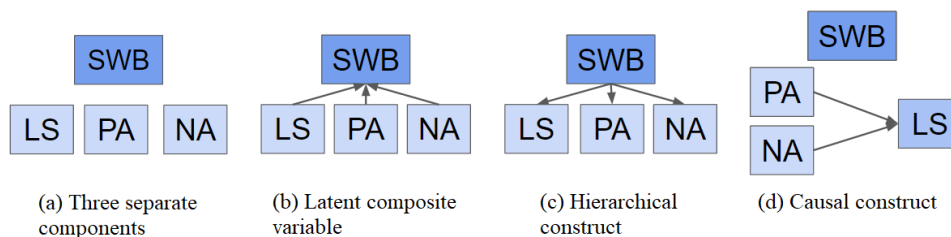

(a) Three separate components

(b) Latent composite variable

(c) Hierarchical construct

(d) Causal construct

Figure 1: Models of different structures of SWB used by researchers.

2.1 SWB Interventions

Not only treating and preventing low SWB is important (including treating mental disorders and targeting risk factors), but also promoting higher SWB in healthy individuals, to strengthen their ability to develop, adapt, and build resilience and competence [Solanes et al., 2021]. Positive Psychology is a research area that is focused on exactly that: promoting positive traits, virtues, and subjective experiences such as SWB. Positive Psychology Interventions (PPI) to promote SWB specifically, are for instance conducting acts of kindness, practicing gratitude, savoring the moment, or thinking about positive experiences. [Solanes et al., 2021] assessed in their review the effectiveness of different PPI and other interventions (like yoga or leisure) on SWB and the quality of the evidence. Their main finding was that PPI might increase PA and decrease NA, but that the evidence supporting this claim was of low to moderate quality. This might partly be due to the different PPI investigated, however, the evidence per type of PPI was also inconsistent. For instance, different studies examining 'conducting acts of kindness' resulted in either low, moderate, or high increases of PA, and 'writing things for which one could feel grateful' resulted in either no increases, low, or moderate increases of PA. This heterogeneity might be affected by the duration of the PPI.

The only intervention described by [Solanes et al., 2021] that showed high or moderate increases in SWB in multiple studies [Layous et al., 2013, Peters et al., 2010, Sheldon and Lyubomirsky, 2006], and no studies reporting low or no increase, was writing about oneself in the future imagining that everything has gone as well as it possibly could, also referred to as Best Possible Self (BPS). It is thought that thinking and writing about your BPS energizes behaviors to achieve the goals of your BPS. Furthermore, having a higher perceived likelihood to achieving a BPS is associated with lower levels of risk-behavior and higher levels of health-promoting behavior [Corte et al., 2022]. In a review specifically conducted on PPI and SWB [Koydemir et al., 2021], some other studies are mentioned in which a significant increase of PA [Manthey et al., 2016, Odou and Vella-Brodrick, 2013, Renner et al., 2014] and LS [Boehm et al., 2011, Peters et al., 2013], and decrease in NA ([Liau et al., 2016, Odou and Vella-Brodrick, 2013, Seear and Vella-Brodrick, 2013]) was found with BPS. Because of these consisting results, and because participants in BPS experiments report high motivation for completing and even continuing their BPS activity [Loveday et al., 2018], BPS was chosen as the intervention used in this study.

The literature suggests that although a smaller effect of BPS on SWB is often found through the use of technology instead of in-person intervention, there still is a significant effect [Manthey et al., 2016, Renner et al., 2014, Seear and Vella-Brodrick, 2013], and some authors do not find a significant difference between digital and in-person intervention of BPS at all [Layous et al., 2013]. Hence, it was assumed for this study that a digital BPS intervention affects SWB positively.

[Diener et al., 2017] states that an intervention is more beneficial if more effort

is put in it and the duration is longer, so a longitudinal design was used for this study. [Loveday et al., 2018] describes that although there is some evidence that conducting BPS weekly is more beneficial than daily, this is not fully researched yet. In this study, participants conducted the BPS weekly and not daily since this is less intrusive for participants. Furthermore, [Carrillo et al., 2019] states that the longer the written text of a BPS, the higher the effect is. However, the participants could feel discomfort when they can not accomplish the number of words that is asked for. Hence, the BPS was asked out in an open-ended question and it was encouraged to write more words, and the number of words that was set as the goal was personalized. Before the start of the experiment participants were asked to write for some minutes about a general topic, and that number of words was used as a baseline of how many words that particular participant should be able to write in a certain amount of time.

An important aspect of BPS is if it is domain specific ("imagine your life regarding doing sports in the future" compared to "imagine your life in the future"). [Corte et al., 2022] stresses that the presence of domain specific BPS is associated with health-promoting behavior. Another reason to use domain specific BPS is that variety in an intervention is proven to be important and achieves longer lasting improvements, because the effect will not be downscaled by adaptation to the activity [Diener et al., 2017]. Varying the intervention can be accomplished by picking another domain each time the BPS is carried out. Thus, domain specific BPS was used in this study.

[Loveday et al., 2018] indicates different (numbers of) domain choices that are used by different authors, varying from three till eight domains. For choosing which domains to use, the following was considered: the literature suggests that researchers should take into account the person-activity fit when conducting BPS [Diener et al., 2017, Layous et al., 2013, Loveday et al., 2018]. Since a specific domain might be higher valued for one individual than another, participants might be more interested in the activity when they could choose in which domain they want to carry out the BPS. Furthermore, interventions have sustaining effect on SWB when individuals develop the habit to continue the intervention activities and [Diener et al., 2017] stresses that researchers should facilitate continued practice. Participants could be encouraged to continue carrying out the BPS in their own time with domains that are not used yet for the study. For these two reasons, using multiple domains could be beneficial.

For this study, the following eight domains were used that the participants could choose between and could continue to use after the original study was ended: romantic, hobbies, family, friendship, community, health, career, and free topic [Loveday et al., 2018]. To ensure that the dropout rate of participants was as low as possible, the study only contained three weeks/domains, after which the participants could choose if they continued with the other domains in a post-experiment phase.

The person-activity fit could be improved even more by personalizing the digital

environment, for instance by providing personalized instructions and feedback [Manthey et al., 2016]. This study examined if personality adaptation leads to a higher increase in SWB. The following subsection will describe some literature that was used for the adaptation.

2.2 Personality Adaptation

Personality is predominantly measured according to the Five-Factor Model (FFM) of personality [Digman, 1990], also called the Big Five, of which most researchers have a consensus that these five factors are necessary and more-or-less sufficient to account for the covariation of most personality traits [McCrae, 2020]. The Big Five consists of the five dimensions [Abdullahi et al., 2020, McCrae, 2020]:

- Neuroticism (N): individuals who i.e. are nervous, unstable, and distressful;

- Extraversion (E): individuals who i.e. are sociable, assertive, and energetic;

- Agreeableness (A): individuals who i.e. are sympathetic, cooperative, and friendly;

- Conscientiousness (C): individuals who i.e. have self-discipline and are organized and goal-oriented;

- Openness (O): individuals who i.e. are creative and intellectually curious.

According to [McCrae, 2011], the Big Five personality traits can guide tailoring, for instance: Extraverts can flourish in a social context, while Introverts prefer to act alone. [Orji et al., 2017] found that personalization in a system motivates people high in almost all the different personality traits; only for people high in N they found no significant association. Which persuasive strategies are preferred or unfavoured by people with different personalities seems to be domain dependent, for instance: different persuasive strategies are preferred by different personality types when comparing educational and mental health domains [Alqahtani et al., 2022, Ndulue et al., 2022]. Therefore, only studies that focus on mental health applications were taken into account here.

Table 1 describes some relevant strategies, including an example as could be used in this study, that are studied by [Alqahtani et al., 2022] and [Orji et al., 2017] to investigate their relations with the Big Five personality traits in the mental health domain (a non-relevant strategy is for instance adding a privacy policy, since this was added for all participants in this study via informed consent). [Alqahtani et al., 2022] uncovered persuasive strategies used in 103 mental health apps, used focus groups to get more insights on these strategies, implemented the strategies in an app and then conducted a study with 561 participants evaluating the persuasiveness per strategy. [Orji et al., 2017] studied persuasive strategies on storyboards of games for

Table 1: Description of persuasive strategies studied in [Alqahtani et al., 2022] and [Orji et al., 2017] to compare persuasiveness between different personalities.

Strategy	Description	Example
Competition	Allows users to compete with each other to perform the desired behavior [Orji et al., 2017].	Adding a sentence like "Other participants already wrote [number] of words in this exercise. You are currently in the [number] position. Write more words to rank higher!".
Cooperation	Requires users to cooperate (work together) to achieve a shared objective and rewards them for achieving their goals collectively [Orji et al., 2017].	Adding a sentence like "The mean number of words written by participants for this exercise is [number]. Try to motivate your fellow participants by writing some more!".
Simulation	Provides the means for a user to observe the cause-and-effect linkage of their behavior [Orji et al., 2017].	Showing the participant their increase in SWB after conducting the exercise.
Self-monitoring and feedback	Allows people to track their own behaviors, providing information on both past and current states [Orji et al., 2017] to improve the user's awareness [Alqahtani et al., 2022].	Adding information on how many words were written and how much time the participant spent doing the exercise in the previous weeks.
Social comparison	Provides a means for the user to view and compare their performance with the performance of other users [Orji et al., 2017].	Adding a sentence like "The mean number of words written by other participants is [number] and the mean number of minutes spent on the exercise is [number].".
Goal setting	Requires users to set a clear behavior goal and recommend certain actions (for achieving the desired goal to users during the system use) [Orji et al., 2017].	Letting the participant set the number of words they want to write and the number of minutes they want to work on the task, with a countdown feature.
Suggestion	Suggests improving the user's current low mood and other mental health-related situations based on evidence of what works [Alqahtani et al., 2022].	Adding a sentence like "Are you sure you want to finish the task? You could spend some more time on it." when a participant wants to save and close the exercise.

Table 1 Continued: Description of persuasive strategies studied in [Alqahtani et al., 2022] and [Orji et al., 2017] to compare persuasiveness between different personalities.

Reward	Offers virtual rewards to users for performing the target behavior [Orji et al., 2017] such as badges and points for encouraging and engaging users in their behavior change activities [Alqahtani et al., 2022].	Adding golden stars when the participant has written many words or is taking time for the exercise.
Punishment	Penalizes the user for not performing the desired behavior or reaching their goal (such as removing acquired rewards or other cherished possessions from the user) [Orji et al., 2017].	Sending an e-mail to the participants after they completed the exercise when they did not spend as much time as asked in the task description.
Verifiability	Providing information about mental health from trusted and credible external sources [Alqahtani et al., 2022].	Providing information about the effectiveness of the exercise for improving SWB with references.
Praise	Praising users for successfully completing a behavior-related task [Alqahtani et al., 2022].	Sending an e-mail to the participants after they completed the exercise with praise that they conducted the experiment and wrote many words.
Encouragement	Offering supportive messages and positive motivational quotes such as "Believe you can and you are halfway there", "Be Strong!", etc. [Alqahtani et al., 2022].	Adding a sentence like: "You can do this, you are halfway there!".

motivating change in risky healthy behavior like unhealthy alcohol use. The storyboards were evaluated by experts in persuasive technology and narrative in games. They validated the storyboards and there measurement instruments. 660 participants evaluated the storyboards.

Since the strategies are studied separately and not in combination with different strategies in both studies, hence the interaction effects are unknown, in this study one strategy was chosen for each participant, matching with the personality trait that was most present in that individual. Therefore, the five strategies that are most effective for the five personality traits, and are as distinctive as possible, were chosen. Table 2 shows the standardized path coefficients of the persuasiveness of the strategies for each Big Five personality trait.

The only association for N is with reward (.14), so reward was chosen as the strategy for participants that are most extreme in the N trait. O has almost only negative associations, which means that the strategy would be persuasive for people low in O. The highest association for people low in O is with verifiability (-.24). For C, verifiability is also high, but since this strategy is higher for low O, it was used for participants most extreme in the lowness of O. The next highest association for C is with goal setting, which has only one other association, so this was used for participants most extreme in the C trait. For A, reward has the highest association, but this strategy was used for N. The next association is praise (.23), but there is also a high association for E, and self-monitoring and feedback is also a good strategy according to both [Alqahtani et al., 2022] (.21) and [Orji et al., 2017] (.12). Hence, self-monitoring and feedback was chosen for participants most extreme in the A trait. Lastly, E has a high association with suggestion (.20), but there are multiple high associations for other traits as well. The next highest association is praise (.19), however, praise has a higher association with A than with E. Social comparison has an almost as high association (.18) and the association with other traits is lower, so this strategy was used for participants most extreme in the E trait.

Table 2: Standardized path coefficients of persuasiveness according to [Alqahtani et al., 2022] and *[Orji et al., 2017] (italic values)*.

	A	E	C	N	O
Competition	*.14*	*.15*			*-.14*
Cooperation	*.19*	*.12*			*-.12*
Simulation	*.14*	*.11*	*.15*		
Self-monitoring and feedback	*.12*, .21	*.14*, .14	.09		*-.09*, .13,
Social comparison	*.12*	*.18*			*-.13*
Goal setting		*.16*	*.16*		
Suggestion	.18	.20	.10		-.19
Reward	*.15*, .23	*.14*, .18		.14	*-.13*, -.10
Punishment	*.19*	*.15*			*-.09*
Verifiability		.10	.17		-.24
Praise	.23	.19			-.12
Encouragement	.18	.15	.09		-.19

Considering the related work described thus far, the following research question and hypothesis were formulated:

Research question: *Does individual SWB improve more when the environment of a digital BPS intervention is adapted to the user's personality?*

Hypothesis: *Compared to a neutral digital BPS intervention, SWB improves more when the digital environment is adapted to the user's personality.*

The following subsections describe how to handle the influencing factors of SWB and the effectiveness of BPS, and how to measure SWB in this study.

2.3   Influencing Factors

SWB has many influencing factors [Das et al., 2020], as well as the effectiveness of BPS [Loveday et al., 2018, Corte et al., 2022]. The experiment in this study contained multiple conditions and to compare those, it should be decided how to deal with the influencing factors. Important factors can be measured for each participant at the beginning of the experiment. Two possible scenarios are then 1) to control for important influencing factors in the analysis, or 2) to make balanced groups for the different conditions of the experiment (for instance: every experiential group has the same amount of old and young individuals).

There are many influencing factors, so controlling for all these variables in the statistical analysis (rather than using them to balance the conditional groups) would greatly reduce the likelihood of significant results. Furthermore, [Dibao-Dina et al., 2015] found that unbalanced rather than balanced randomized controlled trials (RCTs) are more often positive in favor of the new treatment, and concluded that this questions the use of unbalanced RCTs. Therefore, in this study, balanced (rather than unbalanced) RCTs were used. The groups were balanced as much as possible, considering the most influencing factor first, then the second, and so on. Hence, the influencing factors were ranked in order of how much they influence SWB and the effectiveness of BPS.

For SWB, personality traits seem to be the most important factor [Azizan and Mahmud, 2018, Diener et al., 2017, Solanes et al., 2021, Voukelatou et al., 2021], where three of the Big Five dimensions influence SWB the most: Extraversion, Neuroticism [Azizan and Mahmud, 2018, Solanes et al., 2021], and Conscientiousness [Das et al., 2020]. Another reason to balance personality traits first is that the intervention will be personalized according to these traits. Health (both physical and psychological) is consistently a very important factor strongly influencing SWB [Azizan and Mahmud, 2018, Das et al., 2020, Dolan et al., 2008], with psychological health being more important than physical health [Voukelatou et al., 2021]. Having a stable romantic relationship and intimate social relationships (for instance via family or community

membership) consistently influence SWB [Dolan et al., 2008]. Unemployment is consistently a negatively correlated factor [Azizan and Mahmud, 2018], although the extent to which it affects SWB could also depend on other factors such as the perception of the unemployment (if half of the country is unemployed, SWB is less affected) and the substitute activities (if the individual has other (non-job) social network activities, SWB is less affected) [Schimmack, 2006].

Income and income inequality seem to be important factors for SWB [Azizan and Mahmud, 2018, Dolan et al., 2008, Schimmack, 2006], although the results are very mixed, with some authors finding a positive correlation and others finding a negative correlation, or a positive one that flattens with increasing income [Schimmack, 2006]. [Dolan et al., 2008] states that it might be individual's own perception of their income (compared to a certain reference group) rather than absolute income (inequality). Religiousness seems to positively influence SWB [Azizan and Mahmud, 2018, Dolan et al., 2008], however, [Das et al., 2020] states that it may be premature to make claims on the consistency due to the limited number of studies. For both gender and education level, the results are mixed [Das et al., 2020, Dolan et al., 2008], ranging from positive to negative or no correlation in different studies. For age, there seems to be a U-shape where people have lowest SWB in the middle age range (between 32-50) [Das et al., 2020, Dolan et al., 2008, Voukelatou et al., 2021].

There are other variables that influence SWB, such as political environment and inflation [Dolan et al., 2008]. However, these are more important when addressing societal SWB instead of individual SWB (for instance SWB differences between nations). Hence, they are not taken into account here.

