

One Year Later: Longer-Term Maintenance Effects of a Digital Intervention to Change Personality Traits

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Abstract

Objective: Recent research suggests that personality traits can be changed by psychological interventions. However, it is unclear whether these intended personality changes can be maintained or merely reflect ephemeral shifts.

Method: The present study reports 1-year follow-up effects of a 3-month digital intervention for personality trait change (Stieger et al., 2021). Personality traits were measured before the intervention (Pretest: $N = 1523$), directly after the intervention (Posttest: $n = 554$), and three months (Follow-up 1: $n = 437$) and one year (Follow-up 2: $n = 157$) after the end of the intervention.

Results: Attrition analyses suggest that participants who completed the 1-year follow-up were significantly more open to experience ($d = 0.19$), less neurotic ($d = 0.20$), more agreeable ($d = 0.35$) and more conscientious ($d = 0.27$) than participants who did not complete the 1-year follow-up. Also, until the 1-year follow-up, personality trait changes achieved remained stable (for those who wanted to increase in extraversion and conscientiousness) or even changed further in the desired direction (for those who wanted to decrease in neuroticism).

Conclusion: These results suggest that changes in personality traits due to a targeted intervention are not just ephemeral shifts and can even continue.

KEYWORDS: personality change; digital intervention; 1-year follow-up; maintenance effects

One Year Later: Longer-Term Maintenance Effects of a Digital Intervention to Change Personality Traits

Personality trait change through intervention has recently received much attention in the field of personality development. Initial research has demonstrated that personality traits can be changed both by clinical and non-clinical interventions (e.g., Hudson & Fraley, 2015; Jackson et al., 2021; Roberts et al., 2017). Studies in clinical populations have shown that clinical interventions with a focus on mental health problems do not only impact targeted outcomes in terms of symptom reduction, but also lead to positive outcomes in personality trait changes (Sauer-Zavala et al., 2020; Stieger et al., 2022). For example, a systematic review of 207 clinical intervention studies in which personality traits were not the direct target found decreases in the personality trait of neuroticism and increases in the trait of extraversion (Roberts et al., 2017). Further evidence for personality trait changes through intervention comes from prior studies on volitional personality changes in non-clinical populations, which have delved into the impacts of specific intervention elements for changing personality traits. Hudson and Fraley (2015), for example, employed a 16-week intensive longitudinal study and provided indications that the practice of formulating implementation intentions ("if-then" plans) for personality change goals on a weekly basis was linked to changes in personality traits. In a further study employing a 15-week intensive longitudinal approach, the examination of involvement in behavioral activities as a mechanism of change was undertaken (Hudson et al., 2019). It emerged that actively and effectively executing behavioral changes to change one-self proved to be a fruitful avenue for changing personality traits. In addition, a variety of other approaches have been used to target personality change, including behavioral activation (Massey-Abernathy & Robinson, 2021), social skills training (Allemand et al., 2021), cognitive training (Jackson, Hill, et al., 2012), arts education (Grosz et al., 2022), structured coaching programs (Allan et al., 2018), and digital interventions (Allemand & Flückiger, 2022; Stieger, Wepfer, et al., 2020). Overall, the results of these

studies suggest that personality traits can be changed, or at least processes of change can be initiated, through various psychological interventions.

But despite these first promising indications, a main limitation of previous non-clinical intervention research is that the few existing intervention studies included only short follow-up periods of a few weeks or months. Also, interestingly, a recent study, in which participants did not receive any intervention, found that in large part, individual's volitional personality change desires did not predict actual change in the desired direction after 6-months or 1-year (Baranski et al., 2020). So, it remains unclear whether the intended personality changes are permanent or merely reflect temporary state-like shifts in personality traits that return to baseline after an extended period of time. Therefore, the aim of the present study is to investigate the longer-term maintenance effects of the changes achieved by a digital intervention to change personality traits (Stieger et al., 2021) until one year after the end of the intervention.

The Potential of Digital Applications for Intervention Efforts

Over the last decade, personality interventions have been successfully implemented using web apps and emails (e.g., Hudson & Fraley, 2015; Hudson et al., 2019). In addition, studies have used text-messaging on smartphones to deliver personality change interventions. In contrast to web-apps and e-mail-based interventions, a personality change intervention using text-messaging and chatbots has the advantages of immediate engagement, easy accessibility, and the potential for delivering personalized reminders in people's daily lives irrespective of time and place (cf. Allemand & Stieger, in press). In recent years, smartphone apps, which use chatbots to deliver personality change interventions, have received much attention. Smartphone apps offer an appealing and novel way to assist people in their efforts to change their personality traits (Allemand & Flückiger, 2022; Allemand & Stieger, in press). A particularly promising approach are chatbot-based interventions with an automated delivery of interventional components. Such digital interventions can be used to intervene more

frequently and intensively in people's everyday lives, since most people usually have their smartphones with them. While people may meet a real coach or counselor in person once a week or twice a month, a digital coach is always there to advise, support, and coach wherever people are. For instance, a digital coach can encourage self-reflection by asking questions, can send suggestions for behavioral and other activities or provide people with knowledge for their daily lives.

The use of mobile apps as a form of intervention also offers the opportunity to collect data of people in their everyday life. Apps can include self-report ambulatory assessments that ask people to report their current behaviors, thoughts, feelings, and situations multiple times per day (Allemand & Stieger, in press; Trull & Ebner-Priemer, 2014). Ambulatory assessments provide the opportunity for automatic feedback on progress and early indications of intervention success or failure. In addition to self-reports, smartphones' technical abilities and proximity to their users enable the collection of objective data on behavioral and contextual indicators (such as mobility and activity patterns) through mobile sensing (Beierle et al., in press; Harari et al., 2020). In sum, digital interventions through mobile apps are scalable, cost-effective, and easily accessible to a wide range of people, making them a low-threshold intervention option.

Personality Trait Change Through Text-Messaging and Chatbot-Based Interventions

Initial work has taken advantage of digital interventions to examine the malleability of personality traits. To the best of our knowledge, only three smartphone-based interventions for personality trait change exist so far (cf. Allemand & Stieger, in press). First, two studies with a total of 255 participants were conducted to test the effects of a 2-week digital coaching intervention delivered via text messaging (Stieger, Wepfer, et al., 2020). Participants were given the option to focus on either self-discipline or openness to action, both of which are facets of different personality traits. They received two text messages per day that contained reminders to complete implementation intentions, self-reflection tasks, psychoeducation, and

individual feedback. The results indicated that participants selected the personality facets they scored lower in at the beginning of the intervention. Participants who chose to focus on an increase in self-discipline showed a greater increase in this area compared to their changes in openness to action and participants who chose to focus on an increase in openness to action showed a greater increase in this facet compared to their changes in self-discipline. The improvements sustained even after the intervention ended, as evidenced by the two and six-week follow-ups. However, it remains unclear if these changes are long-lasting or will eventually revert over time.

