Becoming More Conscientious or More Open to Experience? Effects of a Two-Week Smartphone-Based Intervention for Personality Change

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Abstract

Research indicates that it might be possible to change personality traits through intervention, but this clinical research has primarily focused on changing neuroticism. To date there are no established, proven techniques for changing other domains of personality, such as conscientiousness and openness. This research examined the effects of a two-week smartphone-based intervention to either change one facet of conscientiousness (i.e., self-discipline) or one facet of openness to experience (i.e., openness to action). Two intervention studies (total $N = 255$) with two active intervention groups for mutual comparisons were conducted. Results of self- and observer-reports showed that people who wanted to become more self-disciplined were less self-disciplined at pretest. Similarly, people who wanted to become more open to action were less open to action at pretest. The results showed that people who chose the self-discipline intervention showed greater increases in self-discipline and people who chose the openness to action intervention showed greater increases in openness to action compared to the other group. Changes were maintained until follow-up two and six weeks after the end of the intervention. Future work is needed to examine whether these personality changes are enduring or reflect temporary accentuation as a result of participation in the intervention.

Keywords: Personality change; conscientiousness; openness to experience; common change factors; smartphone-based intervention

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Conscientiousness is a personality trait that promotes success in school, work, health, and relationships. For example, research has shown that being conscientious is positively related to better school performance and academic achievement (Dumfart & Neubauer, 2016; Poropat, 2009; Trautwein, Lüdtke, Roberts, Schnyder, & Niggli, 2009), better job performance and occupational success (Barrick, Mount, & Judge, 2001; Dudley, Orvis, Lebiecki, & Cortina, 2006), better physical health (Hampson, Edmonds, Goldberg, Dubanoski, & Hillier, 2013; Luo & Roberts, 2015; Roberts, Walton, & Bogg, 2005; Deary, Weiss, & Batty, 2010), longevity (Deary, Batty, Pattie, & Gale, 2008; Kern & Friedman, 2008), and relationship quality and duration (Hill, Nickel, & Roberts, 2014; Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007). Openness to experience is another personality trait that predicts important outcomes in different domains of life. For example, openness has been linked to academic achievement (O'Connor & Paunonen, 2007), intellectual engagement (Ackerman & Heggestad, 1997; Hogan, Staff, Bunting, Deary, & Whalley, 2012), learning (von Stumm, 2018), and creative achievement in the arts and sciences (Kaufman et al., 2016).

Given the importance of conscientiousness and openness to experience, it is not surprising that becoming more conscientious or more open are common change goals for people. Indeed, research has shown that many people have the desire to change their personality traits (Baranski, Morse, & Dunlop, 2017; Hudson, Fraley, Chopik, & Briley, in press; Hudson & Roberts, 2014; Miller, Baranski, Dunlop, & Ozer, 2019; Robinson, Noftle, Guo, Asadi, & Zhang, 2015). Moreover, the desire to change conscientiousness and openness is not only prevalent among younger adults; older adults also express desires to change their personality (Hudson & Fraley, 2016a; Quintus, Egloff & Wrzus, 2017). Although many people want to intentionally change or modify some aspects of their personality, psychological interventions and their evaluations are lacking. In this article, we provide

preliminary evidence of the effects of a brief smartphone-based intervention to change one specific facet of conscientiousness (i.e., self-discipline) and one specific facet of openness to experience (i.e., openness to action).

Personality Change Through Intervention

Intended personality change refers to active and self-regulated efforts to change personality in the desired direction that is guided by intentions and goals for change (Allemand & Flückiger, 2017; Hudson & Fraley, 2017). Personality change in a desired direction includes being aware of a gap between the actual and desired personality, setting goals to change personality, and actively seeking opportunities to close this gap. A recent framework proposed three preconditions for self-regulated personality change (Hennecke, Bleidorn, Denissen, & Wood, 2014). First, people should consider personality trait change as necessary or desirable. Second, behavioral changes need to be considered feasible. Third, these behavioral changes have to become habitual in order to result in trait change. In the absence of a formal program, people may either choose rather informal self-change efforts without relying on the assistance from others (e.g., self-help groups, self-improvement) or choose a targeted psychological intervention with the assistance of a professional psychologist (e.g., counselor, coach, therapist). In the present research, the psychological intervention for intentional personality change was delivered via smartphone without personal contact to participants, thus reflecting a digital self-help intervention.

Intervention efforts for personality change require research designs that explicitly allow people to choose what they would like to change instead of randomizing them into a classical treatment group or a control group. These designs allow for the possibility to test potential selection effects, as it is possible that people want to increase on those traits which they perceive as too low, and decrease on traits they perceive as too high (Hudson & Roberts, 2014). Moreover, interventions for personality change may target different levels of personality since personality traits are thought to have a hierarchical structure and can be

ordered from broad to narrow (Allemand & Flückiger, 2017; Roberts, Lejuez, Krueger, Richards, & Hill, 2014). It is generally assumed that focusing on lower levels of a trait domain makes for a more effective strategy (Roberts, Hill, & Davis, 2017) which is one reason we decided to target facets of the Big Five domains of conscientiousness and openness.

The present work refers to self-discipline as a facet of conscientiousness, and openness to action as a facet of openness to experience (Costa & McCrae, 1995). Self-discipline is conceptualized as a capacity to suppress or inhibit behavioral responses in daily life, which do distract from achieving a certain goal. Instead, self-disciplined people show behaviors, which bring them closer to their goals (Allom, Panetta, Mullan, & Hagger, 2016; Dumfart & Neubauer, 2016). Becoming more self-disciplined entails the ability to repeatedly and effectively manage the conflict between a momentary impulse-driven goal with a small, gratifying short-term gain and a long-term goal with a larger gain, which requires effort and persistence (Duckworth & Gross, 2014). Individual differences in self-discipline are often shown in the context of an achievement setting and the presence of something tempting that has to be suppressed.[1]

Openness to action refers to an individual's tendency to choose novelty over the familiar and the capacity to effectively adapt to changes in life and the environment (Costa & McCrae, 1992; Moutafi, Furnham, & Crump, 2006; Turiano, Spiro, & Mroczek, 2012). Open people are more willing to try new approaches, tend to engage in a variety of different activities, and prefer new forms of stimulation whereas people with lower scores in openness

[1] In the present study we refer to the personality facet of self-discipline as included in the NEO-PI-R (Costa & McCrae, 1995; Ostendorf & Angleitner, 2004). Note that other terms such as effortful control, ego control, delay of gratification (developmental psychology), self-control, self-regulation (social psychology), impulsiveness, constraint (clinical psychology), or grit (personality psychology) may refer to similar facets of conscientiousness in other fields.

to action have harder times when things are changing and prefer to stick with the familiar routines. Becoming more open to action entails broadening one's focus, widening one's interests, and showing a wider variety of new and different behaviors. Individual differences in openness to action are typically shown in the context of unfamiliarity and with the opportunity to show new and unusual behaviors (Aluja, Garcia, & Garcia, 2003; Costa & McCrae, 1992).

Recent Work on Personality Change Through Intervention

Although it remains a controversial topic whether personality should be the focus of interventions (English & Carstensen, 2014), several conceptual frameworks on how to intervene on personality traits have been suggested lately (Allemand & Flückiger, 2017; Chapman, Hampson, & Clarkin, 2014; Magidson, Roberts, Collado-Rodriguez, & Lejuez, 2014; Martin, Oades, & Caputi 2014a; Roberts, Hill, & Davis, 2017). This line of conceptual work suggests that targeting specific behaviors and experiences in everyday life may be most successful for personality trait change. Specific personality expressions are variable and change from one situation to the other (cf. Noftle & Fleeson, 2015; Wrzus & Roberts, 2017) and are seen as more changeable and environmentally malleable compared to the broader and more enduring personality traits (Chapman et al., 2014; Magidson et al., 2014; Roberts et al., 2014). The basic idea is that accumulation of behavioral changes at the narrow level eventually leads to personality change at the broader trait level through bottom-up processes of change (Allemand & Flückiger, 2017; Wrzus & Roberts, 2017). This indicates that personality change can be best elicited through repeating behaviors that differ from typical, trait-like behavior (Roberts & Jackson, 2008; Roberts, 2018). As such, conceptual frameworks for personality change interventions have suggested to primarily target behaviors using a behavioral activation approach (Roberts, Hill, & Davis, 2017; Magidson et al., 2014). Another intervention approach would be to combine bottom-up change processes with top-down change processes (Allemand & Flückiger, 2017). For example, the step-wise process

model of intentional personality change coaching (Martin et al., 2014a) combines behavioral activation with other coaching aspects such as reflecting on behavioral changes or discussing one's change progress. Moreover, the TESSERA framework for personality development throughout adulthood (Wrzus & Roberts, 2016) posits that a combination of associative processes (e.g., behavioral changes and habit formation) and reflective processes (e.g., self-reflection) translates short-term, situational processes into long-term changes is the TESSERA framework (Wrzus & Roberts, 2016).

To date, only a handful of studies have investigated intended personality change. One line of work observed self-directed personality change as a function of having a desire to change albeit without a deliberate intervention (Hudson, Fraley, Chopik, & Briley, in press; Hudson & Fraley, 2015, Study 1; Hudson & Fraley, 2016a). Results from these studies suggest that people who expressed goals to change with respect to any Big Five personality trait tended to show actual personality trait change. Another line of work explicitly tested the effects of a single intervention component or multiple intervention components to change personality traits while most of these studies solely focused on behavioral activation to change specific behaviors (Hudson, Briley, Chopik, & Derringer, in press; Hudson & Fraley, 2015, Study 2; Magidson et al., 2014). For example, the results of a study showed that people who were trained to generate implementation intentions, that is, specific and concrete if-then plans for their change goals, showed personality trait changes over 16 weeks (Hudson & Fraley, 2015, Study 2). A recent study also demonstrated personality trait change as the result of participation in a 10-week, structured face-to-face coaching intervention (Allan, Leeson, De Fruyt, & Martin, 2018; Martin, Oades & Caputi, 2014b). Previous work also discussed intervention approaches to focus on specific traits such as conscientiousness (Magidson et al., 2014; Roberts et al., 2017) using a specific behavioral intervention (i.e., Behavioral Activation). This behavioral intervention was aimed to target and alter behaviors counter to conscientiousness as exemplified in a case study with a substance dependent patient

(Magidson et al., 2014). Despite these initial efforts, to date there has been no documented effort produced to create changes in conscientiousness nor openness to experience.