Some moderating variables of the BPS intervention are described in the literature as well. For individuals higher in Neuroticism, individuals low in emotional processing (EP), and individuals from an individualistic (compared to collectivist) culture, BPS may be more effective [Loveday et al., 2018]. Age and gender may also influence the effectiveness of BPS [Corte et al., 2022]. Since almost all participants of this study were Dutch, the culture was not taken into account in this study. The conditional groups should be balanced considering the influencing factors of the effectiveness of BPS and they were put highest in the ranking after personality.

In summary, the ranking was: personality traits Neuroticism, Extraversion, Conscientiousness, Openness, and Agreeableness, EP, age, gender, psychological health, physical health, romantic relationship, intimate social relationships, unemployment, perception of income (compared to individual's reference group), religiousness, and education level.

2.4   Measurement of SWB

[Scollon, 2018] proposes non-traditional methods to measure SWB, instead of the widely-used self-report measures. However, all the described measures are either (a) not fully developed yet (like smiling in photographs), or (b) not clear if it really

reflects SWB (like Implicit Association Test, where the measure is the reaction time for participants to associate certain terms with others, for example 'my life' and either 'good' or 'bad'), or (c) a very intrusive and irritating method (like Methodology Experience Sampling, where participants should answer questions about their affect and activities in real-time several times a day over several days). At the same time, [Schimmack, 2006] argues that self-report measures on SWB are reliable. Moreover, evidence suggests that mood has a negligible effect on people's judgments, although it is important to ask out SWB anonymously since people may adhere to certain social desirable responding otherwise [Schimmack, 2006]. Consequently, self-report measures were used in this study.

[Das et al., 2020] stresses that in order for SWB studies to be comparable, the same measures should be used. The Positive Affect And Negative Affect Scales (PANAS) [Watson et al., 1988] is the most frequently used measure for PA and NA [Voukelatou et al., 2021, Das et al., 2020]. The Satisfaction With Life Scale (SWLS) [Diener et al., 1985] is the best known measure for LS [Pavot, 2018, Das et al., 2020]. PANAS and SWLS were used in this study.

3 Method

3.1 Research Integrity

A research proposal consisting of the related work and method sections was approved by the Science-Geo Ethics Review Board at Utrecht University. In addition, a privacy impact assessment, an assessment of the yield of this research versus the effort of participants and the privacy impact, and an assessment of the data management plan were conducted by the Ethics Review Board. The approval and data management plan can be found in Appendix A.

3.2 Participants

This study used a between-group, longitudinal design with two conditional groups. Convenience sampling was used with mentally healthy adults. Individuals under 18 years old and individuals with mental health issues, like depression, were excluded.

To substantiate the number of participants that was needed for this study, an overview of the number of participants and design of studies on BPS with comparable dimensions and relevant significant results is given in Table 4, based on studies described in the review of [Loveday et al., 2018] on the effectiveness of the BPS intervention. With these results in mind, it was estimated that 25 participants per condition would be enough to find if there was an effect. However, since the personality adaptation of the BPS activity is a new research topic and there might be a smaller difference between conditions than between the compared conditions in the studies in Table 4, and to compensate for the average dropout rate, a number of 30 participants per condition was aimed for.

Table 3: Number of participants and design of studies on BPS with similar dimensions to this study. T0 represents the starting moment of the experiment.

	#part. T0	Dropout	Design
[Harrist et al., 2007]	75	?	2x2 factorial design, conduct BPS daily for 4 days
[Meevissen et al., 2011]	54	5,6%	2 conditions, conduct BPS once with encouragement to continue
[Peters et al., 2013]	90	8,9%	3 conditions, conduct BPS 1 week daily
[Sheldon and Lyubomirsky, 2006]	67	?	3 conditions, conduct BPS once with encouragement to continue

3.3 Materials

This section describes all the materials that were used. A digital environment was created for this study, which is extensively described first. Then, the different measures and software used are reported.

Appsmith (Digital Environment)

The digital environment for the BPS was created with Appsmith [Appsmith, Inc., 2022], which is a low-code, open-source applications tool. Web pages can be created via drag-and-drop of widgets. Via Javascript (JS), all elements can be changed and interaction can be created. After creating a web page, it can immediately be deployed, after which the URL can be distributed. The environment was hosted on a Utrecht University server. A MySQL database hosted by Utrecht University was coupled to the environment for saving important data regarding the BPS.

One page was created for the control condition and five pages (one per personality trait) for the treatment condition. Appendix B shows images of all pages. Pages were created in Dutch since most participants were Dutch. One page was also created in English for an English-speaking participant. All pages contained the BPS with the following instructions [King, 2001]: *"Think about your life in the future. Imagine that everything has gone as well as it possibly could. You have worked hard and succeeded at accomplishing all of your life goals. Think of this as the realization of all of your life dreams. Now, write for about 10-15 minutes about what you imagined in story form.".* The domain could be chosen via a drop-down menu with the 8 domains: romantic, hobbies, family, friendship, community, health, career, and free topic. The page included a button to submit the exercise and a button to save temporarily. When the page would close by accident, the latest saved version of the text would reload when opening the page again.

The page for the control condition only contained the BPS. For the treatment pages, the persuasive strategies were added next to the exercise. For an overview of the used strategies, see Table 1 and Section 2.2. The page for N contained the strategy 'reward', which was implemented by showing stars that the participant could earn when writing more words. The number of words for which stars were earned was personalized, since participants should not be discomforted when they can not accomplish the number of words that is asked for [Carrillo et al., 2019]. This value could be set by a URL variable.

The page for Low O used the strategy 'verifiability'. This was implemented by adding extra information, including references, about the BPS and the way it could influence SWB. There was a toggle button to show the information or not.

For C, the strategy 'goal setting' was implemented. When opening the page, first a Modal was shown where the participants could set the number of words they wanted to write and the number of minutes they wanted to spend on the exercise. The default values were again personalized and could be set by URL variables. If

Table 4: Database table 'bps' that was created for the Appsmith page with persuasive strategy 'set goal' for participants with C as most present trait. For the other 5 pages, the table included the same variables except for 'words' and 'minutes', which were only saved for the 'set goal' strategy, where participants had to set a number of words and a number of minutes they wanted to spend on the BPS. Information is provided on how the database values could be changed.

Variable	Type	Default	Changed by
ID	string	{{URL.queryParams.ID}}	N/A
domain	string	"romantic"	Dropdown menu changed
start	datetime	NOW()	N/A
lastsave	datetime	NOW()	Buttons 'save' or 'submit' clicked
totaltime	int	0	Buttons 'save' or 'submit' clicked
text	string	""	Buttons 'save' or 'submit' clicked
status	string	"inprogress"	Button 'submit' clicked
words	int	{{URL.queryParams.words}}	Button 'change goal' clicked and input 'words' changed
minutes	int	{{URL.queryParams.minutes}}	Button 'change goal' clicked and input 'minutes' changed

participants changed these values, they were saved so that in case of accidentally closing the page, the set goals could be reloaded. When the goals were set, the progress was shown by a red words - and time counter. When a goal was met, the counter and a checkmark turned green.

For A, the strategy 'self-monitoring' was implemented by adding a words - and time counter. Additionally, it was shown how many words were written and how many minutes were spent during the previous BPS trials of the participant. In the first trial, only a text was shown telling the participant that this information would be provided next time.

Last, for E, 'social comparison' was implemented by showing a words - and time counter, and the average number of words that were written and number of minutes that were spent on the exercise by all other participants. These values were set by URL variables, so they could change each trial.

For each page, a database table 'bps' was created with the variables shown in Table 4. JS was written to interact with the participant. For each page, apart from JS written directly in the widget properties, a main JS object with all the functions and a 'mem' JS object containing local storage for all variables were created. See Appendix E for the main JS code of strategy 'set goal'. In the main object, a function 'init' was run at page load. See for an example Figure 2 for a flowchart of all events in the 'set goal' strategy for personality trait C. At page load, all input fields and buttons were disabled. The 'init' function checked if the URL variables were valid integers and the ID existed. If not, a Modal was shown telling the participant that the URL was not valid. If they were valid, a new function 'check_existing' was called, where the database was searched for an already existing row for the ID with status 'inprogress'. If so, all variables were set according to this table row; if not, a new row was created with the default values of Table 4.
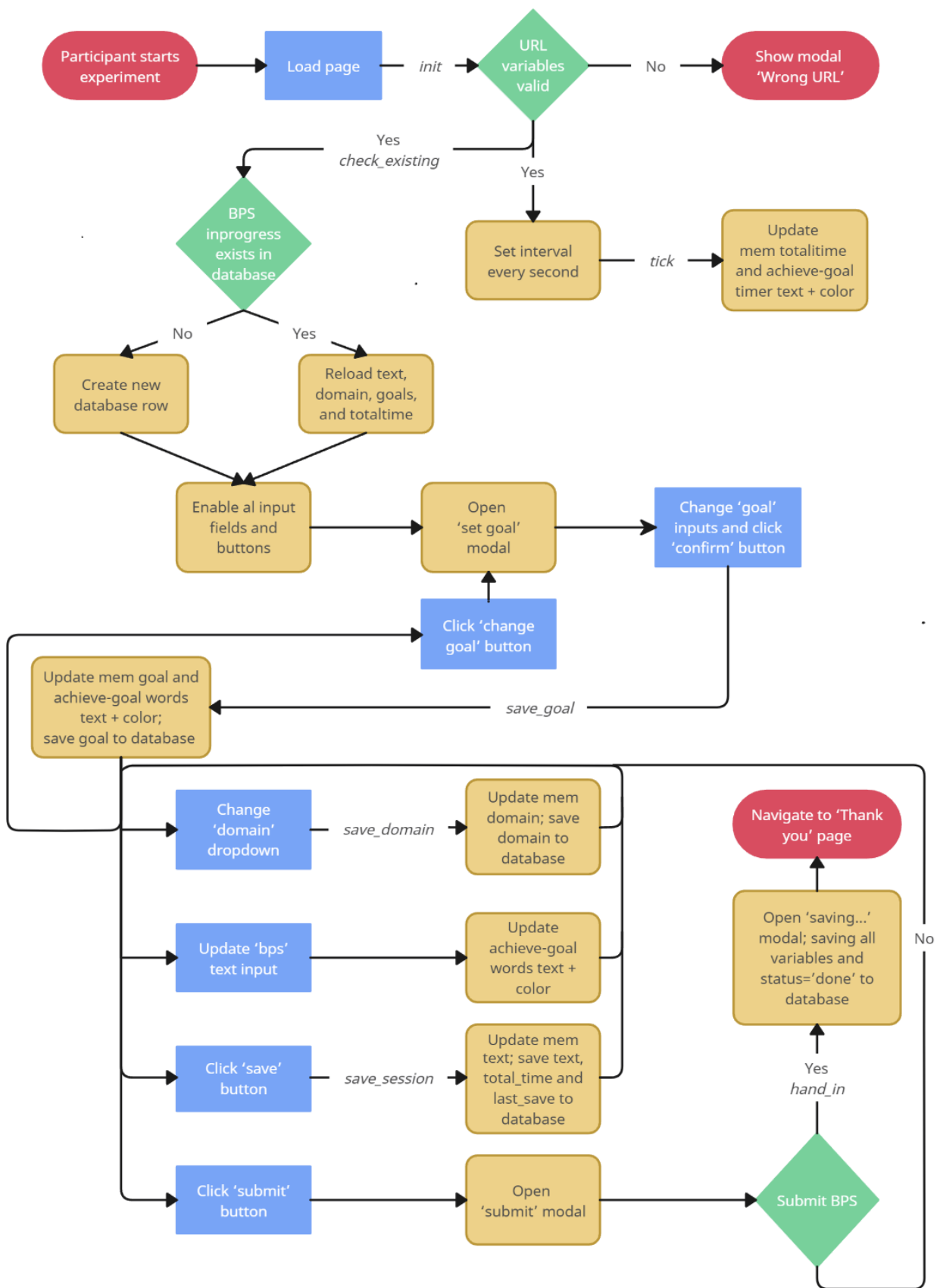
Figure 2: Flowchart of BPS with persuasive strategy 'set goal' for participants with C as most present trait (see Appendix B for screenshots and Appendix E for main JS code). Red ovals represent start and end points. Blue rectangles represent events triggered by the participant. Yellow rounded rectangles represent automatic events (triggered by the implemented code). Green diamonds represent decision points. Italic fonts represent function names in the JS code. In JS functions, JS queries were called when interacting with the database. If at any point the database connection was lost, a Modal appeared urging the participant to stop the exercise and contact the researcher. 'mem' represents the local database stored in a JS Object.

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The input fields and buttons were enabled. Furthermore, an interval function was set to update every second, which updated the 'totaltime' variable in local storage and changed the text and color of the time counter which showed the set goal (green if achieved, red if not). Participants then first had to set their goals for the number of words and minutes and could start writing afterwards.

Participants could trigger events with the page by changing the domain, writing text, and clicking 'save', 'submit', or 'change goal' button. After the event, either JS written in the widgets itself was triggered to change for instance the text and color of the words - and time counters to see if the goal was achieved, or a JS function in the main object was called to save new values to local storage and database. After clicking the 'submit' button, first a Modal was shown to ask if the participant really wanted to submit and finish the exercise. If so, a Modal was shown which told the participant to wait until saving was done. After submitting, all fields in the database were updated and the 'status' field was set to 'done', so that at page reload the participant could start a new trial (in contrast to reloading a page when the participant was still 'inprogress'). If at any point checking, creating, or updating table rows did not work because the database connection was lost, a Modal appeared urging the participant to stop the exercise and contact the researcher.

For all other pages and strategies, the flowchart and main JS code were similar to Figure 2 and Appendix E; only the 'set goal' interaction was different according to the implemented persuasive strategy.

SWB Measures

PA and NA were measured before and after conducting the BPS and at follow-up with the Positive and Negative Affect Schedule (PANAS [Watson et al., 1988]). For Dutch participants, the version of [Peeters et al., 1996] was used. The PANAS includes a scale for NA and a scale for PA, each consisting of ten emotion-related adjectives, for instance 'proud' (PA) or 'distressed' (NA). PANAS items are rated on a 5-point Likert scale representing degrees of experience of each adjective during a specified period. Considering that general PA and NA was of interest in this study, and not PA/NA at a specific time, the specified period was 'general'. PA and NA score were computed by summing the scores of the adjectives. Higher scores for each scale indicate higher levels of PA or NA.

LS was measured before and after conducting the BPS and at follow-up with the Satisfaction With Life Scale (SWLS [Diener et al., 1985]). For Dutch participants, the version of [Van Beuningen, 2012] was used. The scale consists of five questions that are rated on 7-point Likert scale. LS score was computed by summing the scores of the questions. A higher score indicates higher LS. See Appendix C for PANAS and SWLS.

Baseline Measures

The Big Five personality traits were measured with the Big Five Inventory (BFI [Benet-Martinez and John, 1998, John et al., 1991, John et al., 2008, Denissen et al., 2008]) consisting of 44 items. EP was measured with the Emotional Processing scale of the Emotional Approach Coping scales (EAC [Stanton et al., 2000]) consisting of 4 items, considering a current most stressful situation. Sociodemographic information was collected about participants' age, gender, psychological health, physical health, romantic relationship, intimate social relationships, unemployment, perception of income (compared to individual's reference group), religiousness, and education level. Last, a written text was collected where participants wrote for 3 minutes about what kind of activities they did in the current week. See Appendix C for all questions.

Other Measures

For each conducted BPS, the number of words written, the time spent on the exercise, and the written text were stored.

Software and Modules

SWB measures and baseline measures were asked out via the Utrecht University questionnaire environment of Qualtrics [Qualtrics, 2023] For analysing the data, SPSS version 28.0 [IBM Corp., 2021] was used.

For the balancing of the control and treatment groups (see Section 2.3), the Python module smallerize [Marius Mather, 2018] was used, which is a Python implementation of minimisation for clinical trials. Using this module, participants can be assigned to one of the two conditional groups based on the multiple influencing factors of SWB and BPS. Each factor can be given a weight of importance. Factors that are given a higher weight, will have a greater influence on the defined 'imbalance score' (based on the variance between the groups). For finding the optimum allocation of participants, the module minimizes the imbalance score while assigning participants.

3.4 Procedure

The study consisted of a pre-experiment, experiment, and post-experiment phase, which are described below per phase. Figure 3 shows the steps in the different phases.