Second, the smartphone application MindHike is a 7-week chatbot-based intervention that supports and guides people who would like to improve their self-control with education, self-reflection, and behavioral tasks (Allemand et al., 2020). The MindHike application was used in a two-arm randomized controlled trial (RCT) ($N = 86$) to test the effects of the digital self-control coaching intervention to target self-control and physical activity (Stieger et al., 2023). The results of the study suggest significant overall increases in self-reported physical activity and objectively measured daily steps as well as increases in self-control. Participants in the self-control treatment group showed greater increases in physical activity as compared to participants in the active comparison group. These initial results are encouraging and need to be replicated in large-scale RCT's.

Third, a study examined the effects of a 3-month digital intervention called PEACH (PErsonalitycoACH) designed to assist people who want to change one of the Big Five personality traits (Stieger et al., 2018). During the three-month period, participants interacted with a chatbot twice a day and received education, behavioral tasks, feedback, encouragement, and support. The intervention provided micro-interventions, which were small techniques to help people change their thoughts, feelings, and behaviors in everyday life and maintain the change process. A randomized controlled trial was conducted on a large sample of adults ($N = 1523$) to test the effectiveness of the intervention in changing

personality traits (Stieger et al., 2021). The results indicated that participants who received the intervention reported greater changes than those who waited one month before starting the intervention (i.e., the control group). The changes aligned with the participants' self-selected goals for change and were significant for those who wanted to increase or decrease their personality trait levels. Observers, such as friends, family members, or intimate partners, also detected significant but smaller changes in participants who wanted to increase their trait levels but not in those who wanted to decrease them. These changes persisted up to three months after the intervention ended (see also Olaru et al., 2022 for a more fine-grained picture of the intervention effects). The current study reports the follow-up effects one year after the end of the PEACH intervention to examine the stability effects of the achieved changes over a longer follow-up period.

Longer-Term Maintenance Effects of Personality Trait Change Interventions

Current research on personality trait change through non-clinical interventions is limited by the fact that most existing digital and non-digital interventions have relatively short follow-up periods of only a few weeks or a few months. Hence, it is an open question whether changes through interventions are permanent or merely reflect temporary shifts in personality traits that return to baseline after an extended time. A fundamental and yet unanswered question of the previous above-mentioned studies is if observed changes in personality traits, which occur during the intervention, only indicate state-like, ephemeral changes in behaviors or feelings that depend on a person's situation and motives at a particular time (Roberts et al., 2017; Stieger et al., 2022). Longer-term follow-up assessments of personality trait change are required to address this fundamental question. If the effect of the intervention fades when the intervention ends, then one would assume that the intervention only leads to temporary shifts in personality traits. Although virtually nothing is known about whether personality trait changes achieved through digital interventions persist over time or revert to their baseline, preliminary evidence from the clinical literature suggests that longer-term changes can be

achieved. A metanalytic review of 207 clinical intervention studies found no marked decline in the effect of therapy on personality traits during the follow-up period (Roberts et al., 2017). Indeed, the results based on follow-ups of one or more years after treatment suggest that changes in personality traits, particularly decreases in neuroticism, tend to be maintained for relatively long periods after therapy. To the best of our knowledge, only one non-clinical 10-week intervention with weekly sessions examined the long-term effects to change personality traits (Martin-Allan et al., 2019). The results of the 4-year follow-up indicate that the achieved personality changes were still present four years after the original intervention (Martin et al., 2014). However, these results are limited by the fact that the original study ($N = 54$) and the follow-up study ($N = 25$) had very small sample sizes.

One could expect that achieved personality changes can either be maintained beyond the course of intervention, continue in the desired direction, or revert to their baseline after the end of the intervention. There are several reasons or mechanisms why individuals might be able to maintain their achieved personality changes or even continue to change in the desired direction. First, during the intervention, individuals may have become aware of improvements in their desired personality traits and related experiences and behaviors (Hudson, Derringer, et al., 2019), which in turn might have triggered a self-driven commitment to further development. This realization could have led to increased confidence, driven by positive outcomes resulting from their altered behaviors. Also, the satisfaction derived from observing positive changes could have functioned as a motivational catalyst, propelling them to persist in their journey of ongoing improvement (Hudson & Fraley, 2016; Olaru et al., 2023). Second, the educational inputs, continuous feedback, reflection tasks, and daily experiences during the intervention may have provided individuals with a better understanding of themselves and their own personality traits, which might have equipped them with the necessary skills to continue working into the desired direction beyond the intervention. Third, repeatedly expressing new thoughts, feelings, and behaviors during the intervention may have

cultivated new habits and these new habits may become integrated into daily routines, supporting sustained personality changes beyond the intervention (Allemand & Flückiger, 2017; Wrzus & Roberts, 2017). Fourth, individuals may cultivate an ecosystem that fosters their journey towards sustained personality change. During the intervention, individuals might have forged a robust support network comprising friends and family, creating a foundation that not only aids in reinforcing achieved personality changes but also offers essential encouragement. For instance, when individuals receive positive feedback from close others regarding their newly adopted behaviors, it can strengthen the reinforcement of attained personality changes and support the ongoing maintenance of these changes (Wrzus & Roberts, 2017). Moreover, individuals may actively seek out opportunities and environments that align with their targeted personality changes, which may be coupled with the initiation or continuation of connections with individuals who exemplify their desired personality traits (Allemand & Flückiger, 2022; Wrzus & Roberts, 2017).