Although there is sparse research on interventions to change positive traits like conscientiousness, there is long standing evidence for personality changes that result as "accompanying effects" of clinical and subclinical interventions which did not directly target changes in personality traits (De Fruyt, Van Leeuwen, Bagby, Rolland, & Rouillon, 2006; Jackson, Hill, Payne, Roberts, & Stine-Morrow, 2012). A recent meta-analytic review of 207 studies (N = 20,024) provides evidence for small to medium-sized personality trait change through clinical interventions (Roberts et al., 2017). In particular, people became less neurotic and more extraverted as a result of therapy. Most changes in personality traits happened within the first month of therapy. Most interestingly, the results of the meta-analytic review indicate that the type of therapy employed in the studies was not strongly associated with the amount of change in personality traits. This indicates that therapy outcomes can be largely explained by shared principles or common factors rather than by specific therapeutic techniques that are unique to specific types of therapies (Castonguay & Hill, 2012; Prochaska & Norcross, 2010; Wampold & Imel, 2015). Common change factors are assumed to be responsible for intermediate changes in people's characteristics, skills, experiences, and behaviors, and eventually lead to improvements in the ultimate outcome or targeted goal of an intervention.

Conceptual Framework of the Present Intervention

The present intervention is based on a common change factors intervention framework. Allemand and Flückiger (2017) argued that four empirically derived common change factors from psychotherapy process-outcome research provide a useful basis for designing personality change interventions. The first common change factor is actuating discrepancy awareness. Desired personality change can be most effectively targeted when people actually experience a gap between their actual and desired personality (Allemand &

Flückiger, 2017). A critical manifestation of actuating discrepancy awareness is to allow people to choose their change goals. Other ways to target discrepancy awareness are to repetitively remind people of their selected change goals and desired behaviors and to provide individually tailored feedback on the gap between one's actual and desired personality (Martin et al., 2014a).

The second common change factor is activating strengths and resources to realize strengths orientations. This factor leverages individual resources such as hopes, dreams, long-term goals, and future plans rather than problems and deficits (Allemand & Flückiger, 2017). The activation of resources initiates and maintains positive feedback circuits, reinforces positive expectations for change, and increases motivation for the change process (Flückiger, Wüsten, Zinbarg, & Wampold, 2010). As specific beliefs about the malleability of personality traits may facilitate or impair the ability to change personality (Dweck, 2008), one possibility to enhance positive expectations for change is to inform individuals that one's personality does not stay stable over time but is malleable across the entire lifespan (e.g., Roberts & Mroczek, 2008).

The third common change factor is targeting thoughts and feelings to realize insight. The goal of this learning-oriented factor is to challenge thoughts and feelings to increase self-reflection and insight (Allemand & Flückiger, 2017). One way to enhance introspection and motivation is to teach people to reflect their pros and cons of change as well as the experience of change (Miller & Rollnick, 2012).

The fourth common change factor is to practicing targeted behaviors. The goal of this action-oriented factor is to reinforce and engage in new behaviors (Allemand & Flückiger, 2017; Magidson et al., 2014; Roberts et al., 2017). For instance, generating specific implementation intentions (i.e., "if-then plans") helps to specify the where and when of new behaviors. Then practicing these new behaviors is reinforced in order to build new habits that can generalize into personality change (Hudson & Fraley, 2015; Wrzus & Roberts, 2017).

The smartphone-based intervention described in this work was developed with the goal to realize all four common change factors and thus to maximize the intervention effects. The common change factors can be targeted through micro-interventions, which are small interventions including specific tools and techniques to help people to modify and change their experiences and behaviors in their everyday situations and help them to initiate and maintain the change process (Free et al., 2013). For the two-week intervention we focused on micro-interventions that are deliverable via short messages and that were successfully used in previous work (e.g., Hudson & Fraley, 2015, Study 2; Magidson et al., 2014; Martin et al., 2014b). Micro-interventions of the present research are shown in Table 1.

The Present Research

This research constitutes the first documented effort to test whether people are able to intentionally become more self-disciplined or more open to action over a short time period. The focus of the present intervention was on these two personality facets, as the broader domains of conscientiousness and openness to experience are both relevant in the context of education and linked to academic success (Poropat, 2014). The intervention targeted the two narrower facets of self-discipline and openness to action as they are behavior-based and may be more suitable for specific behavioral tasks compared to other facets of conscientiousness or openness to experience.

This work included two open-label intervention studies with two active intervention groups to compare the effectiveness of a two-week smartphone-based intervention targeting personality change. In open-label studies, both the researchers and participants know which type of intervention is being given to participants. Participants of Study 1 (Pilot) were primarily recruited in higher education courses. Study 1 was extended in Study 2 with a larger sample size, a second follow-up assessment six weeks after the end of the intervention and observer-reports on personality change by close associates. Based on the key idea of self-regulated efforts towards desired personality change, people were allowed to choose their

change goal and the intervention group, respectively. In order to ensure that their choice was not biased by a personality feedback on their actual personality scores, people did not receive feedback prior to choosing their intervention group.

The research goals were threefold. The first goal was to compare selection effects of the two intervention groups at the beginning of the intervention. Consistent with the idea of intentional personality change that low scores leave room for increases and high scores leave room for decreases, we expected that people who chose the self-discipline intervention would score lower on self-reported and observer-reported self-discipline at pretest compared to people who choose the openness to action intervention (Hypothesis 1). Likewise, we expected that people who choose the openness to action intervention would show lower self-reported and observer-reported openness to action at pretest compared to people who choose the self-discipline intervention (Hypothesis 2).

The second goal was to test whether the two intervention groups increased over time with respect to their main outcome variables as measured with self- and observer-reports. More specifically, we expected that people in the self-discipline group would increase in self- and observer-reported self-discipline as a result of intervention (Hypothesis 3) and the openness to action group would increase in self-and observer-reported openness to action as a result of intervention (Hypothesis 4).

The third goal was to compare the effects of the two intervention groups over time by combining both studies. More specifically, we expected that people who chose the self-discipline intervention would show greater increases in self-discipline compared to the openness to action group (Hypothesis 5). Additionally, we expected that people who chose the openness to action intervention would show greater increases in openness to action compared to the self-discipline group (Hypothesis 6). The present research questions and hypotheses were not preregistered.

So far, there exist no theories about the duration and intensity of personality change interventions. Thus, it remains unclear how long an intervention should last. Previous personality change interventions included weekly sessions (e.g., Martin et al., 2014b), which is also the common session interval in clinical interventions. A recent meta-analytic review (Roberts et al., 2017) suggests that even interventions with weekly sessions that are not primarily targeting personality change show the most personality trait change within the first month of therapy. We chose to conduct a shorter-term intervention window while offering more of an intervention dose afforded by the use of smartphones. Smartphones are an attractive avenue for delivering psychological interventions in people's everyday life (Klasnja & Pratt, 2014; Marsch, Lord, & Dallery, 2014; Schueller, Muñoz, & Mohr, 2013). Smartphones allowed us to intervene in people's everyday life twice each day, which is a much higher intervention intensity compared to face-to-face interventions, such as seeing a therapist, which typically happens once a week. Thus, the intervention was shorter in duration than prior work (2 weeks), but relatively higher in terms of dose (twice per day). Our expectation was that despite the shorter duration of the overall intervention, that the amount or dosage of the intervention would be great enough to mimic typical interventions that last for 8 to 12 weeks.

Method

Participants

Study 1 (Pilot). A sample of 70 participants was recruited in psychology courses at the University of Zurich and via Facebook groups for students. A power analysis with an α error level of 0.05, a statistical power (1-β) of 0.80, a correlation of 0.40 between the pre- and post-measurements, and a Cohen's $f = .30$ suggested a sample size of at least $N = 64$. Participants were 74.3% female, and ages ranged from 18 to 50 years ($M = 23.47$, $SD = 4.26$). With respect to the highest level of education, 54.3% had a general qualification for university entrance, 28.6% had a Bachelor's degree, 10% had a Master's degree, 4% were secondary

school graduates, and 3% had professional maturity certificate. In the sample, 75.7% of participants described themselves as students, 14.3% were working full-time, 7.1% were working part-time, and 2.9 % were currently unemployed. Of the final sample, 48 participants wanted to increase in self-discipline (68.57%) and 22 participants wanted to increase openness to action (31.43%). All participants were unpaid volunteers. Psychology students from the University of Zurich, who took part at all measurement occasions, received course credits for their participation.

Study 2. To recruit participants for Study 2, Facebook groups, student mailings, flyers, and word-of-mouth advertising were used. The link to a website with detailed information about the study was clicked 1,529 times. The final sample of 185 participants completed the pre-test assessment and started with the intervention. The sample included 76.2% women, and ages ranged from 18 to 64 years (M = 25.30, SD = 8.53). With respect to the highest level of education, 72.4% had a general qualification for university entrance, 14.1% had a Bachelor's degree, 10.8% had a Master's degree, 2.7% were secondary school graduates. In the sample, 82.1% of participants described themselves as students, 16.8% were working full-time, 1.1% were retired or currently unemployed. Of the final sample, 141 participants wanted to increase in self-discipline (76.22%) and 44 participants wanted to increase in openness to action (23.78%). All participants were unpaid volunteers, but participants, who took part at all measurement occasions, could participate in a lottery to win grocery vouchers worth 50 USD (participants) and vouchers for movie theaters worth 30 USD (observers). Additionally, psychology students from the Universtiy of Zurich, who took part at all measurement occasions, received course credits.