Pre-experiment phase

The first green arrow in Figure 3 represents the participants filling out a baseline questionnaire that they received via e-mail. The e-mail included the Informed Consent (that they signed digitally), Information letter for participants, and Privacy
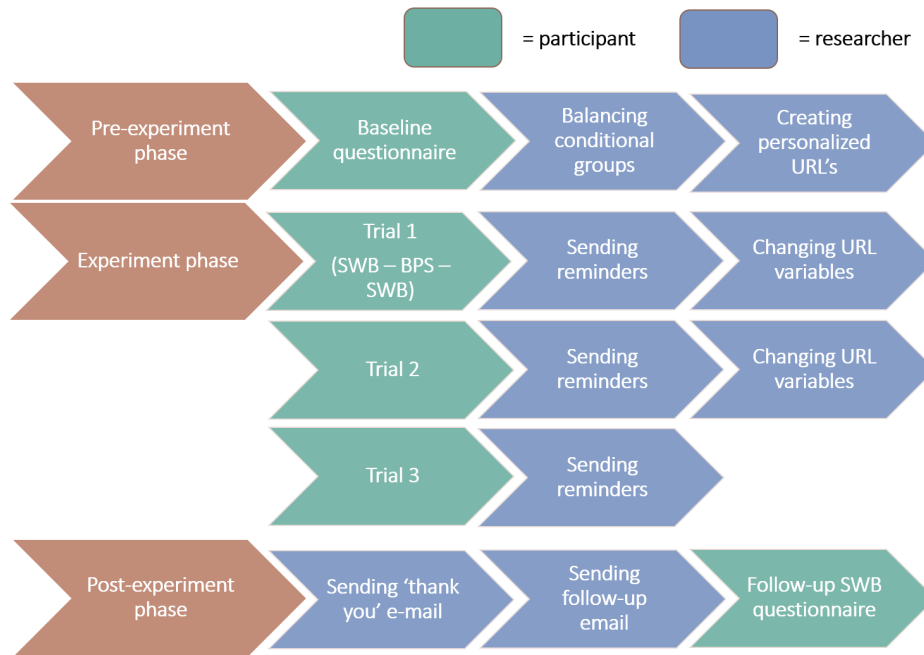
Figure 3: Procedure of this study. In the pre-experiment phase, all actions were done to be able to start the BPS trials. The experiment phase consisted of 3 trials and some tasks conducted by the researcher in between. During the post-experiment phase, participants could start new trials, which was encouraged in the 'thank you' e-mail. The follow-up was done at the end of the post-experiment phase.

Statement (see Appendix D) as attachments. Dutch versions of the Informed Consent and Information letter for participants were sent to all Dutch participants.

The first blue arrow in Figrue 3 represents the balancing of the conditional groups. The groups were created using smallerize (Subsection 3.3). The code can be found in Appendix E. All influencing factors had to be divided into bins since the algorithm only works with discrete cases. Personality traits were put into 4 bins (1-2, 2-3, 3-4, and 4-5). EP was put into a high and low bin (<2.5 and $>= 2.5$). Age was put into 3 bins of low, medium, and high age (<32, 32-50, >50), according to the U-shape described by [Das et al., 2020, Dolan et al., 2008, Voukelatou et al., 2021]. Gender was put into 2 bins, since no participants had a gender different from male or female. Psychological health, physical health, perception of income, and religiousness were put into 3 bins of low, medium, and high (1-2, 3-5, 6-7), as well as quality of romantic relationship, but this factor also included a bin for participants that did not have a romantic relationship. Number of intimate friendships was also divided in 3 bins of low, medium, and high (0-3, 3-5, 5-10), based on the fact that most people have 3 to 5 very intimate friendships [Dunbar, 1992, De Volkskrant, 2022]. Unemployment was put into 2 bins (unemployed or not). Last, education was put into 2 bins (high and medium), since there were no participants with other

education background.

Weights from 1 to 16 were assigned to all influencing factors of both SWB and BPS according to the ranking described in Subsection 2.3. Square roots were used in the weighing to prevent the algorithm from assigning participants only based on the highest weighing factors. Since smallerize assigns participants one by one in a given order, the algorithm was run 1000 times with shuffled orders, and the participant allocation with same-sized groups and the lowest imbalance score was chosen.

The last arrow of the pre-experiment phase represents creating the personalized URLs for the BPS for all participants. For the participants in the control group, the URL of the web page was the same, although the URL contained a variable with the participant ID. For the participants in the treatment group, the URL depended on their personality. Each of the treatment participants got assigned to the personality trait for which they had the highest score (or lowest for trait O). For the participants assigned to A and Low O, only the participant ID was added as a URL variable. For C, the URL variable for the number of minutes was set to a default goal of 10 minutes, and for E it was set to an arbitrary number between 10 and 15 minutes since there was no data yet but a number was needed for the 'social comparison' strategy. Last, for N, E, and C, the number of words was added as a URL variable. The value of this variable was calculated by multiplying the number of words written by the participants in the baseline questionnaire, where they had to write about their week for 3 minutes, with $3\frac{1}{3}$, since the participant should spend at least 10 minutes according to the exercise. For E, the average amount of words calculated this way was taken as the value for social comparison.

One problem occurred considering this calculation. Some participants did not write in full sentences, due to it not being clear from the baseline questionnaire that this was needed. Since the BPS should be written in story form, the number of words in those baseline texts was not representative of the exercise. Therefore, it was decided to use only baseline texts that were written in story form. For N and C participants that did not write the baseline text in story form, the average number of words over all participants with the same personality trait representation was taken as the value for the URL variable.

Experiment phase

The experiment phase consisted of 3 trials conducted weekly. Figure 3 shows the steps of each trial, which were almost identical. The green arrow represents the participant conducting the trial, and two blue arrows represent the tasks of the researcher.

Participants received an e-mail for each trial of the experiment. They were asked to conduct the following steps on a laptop or desktop as soon as possible since the BPS was supposed to be carried out weekly:

1. fill out the SWB questionnaire;

2. do the BPS exercise (the personalized URL was provided);

3. fill out the SWB questionnaire again.

For each trial, after 4 and 7 days, reminders were sent via e-mail to participants who did not finish that trial yet. When participants still did not finish after 4 more days, a message was sent asking them if they wanted to drop out of the experiment. If not, they could still participate.

Participants who finished a trial before sending any reminders received the next trial a week after the previous one. Participants that did need reminders received the next trial a week after the last reminder that was sent to them.

The blue arrow representing changing the URL variables (Figure 3) differed slightly in each trial. Before sending trial 2, the following variables were reset. For E, the average number of words and minutes for trial 2 was calculated from the participants that finished trial 1 at the moment of sending trial 2. Since the number of words for N and C was not personalized yet for participants that did not write the baseline text in story form, this variable was reset using the BPS of trial 1. For trial 3, the only URL variables updated were the words and minutes values for E, using the data from trial 2.

Post-experiment phase

The post-experiment phase started after finishing trial 3, with a 'thank you' e-mail to the participant (Figure 3). To facilitate continued practice for sustainable effect [Diener et al., 2017], in this e-mail participants were invited to continue doing the BPS, for example by finishing all 8 domains or writing more about a certain domain. Their personalized URL for the BPS was provided.

For a supplementary analysis on the continuation of the interventions and the sustainable effect of the interventions, a post-experiment follow-up was sent to the participants where they were asked to fill out the SWB questionnaire once again (the last two arrows of Figure 3). Timing of follow-up to assess the sustainability of interventions differs between previous studies, including follow-ups after 1 week to 6 months [Peters et al., 2013, Seear and Vella-Brodrick, 2013, Odou and Vella-Brodrick, 2013, Sheldon and Lyubomirsky, 2006, Boehm et al., 2011, Manthey et al., 2016, Lyubomirsky et al., 2011, Shapira and Mongrain, 2010], with significant effects found in multiple cases. For this study, in the research proposal for the Ethics Review Board follow-up was chosen to be at 6 weeks after the end of the experiment, considering that it should be as late as possible for testing the sustainable effect but having a time limit of when the research project should be finished. However, the experiment was subject to some delay since it was not taken into account that first, it would take some time to get the approval of the Ethics Review Board, and second, the experiment took 3 weeks more than expected due to participants needing multiple reminders before conducting the trials. Due to the time limit on this research project, follow-up was chosen to be already after 3 weeks instead of 6.

3.5 Analysis

First, the number of words written, the time spent on the exercise, and the written text were examined. Participants were excluded when they did not take the experiment seriously enough, specifically: they did not write more than 1 sentence or the written text contained no verbs and nouns clearly related to the BPS and the chosen domain. In the research proposal accepted by the Ethics Review Board, it was decided to exclude data where participants did not leave the website open for more than 3 minutes. However, inspecting the data revealed that with this criterion many participants would be excluded that clearly *did* take the experiment seriously since they wrote many substantive sentences. It was assumed that participants might have thought about the exercise and which domain they wanted to write about in between trials and consequently could write more quickly than expected. Therefore, it was decided to only exclude participants that did not leave the website open for more than 1 minute.

For the main analysis a Repeated Measure Multivariate ANOVA was used with LS, PA, and NA as the dependent variables with 2 levels: *trials*, consisting of 3 levels representing the 3 trials of the experiment, and *timing*, consisting of 2 levels representing the timing of before and after the BPS during the same trial. The between-subject factor was the group (control or treatment).

Some supplementary analyses were conducted. First, for examining the effect of personality, a Repeated Measure Multivariate ANOVA was used with the same levels and dependent variables as above, and both group (control or treatment) and most present personality trait as between-subject factors. Second, to look into the difference in participants' motivation to conduct the experiment between groups, a Repeated Measures Multivariate ANOVA was conducted with 3 indirect measures of motivation: number of words written, time spent on the exercise, and number of reminders sent to participants per trial. Last, to examine the sustainable effect of the interventions, a One-way Multivariate ANOVA was conducted, with as the dependent variables the difference between the last measuring point of the experiment phase and the values of the post-experiment questionnaire of LS, PA, and NA. The between-subject factor was the group (control or treatment).

Originally, it was planned to conduct a correlation analysis for each condition of the number of times the participants finished the BPS exercise in the post-experiment phase and the difference of NA, PA, and LS between the last measure point of the experiment phase and the follow-up measure point, and to compare the correlation coefficients of the two conditions. However, no participants continued the BPS exercise in the post-experiment phase, so this analysis was not executed.

4 Results

4.1 Participants

There were 57 participants that started the experiment. The dropout rate compared to the total number of starting participants was 5,3% after doing the baseline questionnaire (3 participants), 7,0% after trial 1 (4 participants), and 1,75% after

Table 5: Descriptive statistics of influencing factors of SWB and the effectiveness of BPS that were used for balancing the groups (see Section 2.3 and 3.3), in order of weighing (high to low). Mean and standard deviation are provided as M(SD). For variables with other values (except age, which is evident), footnotes are provided for explanation. Footnotes also explain measure scales. Factors were assumed independent and for all factors, an independent samples t-tests was conducted. The groups did not significantly differ for any factor (t(44), p <0.05), so the balancing of the groups worked. More information on how the groups were balanced can be found in Section 3.4. Column 2 shows if SWB and/or the effectiveness of BPS is influenced by the factor.

	Influences	Overall	Control	Treatment
Sample Size		46	22	24
N[a]	BPS, SWB	2.86(0.74)	2.69(0.84)	3.01(0.63)
E[a]	SWB	3.57(0.73)	3.68(0.62)	3.47(0.82)
C[a]	SWB	3.55(0.70)	3.43(0.79)	3.66(0.60)
O[a]	SWB	3.97(0.55)	3.93(0.49)	4.02(0.61)
A[a]	SWB	3.83(0.57)	3.82(0.61)	3.83(0.53)
EP[b]	BPS	2.92(0.55)	3.00(0.54)	2.84(0.56)
Age	BPS, SWB	40.61(18.96)	40.95(18.78)	40.29(19.53)
Gender[c]	BPS, SWB	24 F; 22 M	11 F; 11 M	13 F; 11 M
Psych Health[d]	SWB	5.63(0.88)	5.59(0.85)	5.67(0.92)
Phys Health[d]	SWB	5.37(0.93)	5.27(1.08)	5.46(0.78)
Romantic[d,e]	SWB	14 N/A;	7 N/A;	7 N/A;
		5.97(1.20)	6.13(1.06)	5.82(1.33)
Social[f]	SWB	7.15(2.67)	7.27(3.07)	7.04(2.31)
Unemployment[g]	SWB	5; 41 Other	3; 19 Other	2; 22 Other
Perc. of Income[d]	SWB	4.13(1.47)	4.23(1.31)	4.04(1.63)
Religiousness[d]	SWB	2.02(1.60)	1.91(1.48)	2.13(1.73)
Education[h]	SWB	36 WO; 10 HBO	17 WO; 5 HBO	19 WO; 5 HBO

[a]Measured on a 5-point Likert scale.
[b]Measured on a 4-point scale.
[c]Gender included options other than Female(F)/Male(M), though no participants chose those options.
[d]Measured on a 7-point Likert scale.
[e]'N/A' refers to having no romantic relationship; mean and standard deviation are calculated on participants that do have a romantic relationship.
[f]Measured on a scale from 0 to 10.
[g]'Other' refers to either studying, working, or doing voluntary work.
[h]'WO' was the highest form of education, 'HBO' was the second highest. There were no participants with lower education levels.

trial 2 (1 participant). Of the 8 dropped out participants, 1 could not get access to a laptop, 3 could not finish because of illness, and 4 did not respond. Of the 49 remaining participants, 1 participant was excluded from the analysis because of missing SWB data, and 2 because they did not take the BPS exercise seriously enough considering the rules explained in Subsection 3.5. Consequently, the analysis was done with data of 46 participants.

Table 5 describes the descriptive statistics of all influential factors that were taken into account in the balancing of the groups (see Section 2.3, 3.3, and 3.4), in the order of weighing (high to low). Responses for N, E, C, O, and A were on a 5-point Likert scale. Responses for EP were on a 4-point scale. Responses for Psychological Health, Physical Health, Satisfaction with Romantic Relationship, Perception of Income, and Religiousness were on a 7-point Likert scale. For Satisfaction with Romantic Relationship, N/A refers to having no romantic relationship; mean and standard deviation are calculated on participants that do have a romantic relationship. Gender included options other than Male/Female, though no participants chose those options. The Number of Intimate Social Relationships was on a scale of 0 to 10. For Unemployment, 'Other' means either studying, working, or doing voluntary work. For Education, WO was the highest form of education, HBO was the second highest. There were no participants with lower education levels.

Factors were assumed independent. For all factors, an independent samples t-tests was conducted. The groups did not significantly differ for any factor (t(44), p <0.05), so the balancing of the groups worked.

Table 6 shows for how many participants the specific personality traits were the most present. For the control group, nothing was done with this information. For the treatment group, participants were distributed amongst persuasive strategies based on this table. As can be seen, there were no participants where the most present personality trait was low O. Hence, the verifiability strategy was not used in the experiment.

Table 6: Number of participants where the personality trait was most present (highest value). In the treatment group, the persuasive strategy was chosen based on the most present trait.

	Overall	Control	Treatment
N	4	2	2
E	12	5	7
C	16	7	9
Low O	0	0	0
A	14	8	6

4.2 Main Analysis

Tested Assumptions

Assumptions for the use of Repeated Measures Multivariate ANOVA were checked. For the use of ANOVA, assumptions are normality, equality of variance, linearity, adequate sample size, and no univariate outliers [Field, A., 2018b]. For Multivariate ANOVA, absence of multicollinearity, multivariate normality, equality of covariance matrices, and no multivariate outliers are added [Field, A., 2018c, Field, A., 2018a, Hair Jr et al., 2019, Tabachnick, Barbara G and Fidell, Linda S, 2019b]. The assumptions are described below.

As a rule of thumb, there should be more participants in each group than the number of dependent variables that are analysed [Laerd Statistics, 2018]. In this study, there are 3 variables that are measured 6 times, so there is a total of 18 dependent variables. Sample sizes were 22 and 24 for the two groups, so this assumption is met.

There was only one univariate outlier found, namely one outlier for LS at trial 1 and timing before the BPS. There are four options to deal with this outlier. First, all data of the participant could be excluded. This is not desirable, due to the decrease in statistical power and the sample size already being quite small. Second, all data of this specific variable could be deleted. This would exclude many data points and timing could not be taken into account anymore in the first trial for LS, hence this option is not desirable either. Third, the variable could be deleted and interpolated using other data, however, this would misrepresent the data set. Therefore, and due to that it was only one value, it is chosen to keep the variable in the data set as it is.

For testing if there were any multivariate outliers, a Mahalanobis Distances variable was created and the p-value of the right-tail of the chi-square distribution was calculated. There were no values less than 0.001, so no multivariate outliers were present.

Multivariate normality can not be checked using SPSS. Instead, checking univariate normality of each dependent variable is a common solution [Field, A., 2018a]. Univariate normality of LS, PA, and NA for each trial and timing for both the control and treatment group was checked using Normal Q-Q plots. Each plot showed the points lying mostly along the straight diagonal line with some minor deviations. Based on these plots, it was assumed that these data were normally distributed.

Scatterplot matrices were used to check the assumption of a linear relationship between each pair of dependent variables for each group. A linear relationship would be represented with a diagonal line, which was seen in many plots. However, a random distribution of data points was shown for many PA/NA plots, with no obvious relation of any order. This means that there was no linear relationship found between PA and NA pairs, so the assumption was not met.