However, without ongoing interventional inputs and reinforcement by a (digital) coach, it is also possible for individuals to revert to their baseline after the end of the intervention. First, individuals may not experience lasting changes in their selected personality traits as they might find that the intervention had limited impact on their thoughts, feelings and behaviors. Thus, they might not be motivated to continue working in their desired direction and adhere to their usual routines and behaviors without significant deviation. Second, individuals may encounter challenges (e.g., lack of time or other priorities in certain situations) in maintaining consistency when applying new behaviors across various contexts. This struggle may hinder their ability to transition short-term changes into lasting changes in their personality traits. The difficulty in incorporating the recommended behavioral tasks into their daily routine may culminate in feelings of frustration or disappointment, which in turn may reduce their motivation to work towards their goal. A

related factor might be persistence versus lack of persistence, as individuals differ in their persistence in (change) goal pursuit (Brandstätter & Bernecker, 2022). Third, as external factors play a significant role in shaping the trajectory of personality changes, the expectations and reactions of others may exert a considerable influence on individuals, potentially prompting them to revert to their familiar patterns of thoughts, feelings, and behaviors (Wrzus & Roberts, 2017). Finally, when individuals encounter challenges in working towards their desired changes, they might shift their focus towards self-acceptance. This redirection of focus involves acknowledging the current personality trait levels and embracing it, even if it does not fully align with the envisioned personality changes, which can lead to a reduced drive to persistently work towards desired personality change. To summarize, it is necessary to investigate the longer-term effects of personality change interventions.

The Current Study

The goal of the present study was to investigate if achieved personality changes as a result of the 3-month digital intervention PEACH (Stieger et al., 2021) can be maintained or even continue in the desired direction until one year after the end of the intervention or if they revert to their baseline. This study had two specific research questions:

First, do participants of the 1-year follow-up differ from those who did not complete the 1-year follow-up? This research question relates to attrition, which is a common phenomenon in longitudinal studies. Attrition analyses from the original study (Stieger et al., 2021) suggested small differences in personality trait levels in terms of effect sizes between those who completed one, two, or three assessments (i.e., pretest, posttest, 3-month follow-up). For this research question, we tested group differences between participants who completed the posttest and/or the 3-month follow-up but did not complete the 1-year follow-up and participants who completed the 1-year follow-up.

Second, can personality trait change be maintained until the 1-year follow-up? Results from the original study (Stieger et al., 2021) have shown that most personality trait changes achieved during the intervention were stable from posttest to the 3-month follow-up and neuroticism continued to decrease after the intervention. In this follow-up study, we tested if achieved personality changes as a result of the 3-month digital coaching intervention PEACH (Stieger et al., 2021) can be maintained or even continue in the desired direction until one year after the end of the intervention or if they revert to their baseline. To achieve sufficient power and sample size for the current analyses, we focus on the three largest intervention groups (i.e., goals to increase in extraversion, decrease in neuroticism, increase in conscientiousness) when presenting results. Moreover, we combine participants who wanted to “increase” in one of the personality traits or “decrease” in one of the traits in collapsed samples for the analyses. In additional analyses, we also explored changes in personality facets between the posttest and the 1-year follow-up assessment.

Method

Participants and Procedure

For the analyses, we used two samples. The Intent-to-treat (ITT) sample¹ included all participants who gave informed consent, passed the screening assessment, and completed the pretest personality assessment ($N = 1\,523$). The Completer sample included all participants who provided data at the 1-year follow-up assessment ($N = 157$). Participants of the Intent-to-treat sample were on average 24.99 years old ($SD = 6.57$) and 47.7% were female. Of all participants, 48.8% were students, 22.1% working full-time, 17.9% working part-time, 0.2% home-maker, 0.2% retired, and 2% were currently not working. With respect to the highest level of education, most participants had a general qualification for university entrance (40.6%), 24% had a Bachelor’s degree, 13.2% a Master’s degree, 3.4% were secondary

¹ Intent-to-treat (ITT) analyses are vital as they reflect real-world scenarios where adherence varies between participants. Also, they avoid overestimating the effects of the intervention and provide a more conservative assessment of the intervention impact.

school graduates, 8.4% completed vocational training and education, 1.4% had a PhD, and 0.3% completed primary school. Also, 47.6% were currently in a relationship or married. In terms of the self-selected personality change goals, most participants desired to decrease in neuroticism (26.6%), increase in conscientiousness (26.1%), or increase in extraversion (24.6%). Others desired to increase in openness (7.4%), decrease in agreeableness (6.4%), increase in agreeableness (4.1%), decrease in conscientiousness (2.6%), decrease in openness (1.8%), or decrease in extraversion (0.2%).

The study protocol of the trial was approved by the Ethics Committee of the Philosophical Faculty of the University of Zurich (No. 17.8.4; Date of approval: August 31st, 2017). Personality traits were measured entirely online before the intervention (pretest), after the 3-month intervention (posttest), 3-month and 1-year after the end of the intervention. For the 1-year follow-up assessment, we asked our participants after the end of the intervention if they would be interested in leaving their e-mail addresses to be contacted one year later for another assessment. Participants did not receive additional monetary compensation for the 1-year follow-up assessment. All participants received the intervention of their choice depending on their self-selected personality change goal. At the beginning of the study, participants were randomized in two treatment groups: The waitlist control group or the intervention group. The only difference between the waitlist control group and the intervention group is that the waitlist control group had a one-month waiting period before the start of the intervention. In this study, the focus is not on differential effects between these two treatment groups as they are reported in a prior publication (see Stieger et al., 2021). However, treatment group (0 = waitlist control group, 1 = intervention group) was added as a control variable in additional analyses to test for the robustness of the effects. The procedure of the study is also depicted in Supplementary Figure 1. A detailed report of the study design, sample size calculation, recruitment process, and measures, intervention features, contents,

techniques, and the PEACH smartphone application can be found in the intervention study protocol (Stieger et al., 2018).

Digital Personality Change Intervention

The digital intervention for personality change used a chatbot via the PEACH smartphone application (available on Android and iOS). The chatbot provided daily guidance and support, offering information, education, feedback, and encouragement to help people achieve their personality change goals (Stieger et al., 2018). The intervention was based on a common change factors model, which identifies four key factors that should be targeted in interventions for effective personality change (Allemand & Flückiger, 2017; 2022). The first factor involves increasing people's awareness of their desire to change, as changes are most effective when individuals are aware of a discrepancy and their need for change. The second factor involves utilizing individuals' resources to foster positive feedback and expectations. The third factor involves targeting reflective processes to help individuals better understand their underlying motivations, expectations, and assumptions to gain insight. Finally, the fourth factor involves targeting behavioral processes of mastery to help individuals practice new behaviors and gradually increase their engagement in new activities outside their comfort zone. By integrating and optimizing all four change factors, the effects of personality change interventions can potentially be maximized (Allemand & Flückiger, 2017; 2022).