Observers (Study 2). Participants were asked at pretest (T1) to share a web link with up to three close friends, family members or their intimate partner to obtain observer-reports on their personality. At posttest (T2), participants were again asked to share the same web link with the same observers to obtain a second observer-report. At pretest (T1), 355

observer-reports on participants' personality facets and traits from close others were collected. At posttest (T2), 266 observers gave their reports. Of these ratings, 215 observers gave their ratings both at T1 and at T2. We excluded 17 observers from the analyses, because they indicated that they did not have contact with their corresponding participant during the intervention phase. This resulted in a final sample of 198 observers, who rated a total of 103 participants. Of those participants, 34% were rated by one observer, 40% by two observers, and 26% by three observers. The final sample of 198 observers, of which 54% were female, ranged in age between 14 to 73 years (M = 37.05, SD = 16.1). One observer was 14 years old and another one was 17 years old. Most observers were family members (53.5 %), 24.2% were friends, 17.2% romantic partners, 2% workmates, 1.5% roommates, and 1.5% were not specified. At pretest and posttest, observers indicated how often they saw their corresponding participant during the last week. A vast majority saw each other on a daily basis (T1 and T2 = 36.9%). Others saw each other on 5-6 days (T1 = 14.6%; T2 = 10.1%), on 3-4 days (T1 = 18.7%; T2 = 24.2), on 1-2 days (T1 = 24.2%; T2 = 28.8%), and only few did not see each during the week before the intervention (5.6%). Those who did not see each other during the intervention were excluded. Frequencies of contact at pretest and posttest were significantly related (r = .80, p <.001). Additionally, more than half of them saw each other longer than two hours during the last week (T1 = 59.1; T2 = 60.6%). Durations of contact at pretest and posttest were also significantly related (r = .57, p <.001).

Design, Procedure, and Intervention Platform

This research was conducted according to the Declaration of Helsinki and in accordance with ethical principles promulgated by the Ethics Committee of the University of Zurich. The open-label study design compared two active intervention groups: (a) a self-discipline group, and (b) an openness to action group. At pretest assessment participants choose whether they want to *increase in self-discipline* or *increase in openness to action*. That is, participants were not randomly assigned to the two groups, as it is the case in randomized

controlled trials. In clinical treatment outcome research, it is common to use a comparative design directly comparing two treatment groups without conceptualizing either as being a formal control group (Basham, 1986). In the present study, participants self-selected the groups and the groups served each other as control groups. The study design included multiple repeated assessments of the outcome variables. In both groups, participants were assessed a few days before the intervention at pretest (T1), after the two-week intervention at posttest (T2), a follow-up two weeks after the intervention (T3) and a second follow-up six weeks after the intervention (T4; only in Study 2). The design and procedure of the studies are shown in Table 2.

The procedure for the study check-in and the assessments was as follows: Recruitment flyers and advertisements specified: "Do you want to become more self-disciplined or more open?" Interested individuals checked-in on the study website, received a comprehensive definition of self-discipline and openness to action, and had to choose one of these two goals. After reading information concerning the study procedure, participants had to give informed consent. Selection criteria were: Age ≥ 18 years, German-speaking, smartphone owner, and motivated to change in self-discipline or openness to action. Subsequently, participants completed the pretest assessment and provided their mobile phone number in order to activate the intervention. After the pretest including the personality questionnaire, participants had to specify three specific behaviors related to their chosen personality facet that they would like to perform more frequently during the two-week intervention (e.g., "I want do go to the gym more often" [self-discipline], "I want to try new recipes" [openness to action,]). For each of the three behaviors, participants had to generate one specific implementation intention in the form of an if-then plan (e.g., "If I finish dinner, then I'm going to the gym" [self-discipline], "If I come home after work, then I'm going to try a new recipe" [openness to action]). Furthermore, participants had to write down their pros and cons for each of the planned behaviors. In Study 2, participants were also asked to forward a text-message to close others

to obtain observer-reports of their personality. This short text-message was prepared by the study team. Observers were informed that the target person is taking part at a study and were asked to fill out a short questionnaire. However, observers were not informed about details of the study and – most importantly – they did not receive information on the goal of the participant. The smartphone-based intervention started the following Monday. The posttest and the follow-up assessments were also completed online via the study website. The procedure was identical across studies with two exceptions. Study 2 included observer-reports at T1 and T2 and a second follow-up assessment six weeks after the end of the two-week intervention.

The procedure for the smartphone-based intervention was as follows: For two weeks, participants received two text messages via the short text message service every day. In the morning (9 am), participants received a scientific input message, a reflective task or reminder message of their implementation intentions. In the evening (8 pm), participants received a web link to a short questionnaire. They were asked whether they have performed their individually planned daily implementation intentions on that day. This served as an adherence check. The text messages included reminders for the completion of the implementation intentions, self-reflection tasks, scientific inputs, and individual feedback. Examples of text-messages are shown in Table 1.

The smartphone-based intervention and assessments were implemented using MobileCoach (mobile-coach.eu; Filler et al. 2015). MobileCoach is an open source platform for the design, delivery, and evaluation of scalable smartphone-based interventions. The platform can be used to send automatic text messages. These messages were tailored based on participants' selection of change goal (i.e., to increase in self-discipline or in openness to action), and included, for instance, self-selected nicknames or individual reminder for implementation intentions. MobileCoach also generates individual web-based feedback that is delivered via text messages with a web link. The platform has been used in several

smartphone-based behavioral health interventions including interventions to reduce problem drinking (Haug et al., 2017) or to reduce smoking (Paz, Haug, Filler, Kowatsch, & Schaub, 2017).

Self-Report Measures

Personality facets. At all measurement occasions, self-discipline and openness to action were measured using the NEO-PI-R (Ostendorf & Angleitner, 2004). For each facet, participants rated eight items on a scale ranging from *strongly disagree* (1) to *strongly agree* (5). In Study 1, Cronbach's alphas ranged between .86 and .91 (Study 2: .88-.89) for self-discipline and between .67 and .79 (Study 2: .65-.71) for openness to action across all measurement occasions.

Personality traits. At all measurement occasions, the Big Five personality traits were measured using the NEO-FFI-30 (Körner et al., 2007). All 30 items were rated on a scale ranging from *strongly disagree* (1) to *strongly agree* (5). In Study 1, Cronbach's alphas ranged across all measurement occasions between .73 and .77 (Study 2: .78-.84) for conscientiousness, between .83 and .88 (Study 2: .79-.83) for openness to experience, between .80 and .82 (Study 2: .65-.74) for extraversion, between .84 and .86 (Study 2: .81-.84) for neuroticism, and between .82 and .83 (Study 2: .74-.82) for agreeableness.

Desire to change personality. At all measurement occasions, participants provided ratings of their goals to change their chosen personality facet using one single-item on a 5-point Likert scale ranging from *I want to be much less self-disciplined / open than I currently am* (1) to *I want to be much more self-disciplined / open than I currently am* (5).

Value of change. At T1 and T2 (only Study 2), for each of the three new behaviors that participants wanted to show during the two weeks of intervention they indicated on a 5-point Likert scale ranging from *low value* (1) to *high value* (5) how desirable or valuable the three new behaviors are. For the analyses, the three scores were combined in a sum score.

Higher scores indicate that participants attributed a high value to show their desired behaviors.

Feasibility of change. At T1 and T2 (only in Study 2), for each of the three new behaviors participants indicated on a 6-point Likert scale ranging from *very difficult* (1) to *very easy* (6) how feasible or difficult they consider showing their new behaviors. For the analyses, the three scores were combined in a sum score. Higher scores indicate that participants rated their behaviors as being easy to show.

Observer-Report Measures (Study 2)

Personality facets. At T1 and T2, observer-reports of self-discipline and openness to action of participants using the NEO-PI-R (Ostendorf & Angleitner, 2004) were provided. For each facet, observers rated eight items on a scale ranging from *strongly disagree* (1) to *strongly agree* (5). Cronbach's alphas at T1 were .87 for self-discipline and .63 for openness to action and at T2 .87 for self-discipline and .67 for openness to action. Medium-sized to large correlations between observer-reports and self-reports were .52 (T1) and .59 (T2) for self-discipline and .38 (T1) and .54 (T2) for openness to action (all *p*s <.001), suggesting substantial convergence between the two different perspectives.

Personality traits. At T1 and T2, observer-reports of the Big Five personality traits using the German version of the Ten Item Personality Inventory (TIPI-G; Muck et al., 2007) were provided. This ten-item measure was used to reduce the burden of observers. Research suggests that the TIPI reaches adequate levels in terms of convergence with widely used Big-Five measures in self- and observer-reports, test-retest reliability, and convergence between self- and observer-ratings (Gosling, Rentfrow, & Swann, 2003). The ten items were rated on a scale ranging from *strongly disagree* (1) to *strongly agree* (7). Cronbach's alphas at T1 were .70 for conscientiousness, .41 for openness to experience, .61 for extraversion, .58 for neuroticism, and .48 for agreeableness. It should be noted that the TIPI scales were designed to capture the Big Five traits with two broad items in order to maximize validity, not to create

scales with high internal reliability (Gosling, Rentfrow, & Swann, 2003). For the main variables, the correlations between observer-reports and self-reports at T1 and T2 were .50 and .42 (*p*s <.001) for conscientiousness, .29 ($p = .003$) and .01 ($p = .89$) for openness to experience. Surprisingly, the latter correlation suggests no convergence between self- and observer-reports at T2 for openness to experience.

Data Analytic Strategy

We used longitudinal multilevel models to investigate intervention effects (Bolger & Laurenceau, 2013). The data structure included repeated assessments of the outcome variables (Level 1: Time) nested within participants (Level 2: Person). We performed the analyses in two steps. First, we tested the intervention effects separately for each intervention group in both studies. To examine changes in the outcome variables, we ran three models. We started with an intercept only model (i.e., a null model without predictors). Then, based on visual inspection of the data we fitted two change models to examine the shape of change for each outcome variable. We fitted a linear unconditional change model with a linear time term to test whether scores in the outcome variables increase or decrease at a constant rate over time (e.g., pretest = 0, posttest = 1, follow-up 1 = 2, follow-up 2 = 4). We also fitted a logarithmic unconditional change model to test whether scores in the outcome variables increase or decrease at a faster rate at the beginning and then increase or decrease at a lower rate (e.g., pretest = 0, posttest = 0.69, follow-up 1 = 1.10, follow-up 2 = 1.61). The rationale for this change model comes from previous dose–effect research (Howard, Kopta, Krause, & Orlinsky, 1986; Stulz, Lutz, Kopta, Minami, & Saunders, 2013). According to this line of research a logarithmic function provides the best fit to the treatment response curve. Basically, this function suggests that as an intervention progresses, more and more effort is needed to bring about comparable change. This also implies that attending an intervention over a longer period of time only increases the effect of the intervention with diminishing impact. We used Akaike information criterion (AIC) and the Bayesian information criterion

(BIC) to compare the relative model fit of the three models, with smaller values indicating better-fitting models (Pinheiro & Bates, 2000).