The assumption of no multicollinearity was not met either. There should be
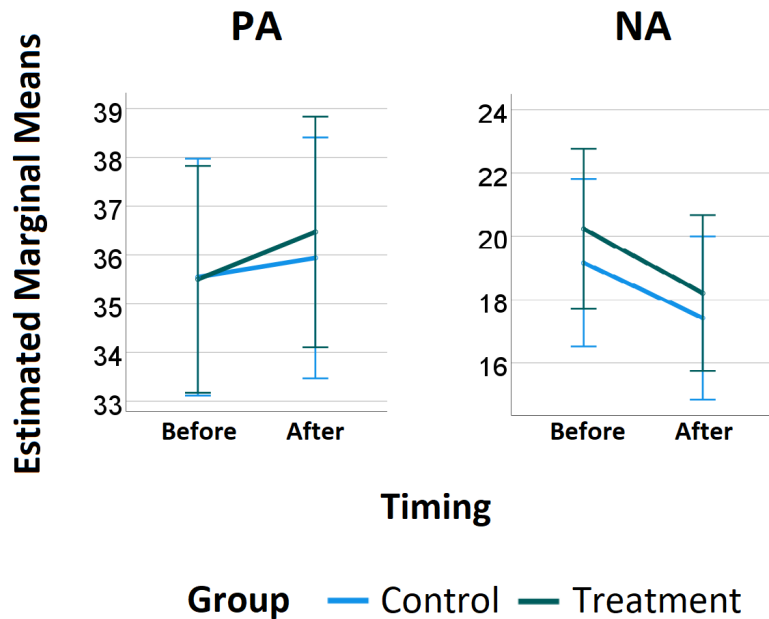
Figure 4: Plots of Estimated Marginal Means of PA and NA before and after conducting the BPS for both conditional groups, including 95% Confidence Interval Error bars. PA is increasing and NA is decreasing significantly over all participants. There is no significant difference in increase/decrease between groups.

a correlation between all variable couples over all the data, but not a too strong one, so for all combinations, Pearson's r value should be below 0.9. However, values above 0.9 were found for each LS variable with the LS variable in the same trial, and for one PA and one NA combination in the same trial.

Furthermore, the assumption of the equality of covariance matrices was checked with Box's test and not met (p = 0.003). Equality of variance was tested with Levene's test and was met for most variables, but was not met for two LS variables.

Results

SPSS presents 4 test statistics when conducting the Repeated Measures Multivariate ANOVA. When interpreting the outcome of the test, the following was taken into account: when groups differ along more than one variate, the test statistic Pillai's trace is most powerful. Furthermore, when sample sizes are equal, this statistic is the most robust to violations of assumptions [Field, A., 2018a]. Since multiple assumptions are violated, Pillai's trace was used to interpret the results.

As described by [Tabachnick, Barbara G and Fidell, Linda S, 2019a], there is a controversy surrounding significance testing and only reporting the p-value. Therefore, in all test reported below, apart from the p-value, the Partial Eta Squared (η_p^2) was provided as well.

Using Pillai's trace, only one significant result for the within subject multivariate
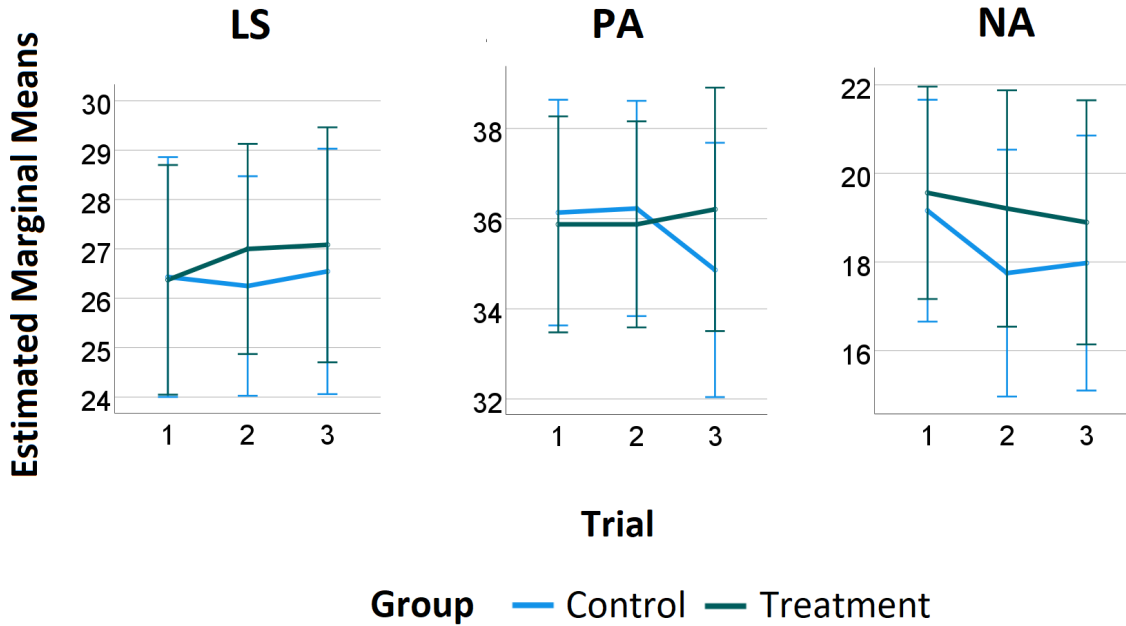
Figure 5: Plots of Estimated Marginal Means of LS, PA, and NA over trials for both conditional groups, including 95% Confidence Interval Error bars. The differences over trials and the differences between groups are not significant.

tests was found, namely a significant difference in timing (V = 0.507, F(3,42) = 14.392, p <0.001, $\eta_p^2 = 0.507$), in other words, there was a significant difference in the SWB over all participants before and after conducting the BPS in a trial. Bonferroni correction was used for the follow-up univariate tests. In the univariate tests, there was a significant difference in timing for PA (F(1,44) = 7.171, p = 0.010, $\eta_p^2 = 0.140$), and NA (F(1,44) = 38.649, p <0.001, $\eta_p^2 = 0.468$). Figure 4 shows that PA was increasing and NA was decreasing fot both groups. This means that SWB increased over all participants during a trial, but SWB did not significantly increase more or less for participants in the treatment group compared to the control group. No significant differences were found between trials, both for all participants and between groups. Figure 5 shows SWB over trials per group.

4.3 Supplementary Analyses

To examine the influence of personality on the results, a Repeated Measures Multivariate ANOVA was executed with not only group, but also most present personality trait as a between-subject factor. Using Pillai's trace, again a significant effect was found for timing in the multivariate tests (V = 0.509, F(3,36) = 12.421, p <0.001, $\eta_p^2 = 0.509$) and PA and NA in timing in the univariate tests (respectively F(1,38) = 10.348, p = 0.003, $\eta_p^2 = 0.214$ and F(1,38) = 27.540, p <0.001, $\eta_p^2 = 0.420$). Figure 6
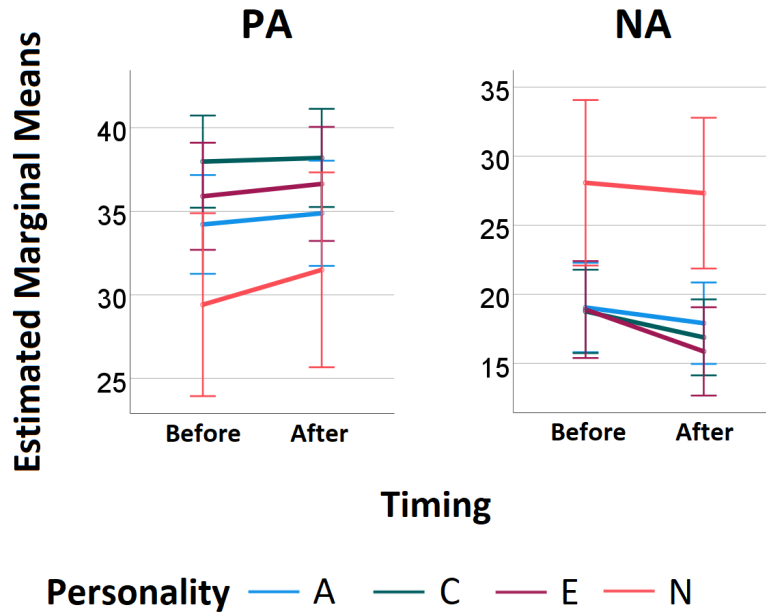
Figure 6: Plots of Estimated Marginal Means of PA and NA before and after conducting the BPS for participants with specific personality traits being most present, including 95% Confidence Interval Error bars. PA is increasing and NA is decreasing significantly over all participants. There is no significant difference in increase/decrease between personalities.

shows that for all personalities, PA increased and NA decreased. With this analysis, an almost significant effect for the multivariate tests was found for timing*group (V = 0.193, F(3,36) = 2.873, p = 0.050, η_p^2 = 0.193), although no significant effects were found for the univariate tests of timing*group. This analysis was only conducted to get some insights on the differences between personalities; the results should not be taken too seriously, since sample sizes are extremely small (for example, only 2 participants per group with most present trait being N).

To examine the difference between groups in motivation of participants to conduct the experiment, 3 indirect measures were tested: number of words written, time spent on the exercise, and number of reminders sent to participants per trial. A Repeated Measures Multivariate ANOVA was conducted with these as dependent variables and group as between-subject factor. Figure 7 shows plots for the 3 variables over trials for each group. Using Pillai's trace, a significant difference was found in the multivariate tests for both trial (V = 0.336, F(6,39) = 3.282, p = 0.010, η_p^2 = 0.336) and trial*group (V = 0.341, F(6,39) = 3,361, p = 0.009, η_p^2 = 0.341). Using Bonferroni corrections, for trial, all univariate tests were significant (words: F(2,88) = 6.035, p = 0.003, η_p^2 = 0.121, time: F(2,88) = 4.441, p = 0.015, η_p^2 = 0.092, reminders: F(2,88) = 4,731, p = 0.011, η_p^2 = 0.097), with a general trend for less motivation (fewer words and minutes, more reminders) over time when taking into account all participants. For trial*group, only time was significant (F(2,88) =
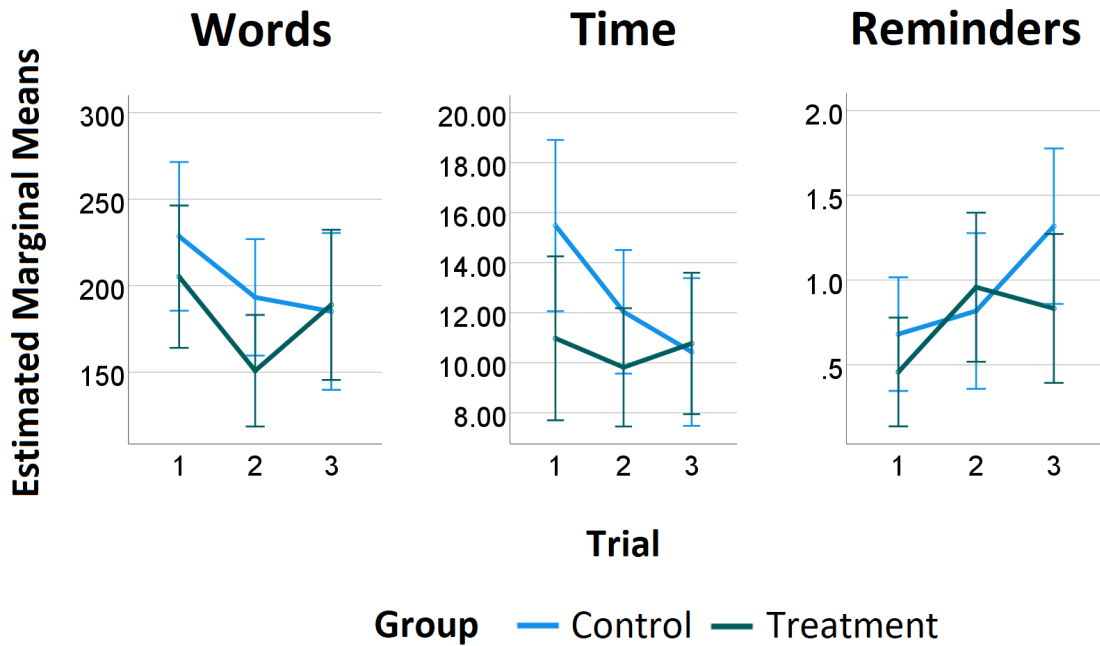
Figure 7: Plots of Estimated Marginal Means of number of words written, time spent on the exercise, and number of reminders sent to participants over trials in each group, including 95% Confidence Interval Error bars. Over all participants, all 3 variables differ significantly over trials. Between groups, time spent on the exercise over trials was significantly different.

3.177, p=0.047, $\eta_p^2 = 0.067$). As shown in Figure 7, the difference between groups is that time spent on the exercise decreases each trial for the control group, while it stays more or less the same for the treatment group.

To examine the sustainable effect of the intervention per group, differences between the last measuring point of the experiment phase and the values of the post-experiment questionnaire of LS, PA, and NA were calculated by subtracting the latter from the former. These values were used as the within-subject factors in a One-way Multivariate ANOVA with the group as the between-subject factor. There were no participants that continued doing the BPS exercise after the end of the experiment phase, so this confounding variable was not taken into account. Of the 46 participants that ended the experiment, 38 filled out the follow-up questionnaire (19 in each group). No significant differences between groups were found.

5 Discussion

The aim of this study was to determine if the effectiveness of the BPS intervention on increasing SWB in a digital environment would enhance with the addition of personalization, namely persuasive strategies based on personality traits. The results showed no significant differences between the groups that received personalized persuasive strategies and those that did not. Therefore, the hypothesis is rejected. The only significant difference was observed between pre- and post-BPS measures for PA and NA over all participants, but not between trials, although previous research showed that conducting the BPS should increase SWB over trials.

As a supplementary analysis, the difference in SWB between the last trial and a follow-up after 3 weeks was tested. This did not result in significant differences between groups either. This discussion will explore the limitations of the study and possible reasons for the lack of significant results between trials as well as between the groups and lay out potential implications for future research.

5.1 Limitations and Future Research

One limitation that might have influenced the reliability of the results is the spread of the experiment over time. The experiment was designed for each participant to conduct on a weekly basis. However, many participants needed multiple reminders before they carried out a trial. Consequently, there was a large variation in when the experiment was carried out, with some completing it in just 2 weeks while others took 6 weeks to finish. This could potentially affect the results of the experiment as the timing between trials could have an impact on the effectiveness of BPS. To ensure consistency in future experiments, it may be helpful to establish a more concrete timeline for participants to follow. For instance, participants could come to a laboratory on specific days, though such a research design might discourage participation due to a higher burden on time and less anonymity.

The lack of significant results may be affected by the implemented persuasive strategies. First, there was very limited related work on persuasive strategies based on personality traits in the mental health area, and more research is needed to determine which strategies work best with specific personality traits. Additionally, an interaction effect may occur when a particular personality trait does not appreciate a certain strategy while another trait does, but an individual has high scores in both traits. Such interactions have, to the author's knowledge, not been studied, and further research could help shed light on how to tailor persuasive strategies to different personality types considering all traits. Last, it is possible that the persuasive strategies used in the experiment were not implemented effectively, resulting in no significant impact. To ensure the success of future experiments, it may be helpful to reevaluate the strategies used and make necessary adjustments to increase effectiveness of the strategies.

Another phenomenon that could affect the significance is that the increase of

SWB might be limited by a 'ceiling effect', which refers to a point at which SWB is already so high that further attempts to increase it are no longer effective. Because of the ceiling effect, it could be that the personalization works, but that it would only be shown when SWB is low enough among participants to increase significantly.

Furthermore, the sample size might have influenced the significance. There were many dependent variables, and the sample sizes of each group were only a few participants more than the number of variables. Moreover, not all personality traits were represented in the sample. There were no participants with low O as the most present personality trait and only 4 with N as the most present trait. A supplementary analysis was conducted on how personality traits might have influenced the effectiveness of the BPS, which resulted in a significant difference between conditional groups, but this result can not be taken seriously because of the extremely small sample size per personality trait. Nonetheless, this analysis was conducted to inspire other researchers to look into this direction. Bigger sample sizes with all personality traits represented may result in other outcomes.

Participants' motivation to continue the experiment and during the experiment might influence the results, since time and effort, and a longer written text, influence the effectiveness of BPS [Diener et al., 2017, Carrillo et al., 2019]. A supplementary analysis was conducted, with indirect measures for motivation being words written and time spent on the BPS, and reminders sent for conducting the experiment. As shown in Figure 7, over all participants, motivation dropped significantly over trials. However, interesting differences are shown between groups. While the motivation for each variable only decreased over trials for the control condition, motivation decreased after trial 1 but increased again after trial 2 for the treatment condition, although the difference between groups over trials was only significant for time spent on the exercise. Future research should look further into motivation when using persuasive strategies based on personality while conducting the BPS. If motivation to continue doing the BPS and spent time and effort during the BPS indeed stays higher when using personality-based persuasive strategies, these strategies can work as a digital coach for people wanting to work on their SWB without the need of time and expenses for a human coach.

5.2   Conclusion

To conclude, research has shown that a high level of SWB is positively correlated with many beneficial outcomes, for instance in health, productiveness, social relationships, and more. Thus, improving SWB benefits individuals as well as society. This underscores the need for effective interventions to increase SWB. BPS is such an intervention. Research emphasizes that the person-activity fit is important for the effectiveness of interventions on increasing SWB, however, no previous research is conducted on using persuasive strategies based on personality to improve the fit and thereby the effectiveness. Therefore, this study aimed to investigate if persua-

sive strategies based on personality traits could enhance the effectiveness of a BPS intervention on increasing SWB in a digital environment.