Measures

Personality change goals. At pretest, participants chose one out of nine change goals for the intervention. Change goals included all Big Five traits in both directions except for neuroticism (only decreases were possible). To help participants with the goal selection, they received descriptions of normal characteristics of individuals with high versus low levels in each trait. For example, for the goal to increase in extraversion: "I want to be more extroverted, which means to be more sociable; to have more energy and zest for action; to be less quiet; to be more active and more enterprising; to take the lead more often: to take

decisions in groups more often”. The present forced-choice format to assess personality change goals is inspired by other measures of goals to change specific traits (see Baranski et al., 2017; Hudson & Fraley, 2015; Hudson & Roberts, 2014; Robinson et al., 2015). In Supplementary Table 1 in Stieger et al. (2020) we provide the nine change goals and their detailed descriptions used in this study. Details on differences between personality change goal groups at pretest are also reported in Stieger et al. (2020).

Big Five personality traits. Personality traits and facets were measured four times (pretest, posttest, 3-month follow-up, 1-year follow-up) with the 60-item Big Five Inventory-2 (BFI-2; Soto & John, 2017). Participants indicated how strongly they agree or disagree with each statement on a 5-point Likert scale ranging from *1 = strongly disagree* to *5 = strongly agree*. Cronbach’s alphas ranged across the measurement occasions between 0.86 and 0.88 for conscientiousness, between 0.83 and 0.89 for openness to experience, between 0.86 and 0.88 for extraversion, between 0.81 and 0.88 for neuroticism, and between 0.79 and 0.83 for agreeableness.

Control measures. Following the statistical approach of the original study (Stieger et al., 2021) and to test for the robustness of the effects, we included age, gender (0 = female, 1 = male), treatment group (0 = waitlist control group, 1 = intervention group²), and conversation style of the chatbot (0 = conversational agent with low self-awareness, 1 = conversational agent with high self-awareness³; see Stieger et al., 2018) as control variables in additional analyses.

² The only difference between the waitlist control group and the intervention group is that the waitlist control group had a one-month waiting period before the start of the intervention. Differential effects between the two treatment groups specifically during the 1-month period are reported in an earlier publication using this data (Stieger et al., 2021) and not the focus of the present study.

³ The conversational agent with high self-awareness presented itself as a tangible and present entity by actively referring to itself (e.g., “May I help you?”). The conversational agent with low self-awareness refrained from referring to itself (e.g., “Do you need help?”) and remained less tangible as an entity, fading the anthropomorphic identity of the conversational agent into

Statistical Analysis

For all analyses, we focused on both the Intent-to-treat sample (ITT; $N = 1,523$), which includes all available data, and the Completer sample, which only includes data of all participants who completed the 1-year follow-up ($N = 157$). Longitudinal multilevel models (Bolger & Laurenceau, 2012) and the lme4 package (Bates et al., 2014) in R (R Core Team, 2022) with random intercepts and fixed slopes were used to investigate the maintenance effects. The data structure included repeated assessments of personality traits (Level 1: Time) nested within participants (Level 2: Person). To be consistent across different analyses and to be able to compare changes in personality traits over time between change goals, models with a linear time terms were fitted. All models were estimated with maximum likelihood (ML) to address missing data. In reporting the results, we focus on the fixed effects.

For both samples (ITT sample; completer sample) linear conditional change models were fitted to test changes from pretest, to posttest, to the 3-month follow-up, and to the 1-year follow-up assessment. Time was defined as 0 (pre), 1 (post), 2 (3-month), and 5 (1-year) to capture the different time intervals. These analyses were controlled for age, gender, treatment group and conversation style. Separate multilevel analyses were conducted for all three change goals. In addition, we collapsed the data across participants who wanted to increase on a trait and across participants who wanted to decrease on a trait to examine the combined changes from pretest to the 1-year follow-up.

To test maintenance effects between the posttest (directly after the intervention) to the 3-month follow-up, and the 1-year follow-up, we again conducted the comparable multilevel analyses using the posttest, 3-month follow-up, and 1-year follow-up assessment. For these analyses, time was defined as 0 (post), 1 (3-month), and 4 (1-year) to capture the different time intervals.

the background. Results reported in the original article (Stieger et al., 2021) revealed that the conversational style did not moderate the effects of the intervention.

Second, linear conditional change models were fitted to test for differential effects between the change goals. A dummy variable for change goal (1 = participants in one specific change goal, 0 = all other participants) and a time by change goal interaction term were added as Level 2 predictors to investigate whether the effects differed between the change goals. Again, age, gender, treatment group, and conversation style were added as covariates to the multilevel models to test for the robustness of the results.

Transparency and Openness

The present secondary data analyses of this study were exploratory and not pre-registered. Data and analyses code are available at the OSF repository and can be accessed at https://osf.io/n6xdg/?view_only=a7200d4cdb28477683d10216de903175. Previous articles have used the dataset to examine the effects of the digital intervention on personality traits (Stieger et al., 2021) and personality facets and nuances (Olaru et al., 2022) during and until three months after the end of the intervention, predictors of personality change goals at pretest (Stieger, Eck et al., 2020), and associations between changes in personality traits and changes in life satisfaction (Olaru et al., 2023), associations between personality states and situational cues (Lindner et al., 2023), and associations between personality states and smartphone sensing (Rüegger et al., 2020). Data from the 1-year follow-up assessment are unique to this study.

Results

Attrition Effects

Of the entire sample ($N = 1'523$), $n = 554$ participated at the posttest directly after the end of the intervention, $n = 437$ at the 3-month follow-up, and $n = 157$ at the 1-year follow-up. The sample sizes at each measurement occasion and for the change goals are shown in Table 1. Attrition analyses were conducted to test group differences between participants who completed the posttest and/or the 3-mo follow-up but did not complete the 1-year follow-up ($n = 430$) and participants who also completed the 1-year follow-up ($n = 157$). The results of

independent *t*-tests showed that participants who completed the 1-year follow-up ($M = 3.78$, $SD = 0.68$) were significantly more open to experiences at the posttest compared to those who did not complete the 1-year follow-up ($M = 3.65$, $SD = 0.70$); $t(552) = -1.98$, $p = .048$, $d = 0.19$). Also, participants who completed the 1-year follow-up ($M = 2.53$, $SD = 0.56$) were significantly less neurotic at the posttest compared to those who did not complete the 1-year follow-up ($M = 2.65$, $SD = 0.66$); $t(317.70) = 2.33$, $p = .020$, $d = 0.20$). In addition, participants who completed the 1-year follow-up ($M = 3.94$, $SD = 0.49$) were significantly more agreeable at the posttest compared to those who did not complete the 1-year follow-up ($M = 3.77$, $SD = 0.49$); $t(552) = -3.60$, $p < .001$, $d = 0.35$). Finally, participants who completed the 1-year follow-up ($M = 3.66$, $SD = 0.62$) were significantly more conscientious at the posttest compared to those who did not complete the 1-year follow-up ($M = 3.49$, $SD = 0.65$); $t(552) = -2.72$, $p = .003$, $d = 0.27$). They did not differ significantly with respect to age, gender, extraversion, or conversational type of the chatbot.