Second, we combined the samples of the two studies and repeated the three models jointly for both groups. The rationale for this combined analysis is to have more statistical power for the inclusion of the group as well as the slope by group interaction as between-person predictors. For each best fitting model we then estimated a conditional change model with intervention group (0 = openness to action, 1 = self-discipline) and the slope by group interaction as Level 2 predictors to investigate whether change over time differed between the intervention groups. We were primarily interested in the effects of the group on the average slope of the outcome variables over time. Such time by group interaction effects would indicate that participants in one group changed differentially over time compared with participants from the other group. In a next step, we added covariates to the models to test for the robustness of the results. Particularly we controlled for potential effects of variables that differed between the two groups at T1 (i.e., age, desire to change personality, value and feasibility of change). To be consistent, we added the same covariates to all models.

All models were estimated with maximum likelihood (ML) to be able to compare the models based on AIC and BIC. We used an unstructured covariance structure for all models, which specifies no patterns in the covariance matrix and is completely general. In all models we estimated both fixed and random effects but in reporting the results we focus on the fixed effects. Data and R-codes are available on the Open Science Framework (OSF; https://osf.io/an5dj/)

Results

Study 1 (Pilot)

Most participants completed three waves of assessment ($M = 2.54$, $SD = 0.72$). Attrition analyses were conducted to test group differences between participants who completed all measurement waves (66.7%) versus participants who did complete one or two

waves (33.3%). The results of independent *t*-tests revealed that they did not differ in demographic and outcome variables assessed at T1.

Adherence to intervention. Two research assistants rated whether the three self-generated implementation intentions targeted self-discipline or openness to action. The interrater agreement (Cohen's Kappa) for the three implementation intentions ranged between .72 and .73. Of the self-discipline group, 93.06% of their self-generated implementation intentions were rated as targeting self-discipline, 3.47% openness to action, and 3.47% were unidentifiable. In contrast, of the openness to action group, 59.09% were rated as targeting openness to action, while 36.36% were seen as targeting self-discipline (4.55% were unidentifiable). The results suggest that the openness to action group struggled to build implementation intentions that primarily targeted their chosen facet and often built implementation intentions that were inadvertently focused on self-discipline. It may be easier to build implementation intentions that target self-discipline because this concept is more easy to understand for layperson as compared to the concept of openness to action. During the two weeks of intervention, 12.86% of all participants fulfilled an implementation intention on all days of the intervention, 60% participants on 10-13 days, 15.71% participants on 5-9 days, and 11.43% participants on 0-4 of days.

Selection effects. Table 3 presents descriptive statistics for all outcome variables across assessments for both intervention groups and Table 4 includes the effect sizes across intervention groups. First, we tested with independent *t*-tests whether the two intervention groups differed at T1 with respect to the main outcome variables as well as demographic and intervention variables. In line with Hypothesis 1, at T1 people in the self-discipline group showed significantly lower self-discipline compared to the openness to action group (d = 0.82). Additionally, the self-discipline group was significantly lower in conscientiousness as compared to the openness to action group (d = 0.65). In line with Hypothesis 2, at T1 the openness to action group evidenced significantly lower scores in openness to action compared

to the self-discipline group (d = 0.57). However, with respect to openness to experience the self-discipline group and the openness to action group did not significantly differ (d = 0.12). Additional analyses revealed that participants in the self-discipline group showed significantly higher scores in their desire to change compared to participants in the openness to action group (d = 0.66).

Intervention effects. Table 3 presents the test-retest correlations and Table 4 presents effect sizes across time separately for both group. Following the analytic strategy, we fitted intercept-only models, linear, and logarithmic change models to test the shape of change in all outcome variables (Supplementary Table 1). Next, we tested whether each group increased with respect to the focal outcome variables as a result of the intervention. In line with Hypothesis 3, the self-discipline group significantly increased in self-discipline (b = 0.37, 95% CI [0.21, 0.52], SE = 0.08, p < .001) and conscientiousness (b = 0.19, 95% CI [0.06, 0.31], SE = 0.06, p = 0.005) over time. In turn, the self-discipline group did neither significantly increase in openness to action (b = 0.07, 95% CI [-0.03, 0.17], SE = 0.05, p = 0.15) nor in openness to experience (b = -0.03, 95% CI [-0.20, 0.11], SE = 0.07, p = 0.65). In line with Hypothesis 4, the openness to action group showed a significant increase in openness to action (b = 0.35, 95% CI [0.16, 0.53], SE = 0.09, p = 0.002) as a result of the intervention. However, the openness to action group did neither increase in openness to experience (b = -0.04, 95% CI [-0.20, 0.12], SE = 0.08, p = 0.61), nor in self-discipline (b = 0.25, 95% CI [-0.01, 0.52], SE = 0.13, p = 0.07) and conscientiousness (b = 0.07, 95% CI [-0.08, 0.26], SE = 0.08, p = 0.37). Moreover, the openness to action group showed a significant albeit small increase in extraversion over time (b = 0.20, 95% CI [0.02, 0.40], SE = 0.09, p = 0.04) (Supplementary Table 2). Figure 1 illustrates the average changes in standard deviations across groups and time. The changes in standard deviations indicate that the self-discipline group changed most in self-discipline across time and the openness to action group changed most in openness to action over time. In terms of effect sizes, we found a medium effect size

for self-discipline across time in the self-discipline group and a large effect size for openness to action across time in the openness to action group. In support of these personality changes, the desire to change significantly decreased from T1 to T3 in the self-discipline group (b = -0.14, 95% CI [-0.25, -0.04], SE = 0.05, p = 0.006), but not in the openness to action group (b = -0.16, 95% CI [-0.33, 0.01], SE = 0.10, p = 0.11).

Study 2

Most participants completed three waves of assessment (M = 3.19, SD = 1.12). To test group differences between participants who completed all measurement waves (59.5%) versus participants who did complete one, two or three waves (40.5%), attrition analyses were conducted. The independent t-tests revealed that participants who completed all waves were significantly more self-disciplined at T1 compared to participants who did not complete all waves (d = 0.32). Additionally, participants who completed all waves were significantly less open to experience at pretest compared to participants who did not complete all waves (d = 0.36). Other variables did not differ between the groups at T1.

Adherence to intervention. To check whether the three self-generated implementation intentions targeted self-discipline or openness to action, two research assistants rated them with an interrater agreement (Cohen's Kappa) between .75 and .85. Of the self-discipline group, 87.72% of their implementation intentions were rated as targeting self-discipline, 2.41% openness to action, and 9.87% were unidentifiable. Of the openness to action group, 57.97% were rated as targeting openness to action, and once again a large minority were judged as targeting 32.61% self-discipline (9.42% were unidentifiable). During the two weeks of intervention, 16.22% of all participants fulfilled an implementation intention on all days, 52.97% participants on 10-13 days, 25.41% participants on 5-9 days, and 5.41% participants on 0-4 days.

Selection effects. Descriptive statistics both intervention groups are shown in Table 5 and effect sizes across groups in Table 6. As in Study 1, we tested with independent t-tests

whether the two intervention groups differed at T1. In line with Hypothesis 1, people in the self-discipline group were significantly lower in self-discipline compared to the openness to action group (d = 1.47). Additionally, the self-discipline group was significantly lower in conscientiousness in comparison to the openness to action group (d = 0.95). In terms of effect sizes, these group differences reflect large effects. In line with Hypothesis 2, the openness to action group was significantly lower in openness to action compared to the self-discipline group (d = 0.49). However, scores in openness to experience did not differ statistically between the self-discipline group and the openness to action group (d = 0). We also checked for potential differences across the two intervention groups in demographic and outcome variables. Participants in the self-discipline group were younger as compared to the openness to action group (d = 0.45) and had a higher desire to change compared to the openness to action group (d = 0.77). Furthermore, the self-discipline group reported a higher value of change as compared to the other group (d = 0.77) and a higher difficulty for showing their new behaviors as compared to the openness to action group (d = 0.77).

Descriptive statistics for all observer-reported outcome variables are reported in Table 7 and effect sizes of observer-reports across both intervention groups in Table 8. To be consistent with the analyses of the self-reports, we also checked for observer-reported differences across the two intervention groups. People in the self-discipline group were rated as being significantly lower in self-discipline compared to the openness to action group (t(101) = 3.45, p = 0.001, d = 0.83) and in conscientiousness in comparison to the other group (t(101) = 2.80, p = 0.006, d = 0.69). However, people in the openness to action group were rated as having relatively similar scores in openness to action as the self-discipline group (t(101) = -1.75, p = 0.08, d = 0.40). Similarly, people in the openness to action group were rated as having relatively similar scores in openness to experience as the self-discipline group (t(101) = -.28, p = .78, d = 0.07).

Intervention effects: Self-reports. Table 5 presents the test-retest correlations and

Table 6 shows the effect sizes across time separately for both group. We fitted intercept-only models, linear, and logarithmic change models, which suggested the logarithmic model as the best model to describe the shape of change (Supplementary Table 1). Next, we tested whether the two intervention groups increased in their chosen personality facets as a result of the intervention. In line with Hypothesis 3, the self-discipline group significantly increased in self-discipline (b = 0.32, 95% CI [0.25, 0.40], SE = 0.04, p < .001) and conscientiousness (b = 0.18, 95% CI [0.13, 0.24], SE = 0.03, p < .001). In terms of effect sizes, we found medium to large effect sizes for the changes in self-discipline for the self-discipline group. On the contrary, the self-discipline group did neither significantly change in openness to action (b = 0.05, 95% CI [-0.00, 0.10], SE = 0.03, p = 0.07) nor in openness to experience (b = -0.00, 95% CI [-0.01, 0.06], SE = 0.03, p = 0.89). Additionally, the self-discipline group showed a significant increase in extraversion (b = 0.05, 95% CI [0.00, 0.09], SE = 0.02, p = 0.03) as well as a significant decrease in neuroticism (b = -0.18, 95% CI [-0.24, -0.12], SE = 0.03, p < .001) over time.