The BPS exercise was conducted weekly for 3 weeks by 46 participants, divided into 2 balanced control and treatment groups. They filled out an SWB questionnaire before and after the BPS each trial. In the treatment group, a persuasive strategy was shown in the digital environment based on the most present personality trait of the participant. The results did not show significant differences between the groups that received personalized persuasive strategies and those that did not, nor between the trials. Several limitations of the study were explored that could have impacted the reliability of the results, including the spread of the experiment over time, limited related work on persuasive strategies based on personality traits, the ceiling effect of SWB, small sample sizes, and participants' motivation to continue the experiment and during the experiment. Future research should address these limitations. Furthermore, motivation might be an interesting topic for future research, since the results of the supplementary analysis of this study suggest that using personalized persuasive strategies might work as a digital coach to keep motivation high for conducting the intervention, and thereby increasing SWB.

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A   Research Integrity

Utrecht University

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Date	31 January 2023
Subject	ERB Review Bèta S-22886

Dear Dr. Van den Broek,

The Science-Geosciences Ethics Review Board (SG ERB) provides professional and independent reviews of research proposals involving human subjects, and advises on ethical and privacy issues. The SG-ERB reviews studies, which, according to the committee, do not fall under the scope of the Dutch Medical Research involving Human Subjects Act (WMO: Wet medisch wetenschappelijk onderzoek met mensen).

The research proposal entitled '*Studying Subjective Well-Being Through a Personalized Digital Best Possible Self Intervention*' has been approved by the SG ERB. The committee has no objections to the research activities as described in the submitted proposal.

The committee emphasises that any protocol changes should be submitted for approval by the SG ERB.

On behalf of the committee, I wish you success in carrying out your experiments.

Yours sincerely,

Dr. I.C. van Liempt

Interim Chair of the Science Chamber of the SG ERB

Improving Subjective Well-Being Through a Personalized Digital Best Possible Self Intervention

Data Collection

1.1 Will you re-use existing data ?

If yes: explain which existing data you will re-use and under which terms of use.

- No, I will be collecting/generating new data

1.2 Describe your data.
Fill the table below with a brief description of the data, including the type, format and volume.

#	Data Description	Data Type	Format	Total Volume
1	Questionnaire personal data	Tabular	.csv	0,1 MB
2	Questionnaires Subjective Well-Being	Tabular	.csv	0,5 MB
3	Text written, time spent and number of sentences written for an online task	Tabular	.csv	2,0 MB

Data Documentation

2.1 Describe the documentation and metadata that you will use to to make your data reproducible and interoperable. Describe which files you will provide, along with a brief description of the information they will contain, to make your data reproducible and interoperable. Describe the information that you will provide to make the data items in questions 2.1 reusable and interoperable. If using a specific metadata standard, please mention this below.

For each type of data, there will be an annotated .csv file and there will be a readme.txt file with further explanation on how to interpret the data. This file also contains explanation of the methodological procedures used to collect and analyze the data. The metadeta will include the conditional group per participant. Furthermore, images will be added of the online environment that will be created for the different conditions of the study. The readme.txt file will contain information on the tool used to create the environments and on how the interactive elements of this environment work.

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2.2 Describe the folder structure you will provide to make your data reproducible and interoperable.

Describe the folder structure, naming conventions and/or version control you will use for this project.

The folder structure will be broken down into the .csv files and the environment images. The images folder will be broken down into the different conditions of the experiment.
>Project Folder
   README.txt

  >>Csv Files
    personal_data.csv
    subjective_well-being.csv
    task_data.csv
    participant_group.csv

  >>Environment Images
   >>>Control condition
    (i.e. home_page_bps.png)
   >>>Personalized BPS condition
    (i.e. home_page_personalized_bps.png)

Data Storage

3.1. Select the storage solution where you will store and back-up your data.
Select the locations where your data will be stored. You may select more than one. Please describe the storage solution and the backup strategy of your storage solution if it does not appear in the list below.

- Other (please specify below)

IT Service Desk of UU hosts a website including database.

Data Privacy and Security

4.1 Will you be collecting or using personal data ?

Personal data is any data which, alone or in combination with other information, can identify a living person. Such data must abide by the GDPR and requires additional safeguards and documentation to be processed lawfully.

- Yes, I will collect and/or use personal data

Direct personal identifiers are limited to gender, age, and religion. However, participants will write about their experiences or fictional experiences. It could be that they write about particular information that may identify them. The aggregated data will be analysed and only metadeta and its statistics will be published. In case of other researchers wanting to use the data for further studying this topic, only features (like number of sentences) of the written texts will be shared and not the text itself.
In case of a participant that stops before the end of the study, all data of that participant will be deleted.

4.2 What is the legal basis by which you are collecting and/or processing this data ?
If you are uncertain as to which legal basis applies to your type of research, please do not hesitate to contact us at info.rdm@uu.nl or by using the "Request feedback" button and leaving a comment alongside this question.

- Informed consent

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4.3 Select the privacy and security measures you will employ to protect the privacy of your data subjects. Check all that apply.

- Encryption
- Aggregation/Abstraction
- Access control
- Minimization
- Pseudonymization
- Secure storage

4.4 Who is the controller of the personal data ?

The controller of the personal data is the entity which determines what is done with the data. In most cases the controller is Utrecht University.

Utrecht University is the controller of the collected personal data. Nevertheless, the principal investigator of the research project will ensure that the data is handled and processed in accordance with the GDPR.

4.5 How will ownership and intellectual property rights of the data be managed?

Describe who controls access to the data and who determines what is done to the data.

The principal investigator will determine who has access to the data within the research group. All intellectual property rights belong to Utrecht University.

During the project, the principal investigator, the daily supervisor and a master student will have access to the data.

If any member wishes to grant (temporary) access to others, they should seek approval from the principal investigator.

Data Selection, Preservation & Sharing

5.1 Describe the data you will be preserving and the storage solution where it will be preserved?

Describe which data will be preserved under long-term storage. You may refer back to the data described in question 1.2 to specify which data will be preserved. Explain where you will preserve your data, and how procedures are applied to ensure the survival of the data for the long term.

All collected data will be preserved.
The data will be kept for at least ten years. They will be stored via a database hosted by the IT Service Desk.

5.2 Describe the data you will be sharing and the repository where it will be shared?

Describe which data you will be sharing. Select where you will make your data findable and available to others. If selecting "Other" please specify below which repository and provide a URL.

Please also write below if you will apply any conditions to the re-use of your data. (i.e. Creative commons license or Data Transfer Agreement).

- Other

Not foreseen

5.3 Are specialized, uncommon or expensive software, tools or facilities required to use the data?

Please list any specialized, uncommon or expensive software, tools or facilities that are absolutely required to obtain, use or handle your data, if any.

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No, all the data can be accessed by free, open-source or non-proprietary software.

Data Management Costs and Resources

6.1 What are the foreseeable research data management costs and how do you expect to cover them ?
Please specify the known and expected costs involved in managing, storing and sharing your data. Also explain how you plan to cover these costs.

No costs

6.2 Who will be responsible for data management?
Please specify who is responsible for updating the DMP and ensuring it is being followed accordingly.

The master student Tinka Veldhuis will be responsible for maintaining the DMP up to date. The principal investigator Egon van den Broek will be responsible for granting permissions.

6.3 State if you contacted an RDM consultant from Utrecht University to help you fill out your DMP.

Please list their name and date of contact.
This is mandatory forNWO grants.

No

B Screenshots of the Different Versions of BPS Pages
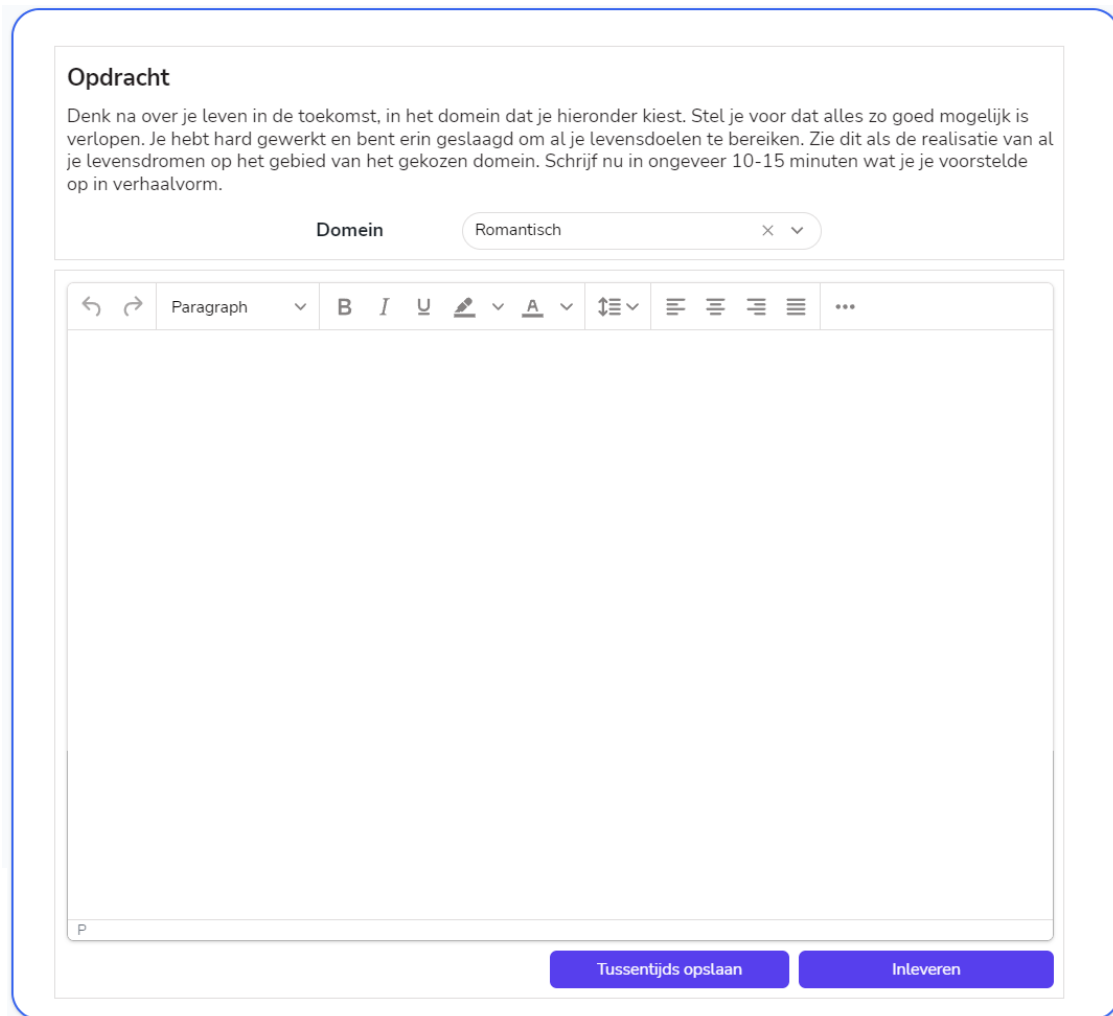
Figure 8: Control version of BPS with explanation of the exercise, domain choice drop-down menu, hand in button, and temporarily save button.
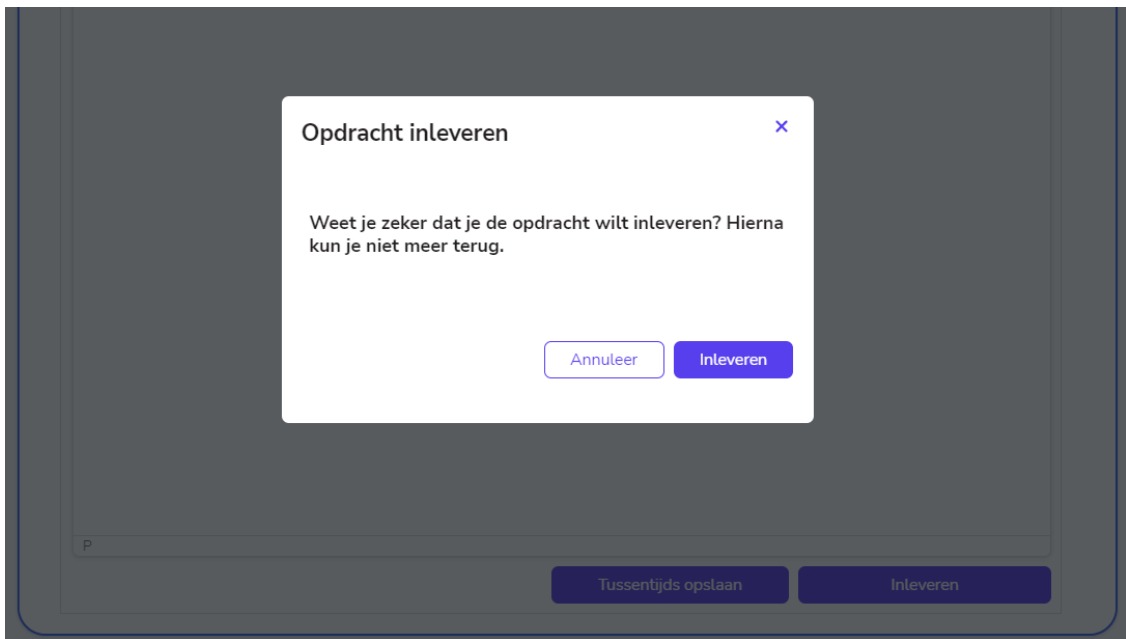
Figure 9: Modal that appears when clicking the button to hand in. Options are to cancel or to hand in.

Figure 10: Neuroticism version with strategy 'reward'. When writing more text, golden stars can be earned.

Figure 11: Low Openness version with strategy 'verifiability'. Information and references are provided on BPS and its influences on SWB. with a toggle button to not show the text.

Figure 12: Conscientiousness version with strategy 'goal setting'. The button can be clicked to change the goal of how many words to write and minutes to spend on the exercise. The red text and check mark turn green when a goal is met.
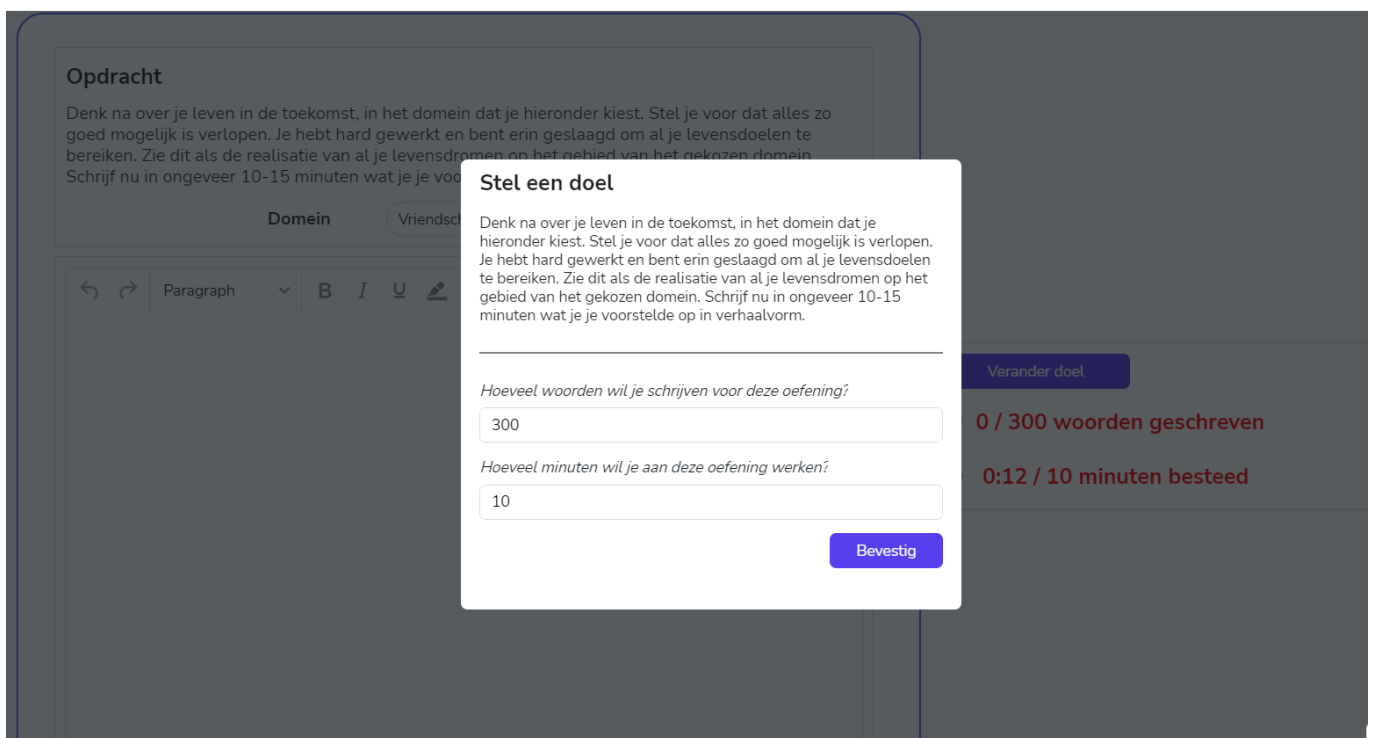
Figure 13: Modal for goal setting that appears in the Conscientiousness version when first opening the page each week. It can be opened again by clicking the button in the figure above.