Maintenance Effects

In the main analyses, we tested if achieved personality changes as a result of the 3-month digital intervention PEACH (Stieger et al., 2021) were maintained or even continued in the desired direction until one year after the end of the intervention or if they revert to their baseline. Descriptive statistics and effect sizes across time are shown in Table 1 for the ITT sample and in Supplementary Table 1 for the Completer sample. The results of the multilevel analyses examining changes across the four measurement occasions (pretest, posttest, 3-mo follow-up, 1-year follow-up) are shown in Table 2 for the ITT sample and in Supplementary Table 2 for the Completer sample. As shown with both samples, participants showed significant changes in the desired direction up until the 1-year follow-up assessment. The results of the multilevel analyses examining changes after the end of the intervention between the posttest, the 3-month follow-up, and the 1-year follow-up are shown in Table 3 for the ITT sample and in Supplementary Table 3 for the Completer sample. As shown with both

samples, participants who wanted to decrease in neuroticism showed another significant decrease after the end of the intervention to the 1-year follow-up assessment. Also, the collapsed group of all participants who wanted to decrease on a trait also showed another significant decrease until the 1-year follow-up assessment. Participants who desired to increase on a trait did not show significant changes after the end of the intervention but remained stable. Figure 1 depicts the maintenance effects in standard deviations using the ITT sample and Supplementary Figure 2 using the Completer sample. As shown in Supplementary Table 4-7, changes in specific personality facets between the posttest and the 1-year follow-up are consistent with the maintenance effects found in the trait domains.

Furthermore, we tested a series of multilevel models with time by change goal interaction effects. That is, we examined whether participants showed greater changes in personality traits they wanted to change compared to those who did not want to change the same trait until the 1-year follow-up assessment. The results of these multilevel analyses are shown in Table 4 for the ITT sample and in Supplementary Table 8 for the Completer sample. As shown with both samples, changes across the four measurement occasions (pretest, posttest, 3-mo follow-up, 1-year follow-up) were significantly greater for participants who wanted to change in the respective traits as compared to those who did not want to change in those traits. In addition, after the end of the intervention between the posttest and the 1-year follow-up assessment, participants who wanted to decrease in neuroticism showed greater decreases in neuroticism compared to participants who did not want to decrease in neuroticism. Participants who wanted to increase in extraversion or in conscientiousness remained stable after the end of the intervention but did not show significantly greater changes in those traits compared to the other participants. Again, these effects can be found in both samples. The interaction effects from the posttest to the 1-year follow-up assessment are shown in Table 5 for the ITT sample and in Supplementary Table 9 for the Completer sample.

Discussion

In the realm of personality development, changing personality traits through interventions has gained significant attention. Initial research indicates that both clinical and non-clinical interventions can alter personality traits, as shown by previous studies (e.g., Hudson & Fraley, 2015; Jackson et al., 2021; Roberts et al., 2017). Moreover, research involving individuals with mental health issues reveals that clinical interventions, beyond addressing symptoms, also bring about positive changes in personality traits (Sauer-Zavala et al., 2020; Stieger et al., 2022). Although there is increasing interest in personality trait change through interventions, there is virtually no research that has examined the long-term effects of personality trait change through nonclinical psychological interventions because previous studies have included only short follow-up periods of a few weeks or months. To contribute to this research, the goal of the present study was to examine whether the changes produced by a digital intervention are permanent or only reflect temporary shifts. In doing so, we asked participants who had taken part in a digital intervention to change one personality trait (Stieger et al., 2021) to complete another assessment one year after the intervention.

Two important research questions were examined in this 1-year follow-up study. The first question refers to attrition effects. Many participants were lost during the study. From the originally 1,523 participants who signed in for the study, 36% participated at the posttest at the end of the intervention, 29% participated at the 3-month follow-up, and only 10% participated in the 1-year follow-up assessment. Indeed, loss of participants is a common and problematic issue in longitudinal studies such as intervention studies (Linardon & Fuller-Tyszkiewicz, 2020; Young et al., 2006). It is possible that attrition is even greater when assessments and interventions are conducted entirely digitally and without face-to-face contact with participants, as was the case in this study. Attrition is problematic because it reduces the sample size and thus also may reduce statistical power. Moreover, if the loss of participants is selective, it can lead to non-responsive bias which affects the validity of the findings (Twisk & de Vente, 2002; Young et al., 2006). The results of our attrition analyses

have shown that participants who completed the 1-year follow-up differed on personality traits from those who did not complete the 1-year follow-up. Particularly, they are more open to experience, more agreeable, more conscientious, and less neurotic than those who did not complete the 1-year follow-up. Similar to the findings with respect to the 3-month follow-up (Stieger et al., 2021), the results suggest small differences in terms of effect sizes. Although the current results show little difference between those who completed the 1-year follow-up and those who did not, future personality change intervention studies should employ strategies to prevent attrition. One strategy, for instance, would be to combine digital coaching with face-to-face coaching with the physical presence of a coach (e.g., in person or online) and accompany the change efforts in everyday life with digital coaching.