In line with Hypothesis 4, the openness to action group showed a significant medium sized increase in openness to action (b = 0.13, 95% CI [0.04, 0.21], SE = 0.04, p = 0.005). However, the intervention did neither result in changes in openness to experience (b = -0.07, 95% CI [-0.16, 0.01], SE = 0.04, p = 0.10), self-discipline (b = 0.07, 95% CI [-0.01, 0.16], SE = 0.04, p = 0.07), nor conscientiousness (b = 0.05, 95% CI [-0.04, 0.13], SE = 0.04, p = 0.27). Moreover, they showed a significant decrease in neuroticism over time (b = -0.17, 95% CI [-0.30, -0.04], SE = 0.07, p = 0.01) (Supplementary Table 3). Figure 2 shows the average changes in standard deviation units across groups and time. The changes in standard deviations indicate that the self-discipline group changed most in self-discipline across time and the openness to action group changed most in openness to action over time.

Further evidence for the effects of the intervention were obtained. That is, the desire to change decreased from T1 to T4 in the self-discipline group (b = -0.10, 95% CI [-0.14, -0.06],

SE = 0.02, $p < .001$), but not in the openness to action group (b = -0.02, 95% CI [-0.07, 0.03], *SE* = 0.02, $p = 0.37$). The self-discipline group also showed a decrease from T1 to T2 in their value of change (b = -0.48, 95% CI [-0.78, -0.18], *SE* = 0.15, $p = 0.002$), but not the openness to action group (b = 0.10, 95% CI [-0.40, 0.60], *SE* = 0.25, $p = 0.68$). Moreover, participants in the self-discipline group showed a significant increase from T1 to T2 in their perceived feasibility of change (b = 1.96, 95% CI [1.46, 2.47], *SE* = 0.26, $p < .001$), but not the other group (b = 0.78, 95% CI [-0.04, 1.59], *SE* = 0.50, $p = 0.06$). This indicates that people in the self-discipline group had less difficulty implementing changes after the intervention compared to the openness to action group.

Intervention effects: Observer-reports. Table 7 shows test-retest correlations and Table 8 effect sizes across time separately for each group. To examine observer-reported changes, we fitted intercept-only and linear models (Supplementary Table 4) and tested whether observers are also able to detect changes in the two intervention groups. In line with Hypothesis 3, observers indicated significant increases in the self-discipline group in self-discipline (b = 0.12, 95% CI [0.03, 0.20], *SE* = 0.04, $p = 0.008$), but they did not detect changes in conscientiousness (b = 0.03, 95% CI [-0.08, 0.14], *SE* = 0.06, $p = 0.54$). According to the observers, the self-discipline group did neither change in openness to action (b = 0.05, 95% CI [-0.01, 0.11], *SE* = 0.03, $p = 0.12$) nor in openness to experience (b = 0.06, 95% CI [-0.04, 0.16], *SE* = 0.05, $p = 0.24$). Additionally, observers indicated a significant decrease in neuroticism in the self-discipline group (b = -0.18, 95% CI [-0.28, -0.08], *SE* = 0.05, $p < .001$).

In line with Hypothesis 4, observers reported a significant increase in openness to action in the openness to action group (b = 0.18, 95% CI [0.07, 0.28], *SE* = 0.05, $p = 0.002$). However, observers did neither detect changes in openness to experience (b = -0.10, 95% CI [-0.10, 0.28], *SE* = 0.09, $p = 0.37$), self-discipline (b = 0.05, 95% CI [-0.05, 0.15], *SE* = 0.05, $p = 0.07$) nor conscientiousness (b = 0.05, 95% CI [-0.08, 0.19], *SE* = 0.07, $p = 0.27$).

Additionally, observers indicated a significant decrease in neuroticism over time (b = -0.28, 95% CI [-0.53, -0.04], SE = 0.12, p = 0.01). Figure 3 illustrates the average changes in standard deviations across groups and time.

Combined Studies 1 and 2

Finally, we combined the samples of Studies 1 and 2 to have more statistical power in order to test whether the two intervention groups differed in their changes as a result of intervention. For these analyses we used data from all measurement occasions despite the fact that Study 1 included three assessments and Study 2 four assessments. Descriptive statistics and test-retest correlations of the combined sample are shown in Table 9 and effect sizes for both groups are shown in Table 10. Figure 4 illustrates the average changes in standard deviations across groups and time in the combined sample. For the combined sample, the logarithmic model was again the best model to describe the shape of change (Supplementary Table 5). We then ran multilevel models to test the logarithmic slope by group interactions as described in the Data Analytic Strategy section. Table 11 presents the results of these logarithmic slope by group interaction effects without covariates. The models with covariates can be found in Supplementary Table 6 as the interaction results were not affected when adding the covariates. Here we focus on the logarithmic slope by group results. We found three significant interaction effects. First, the logarithmic slope by group interaction effect for self-discipline (b = 0.24, 95% CI [0.12, 0.35], SD = 0.06, p < .001) was significant. Whereas the openness to action group showed a small 0.1 unit increase in self-discipline over time (p = 0.03), the self-discipline group showed a 0.34 (0.1 + 0.24) unit increase in self-discipline (p < .001). Second, the interaction effect between logarithmic slope of openness to action and group was also significant (b = -0.12, 95% CI [-0.21, -0.04], SD = 0.04, p = 0.005). The openness to action group showed a significant 0.18 unit increase in openness to action (p < .001), whereas the self-discipline group showed a 0.06 (0.18 - 0.12) unit increase in openness to action (p = 0.03). Third, the logarithmic slope by group interaction effect for

conscientiousness was significant (b = 0.13, 95% CI [0.03, 0.22], SD = 0.05, p = 0.007) and mirrored the findings for self-discipline. Whereas the openness to action group did not significantly increase in conscientiousness (p = 0.16), the self-discipline group showed a significant 0.18 (0.05 + 0.13) unit increase in conscientiousness (p < .001) . Moreover, both groups significantly decreased in neuroticism as a result of intervention (Table 11).[2]

Finally, we compared the two intervention groups with respect to their desire to change. The logarithmic slope by group interaction was significant for desire to change (b = -0.06, 95% CI [-0.12, -0.01], SE = 0.03, p = 0.02). The openness to action group did not significantly decrease in desire to change (p = 0.08), whereas the self-discipline group showed a significant -0.10 (-0.04 - 0.06) unit decrease in desire to change (p < .001).

Discussion

The goal of this research was to test whether a short-term smartphone-based intervention could help people become more self-disciplined or more open to action. To do so, we conducted two brief intervention studies with a common change factors intervention framework, smartphones to deliver micro-interventions and repeated assessments of the outcome variables.

Six important findings emerged from the present research. First, findings from both self- and observer-reports suggested that participants who wanted to become more self-disciplined were less self-disciplined before the intervention. Second, participants who wanted to become more open to action were less open to action before the intervention. Third, participants who chose the self-discipline intervention showed increases in self- and observer-reported self-discipline over time. Fourth, the openness to action group showed increases in self-and observer-reported openness to action. Fifth, participants who chose the self-discipline

[2] In order to rule out regression to the mean, we rerun all logarithmic models and controlled for time 1 levels of the outcome variables. The results suggest that the logarithmic slope by group interactions still hold (see Supplementary Table 7).

intervention showed greater increases in self-discipline over time as compared to the openness to action group. Finally, participants who chose the openness to action intervention showed greater increases in openness to action compared to the self-discipline group. Further support for the intended personality changes comes from the additional findings indicating that the desire to change personality significantly decreased over time in the self-discipline group. In sum, findings from both self-reports and observer-reports by close others provide initial evidence for the efficacy of a short-term intervention to change self-discipline and openness to action.

Selection Effects for Participation in the Intervention

It has been suggested that interventions to change personality should, ideally, be targeted at those who would like to change their personality (Martin et al., 2014a; Roberts et al., 2017). We took advantage of this idealized feature of personality interventions by providing people the choice of what type of intervention they experienced with the assumption that they would sign up for the type of intervention they found most appealing. As would be expected, people who sought out the interventions tended to be low on the traits of interest. Indeed, although participants were blind with respect to their levels of self-discipline and openness to action (they did not receive any feedback on their actual personality scores prior to choosing the intervention group), they wanted to change in the personality facet in which they had lower scores. This implies that people understand their personality well enough to identify interventions that would address the types of changes they desire. Furthermore, the group differences in self-discipline were replicated by observer-reports. Close others also rated participants as having lower scores in the personality facet they wanted to change. The inclusion of multiple sources such as self- and observer-reports to assess personality is in line with suggestions to provide congruent or complementary information about personality (Back & Vazire, 2012; Vazire 2010).

Previous literature suggests that desires to change are, in part, motivated by dissatisfaction with specific life domains (Baumeister, 1994; Hudson & Roberts, 2014; Kiecolt, 1994). For instance, previous research showed that people who were dissatisfied with financial or academic aspects of their lives tended to express desires to increase in conscientiousness because they hoped to fix financial or academic problems by becoming more hardworking and organized (Hudson & Roberts, 2014). Desires to change occur because change in a specific direction is seen as socially desirable by others and by the person him- or herself (Dunlop, Telford, & Morrison, 2012). The social environment constitutes an important source of information for the person him- or herself and a potential source to motivate desires to change (Blumer, 1969; Stryker & Statham, 1985). As a consequence, the selection of the intervention group may have been driven, in part, by experiencing a discrepancy between the actual personality and levels of personality characteristics, that are seen as desirable by ourselves and by our social environment (Martin et al., 2014b). In general, the current results support the notion that people want to increase in those traits, in which they have lower scores (Baranski et al., 2017; Miller et al., 2019; Hudson & Roberts, 2014) and extends prior research by showing that observers were also able to detect the gap between current and desired traits.