Figure 14: Agreeableness version with strategy 'self-monitoring'. It is shown how many words were written and how many minutes were spent during the previous times the participant did the exercise. The first time, only a text is shown telling that this information will be provided next time.

Figure 15: Extraversion version with strategy 'social comparison. The average number of words written and time spent by all participants is shown under the word - and time counters for comparison.

C   Questionnaires

Positive And Negative Affect Scales (PANAS)

[Watson et al., 1988]

The Positive And Negative Affect Scales consist of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer. Indicate to what extent you generally feel this way, that is, how you feel on the average.

1. Enthusiastic	11. Scared
2. Interested	12. Afraid
3. Determined	13. Upset
4. Excited	14. Distressed
5. Inspired	15. Jittery
6. Alert	16. Nervous
7. Active	17. Ashamed
8. Strong	18. Guilty
9. Proud	19. Irritable
10. Attentive	20. Hostile

Responding is on a 5-point Likert scale:

- Very slightly / not at all
- A little
- Moderately
- Quite a bit
- Extremely

Satisfaction With Life Scale (SWLS)

[Diener et al., 1985]

Below are five statements that you may agree or disagree with. Indicate your agreement with each item by tapping the appropriate box, from strongly disagree, to strongly agree. Please be open and honest in your responding.

1. In most ways my life is close to my ideal.

2. The conditions of my life are excellent.

3. I am satisfied with my life.

4. So far I have gotten the important things I want in life.

5. If I could live my life over, I would change almost nothing.

Responding is on a 7-point Likert scale:

- Strongly disagree

- Disagree

- Slightly disagree

- Neither agree nor disagree

- Slightly agree

- Agree

- Strongly agree

Baseline Questions

1. What is your participant-ID?

2. How old are you?

3. What is your gender? (Male/Female/Not listed (please specify)/Prefer not to say)

4. How would you describe your mental health? (7-point: Very poor - Excellent)

5. How would you describe your physical health? (7-point: Very poor - Excellent)

6. How satisfied are you with the relationship with your partner? (7-point: Very dissatisfied - Very satisfied / Does not apply)

7. How many close friends do you have? (Slider 0-10)

8. What is your highest level of education? If you are now in training, this also counts. (Primary education / Secundary education / MBO / HBO / WO)

9. Which description best describes your current life? (I am studying / I am employed / I do volunteer work / I am unemployed)

10. What do you think of your income, compared to a comparison group relevant to you? (7-point: I earn very little - I earn very much)

11. Do you agree with the statement: 'I am religious'? (7-point: Strongly disagree - Strongly agree)

12. Write here in about 3 minutes about what you have done in the past week.

Emotional Processing Scale

From Emotional Approach Coping Scales [Stanton et al., 2000]

For the following statements, indicate how you deal with stressful situations. Think of a stressful situation from now or recently.

1. I take time to figure out what I'm really feeling.

2. I delve into my feelings to get a thorough understanding of them.

3. I realize that my feelings are valid and important.

4. I acknowledge my emotions.

Responding is on a scale from 1 (I usually don't do this at all) to 4 (I usually do this a lot).

Big Five Inventory (BFI) 44-item

[Benet-Martinez and John, 1998, John et al., 1991, John et al., 2008]

Here are some characteristics that may or may not apply to you. For each statement, indicate the extent to which you agree or disagree with that statement.

I am someone who...

1. Is talkative
2. Tends to find fault with others
3. Does a thorough job
4. Is depressed, blue
5. Is original, comes up with new ideas
6. Is reserved
7. Is helpful and unselfish with others
8. Can be somewhat careless
9. Is relaxed, handles stress well
10. Is curious about many different things
11. Is full of energy
12. Starts quarrels with others
13. Is a reliable worker
14. Can be tense
15. Is ingenious, a deep thinker
16. Generates a lot of enthusiasm
17. Has a forgiving nature
18. Tends to be disorganized
19. Worries a lot
20. Has an active imagination
21. Tends to be quiet
22. Is generally trusting
23. Tends to be lazy
24. Is emotionally stable, not easily upset
25. Is inventive
26. Has an assertive personality
27. Can be cold and aloof
28. Perseveres until the task is finished
29. Can be moody
30. Values artistic, aesthetic experiences
31. Is sometimes shy, inhibited
32. Is considerate and kind to almost everyone
33. Does things efficiently
34. Remains calm in tense situations
35. Prefers work that is routine
36. Is outgoing, sociable
37. Is sometimes rude to others
38. Makes plans and follows through with them
39. Gets nervous easily
40. Likes to reflect, play with ideas
41. Has few artistic interests

42. Likes to cooperate with others

43. Is easily distracted

44. Is sophisticated in art, music, or literature

Responding is on a 5-point Likert scale:

- Strongly disagree

- Disagree a little

- Neither agree nor disagree

- Agree a little

- Strongly agree

BFI scale scoring ("R" denotes reverse-scored items):

- Extraversion: 1, 6R, 11, 16, 21R, 26, 31R, 36

- Agreeableness: 2R, 7, 12R, 17, 22, 27R, 32, 37R, 42

- Conscientiousness: 3, 8R, 13, 18R, 23R, 28, 33, 38, 43R

- Neuroticism: 4, 9R, 14, 19, 24R, 29, 34R, 39

- Openness: 5, 10, 15, 20, 25, 30, 35R, 40, 41R, 44

D   Participant Documents

Informed consent

Title of the research project: Studying Subjective Well-Being

I have read the information letter for participants. I have had the chance to ask additional questions. My questions have been answered enough. I had enough time to decide whether to participate.

I know that participating is completely voluntary. I am aware that I can decide at any time not to participate without giving a reason. I am aware that all my data will be deleted in that case.

I know some people can see my data. These people are listed in the 'Privacy Statement' that I have read. I myself have the right to inspect the way in which my data is stored.

I give permission to use my data for the purposes stated in the information letter. I know that if there is reason to use the data for another research purpose, permission will be requested from me again.

I give permission to keep data for another 10 years after the end of this study for further analysis in the context of this study.

The researchers, Tinka Veldhuis, Lukas Arts, and Egon van den Broek, hereby declare that you have been sufficiently informed about the aforementioned research. If information becomes known during the study that could influence your consent, they will inform you in a timely manner in such a way that they can be sure that the information has reached you.

[You will be asked to agree with this statement in an online questionnaire]

☐ *I agree with this statement and I agree to participate in this study*

Information letter for participants

Studying Subjective Well-Being

Tinka Veldhuis
Utrecht University

Date: January 26, 2023

What is the goal of this study?

The goal of this study is to investigate individual's Subjective Well-Being (SWB), which means: the general evaluations of an individual of their life and their emotional experiences).

What do I have to do when I participate in this study?

When you participate in this study, first of all you will fill out a questionnaire in which information is asked that is necessary for this research. Questions will contain for instance your personality, mental and physical health, (romantic) relationships and religion. Next, you will start the study, which takes three weeks. Each week, you will be asked once to go to a website on your laptop or desktop (at home), where you will fill out an SWB questionnaire, conduct a task that is explained on the website, and fill out again the SWB questionnaire. After three weeks you will be finished. Six weeks later, you will again receive an email asking to fill out the SWB questionnaire one last time.

How much time will this study take for me?

Filling out the first questionnaire will take approximately 5 to 10 minutes. Conducting the task on the website will take approximately 15 to 20 minutes each week. The follow-up after six weeks will take approximately 5 minutes. This gives a total of 55 to 75 minutes.

What are potential risks?

There are no risks when participating in this study.

Are there any potential benefits?

A potential benefit is that you will evaluate your life and emotional experiences more positively after participating in this study.

Will my personal data and the information about my participation be treated confidentially?

Your answers will be treated in the strictest confidence and the digital data will be stored in secure computer files that are only accessible to the researchers. No publication about this research will contain your name, nor any other information that can be traced back to you as a person. Results of this research will only be shared on an aggregative level (so no individual data will be shared) in a thesis and thesis presentation on Utrecht University. In the case of a research publication, the same applies. Furthermore, in case of other researchers asking for the data to further study the topic of this research, only completely anonymized data will be shared. In the task that has to be

conducted, the participant will write some text. Only anonymous features derived from these stories (like number of sentences) will be shared with other researchers.

What are my rights if I participate in the study?

Your participation in the survey is completely voluntary. You will not receive any compensation for your participation. You may refuse to participate or, if you decide to participate, discontinue your participation at any time without any adverse consequences. In that case, all your data will be deleted.

Who can I contact if I have questions about the study?

If you have any questions, comments or concerns regarding this research project, please contact the researcher Tinka Veldhuis at t.veldhuis@students.uu.nl.

If you have any questions about your rights as a participant in the study or if you have any concerns about the way in which the participants in the study are treated, please contact the researcher Egon van den Broek at e.l.vandenbroek@uu.nl.

If you have any concerns regarding this research project that you want to discuss with someone other than the researchers, please contact Judith Masthoff at j.f.m.masthoff@uu.nl.

PRIVACY STATEMENT: DECLARATION OF THE PROTECTION OF PERSONAL DATA

Utrecht, January 26, 2023

We, researchers of *Studying Subjective Well-Being*, hereby declare that with regard to the protection of personal data, we will comply with the "Gedragscode Gezondheidsonderzoek (code Goed Gedrag)" approved by the Dutch data protection authority ("Autoriteit Persoonsgegevens").

Researchers:

Tinka Veldhuis

Datum: ………………………

Signature: ………………………

Lukas Arts

Datum: ………………………

Signature: ………………………

Egon van den Broek

Datum: ………………………

Signature: ………………………

E   Scripts of Implemented Code

Python code using smallerize for balancing RCTs

The below code is the Python code that is written to create balanced RCTs, so that influencing factors of SWB and the effectiveness of BPS do not have to be taken into account in the analysis (as described in Section 2.3). Module 'smallerize' is used as described in Section 3.3 and 3.4. All texts behind '#' are notes for explaining the code.

First, the control and treatment groups are defined, as well as the influencing factors including their weight and value bins (see Section 2.3 and 3.4). Next, from the 'smallerize' module, a minimizer is set up, which will minimize a defined imbalance score of the groups calculated by the variance of the influencing factors, by assigning participants to the group where the imbalance score would be lowest. After getting the participant information, the minimizer algorithm is run. Since the minimizer handles the participants in the order that is given, different orders lead to different allocations. Therefore, the minimizer algorithm is run 1000 times, with random shuffled orders or participants, and the allocations among groups and imbalance scores are saved for each order. Next, of the 1000 allocations calculated, only allocations with groups that have the same size (28 and 29 specifically) are considered. Last, the allocation is chosen that has the lowest imbalance score.

```python
from smallerize import Arm, Factor, Minimizer
import pandas as pd
import random
import math

#Define control and treatment group for smallerize module
groups = [Arm('Treatment'), Arm('Control')]

#Define influencing factors with their levels and weights
# for smallerize module
factors = [
    Factor('N', levels=["1", "2", "3", "4"],weight=math.sqrt(16.0)),
    Factor('E', levels=["1", "2", "3", "4"],weight=math.sqrt(15.0)),
    Factor('C', levels=["1", "2", "3", "4"],weight=math.sqrt(14.0)),
    Factor('O', levels=["1", "2", "3", "4"],weight=math.sqrt(13.0)),
    Factor('A', levels=["1", "2", "3", "4"],weight=math.sqrt(12.0)),
    Factor('EP', levels=["Low", "High"],weight=math.sqrt(11.0)),
    Factor('Age', levels=["Low", "Medium", "High"],
        weight=math.sqrt(10.0)),
    Factor('Gender', levels=['Male', 'Female'],weight=math.sqrt(9.0)),
    Factor('Psychological_health', levels=["Low", "Medium", "High"],
        weight=math.sqrt(8.0)),
    Factor('Physical_health', levels=["Low", "Medium", "High"],
        weight=math.sqrt(7.0)),
    Factor('Romantic', levels=["Low", "Medium", "High", "Nvt"],
        weight=math.sqrt(6.0)),
    Factor('Friends', levels=["Low", "Medium", "High"],
```

```
            weight=math.sqrt(5.0)),
    Factor('Status', levels=["Other", "Unemployed"],
        weight=math.sqrt(4.0)),
    Factor('Income', levels=["Low", "Medium", "High"],
        weight=math.sqrt(3.0)),
    Factor('Religiousness', levels=["Low", "Medium", "High"],
        weight=math.sqrt(2.0)),
    Factor('Education', levels=["Medium", "High"],
        weight=math.sqrt(1.0)),
]

#Create the minimizer from smallerize module, using the groups and
# influencing factors set above.
# Imbalance between the two groups is measured via the 'variance'
# method, which means that a higher imbalance score is given to
# a created allocation of participants, when the variance between
# the groups is bigger.
# The probability method refers to if the algorithm assigns a
# participant to the group where the imbalance score will be
# lowest. 'best_only' makes sure this always happens, instead of using
# a chance value (p) of assigning to the best group.
minimizer = Minimizer(
    factors=factors,
    arms=groups,
    d_imbalance_method='variance',
    total_imbalance_method='weighted_sum',
    probability_method='best_only',
    preferred_p=0.7
)

#Get the participants and their factors.
excel = pd.read_excel(r'participants.xlsx')
rows = excel.values.tolist()

#Create a list that contains all participants and the values
# for their influencing factors from the excel.
participants = []
for row in rows:
    participant = {
        'ID': row[0],
        'factors': {
            'Age': row[1],
            'Gender': row[2],
            'Psychological_health': row[3],
            'Physical_health': row[4],
            'Romantic': row[5],
            'Friends': row[6],
            'Education': row[7],
            'Status': row[8],
            'Income': row[9],
            'Religiousness': row[10],
```

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```python
                    'EP': row[11],
                    'N': row[12],
                    'E': row[13],
                    'O': row[14],
                    'C': row[15],
                    'A': row[16],
                    }
            }
        participants.append(participant)

#Run the smallerize algorithm a couple of times to find the lowest
# imbalance score with randomly shuffled order of participants
# (this is done because smallerize assigns participants in the order
# that is given; different group allocations will be created when
# changing the order).
i = 0
groups_info = []

while i < 1000:
    random.shuffle(participants)

    #Save allocation of participants to groups variable.
    groups = []
    #Save imbalance per influencing factor per allocation.
    per_factor = 0
    #Save total imbalance per allocation.
    total_imbalance = 0
    #Save number of participants in control group (the number of
    # participants in the treatment group can be calculated).
    number_control = 0

    #Assign each participant to a group using smallerize, which
    # assigns it to the group that would increase the imbalance
    # score the least.
    for participant in participants:
        assigned_group = minimizer.assign_participant(
            participant['factors'])
        groups.append({
            'ID': participant['ID'],
            'group': assigned_group
        })

        if (assigned_group == "Control"):
            number_control = number_control+1

        #If it is the last participant, then get the imbalance scores
        # for the this allocation.
        if (participant == participants[-1]):
            per_factor = minimizer.get_new_ds(participant['factors'])
            total_imbalance = minimizer.get_new_total_imbalances(
                participant['factors'])
```

```python
    #After assigning all participants to a group, save the
    # allocation, the imbalance score and the number of participants
    # in a group.
    groups_info.append({
        'groups': groups,
        'per_factor': per_factor[assigned_group],
        'total_imbalance': total_imbalance[assigned_group],
        'number_control': number_control
    })
    i = i+1

#Only use allocations where both groups have the same amount of
# participants (total number is 57).
filtered_groups = []
for x in groups_info:
    if x['number_control'] == 28 or x['number_control'] == 29:
        filtered_groups.append(x)

#Find the lowest imbalance score in the given group allocations.
lowest_imbalance = filtered_groups[0]['total_imbalance']
for x in filtered_groups:
    if x['total_imbalance'] < lowest_imbalance:
        lowest_imbalance = x['total_imbalance']

#Find all allocations with the lowest imbalance score
# (if there are multiple).
all_lowest_imbalances = []
for x in filtered_groups:
    if x['total_imbalance'] == lowest_imbalance:
        all_lowest_imbalances.append(x)

#Print the group allocation with the lowest imbalance score.
# There was only one group allocation with this score.
# This allocation was used in the experiment.
print(all_lowest_imbalances)
```

JS code for Appsmith environment

The below code is from the main JS object that belongs to the page with persuasive strategy 'set goal' for participants where the personality trait C is most present. All texts behind '#' are notes for explaining the code. See Section 3.3 for further explanation and Figure 2 for a flowchart corresponding to this code.

The code provided is to give a general impression of the Appsmith environment. Other code, like database queries and code specifically written in the front-end elements, is not provided here. The code for the other strategies is not provided, since there is a lot of overlap. The 'save goal' and words - and time counters are specific to the 'set goal' strategy. Other strategies included for instance code to show golden stars when many words were written ('reward' strategy for N trait).

At page load, the 'init' function is run that checks if the URL variables (ID, words and minutes) are valid in the 'check_id' function. If not, an error is shown. Otherwise, the database is accessed to see if there is already a BPS of the current participant in progress in the 'check_existing' function. If not, a new database entry is created. Otherwise, the data is retrieved and all page elements are loaded based on these data. Apart from the database, data is stored in local memory JS objects 'mem' and 'set_goal_mem' to easily update page elements. Next, all input fields are enabled, so that the participant can start writing, change the domain ('save_domain' function), save the BPS ('save_session' function, that saves the text and total time spent on the exercise) or hand in the BPS ('hand_in' function). For the 'set goal' strategy specifically, a Modal is shown to change the goal for the number of words to write, and the number of minutes to spend on the exercise ('save_goal' function, that also updates the words - and time counters based on the set goal). Last, the 'tick' function is set to run every second. From the moment all data is loaded, this function updates the total time in local memory and updates the time counter that is shown to the participant.