The main research question refers to maintenance effects of the achieved personality changes. The analyses were conducted with all available data (ITT sample) as well as data of all participants who completed the 1-year follow-up assessment (Completer sample). The results indicate that the changes reported in Stieger et al. (2021) remained stable or even changed further in the desired direction until the 1-year follow-up in both samples. Participants who wanted to increase in extraversion and conscientiousness did not show significant changes after the end of the intervention but remained stable. Also, after the end of the intervention until the 1-year follow-up assessment, participants of both samples who wanted to decrease in neuroticism showed another significant decrease. These results suggest that the achieved changes in personality traits through intervention remain stable or even continue to change. Overall, the current results provide further evidence to the idea that personality traits can be changed through clinical and non-clinical interventions (e.g., Hudson & Fraley, 2015; Jackson et al., 2021; Roberts et al., 2017; Stieger et al., 2022; Stieger, Wepfer, et al., 2020). The results suggest that the achieved changes seem permanent or continue and do not reflect temporary shifts that revert to baseline after one year. Interestingly, those participants who wanted to decrease on a personality trait, particularly in

neuroticism, showed continued changes from posttest to the 1-year follow-up. It is possible that decreases and increases in personality traits have differential consequences for the individual. Future research is needed to replicate the maintenance effects and to explore why neuroticism continued to decline while extraversion and conscientiousness remained stable. Research is also needed to examine which specific intervention strategies are most effective in helping people to achieve long-lasting changes.

Limitations and Future Directions

There are limitations of the present study that deserve attention in future research. It is important to acknowledge that the observed effects and outcomes of the intervention could potentially be influenced by the absence of participants who did not participate in the voluntary follow-up assessments after three months and one year including those who decided not to participate in the full 3-month intervention. We can only speculate why these individuals did not participate at the follow-up assessments. For example, the results might primarily apply to more open, emotionally stable, agreeable, and conscientious individuals as they were more likely to complete the 1-year follow-up assessment. Attrition is a common and problematic phenomenon in longitudinal studies that can undermine the validity of findings (Linardon & Fuller-Tyszkiewicz, 2020; Young et al., 2006). Loss of participants was a particular challenge for the present digital intervention study, which delivered the entire intervention without any in-person contact to participants and all outcome assessments were assessed entirely online. Also, there was no additional monetary compensation for the 1-year follow-up assessment in the present study. However, it is important to note that attrition was reasonable until the 3-month follow-up (Stieger et al., 2021). Meta-analyses on dropout rates in app-based health interventions (Meyerowitz-Katz et al., 2020) and smartphone-delivered interventions for mental health problems (Linardon & Fuller-Tyszkiewicz, 2000) show that attrition is generally high in digital interventions and significantly higher in trials that do not use an in-person enrollment method. Based on prior findings (e.g., Stieger et al., 2023), future

research may use tailored recruitment and follow-up strategies depending on individual conscientiousness levels. In addition, in the future, it would be interesting to examine differences in the attrition rate and maintenance effects between participants who receive a chatbot-based intervention, which aims to imitate a conversation with a real coach, and participants who receive a less interactive and less intensive digital intervention (e.g., e-mail- or web-based interventions) as these differences remain unclear to this date.

Second, the 1-year follow-up assessment only included self-reports to measure personality traits, while for the pretest to the 3-month follow-up we also had observer-reports (Stieger et al., 2021). Future research on the long-term maintenance effects of personality change interventions should use multimethod assessment approaches. For example, it would be interesting to use a variety of behavioral assessments techniques to examine the manifestation of personality traits and personality change in standardized conditions in the lab as well as in daily life.

Third, another limitation of this study is that we lack insights into the experiences of participants during the year after the end of the intervention. Incorporating more frequent and repeated assessments during this period could have yielded valuable insights into the specific behaviors, strategies, and contextual factors that contributed to the sustained or diminished personality changes observed. Such an investigation would have provided a comprehensive understanding of the dynamics underlying the post-intervention phase, enhancing our ability to identify critical mechanisms that foster long-term personality changes. Consequently, future research could consider implementing extended and more frequent follow-up assessments.

Finally, a criticism regarding self-reported changes is that participants may have changed their behaviors and experiences based on what they think the research is about. The impact of demand effects is not limited to personality change interventions, but is a challenge commonly faced in research related to psychotherapy, counseling, and coaching. It is difficult

to completely eliminate these effects. However, it is important for future studies on personality change interventions to consider the potential impact of demand characteristics and factor them in their research design.

Conclusion

This research makes an important contribution to the study of personality trait change through nonclinical psychological interventions by providing initial evidence of the 1-year stability of the changes achieved. This study also highlights the problem of attrition, which is common in longitudinal research, as only a small proportion of the original participants provided data for the 1-year follow-up and differed from those who did not participate in the follow-up, albeit with small effect sizes. The most interesting finding is that the intended changes reported in the original study (Stieger et al., 2021) have remained stable or even continued to change in the desired direction, suggesting that the achieved personality trait changes were not just temporary shifts.

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Table 1. *Descriptive Statistics and Effect Sizes Across Time – Intent-to-treat Sample*

Outcome	Change goal	Pretest (T1)			Posttest (T2)			3-month follow-up (T3)			1-year follow-up (T4)			Effect sizes			Test-retest		
		<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	<i>N</i>	<i>M</i>	<i>SD</i>	<i>d</i> _{T1, T2}	<i>d</i> _{T1, T4}	<i>d</i> _{T2, T4}	<i>r</i> _{T1, T2}	<i>r</i> _{T1, T4}	<i>r</i> _{T2, T4}
Extraversion	E +	375	2.82	0.62	110	3.07	0.58	96	3.08	0.61	32	3.07	0.66	0.51	0.48	0.00	0.69	0.64	0.84
	Other	1147	3.39	0.66	444	3.38	0.62	341	3.37	0.65	125	3.43	0.59	-0.03	0.08	0.11	0.81	0.74	0.76
Neuroticism	N -	405	3.11	0.58	169	2.91	0.60	137	2.81	0.61	57	2.57	0.63	-0.39	-0.75	-0.60	0.61	0.23	0.55
	Other	1117	2.54	0.61	385	2.50	0.61	300	2.51	0.63	100	2.38	0.55	-0.08	-0.28	-0.24	0.65	0.55	0.65
Conscientiousness	C +	397	3.00	0.62	140	3.19	0.63	101	3.24	0.59	34	3.31	0.60	0.35	0.71	0.28	0.61	0.75	0.77
	Other	1125	3.60	0.64	414	3.65	0.60	336	3.65	0.57	123	3.77	0.64	0.11	0.34	0.25	0.73	0.70	0.69
Respective trait	Increase	948	3.00	0.65	319	3.20	0.64	252	3.23	0.64	79	3.27	0.65	0.39	0.52	0.18	0.68	0.73	0.81
	Decrease	574	3.38	0.70	234	3.19	0.72	184	3.07	0.73	75	2.89	0.84	-0.39	-0.78	-0.64	0.76	0.60	0.79

Note. Outcomes = respective traits participants wanted to change. T1 = pretest; T2 = posttest; T3 = 3-month follow-up, T4 = 1-year follow-up. E + = goal to increase in extraversion; N - = goal to decrease in neuroticism; C + = goal to increase in conscientiousness; increase = collapsed sample of all participants who wanted to increase on a trait; decrease = collapsed sample of all participants who wanted to decrease on a trait. The effect size across time was a standardized mean difference and was calculated by subtracting the mean of the later assessment from the mean of the earlier assessment and dividing this raw mean difference by the standard deviation of the raw scores at the earlier assessment and taking the test-retest correlation into account (Morris & DeShon, 2002).