Effects of the Brief Intervention for Personality Change

The main goal of the present research was to test whether a brief intervention could help people to become more self-disciplined or more open to action over the course of the intervention and beyond. Our findings provide evidence that the intervention worked to change personality over a short time period. On average, participants were able to change in their self-selected personality facet, and the intended change on the facet level maintained until follow-up assessments. One potential critique could be that self-reported changes only occurred because people were aware of being part of an intervention and thus changed their behaviors accordingly during the intervention (McCarney et al., 2007). To deal with such a

critique we included observer-reports by close others in Study 2. The observer-reports provided further evidence that participants changed on the personality facet on which they wanted to change. To our knowledge, this constitutes one of the first empirical efforts to change traits other than neuroticism and in particular conscientiousness and openness and the only study to show that the changes that resulted are detectable by close associates.

When taking a closer look at the self-reports, changes in self-discipline were greater than self-reported changes in openness to action. One potential explanation is that participants in the self-discipline group had a greater desire to change, which may be the reason for their greater subsequent change (cf. Hudson & Fraley, 2015). However, results suggest that participants in the self-discipline group did not work harder to change themselves and did not show their desired behaviors more often. The group differences may also reflect differences in what it implies to become more self-disciplined versus more open to action. It may be that the concept of openness to action is not as easy to understand for layperson as the concept of self-discipline. Whereas people in the self-discipline group had no problems to come up with behaviors that target change in self-discipline, some people in the openness to action group struggled to build implementation intentions that primarily targeted their facet. Consequently, they often built ambivalent implementation intentions. For instance, “If I’m coming home in the evening, then I want to read a book” may indeed target openness to action since it can involve the consideration of a new and unusual activity for a certain person. However, reading a book repeatedly may also target self-discipline, when doing other tempting things has to be suppressed.

Interestingly, close others reported stronger increases in openness to action as compared to changes in self-discipline after the two weeks of intervention. Close others may provide complementary information on openness to action because behavioral changes in openness to action may attract more attention from close others compared to changes in self-discipline. Showing specific behaviors more often and more intensively may be less visible to

others than trying a wide variety of new behaviors and activities.

Consistent with the assumption that narrow and more specific personality facets are more changeable over shorter time periods than broader personality traits (Allemand & Flückiger, 2017; Roberts et al., 2014), the findings indicate stronger effects on the facet level as compared to changes at the trait level both for self-reports and observer-reports. Interestingly, in contrast to previous studies that targeted change in broader personality traits (e.g., Hudson & Fraley, 2015), the effect sizes for facet changes were larger. Potential factors that may have contributed to these larger effects may be the intensity of the intervention with two text-messages each day, the intervention approach to simultaneously target multiple common change factors, and the focus on narrow and specific facets rather than the broader personality traits. Changes at the broader trait level may take more time and effort because a broader variety of behaviors in different contexts have to be targeted. However, the present research has also shown that participants who wanted to become more self-disciplined also became more conscientious over time. In contrast, the broad constructs of openness to experience did not change over the short time period, only the specific facet of openness to action changed for those who wanted to become more open to action.

Surprisingly, self- and observer-reports at posttest were not related with respect to the broad trait of openness to experience. Openness to experience is broader in scope than conscientiousness (McCrae, 1994) and therefore the changes that occur for any given facet may not generalize as easily to other aspects of the openness domain. Future research should test whether targeting multiple narrow facets of one broader personality trait at the same time may lead to more change on the trait-level than targeting facets in a sequential order.

Finally, we found an increase in extraversion and a decrease in neuroticism as a result of participation in the intervention, albeit with smaller effect sizes. It is possible that the intervention framework did not only target the chosen facet but also other domains as it included diverse intervention tasks with the goal to realize the four common change factors.

Moreover, extraversion and neuroticism share affective features. Whereas extraversion is typically related to positive affect, neuroticism and negative affect show shared variance. It is possible that participation in interventions increases positive affective tendencies and decreases negative affective tendencies. Two recent findings support this assumption. On the one hand, intervention work has shown that neuroticism and extraversion changed as a result of therapy that target psychological distress (Roberts et al., 2017). On the other hand, research on intentional personality change found increases in well-being as a result of desired personality changes (Hudson & Fraley, 2016b). In the present study, most participants were able to get closer to their goal and to change in the desired direction, which may have led to more positive and less negative affect.

Overall, the present findings add to literature in many ways. First, it provides further evidence for the assumption of plasticity of personality and empirical support for intentional personality change. The findings are in contrast with traditional positions, which assume that personality is relatively resistant to change in adulthood (e.g., McCrae & Costa, 2003). However, the current results are consistent with recent literature suggesting that personality is more amenable to change than was previously thought (Hudson & Fraley, 2015; Jackson et al., 2012; Martin et al., 2014b; Roberts et al., 2017).

Second, the present findings fuel the discussion on the degree of plasticity of personality and on how long it takes to change personality. Despite the shorter duration of the intervention compared to previous studies on personality change (Hudson & Fraley, 2015; Martin et al., 2014b), we were able to observe small to medium sized changes in two weeks, which lasted until follow-up assessments. The logarithmic pattern of change suggests a strong increase during the two weeks of intervention and a stable plateau after the end of the intervention. This is in line with the finding of recent meta-analytic work, which has shown that most change happens within the first few weeks of therapy (Roberts et al., 2017). Of

course, it remains an open question whether these changes persist over longer periods of time - a focus for future research.

Third, the present research followed the call to also include observer-reports when examining intentional personality change (Hudson & Fraley, 2015, 2017; Hudson & Roberts, 2014; Roberts et al., 2017). The findings based on observer-reports were largely consistent with the self-reported findings, albeit with smaller effect sizes. Since observer-reports result from repeatedly observing an individuals' behavior in relevant situations (Back et al., 2011), these results indicate that observers are able to detect some behavioral changes even during very short periods of time. However, the smaller effect sizes indicate that observers may be less able to detect the same amount of changes because they may be slower in updating their impression (Paulhus & Vazire, 2007). Thus, it may require greater changes and changes that last for a longer period of time to be equally detectable to observers. One potential critique could be that participants could have conveyed additional information to their observers at any point during the intervention. This exchange of information might have affected the observer-ratings. When collecting observer-reports in real life, this potential exchange can hardly be avoided as observers had to be close associates. However, the results of the obtained observer-reports point to differences between the two intervention groups, which highlights the fact that observers did not simply provide "friendly" reports in the direction of participants goals.

Limitations and Future Directions

The present research is limited in ways that should promote future research. A first potential critique is the short duration of the intervention and the limited number of follow-up assessments to examine long-term effects. From a theoretical and empirical point of view it is still unclear how and when repeated short-term behavioral and experiential changes become habitual and transfer into long-term changes. It may be that the intended changes reflect temporary accentuation of personality as a result of participation in the intervention. Although

the changes remained stable after the discontinuation of the intervention, it may be that individuals revert back to their baseline scores after some time. Future work is needed to figure out the most appropriate longitudinal design of such an intervention to capture lasting changes. Also, although this study used a comparative design to directly compare two treatment groups, which is a common strategy in clinical treatment outcome research (Basham, 1986), innovative study designs are needed in the future to better understand and separate these personality change effects.

Second, demand characteristics may have had an effect on self-reported changes such that participants changed their behavior in response of the awareness of being part of an intervention study. Demand effects not only play a role in personality change interventions, but also represent a challenge in psychotherapy, counseling and coaching research; interventionists' wishes and expectations may also convey to clients and thus influence their behavior and ultimately the intervention outcome (Kanter, Kohlberg, & Loftus, 2002). Horvath (1984) even argued that demand characteristics are important components of therapeutic treatment itself. Such demand characteristics can hardly be eliminated from personality change intervention studies as self-selection is a crucial component of intentional personality change. However, future personality change intervention studies should take the effects of demand characteristics systematically into account.

Moreover, these demand effects may have transferred to observers as the intervention study was conducted via smartphone in daily life of the participants. It is possible that participants and observers shared information during the study as observers had to be close others that spend a lot of time with the target person. Future research should ask both participants and observers after the study if, how often, and to what extent they were talking about the self-selected goal and the intervention in general.

Third, the present intervention was motivated by a common change factors intervention framework to maximize the effectiveness. However, from the present findings it

is not clear which mechanisms were responsible for the personality changes. Future research is needed to understand what types of interventions help people to attain their change goals, and which strategies are most effective. In order to do this, the effectiveness of different strategies should be formally tested using intensive longitudinal experiments to separate effects of the change mechanisms.

Finally, the present intervention was delivered via text-messages to reach participants low-threshold in their everyday lives, which was useful to keep participants committed to the intervention and enhance their change motivation over the two weeks. However, future smartphone-based interventions that last over longer time periods should be more individualized, diversified, and provide more guidance throughout the intervention process. One potential approach may be to use a smartphone application with a text-based conversational agent ("chatbot") to provide such an intervention. A smartphone application may be more interactive and more useful to keep participants motivated and to deliver a wider variety of micro-interventions over longer time periods. Moreover, it allows to collect smartphone sensing data to examine whether self- or observer reported changes are also reflected in behavioral data that are extracted from sensing data (Stieger et al., 2018).

Conclusion

This research supports the idea that personality can be changed with the help of a smartphone-based psychological intervention. Participation in the personality change intervention appeared to help people to make progress toward their desired changes. These findings provide a novel and important contribution to the field of personality psychology by challenging traditional positions that highlight the immutability of personality. Future work is needed to examine whether intended short-term changes transfer into permanent long-term changes and which specific strategies are most effective in helping people to achieve long-lasting desired changes.