```
export default {
    #init function is called on page load
    init: async () => {
        this.check_id();
    },

    #check_id function checks if the ID from the URL corresponds to
    # a participant and checks the other URL variables.
    check_id: () => {
        #get the variables from the URL
        mem.ID = appsmith.URL.queryParams.ID;
        var words =      appsmith.URL.queryParams.words;
        var minutes = appsmith.URL.queryParams.minutes;

        #Check if ID is beteen 1 and 57 (all IDs in this experiment)
        # check if words and minutes for 'set goal' are integers
```

```
        if (!isNaN(mem.ID)
            && Number.isInteger(Number(mem.ID))
            && Number(mem.ID) > 0
            && Number(mem.ID) < 58
            && !isNaN(words)
            && Number.isInteger(Number(words))
            && !isNaN(minutes)
            && Number.isInteger(Number(minutes)
        ) {
          #If URL variables are valid, check if there is a BPS exercise
          # of the participant that is still in progress
          this.check_existing();

          #Call the 'tick' function every second
          setInterval(function() {
            this.tick();
          },1000);
        } else {
          #If URL variables are not valid, show a modal telling the
          # participant that they used the wrong URL
          showModal("wrong_link");
        }
    },

    #check_existing function checks if a BPS that is still in progress
    # exists for the participant. Function also loads all variables and
    # makes the environment ready to start the exercise.
    check_existing: async () => {
        #Run a JS query to see if there is already a table row for the
        # participant ID with status 'inprogress'
        check_exists.run({"ID":mem.ID}).then((resp) => {
            if(resp.length == 0) {
              #If the response contains no table rows, run a JS query
              # that creates a new row
              create_session.run().then(() => {
                #After creating a new row, open the 'Set Goal' modal
                showModal('setGoalModal)

                #Enable all input fields and buttons, so the participant
                # can get started on the BPS
                domain.isDisabled = false;
                bpstext.isDisabled = false;
                Button8.isDisabled = false;
                Button3.isDisabled = false;

                #At page load, the 'dologic' variable in the local memory
                # 'mem' is set to false. When everything is ready, it is
                # set to true; this will affect the function 'tick' that
                # runs every second.
                mem.dologic = true
              }).catch((e)=>{
```

```
            #If JS query fails, the connection with the database is
            # lost. A modal is shown telling the participant to stop
            # and contact the researcher.
            showModal("ConnectionLostModal");
        })
    } else {
        #If the response contains a row for the participant with
        # a BPS that is in progress, all local storage variables
        # will be updated according to this row.
        mem.domain = resp[0].domain;
        mem.totaltime = resp[0].totaltime;
        mem.text = resp[0].text;
        set_goal_mem.words = resp[0].words;
        set_goal_mem.minutes = resp[0].minutes;

        #All widget values will be set as well.
        bpstext.text = resp[0].text;
        domain.value = resp[0].domain;

        #Update the word counter and text for when a goal is
        # achieved. A checkmark is enabled when the goal is
        # achieved for the number of words. The text color is
        # green if achieved, red otherwise. (Time counter is
        # updated in 'tick' function.)
        var textlength = bpstext.text.trim()
            .replace(/(<([^>]+)>)/gi,"").replaceAll(" ","")
            .split(/\s+/).filter(function(num) {
                return num != ""
            }).length;
        check.isDisabled = textlength < resp[0].words
            ? true : false;
        words.text = textlength + " / " + resp[0].words
            + (textlength == 1 ? " woord" : " woorden")
            + " geschreven";
        words.textColor = textlength < resp[0].words
            ? "red" : "green";

        #Enable all input fields and buttons, so the participant
        # can get started on the BPS
        domain.isDisabled = false;
        bpstext.isDisabled = false;
        Button8.isDisabled = false;
        Button3.isDisabled = false;

        #At page load, the 'dologic' variable in the local memory
        # 'mem' is set to false. When everything is ready, it is
        # set to true; this will affect the function 'tick' that
        # runs every second.
        mem.dologic = true;
    }
}).catch((e) => {
```

```
            #If JS query fails, the connection with the database is
            # lost. A modal is shown telling the participant to stop
            # and contact the researcher.
            showModal("ConnectionLostModal");
          })
      },

  #save_domain function is triggered by the participant clicking
  # a new value in the dropdown menu for domain.
  save_domain: () => {
    #Update local storage memory.
    mem.domain = domain.value;

    #Run query to update database row.
    save_domain.run().then(() => {})
      .catch((e) => {
        #Show modal if query fails.
        showModal("ConnectionLostModal");
    });
  },

  #hand_in function submits the BPS and is triggered by the
  # participant clicking the 'submit' button.
  hand_in: () => {
    #Update local storage memory.
    mem.text = bpstext.text;

    #Modal is shown telling the participant to wait while saving.
    showModal("SavingModal");

    #Run a JS query that updates all rows, including the status
    # 'done', so that at reload of the page, a new row will be
    # created for a new trial.
    hand_in.run().then(() => {
      #Navigate to page that thanks the participant and asks to
      # fill out the SWB questionnaire.
      navigateTo("End");
    }).catch((e) => {
      #Show modal if query fails.
      showModal("ConnectionLostModal");
    });
  },

  #save_session function is triggered by the participant clicking the
  # 'save' button.
  save_session: () => {
    #Update local storage memory.
    mem.text = bpstext.text;

    #Run query to update database row.
    save_session.run().then(() => {
```

```
      #Show alert telling the participant that the text is saved.
      showAlert("Opgeslagen", "success");
    }).catch((e) => {
      #Show modal if query fails.
      showModal("ConnectionLostModal");
    });
},


#save_goal function is triggered by the participant clicking
# the 'change goal' button and changing the input fields for
# number of words and minutes to spend on the exercise.
save_goal: () => {
  #Update local storage memory.
  set_goal_mem.words = Input1.value;
  set_goal_mem.minutes = Input1Copy.value;

  #Run query to update database row.
  save_goal.run().then(() => {})
    .catch((e) => {
      #Show modal if query fails.
      showModal("ConnectionLostModal");
    });

  #Update the word counter and text for when a goal is achieved.
  # A checkmark is enabled when the goal is achieved for the
  # number of words. The text color is green if achieved,
  # red otherwise. (Time counter is updated in 'tick' function.)
  var textlength =  bpstext.text.trim().replace(/(<([^>]+)>)/gi,"")
    .replaceAll(" ","").split(/\s+/).filter(function(num) {
      return num != ""
    }).length;
  check.isDisabled = textlength < Input1.value ? true : false;
  words.text = textlength + " / " + Input1.value
    + (textlength == 1 ? " woord" : " woorden") + " geschreven";
  words.textColor = textlength < Input1.value ? "red" : "green";
},

#tick function is triggered by the setInterval in check_id function
# and runs every second. It updates the totaltime with one second
# and updates the time counter and text that tells the participant
# if their goal is achieved or not.
tick: () => {
  #At page load, variable 'dologic' is set to false in local
  # memory. It is set to true after loading all relevant data.
  if(mem.dologic) {
    #Update time with 1 second in local memory.
    mem.totaltime = mem.totaltime + 1;

    #Update time counter text telling participant how much
    # time is spent compared with the set goal.
```

```
        var min = Math.floor(mem.totaltime/60);
        var sec = Math.floor(mem.totaltime%60);
        time.text =  min + ":" + (sec < 10 ? "0":"") + sec+ " / "
          + set_goal_mem.minutes + " minuten besteed";