Table 2. *Changes From Pretest to 1-Year Follow-Up – Intent-to-treat Sample*

Change goal	Increase in extraversion (<i>n</i> = 375)		Decrease in neuroticism (<i>n</i> = 406)		Increase in conscientiousness (<i>n</i> = 397)		Increase (<i>n</i> = 948)		Decrease (<i>n</i> = 575)	
Fixed effects	Without cov.	With cov.	Without cov.	With cov.	Without cov.	With cov.	Without cov.	With cov.	Without cov.	With cov.
Intercept										
Estimate (SE)	2.86***(0.03)	2.88***(0.13)	3.09***(0.03)	3.16***(0.11)	3.00***(0.03)	2.87***(0.12)	3.01***(0.02)	2.94***(0.09)	3.36***(0.03)	3.06***(0.11)
95% CI	2.79; 2.92	2.62; 3.14	3.03; 3.14	2.94; 3.37	2.94; 3.06	2.63; 3.12	2.97; 3.05	2.77; 3.11	3.30; 3.41	2.85; 3.28
Time										
Estimate (SE)	0.07***(0.01)	0.07***(0.01)	-0.11***(0.01)	-0.11***(0.01)	0.08***(0.01)	0.08***(0.01)	0.07***(0.01)	0.07***(0.01)	-0.10***(0.01)	-0.10***(0.01)
95% CI	0.04; 0.09	0.04; 0.09	-0.14; -0.09	-0.14; -0.09	0.06; 0.11	0.06; 0.11	0.06; 0.09	0.06; 0.09	-0.12; -0.08	-0.12; -0.08

Note. * $p < .05$, ** $p < .01$, *** $p < .001$; covariates: age, gender, treatment group and conversation style; increase = collapsed sample of all participants who wanted to increase on a trait; decrease = collapsed sample of all participants who wanted to decrease on a trait.

Table 3. *Changes From Posttest to 1-Year Follow-Up – Intent-to-treat Sample*

Change goal	Increase in extraversion (<i>n</i> = 118)		Decrease in neuroticism (<i>n</i> = 178)		Increase in conscientiousness (<i>n</i> = 141)		Increase (<i>n</i> = 336)		Decrease (<i>n</i> = 248)	
Fixed effects	Without cov.	With cov.	Without cov.	With cov.	Without cov.	With cov.	Without cov.	With cov.	Without cov.	With cov.
Intercept										
Estimate (SE)	3.06***(0.06)	3.21***(0.20)	2.91***(0.04)	2.88***(0.16)	3.18***(0.05)	2.89***(0.18)	3.19***(0.03)	3.04***(0.13)	3.19***(0.05)	2.78***(0.16)
95% CI	2.95; 3.16	2.81; 3.62	2.82; 2.99	2.56; 3.20	3.09; 3.28	2.52; 3.25	3.12; 3.26	2.79; 3.29	3.09; 3.28	2.47; 3.10
Time										
Estimate (SE)	0.01(0.01)	0.01(0.01)	-0.06***(0.01)	-0.07***(0.01)	0.01(0.02)	0.01(0.01)	0.01(0.01)	0.01(0.01)	-0.05***(0.01)	-0.05***(0.01)
95% CI	-0.01; 0.04	-0.01; 0.04	-0.09; -0.04	-0.09; -0.03	-0.02; 0.05	-0.02; 0.05	-0.00; 0.03	-0.00; 0.03	-0.07; -0.03	-0.07; -0.03

Note. * $p < .05$, ** $p < .01$, *** $p < .001$; covariates: age, gender, treatment group, and conversation style; increase = collapsed sample of all participants who wanted to increase on a trait; decrease = collapsed sample of all participants who wanted to decrease on a trait.

Table 4. *Changes From Pretest to 1-Year Follow-Up Across Change Goals – Intent-to-treat Sample*

Change goal Fixed effects	Increase in extraversion		Decrease in neuroticism		Increase in conscientiousness	
	Without cov.	With cov.	Without cov.	With cov.	Without cov.	With cov.
Intercept						
Estimate (SE)	3.39***(0.02)	3.29***(0.07)	2.53***(0.02)	2.81***(0.06)	3.59***(0.02)	3.35***(0.06)
95% CI	3.36; 3.43	3.17; 3.42	2.50; 2.57	2.69; 2.92	3.55; 3.62	3.23; 3.48
Time						
Estimate (SE)	0.02**(0.01)	0.02**(0.01)	-0.02*(0.01)	-0.02*(0.01)	0.00(0.01)	0.00(0.01)
95% CI	0.01; 0.03	0.01; 0.03	-0.03; -0.00	-0.03; -0.00	-0.01; 0.02	-0.01; 0.02
Change goal						
Estimate (SE)	-0.54***(0.04)	-0.52***(0.04)	0.55***(0.03)	0.50***(0.03)	-0.59***(0.04)	-0.58***(0.04)
95% CI	-0.61; 0.47	-0.59; -0.44	0.48; 0.62	0.43; 0.56	-0.66; -0.52	-0.65; -0.51
Time by change goal						
Estimate (SE)	0.05***(0.01)	0.05***(0.01)	-0.10***(0.01)	-0.10***(0.01)	0.08***(0.01)	0.08***(0.01)
95% CI	0.02; 0.08	0.02; 0.08	-0.12; -0.07	-0.12; -0.07	0.05; 0.11	0.05; 0.10

Note. * $p < .05$, ** $p < .01$, *** $p < .001$; covariates: age, gender, treatment group, and conversation style.