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Table 1. *Micro-Interventions Based on Common Change Factors*

Common change factor	Description of micro-interventions	Text-message examples
Actuating discrepancy awareness	• To actuate discrepancy awareness, participants were reminded on a regular basis about their change goal and their desired behaviors. • Every evening, participants received feedback on how many days they showed their desired behaviors.	• "Hello [Name of participant]. Do you remember your goal to become more self-disciplined/open to action and your desired behaviors? Here's a reminder of two of your implementation intentions: [Implementation intention 1 & 2] • "Hey [Name of participant]. You have already achieved your weekly goal as follows: [Percentage of days the three behaviors have been shown]."
Activating strengths and resources to realize strengths- orientation	• To activate strengths and resources, participants were asked about their long-term goals and benefits of attaining their change goal. • Additionally, participants received psychoeducation in the form of scientific inputs to reinforce their positive expectations for change.	• "Good morning [Name of participant]. Here is a reflective task for you: Imagine what advantages it would have for your short-term and long-term goals if you were to carry out your desired behaviors." • "Hello [Name of participant]. As already mentioned, self-discipline is related to better grades in school/university. Self-discipline is even more strongly related to school grades than IQ!" • "Good morning [Name of participant]. Did you know that openness to action has an influence on your mood? Research has shown that on average people who are more open to action have a better mood."
Targeting thoughts and feelings to realize insight	• To target thoughts and feelings, participants had to write down their pros and cons of change at the beginning of the intervention and received reminders on these pros and cons during the intervention. • Additionally, participants were asked to reflect their daily experiences and behaviors during the intervention and had	• "Do you still remember the advantages you hope to gain from your new behaviors? Here is a reminder: [advantage 1], [advantage 2], [advantage 3]." • "Hey [Name of participant]. Sometimes it is difficult to be self-disciplined/open to action. There are many reasons that may hinder you from

	to indicate whether they were able to show their desired behaviors.	showing your desired behaviors. What may be obstacles that hinder you from showing them and how you could master them?"
Targeting behaviors to realize practice	• To practice new behaviors, participants generated three specific implementation intentions ("if-then plans") for the two weeks of intervention. • Moreover, they received a daily reminder for their implementation intentions.	• "Good morning [Name of participant]. You have set yourself the following goals for today: [Reminder of three implementation intentions]. We wish you a lot of success in achieving your goals and look forward to your progress." • "Good morning [Name of participant]. Do you remember how you created the so-called implementation intentions? Implementation intentions are if-then plans that connect a specific situation with a certain behavior. For example, you have created the following implementation intention for today: [Reminder of implementation intention].

Table 2. *Design and Procedure of Studies 1 and 2*

Pretest (T1) Day 0	Intervention Day 1-14	Posttest (T2) Day 15	Follow-up (T3) Day 28	Follow-up 2 (T4)* Day 56
Self-report	Morning text-message (9 am)	Self-report	Self-report	Self-report
- Personality facets - Personality traits - Desire to change - Value of change - Feasibility of change	- Reminder of implementation intentions - Scientific input - Reflective task	- Personality facets - Personality traits - Desire to change - Value of change - Feasibility of change	- Personality facets - Personality traits - Desire to change	- Personality facets - Personality traits - Desire to change
Observer-reports (T1)*	Evening text-message (8 pm)	Observer-reports (T2)*		
- Personality facets - Personality traits	- Daily assessment on implementation intentions - Individual feedback	- Personality facets - Personality traits		

Note. *Only in Study 2.

Table 3. *Means and Standard Deviations for all Outcome Variables Across Assessments for Both Intervention Groups in Study 1*

Outcome	Group	Pretest: T1		Posttest: T2		Follow-up: T3		Test-retest	
		M	*SD*	*M*	*SD*	*M*	*SD*	$r_{T1, T2}$	$r_{T1, T3}$
Self-discipline	Self-discipline	2.81	0.76	3.17	0.64	3.17	0.71	0.78**	0.74**
	Openness to action	3.51	0.94	3.76	0.71	3.82	0.68	0.88**	0.88**
	Total	3.03	0.88	3.35	0.71	3.38	0.76	0.85**	0.82**
Openness to action	Self-discipline	3.15	0.56	3.23	0.58	3.20	0.53	0.85**	0.79**
	Openness to action	2.84	0.52	3.14	0.58	3.23	0.56	0.84**	0.81**
	Total	3.05	0.56	3.20	0.58	3.21	0.54	0.84**	0.76**
Conscientiousness	Self-discipline	3.49	0.70	3.74	0.59	3.67	0.52	0.80**	0.79**
	Openness to action	3.91	0.59	4.11	0.56	4.07	0.49	0.77**	0.80**
	Total	3.61	0.69	3.86	0.60	3.80	0.54	0.81**	0.82**
Openness to experience	Self-discipline	3.68	0.89	3.66	0.92	3.66	0.94	0.90**	0.87**
	Openness to action	3.78	0.82	3.73	0.83	3.64	0.86	0.94**	0.90**
	Total	3.71	0.86	3.68	0.88	3.65	0.91	0.91**	0.88**
Extraversion	Self-discipline	3.33	0.72	3.38	0.73	3.37	0.64	0.89**	0.83**
	Openness to action	3.19	0.74	3.44	0.60	3.50	0.69	0.82**	0.83**
	Total	3.29	0.72	3.40	0.68	3.41	0.65	0.87**	0.83**
Neuroticism	Self-discipline	2.70	0.90	2.64	0.86	2.68	0.84	0.83**	0.84**
	Openness to action	2.53	0.86	2.34	0.80	2.25	0.71	0.88**	0.82**
	Total	2.65	0.88	2.55	0.84	2.54	0.82	0.85**	0.85**
Agreeableness	Self-discipline	3.93	0.77	3.92	0.75	3.93	0.74	0.85**	0.87**
	Openness to action	4.01	0.66	4.06	0.55	4.22	0.53	0.79**	0.84**
	Total	3.96	0.73	3.96	0.69	4.02	0.69	0.83**	0.87**
Desire to change	Self-discipline	4.44	0.54	4.23	0.48	4.15	0.50	0.41**	0.23
	Openness to action	4.14	0.35	3.94	0.54	3.81	0.83	0.04	0.32
	Total	4.34	0.51	4.14	0.51	4.04	0.64	0.36**	0.28*
Value of change[a]	Self-discipline	12.47	1.47	-	-	-	-	-	-
	Openness to action	11.91	1.41	-	-	-	-	-	-

	Total	12.26	1.46	-	-	-	-	-	-
Feasibility of change[b]	Self-discipline	9.17	2.15	-	-	-	-	-	-
	Openness to action	9.23	2.96	-	-	-	-	-	-
	Total	9.19	2.41	-	-	-	-	-	-

Note. Self-discipline group: T1: $n = 48$, T2: $n = 40$, T3: $n = 34$; openness to action group: T1: $n = 22$, T2: $n = 18$, T3: $n = 16$. Potential range for personality facets, traits, desire to change: 1-5; [a] = three behaviors were combined into a sum score with a potential range from 1-15; [b] = three behaviors were combined into a sum score with a possible range from 3-18; * $p < .05$, ** $p < .01$.

Table 4. *Effect Sizes Across Intervention Groups and Time in Study 1*

	Effect size across groups			Effect size across time	
Outcome	d_{T1}	d_{T2}	d_{T3}	$d_{T1, T2}$ (S/O)	$d_{T1, T3}$ (S/O)
Self-discipline	0.82**	0.87	0.94	0.71/0.54	0.66/0.67
Openness to action	0.57*	0.16	0.06	0.26/1.02	0.14/1.22
Conscientiousness	0.65*	0.64	0.52	0.57/0.50	0.40/0.43
Openness to experience	0.12	0.08	0.02	-0.05/-0.18	-0.04/-0.38
Extraversion	0.19	0.09	0.20	0.15/0.56	0.10/0.72
Neuroticism	0.19	0.36	0.55	-0.11/-0.45	-0.04/-0.54
Agreeableness	0.11	0.21	0.45	-0.02/0.12	0.00/0.56
Desire to change	0.66**	0.57	0.50	-0.36/-0.41	-0.43/-0.81
Value of change	0.39	-	-	-	-
Feasibility of change	0.02	-	-	-	-

Note. S = self-discipline group; O = openness to action group; the effect size across groups was a standardized mean difference and was calculated by subtracting the mean of the outcome scores of the self-discipline group from the mean of the outcome scores of the openness to action group at the same measurement occasion and dividing this raw mean difference by the pooled standard deviation. The effect size across time was a standardized mean difference and was calculated by subtracting the mean of the T2 (posttest), and T3 (follow-up assessment) from the mean of the T1 (pretest) scores and dividing this raw mean difference by the standard deviation of the raw scores at T1 and taking the correlation between T1 and T2, and T3 into account (Morris & DeShon, 2002); significance levels indicate the results of independent *t*-test to test T1-differences (see Results section): * $p < .05$, ** $p < .01$.

Table 5. *Means and Standard Deviations for all Outcome Variables Across Assessments for Both Intervention Groups in Study 2*