        #Text turns green and checkmark is enabled when goal is
        # achieved. Text turns red and checkmark disabled otherwise.
        if (time.textColor == 'red') {
          if (mem.totaltime / 60 >= set_goal_mem.minutes) {
            time.textColor = 'green';
            check2.isDisabled = false;
          }
        } else {
          if (mem.totaltime / 60 < set_goal_mem.minutes) {
            time.textColor = 'red';
            check2.isDisabled = true;
          }
        }
      }
    }
}
```

F   Systematic Review of Reviews on SWB

A Systematic Review of Reviews: Improving Subjective Well-Being Through an Intervention

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1 Introduction

Subjective Well-Being (SWB), defined as people's overall evaluations of their lives and their emotional experiences, has gained more and more interest since the first review of SWB in 1984 [Diener, 1984], with in 2015 alone 14,000 publications that mentioned SWB [Diener et al., 2017]. SWB is sometimes used interchangeably with the term 'happiness', however, this is a loose term with ambiguous meaning and is therefore avoided here and in most scientific literature [Diener et al., 2017]. SWB is studied in many disciplines, like psychology, philosophy, public policy, sociology, and economics [Diener et al., 2017, Das et al., 2020]. In this study, the emphasis will be on individual SWB (in contrast to mean SWB of an entire population, like in public policy). SWB is an umbrella term that refers to an cognitive (or evaluative) and an affective (or emotional) dimension [Das et al., 2020], where the cognitive dimension is depicted by Life Satisfaction (LS) and the affective dimension is depicted by Positive Affect (PA) and Negative Affect (NA). Higher SWB is indicated by higher LS and PA, and lower NA [Heintzelman and Tay, 2018]. The three dimensions are separable when factor-analyzed and have separable determinants and correlates, for instance, PA seems to be influenced by social relationships, NA by internal conflicts, and LS by health and income [Diener et al., 2017]. SWB focuses on the subjective feeling and thinking states of well-being known as the hedonic view of well-being, in contrast to Eudaimonic Well-Being (EWB), which views well-being as an external assessment of whether an individual possesses desirable qualities [Das et al., 2020]. Having higher SWB has many beneficial outcomes, such as being more healthy, living longer, having more supportive social relationships, and working more productively [Diener et al.,

2017], which raises the question if SWB can be positively altered in the population. It was claimed for some time that SWB was almost entirely dependent on genes and that it could not be changed by situations or circumstances in the long term, due to people's adaptation to them. However, now, it is believed that on average the heritability of SWB is 40%, leaving 60% dependent on the environment, and it is proven that interventions can increase SWB [Diener et al., 2017]. For interventions to have sustaining effect, authors emphasize attention should be given to the person-activity fit: to which extent the type and format of the intervention match an individual's needs and preferences [Diener et al., 2017, Layous et al., 2013, Loveday et al., 2018, McCrae, 2011]. The activity must be fitted to achieve a way of sustaining interest and to remain fresh, meaningful and positive for a person [McCrae, 2011]. [Manthey et al., 2016] states that providing personalized instructions and feedback in an online environment might increase the effectiveness of interventions. Although researchers study the effectiveness of online interventions increasing SWB with promising results [Heintzelman et al., 2020, Manthey et al., 2016, Renner et al., 2014, Seear and Vella-Brodrick, 2013], and personalization is thought to be an important aspect in the Human Computer Interaction community, for instance in persuasive technologies [Kientz and Halko, 2010, Orji et al., 2017], to the author's knowledge, no studies have been conducted on the effect of personalizing the online environment and thereby enhancing the person-activity fit. To this end, this study will examine the following research question:

Research Question 1 *To what extent is the effectiveness of an online intervention method for increasing individual SWB better when the online environment is adapted to the user's personality, compared to a non-*

adaptive, neutral environment?

To investigate this question, an online intervention method based on the literature on SWB needs to be developed, which is then adapted according to personality. Due to the enormous amount of studies on SWB as mentioned above, first a systematic review of *reviews* will be given (instead of primary studies) of SWB in Section 2. The implications of the findings in the systematic review for this study will be explained in Section 2.4.

2 Systematic Review of Reviews

2.1 Methods

Google Scholar was searched on August 16, 2022 for reviews on SWB and its determinants. The search terms were ['Subjective Well-Being' or 'Life Satisfaction' or 'Happiness'] and ['Review' or 'Survey'] and ['Determinants' or 'Factors'], where the word(s) in the first two pairs of brackets had the restriction to appear in the title, and the words in the last pair of brackets had no restriction. There was no restriction on the year that the review was published.

Inclusion criteria were firstly that the record was written in English, that it was publicly available, and that it was in fact a review on SWB and not a primary study. Furthermore, the reviews were included if they gave information about (a) general SWB (in contrast with domain specific SWB, e.g. Work Satisfaction), (b) determinants of SWB in general (in contrast with reviews about one specific determinant, e.g. income), (c) the adult population (in contrast with children or adolescents), (d) healthy people (in contrast with people with specific diseases or problems), (e) a general setting and population (in contrast with a specific country, era, profession, etc.), and (f) measurement of SWB in general (in contrast with one specific measurement instrument).

2.2 Review selection

With the systematic search on Google Scholar, 489 records were identified. After discarding 6 duplicates, 483 records were first screened by reading the title. This resulted in 429 records being excluded that did clearly not meet the inclusion criteria (for instance, because the title clearly

stated only one determinant or domain). Another 45 records were excluded after reading the abstract. Most of them (n = 22) were primary studies instead of reviews. Other reasons for exclusion were that the record was not in English (n = 1), that it considered youth or adolescents instead of adults (n = 7), that it was a book review and not a review on SWB (n = 2), that it only considered one domain (n = 4), or one determinant (n = 4), or one measurement instrument (n = 2), or that is was not fully available (n = 4). The remaining nine records were assessed for eligibility. One record was excluded because it was a conceptual review with few references [Sundaresan, 2021]. One record was excluded because it was not relevant when focusing on individual SWB, since it examined the use of a macro-micro model in studies on differences between mean country-level SWB [Nonnenmacher and Friedrichs, 2013]. The last 7 records were included for review. See Figure 1 for an overview of the review selection.

Table 1 gives an overview of some of the characteristics of the included reviews. There were three reviews on determinants of SWB, where one focused on individual SWB from a psychology point of view ([Azizan and Mahmud, 2018]), and the other two focused more on SWB of the population from an economic or public policy point of view ([Dolan et al., 2008, Scollon, 2018]). There were two reviews on measurement of SWB, where one examined the domains included in measurement instruments ([Charlemagne-Badal et al., 2015]), and one reported on different measurement instruments than the traditional self-report ([Scollon, 2018]). There was one review on the structure of the concept of SWB ([Busseri and Sadava, 2011]), one review on interventions to increase SWB ([Solanes et al., 2021]), and lastly one review on the difference of SWB between different countries ([Nonnenmacher and Friedrichs, 2013]). From the reviews, five were journal articles, two were book chapters, and one was an article from a conference proceedings.

2.3 Results of Systematic Review

2.3.1 Definition and Structure of SWB

Although there has been much debate on the definition of SWB and its components [Charlemagne-Badal et al., 2015, Schimmack, 2006], there seems to be a consensus among most authors that it is the subjective global evaluation of one's life as a whole [Busseri and Sadava,
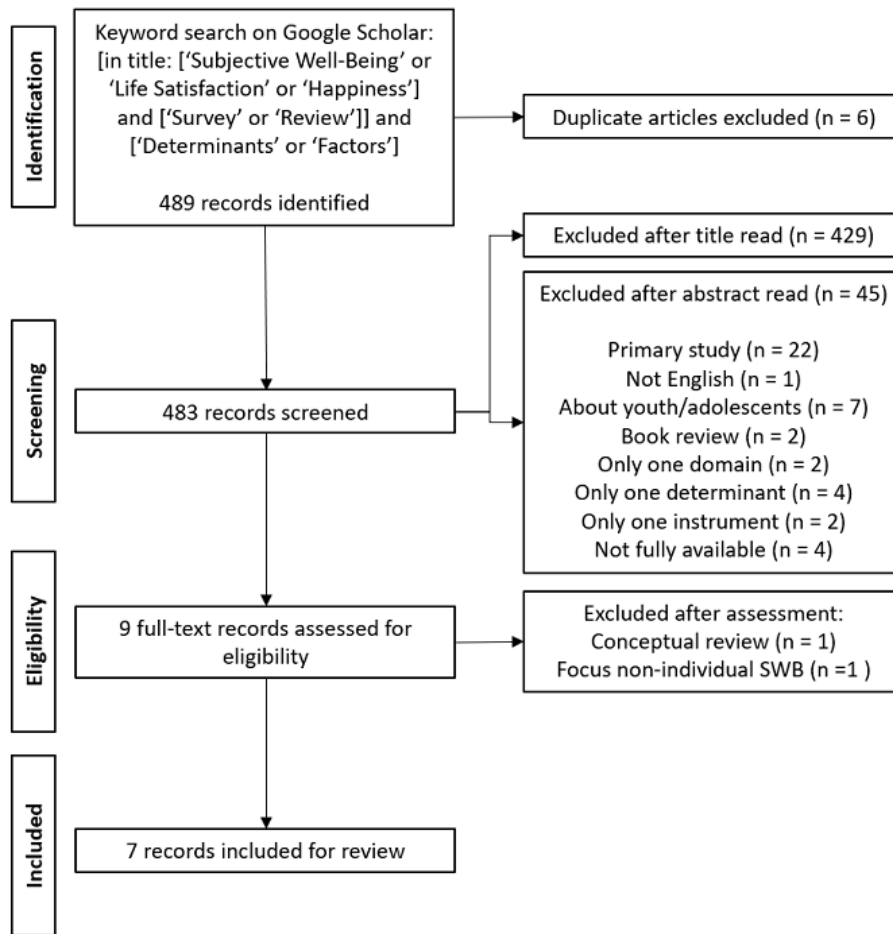
Figure 1: Search strategy and review selection

2011, Dolan et al., 2008, Nonnenmacher and Friedrichs, 2013], consisting of a cognitive judgment part, which is referred to as Life Satisfaction (LS), and affective reactions to one's own life, which consists in turn of a Positive Affect (PA) component and a Negative Affect (NA) component [Azizan and Mahmud, 2018, Busseri and Sadava, 2011, Solanes et al., 2021]. In other words: it is how we think and feel about our life [Dolan et al., 2008]. Sometimes the balance of PA and NA is combined into one 'hedonic' component, however, authors stress that this is not a good idea, since the two might not be each other's opposites and important information might be lost [Busseri and Sadava, 2011, Solanes et al., 2021]. SWB is seen as the subjective part of the overall 'Quality of Life' or 'Good Life' [Azizan and Mahmud, 2018, Solanes et al., 2021]. High SWB is associated with optimal human functioning [Busseri and Sadava, 2011] and positive outcomes such as lower mortality and higher self-esteem [Solanes et al., 2021]. Therefore, it is considered as both an important personal and societal goal to increase SWB [Busseri and Sadava, 2011].

[Busseri and Sadava, 2011] describe in their review on the structure of SWB five different models that are used throughout the literature and the implications of using each model regarding measurement, analysis and interpretation, and integration and synthesis in studies on SWB. Some information will be provided in Table 2, see [Busseri and Sadava, 2011] for a full review. [Busseri

	Review on	Research field	Type of source
[Azizan and Mahmud, 2018]	Determinants	Psychology	Conference proceedings
[Busseri and Sadava, 2011]	Structure	Social Psychology	Journal article
[Charlemagne-Badal et al., 2015]	Measurement	Psychology	Journal article
[Dolan et al., 2008]	Determinants	Economic Psychology	Journal article
[Schimmack, 2006]	Multiple subjects	Public Policy	Book chapter
[Scollon, 2018]	Measurement	Psychology	Book chapter
[Solanes et al., 2021]	Interventions	Psychology	Journal article

Table 1: Characteristics of included reviews.

and Sadava, 2011] stresses that researchers should not adopt one of the models and an analytic approach, without any explicit justification of the implications of these choices. They urge to compare the different models to see to which extent the results and conclusions on SWB are similar or different when considering different models.

2.3.2 Determinants of SWB

A distinction could be made between internal and external determinants of SWB, where internal determinants are factors from within an individual, independent of the environment and external determinants are factors from the environment [Schimmack, 2006]. Although according to [Schimmack, 2006] there is evidence that internal determinants have a much stronger effect on SWB then external determinants, other authors do not make a distinction between the two. Both [Azizan and Mahmud, 2018] and [Solanes et al., 2021] point to personality as the most important factor influencing SWB, especially the traits Extraversion (positively correlacted with PA) and Neuroticism (positively correlated with NA and negatively correlated with LS). However, [Dolan et al., 2008] argues that when large datasets are considered and both social trust and religious beliefs are controlled for, the relationship between personality and SWB seems to be weaker than often thought. Income and income inequality seem to be very important factors for SWB [Azizan and Mahmud, 2018, Dolan et al., 2008, Schimmack, 2006], however, the results are very mixed, with some authors finding a positive correlation and others finding a negative correlation, or a positive one that flattens with increasing income [Schimmack, 2006]. [Dolan et al., 2008] states that it might be individual's own perception of their income (compared to a certain reference group) rather than absolute in-

come (inequality). Health (both physical and psychological) is consistently a very important factor [Azizan and Mahmud, 2018, Dolan et al., 2008]. Unemployment is consistently a negatively correlated factor [Azizan and Mahmud, 2018], however, the extent to which it affects SWB could also depend on other factors such as the perception of the unemployment (if half of the country is unemployed, SWB is less affected) and the substitute activities (if the individual has other (non-job) social network activities, SWB is less affected) [Schimmack, 2006]. It is consistently shown that religion and spirituality have a positive effect on SWB [Azizan and Mahmud, 2018, Dolan et al., 2008].

Additionally, [Dolan et al., 2008] states the following determinants. For age, there seems to be a U-shape where people have lowest SWB in the middle age range (between 32-50). There seems to be mixed results about gender, with [Dolan et al., 2008] stating that there might be no difference. The results about education level differ a lot between studies, ranging from positive to negative or no correlation. Seeing friends and family, being a member of communities or organisations, having trust (both social trust in the people around you and trust in government/police/law), and being in a stable intimate relationship, are all important factors that positively affect SWB. Caring for others negatively affects SWB, this may be due to loss of autonomy over your life and choices [Dolan et al., 2008]. There are other variables that influence SWB, such as political environment and inflation [Dolan et al., 2008], however, these are more important when addressing societal SWB instead of individual SWB, for instance SWB differences between nations, and are therefore not taken into account here.

Table 2: Structural conceptualizations of SWB (see [Busseri and Sadava, 2011]).

Model	Description	Measurement	Analysis and interpretation	Integration and synthesis
Model 1: Three separate components	SWB is not seen as a psychological construct, but rather as a term for a research domain. LS, PA, and NA are components that all should be treated separately.	The three components can be studied separately.	The correlates, predictors, or potential outcomes of LS, PA, and NA should be examined as separate outcomes. To identify associations and isolate variance that is unique to one component, this approach should control for the other two components.	Findings can be integrated with existing literature on SWB.
Model 2: Hierarchical construct / Latent factor	SWB is seen as an underlying latent factor that is the cause of changes in its indicators LS, PA, and inverse NA.	All three components should be measured.	An SEM approach should be estimated as a latent factor, manifested in the common variance among the three components. Correlates, predictors, and potential outcomes of this latent factor could then be explored along with simultaneous assessment of any residual links involving the individual SWB components independent of the higher order latent SWB factor.	All existing reviews on SWB treated SWB as in model 1. Researchers should not assume that findings based on one structural conceptualization of SWB apply to another one. Therefore, few integrative or summary statements can be offered for this model.
Model 3: Causal system	SWB is the term for a causal system where LS is the outcome of relative contributions of PA and NA. SWB could also be seen as a synonym for LS.	All three components could be measured, but LS could also be studied separately as the key criterion of interest for SWB.	A multiple regression, path analysis, or SEM approach should be employed to test PA and NA as simultaneous predictors of LS. Additional predictors (or correlates) of LS could then be explored after first accounting for the hypothesized proximal effects of PA and NA.	See model 2.
Model 4: Latent composite variable	SWB is seen as a latent composite variable that is produced by combination of the causal indicators LS, PA, and inverse NA (note the difference with model 2, where SWB is not caused by its indicators, but the other way around).	All three components should be measured.	An SWB index (e.g., an aggregate of standardized scores for LS, PA, and reverse-scored NA) should be computed, which is then explored in relation to other variables. Although less commonly employed, a more sophisticated approach would be to employ SEM to estimate SWB as a latent composite variable resulting from its three primary causal indicators.	See model 2.
Model 5: Configuration of components	SWB is seen as an integrated system of distinct configurations of LS, PA, and NA. It is emphasized that the structure of SWB may vary between individuals, and even within individuals over time.	All three components should be measured.	A person-centered statistical approach should be employed to identify and then compare individuals characterized by distinct configurations of LS, PA, and NA. Correlates, predictors, and potential outcomes predicted by SWB configurations could then be evaluated.	See model 2.

2.3.3 Measurement of SWB

According to [Charlemagne-Badal et al., 2015], SWB is multidimensional, so different domains should be considered and they propose fifteen domains that all should be measured when addressing SWB: cognitive health, emotional health, economic health, environment, non-leisure activities, physical health, spirituality/meaning, life satisfaction, vitality, healthcare, health behavior, intellectual pursuits, leisure, and sleep. However, [Schimmack, 2006] argues for the approach were individuals make a judgment of their lives by thinking about the most important aspects of their lives, instead of specific domains being imposed in the questions, since for every individual and at every moment in time, it can differ which domains are important or not. Therefore, it would be insufficient to ask about specific domains that the researcher considers most important and draw conclusions of a person's general SWB from that.

There are non-traditional methods to measure SWB instead of the widely used self-reports, however, from all proposed methods of [Scollon, 2018], it is (a) not fully developed yet (like smiling in photographs), or (b) not clear if it really reflects SWB (like Implicit Association Test, where the measure is the reaction time for participants to associate certain terms with others, for example 'my life' and either 'good' or 'bad'), or (c) a very intrusive and irritating method (like Methodology Experience Sampling, where participants should answer questions about their affect and activities in real-time several times a day over several days). [Schimmack, 2006] argues that self-reports on LS are a reliable measure, and that evidence suggests that mood has a negligible effect on people's LS judgments. However, it is important to ask out LS anonymously, since people may adhere to certain social desirable responding otherwise [Schimmack, 2006].

2.3.4 Interventions for higher SWB

[Solanes et al., 2021] states that not only treating and preventing low SWB is important (including treating mental disorders and targeting risk factors), but also promoting higher SWB in healthy individuals, to strengthen their ability to develop, adapt, and build resilience and competence. Positive Psychology is a research area that is focused on exactly that: promoting positive traits, virtues, and subjective experiences such as SWB. Positive Psychology Interventions (PPI) to promote SWB

specifically, are for instance conducting acts of kindness, practicing gratitude, savoring the moment, or thinking about positive experiences. [Solanes et al., 2021] assessed in their review the efficacy of different PPI and other interventions (like yoga or leisure) on SWB and the quality of the evidence. Their main finding was that PPI might increase PA and decrease NA, but that the evidence supporting this claim was of low to moderate quality. This might partly be due to the different PPI investigated, however, the evidence per type of PPI was also inconsistent. For instance, different studies examining ´conducting acts of kindness´ resulted in either low, moderate, or high increases of PA, and ´writing things for which one could feel grateful´ resulted in either no increases, low, or moderate increases of PA. This heterogeneity might be affected by the duration of the PPI. The only intervention described by [Solanes et al., 2021] that showed high or moderate increases in SWB (via PA; components of SWB are treated separately as in model 1 of Table 2) in multiple studies, and no studies reporting low or no increase, was writing about oneself in the future imagining that everything has gone as well as it possibly could. For the other interventions (not PPI), the quality of the evidence that it would increase SWB was overall very low. Besides the heterogeneity of the results, the quality of the evidence for PPI and other interventions was also affected by unclear binding, pre-protocol analysis instead of intention-to-treat analyses, and study limitations that may exaggerate the effects, introduce bias, or violate the principle of randomization.

2.4 Implications of Systematic Review on This Study

The results described in the previous sections have implications for this study concerning the methods and analyses. Considering the research question, an experiment with a between-group design will be used in this study to investigate the increase of SWB through a personalized or non-personalized online intervention. The following implications for the design of the experiment follow from the results above and are supported by additional literature.

2.4.1 Structure and Analysis of SWB

Considering [Busseri and Sadava, 2011], the structural conceptualization of SWB has to be taken into account.

For this study, it is chosen to measure both NA, PA, and LS, and analyse the data using the first four models described in Table 2 consecutively, with model five taken out of consideration, since no guidelines are given on how to interpret different configurations. The results can than be compared to see if different models lead to different or similar conclusions [Busseri and Sadava, 2011].

2.4.2 Intervention for Increasing SWB

An intervention should be chosen with which it would be likely to increase individual's SWB. Since the quality of evidence for non-PP interventions was overall very low in [Solanes et al., 2021], a PPI will be chosen for this study. As mentioned, the only PPI that demonstrated consistently high or moderate increases [Layous et al., 2013, Peters et al., 2010, Sheldon and Lyubomirsky, 2006], is writing about oneself in the future imagining that everything has gone as well as it possibly could, also referred to as Best Possible Self (BPS) [King, 2001]. It is thought that thinking and writing about your BPS energizes behaviors to achieve the goals of your BPS. Furthermore, having a higher perceived likelihood to achieving a BPS is associated with lower levels of risk-behavior and higher levels of health-promoting behavior [Corte et al., 2022]. In a review cited by [Solanes et al., 2021] specifically conducted on PPI and SWB [Koydemir et al., 2021], some other studies are mentioned in which a significant increase of PA [Manthey et al., 2016, Odou and Vella-Brodrick, 2013, Renner et al., 2014] and decrease in NA ([Liau et al., 2016, Odou and Vella-Brodrick, 2013, Seear and Vella-Brodrick, 2013]) was found with BPS. In [Liau et al., 2016] and [Seear and Vella-Brodrick, 2013] no significant increase in PA was found. [Liau et al., 2016] suggested that this could be due to cultural differences, since their participants were Asian and most other studies are conducted in Europe or the US. [Seear and Vella-Brodrick, 2013] suggested that BPS might be more helpful for younger participants, since most studies are conducted with university students, while their participants were on average older. The literature suggests that although a smaller effect of BPS on SWB is often found through the use of technology instead of in-person intervention, there still is a significant effect [Manthey et al., 2016, Renner et al., 2014, Seear and Vella-Brodrick, 2013], and some authors do not find a significant difference between on-line and in-person intervention of BPS at all [Layous et al., 2013]. Hence, it will be assumed for this study that a positive effect can be found with an online intervention, nonetheless, an extra control group that conducts a non-intervention task will be added to make sure the intervention affects SWB at all, independent of the personalizing. Apart from the consistency of higher PA (and lower NA) in the results described above, BPS can be easily performed online individually in a longitudinal design (in contrast with, for example, conducting acts of kindness). Furthermore, participants in BPS experiments report high motivation for completing and even continuing their BPS activity [Loveday et al., 2018]. Therefore, BPS was chosen as the intervention used in this study.

2.4.3 Handling Determinants

The experiment in this study will contain multiple conditions and to compare those, it should be decided how to deal with the determinants of SWB. Important determinants of SWB can be measured for each participant at the beginning of the experiment. Two possible scenarios are then 1) to control for important determinants in the analysis, or 2) to make balanced groups for the different conditions of the experiment (for instance: every experiential group has the same amount of participants with low income compared to high income). The most important determinants, for which there is consistent evidence that they affect individual SWB according to the literature, are: personality, income (inequality), religiousness, age, psychological and physical health, unemployment, intimate relations, and being a member of communities [Azizan and Mahmud, 2018, Dolan et al., 2008, Schimmack, 2006, Solanes et al., 2021]. Since controlling for all these determinants requires many participants to still be able to find significant effects, balancing the groups for the different conditions is preferred. In this study, the groups will be balanced as much as possible, considering the most influencing factor for SWB first, then the second, and so on. Hence, the determinants should be ranked in order of how much they influence SWB. Personality traits seem to be the most important factor [Azizan and Mahmud, 2018, Diener et al., 2017, Solanes et al., 2021, Voukelatou et al., 2021], where three of the Big Five dimensions influence SWB the most: Extraversion, Neuroticism [Azizan and Mahmud, 2018, Solanes et al., 2021], and Conscientiousness [Das

et al., 2020]. Another reason to balance personality traits first is that the intervention will be personalized according to these traits, hence balanced groups are necessary. Furthermore, health is strongly correlated with SWB [Das et al., 2020], with psychological health being more important than physical health [Voukelatou et al., 2021]. Having a romantic relationship and (the number of) intimate social relationships (for instance via community membership) consistently influence SWB. Income (inequality) affects SWB, but the results are not always consistent. Religiousness seems to influence SWB [Azizan and Mahmud, 2018, Dolan et al., 2008], however, [Das et al., 2020] states that it may be premature to make claims on the consistency due to the limited number of studies. For gender, the results are mixed [Das et al., 2020, Dolan et al., 2008], and will therefore be put lowest in the ranking. Since the participant group of this study consists of students with similar education level and age, these will not be taken into account, just like unemployment. In summary, the ranking will be: personality traits Extraversion, Neuroticism, Conscientiousness, Openness, and Agreeableness, psychological health, physical health, romantic relationship, intimate social relationships and community membership, income (inequality), religiousness, gender.

2.4.4 Measure of SWB dimensions

It should be decided which instruments will be used to measure SWB. For this study, self-report instruments will be used, considering that other types of instruments proposed by [Scollon, 2018] are not suited for this research due to the reasons explained in Section 2.3.3. [Das et al., 2020] stresses that in order for SWB studies to be comparable, the same measures should be used. Therefore, the most often used measures for SWB will be used in this study as well. The Positive Affect And Negative Affect Scales (PANAS) [Watson et al., 1988] is the most frequently used measure for PA and NA [Voukelatou et al., 2021, Das et al., 2020]. The Satisfaction With Life Scale (SWLS) [Diener et al., 1985] is the best known measure for LS [Pavot, 2018, Das et al., 2020].

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