Table 5. *Changes From Posttest to 1-Year Follow-Up Across Change Goals – Intent-to-treat Sample*

Change goal Fixed effects	Increase in extraversion		Decrease in neuroticism		Increase in conscientiousness	
	Without cov.	With cov.	Without cov.	With cov.	Without cov.	With cov.
Intercept						
Estimate (SE)	3.37***(0.03)	3.26***(0.09)	2.50***(0.03)	2.70***(0.09)	3.64***(0.03)	3.39***(0.09)
95% CI	3.31; 3.42	3.08; 3.44	2.44; 2.56	2.53; 2.87	3.58; 3.69	3.22; 3.56
Time						
Estimate (SE)	0.01(0.00)	0.01(0.01)	0.00(0.01)	-0.00(0.01)	0.01(0.01)	0.01(0.01)
95% CI	-0.00; 0.02	-0.00; 0.02	-0.02; 0.02	-0.02; 0.02	-0.01; 0.03	-0.00; 0.03
Change goal						
Estimate (SE)	-0.31***(0.06)	-0.28***(0.06)	0.41***(0.05)	0.35***(0.05)	-0.45***(0.06)	-0.45***(0.06)
95% CI	-0.44; -0.19	-0.41; -0.15	0.31; 0.52	0.24; 0.46	-0.56; -0.34	-0.56; -0.34
Time by change goal						
Estimate (SE)	0.00(0.02)	0.00(0.02)	-0.06*(0.02)	-0.06*(0.02)	0.00(0.02)	0.00(0.02)
95% CI	-0.03; 0.03	-0.03; 0.03	-0.10; -0.03	-0.10; -0.03	-0.03; 0.04	-0.03; 0.04

Note. * $p < .05$, ** $p < .01$, *** $p < .001$; covariates: age, gender, treatment group, and conversation style.

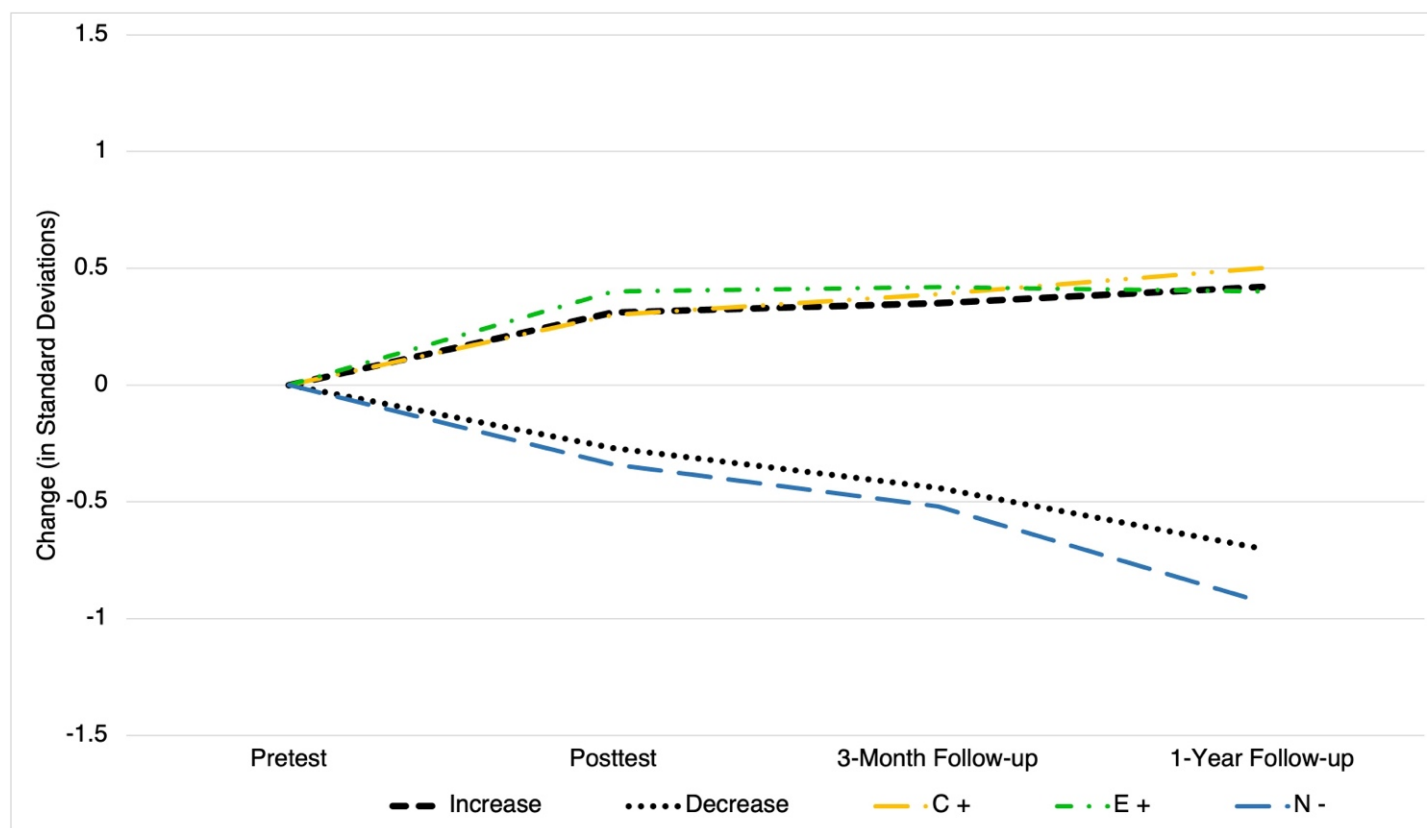
Figure 1. *Change in SD Over Time in Selected Personality Traits – Intent-to-treat Sample*

Figure 1. Change in *SD* over time in selected personality traits. The y-axis is the change in the outcome variable measured in *SD* units. Estimates for each time point for each outcome were calculated by subtracting the Pretest mean from the mean of the outcome at a specific time point and dividing by the *SD* of that outcome at Pretest. Positive values indicate an increase in the outcome variable and negative values a decrease in the outcome. Increase: average change in selected traits in participants with the goals to increase in extraversion and conscientiousness; Decrease: average change in selected traits in participants with goals to decrease in neuroticism; C+: average change in conscientiousness among people who wanted to increase in conscientiousness; E+: average change in extraversion among people who wanted to increase in extraversion; N-: average change in neuroticism among people who wanted to decrease in neuroticism.