Outcome	Groups	Pretest: T1		Posttest: T2		Follow-up: T3		Follow-up 2: T4		Test-retest		
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	$r_{T1, T2}$	$r_{T1, T3}$	$r_{T1, T4}$
Self-discipline	Self-discipline	2.73	0.71	3.18	0.70	3.20	0.68	3.33	0.70	0.66*	0.73*	0.65*
	Openness to action	3.68	0.58	3.83	0.54	3.82	0.57	3.77	0.59	0.66*	0.70*	0.80*
	Total	2.96	0.79	3.36	0.72	3.37	0.71	3.45	0.70	0.73*	0.77*	0.70*
Openness to action	Self-discipline	3.07	0.56	3.12	0.54	3.09	0.56	3.15	0.55	0.83*	0.73*	0.72*
	Openness to action	2.79	0.59	3.06	0.45	3.03	0.49	3.02	0.41	0.70*	0.81*	0.68*
	Total	3.00	0.58	3.10	0.52	3.07	0.54	3.11	0.51	0.79*	0.75*	0.71*
Conscientiousness	Self-discipline	3.53	0.65	3.80	0.65	3.79	0.57	3.88	0.56	0.74*	0.74*	0.70*
	Openness to action	4.09	0.52	4.21	0.53	4.21	0.52	4.13	0.54	0.71*	0.62*	0.78*
	Total	3.67	0.67	3.91	0.65	3.91	0.57	3.94	0.56	0.76*	0.75*	0.71*
Openness to experience	Self-discipline	3.70	0.79	3.67	0.78	3.64	0.82	3.62	0.86	0.84*	0.86*	0.80*
	Openness to action	3.70	0.76	3.65	0.83	3.57	0.87	3.44	0.81	0.87*	0.85*	0.85*
	Total	3.70	0.78	3.66	0.79	3.62	0.83	3.57	0.85	0.85*	0.86*	0.81*
Extraversion	Self-discipline	3.29	0.62	3.36	0.56	3.38	0.52	3.40	0.63	0.80*	0.78*	0.82*
	Openness to action	3.27	0.50	3.33	0.46	3.34	0.51	3.27	0.54	0.75*	0.86*	0.73*
	Total	3.29	0.59	3.36	0.54	3.36	0.52	3.37	0.61	0.79*	0.80*	0.81*
Neuroticism	Self-discipline	2.90	0.82	2.61	0.79	2.71	0.73	2.65	0.78	0.76*	0.80*	0.78*
	Openness to action	2.70	0.73	2.51	0.73	2.50	0.70	2.51	0.77	0.58*	0.65*	0.64*
	Total	2.86	0.81	2.59	0.78	2.65	0.72	2.61	0.78	0.72*	0.77*	0.75*
Agreeableness	Self-discipline	3.75	0.70	3.81	0.63	3.74	0.71	3.77	0.69	0.87*	0.84*	0.82*
	Openness to action	4.03	0.60	4.11	0.62	4.13	0.58	4.02	0.70	0.67*	0.73*	0.74*
	Total	3.82	0.69	3.89	0.63	3.85	0.69	3.84	0.70	0.83*	0.82*	0.80*
Desire to change	Self-discipline	4.40	0.57	4.15	0.62	4.08	0.65	3.97	0.74	0.41*	0.43*	0.36*
	Openness to action	3.98	0.52	4.00	0.54	3.86	0.59	3.91	0.53	0.26	0.29	0.24
	Total	4.30	0.56	4.11	0.60	4.02	0.64	3.95	0.69	0.40*	0.42*	0.34*
Value of change	Self-discipline	12.86	1.33	12.35	1.60	-	-	-	-	0.36	-	-
	Openness to action	11.75	1.53	11.86	1.75	-	-	-	-	0.50	-	-
	Total	12.59	1.46	12.22	1.65	-	-	-	-	0.43	-	-
Feasibility of change	Self-discipline	8.60	2.63	10.56	2.81	-	-	-	-	0.47	-	-
	Openness to action	10.57	2.49	11.31	2.37	-	-	-	-	0.40	-	-

Total	9.06	2.72	10.77	2.71	-	-	-	-	0.44	-	-

Note. Self-discipline group: T1: n = 141, T2: n = 111, T3: n = 96, T4: n = 87; openness to action group: T1: n = 44, T2: n = 42, T3: n = 37, T4: n = 32. Potential range for personality facets, traits, desire to change: 1-5; [a] = three behaviors were combined into a sum score with a potential range from 1-15; [b]= three behaviors were combined into a sum score with a potential range from 3-18; * $p < .01$

Table 6. *Effect Sizes Across Intervention Groups and Time in Study 2*

	Effect size across groups				Effect size across time		
Outcome	d_{T1}	d_{T2}	d_{T3}	d_{T4}	$d_{T1, T2}$ (S/O)	$d_{T1, T3}$ (S/O)	$d_{T1, T4}$ (S/O)
Self-discipline	1.47*	1.04	0.99	0.68	0.77/0.31	0.90/0.31	1.01/0.25
Openness to action	0.49*	0.12	0.11	0.27	0.15/0.59	0.05/0.66	0.19/0.49
Conscientiousness	0.95*	0.69	0.77	0.45	0.58/0.30	0.56/0.27	0.70/0.12
Openness to experience	0.00	0.02	0.08	0.22	-0.07/-0.13	-0.14/-0.31	-0.16/-0.63
Extraversion	0.04	0.06	0.08	0.22	0.18/0.17	0.22/0.27	0.30/0.00
Neuroticism	0.26	0.13	0.29	0.18	-0.51/-0.28	-0.37/-0.33	-0.46/-0.31
Agreeableness	0.43	0.48	0.60	0.36	0.17/0.16	-0.03/0.23	0.05/-0.02
Desire to change	0.77**	0.26	0.35	0.09	-0.40/0.03	-0.53/-0.19	-0.67/-0.11
Value of change	0.77**	0.29	-	-	-0.34/0.07	-	-
Feasibility of change	0.77**	0.29	-	-	0.73/0.27	-	-

Note. S = self-discipline group; O = openness to action group; the effect size across groups was a standardized mean difference and was calculated by subtracting the mean of the outcome scores of the self-discipline group from the mean of the outcome scores of the openness to action group at the same measurement occasion and dividing this raw mean difference by the pooled standard deviation. The effect size across time was a standardized mean difference and was calculated by subtracting the mean of the T2 (posttest), T3 (follow-up assessment), and T4 (follow-up assessment 2) from the mean of the T1 (pretest) scores and dividing this raw mean difference by the standard deviation of the raw scores at T1 and taking the correlation between T1 and T2 and T3, and T4 into account (Morris & DeShon, 2002); significance levels indicate the results of independent *t*-test to test T1-differences (see Results section): * $p < .01$, ** $p < .001$.

Table 7. *Means and Standard Deviations for all Outcome Variables Across Observer-Reports for Both Intervention Groups in Study 2*

Outcome	Group	Pretest: T1		Posttest: T2		Test-retest
		M	*SD*	*M*	*SD*	$r_{T1, T2}$
Self-discipline	Self-discipline	3.67	0.69	3.79	0.57	0.84*
	Openness to action	4.14	0.40	4.19	0.41	0.76*
	Total	3.80	0.65	3.90	0.56	0.85*
Openness to action	Self-discipline	3.04	0.48	3.09	0.49	0.84*
	Openness to action	2.86	0.43	3.03	0.41	0.78*
	Total	2.99	0.48	3.07	0.47	0.82*
Conscientiousness	Self-discipline	4.20	0.70	4.24	0.61	0.74*
	Openness to action	4.59	0.38	4.64	0.45	0.63*
	Total	4.31	0.65	4.35	0.59	0.75*
Openness to experience	Self-discipline	4.02	0.59	4.08	0.51	0.68*
	Openness to action	3.98	0.55	4.07	0.55	0.56*
	Total	4.01	0.58	4.08	0.51	0.65*
Extraversion	Self-discipline	3.47	0.83	3.45	0.80	0.85*
	Openness to action	3.39	0.82	3.48	0.78	0.88*
	Total	3.44	0.82	3.46	0.79	0.85*
Neuroticism	Self-discipline	2.43	0.91	2.25	0.84	0.88*
	Openness to action	2.29	0.90	2.00	0.76	0.68*
	Total	2.39	0.90	2.18	0.82	0.83*
Agreeableness	Self-discipline	4.04	0.62	3.98	0.64	0.58*
	Openness to action	4.00	0.57	4.10	0.62	0.71*
	Total	4.03	0.61	4.02	0.63	0.61*

Note. Self-discipline group: T1 and T2: $n = 74$ were rated by 143 observers ; openness to action group: T1 and T2: $n = 29$ were rated by 55 observers; potential range for personality facets: 1-5*;* potential range for personality traits: 1-7; * $p < .01$.

Table 8. *Effect Sizes of Observer-Reports in Study 2*

	Effect size across groups		Effect size across time
Outcome	d_{T1}	d_{T2}	$d_{T1,\,T2}$ (S/O)
Self-discipline	0.83*	0.81	0.31/0.18
Openness to action	0.40	0.13	0.18/0.60
Conscientiousness	0.69*	0.75	0.08/0.15
Openness to experience	0.07	0.02	0.13/0.17
Extraversion	0.10	0.04	-0.04/0.22
Neuroticism	0.16	0.32	-0.40/-0.41
Agreeableness	0.07	0.19	-0.11/0.23

Note. S = self-discipline group; O = openness to action group; the effect size across groups was a standardized mean difference and was calculated by subtracting the mean of the outcome scores of the self-discipline group from the mean of the outcome scores of the openness to action group at the same measurement occasion and dividing this raw mean difference by the pooled standard deviation. The effect size across time was a standardized mean difference and was calculated by subtracting the mean of the T2 (posttest) from the mean of the T1 (pretest) scores and dividing this raw mean difference by the standard deviation of the raw scores at T1 and taking the correlation with T2 into account (Morris & DeShon, 2002); significance levels indicate the results of independent *t*-test to test T1-differences (see Results section): * $p < .01$.

Table 9. *Means and Standard Deviations for all Outcome Variables Across Assessments for Both Intervention Groups in the Combined Studies 1 and 2*

Outcome	Groups	Pretest: T1		Posttest: T2		Follow-up: T3		Follow-up 2: T4		Test-retest		
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	$r_{T1, T2}$	$r_{T1, T3}$	$r_{T1, T4}$
Self-discipline	Self-discipline	2.75	0.72	3.18	0.68	3.19	0.68	3.33	0.70	0.69*	0.73*	0.65*
	Openness to action	3.63	0.72	3.81	0.59	3.82	0.60	3.77	0.59	0.76*	0.77*	0.80*
	Total	2.98	0.82	3.36	0.71	3.37	0.72	3.45	0.70	0.76*	0.79*	0.70*
Openness to action	Self-discipline	3.10	0.56	3.15	0.55	3.12	0.55	3.15	0.55	0.83*	0.75*	0.72*
	Openness to action	2.81	0.57	3.10	0.50	3.09	0.52	3.02	0.41	0.73*	0.78*	0.68*
	Total	3.02	0.54	3.13	0.54	3.11	0.54	3.11	0.51	0.80*	0.74*	0.71*
Conscientiousness	Self-discipline	3.52	0.66	3.78	0.63	3.76	0.55	3.88	0.56	0.75*	0.75*	0.69*
	Openness to action	4.03	0.55	4.18	0.54	4.17	0.51	4.13	0.54	0.73*	0.67*	0.78*
	Total	3.65	0.67	3.90	0.63	3.88	0.57	3.94	0.56	0.77*	0.76*	0.71*
Openness to experience	Self-discipline	3.69	0.81	3.67	0.82	3.64	0.85	3.62	0.86	0.86*	0.86*	0.80*
	Openness to action	3.73	0.78	3.68	0.82	3.59	0.86	3.44	0.81	0.89*	0.86*	0.85*
	Total	3.70	0.80	3.67	0.82	3.63	0.85	3.57	0.85	0.81*	0.89*	0.91*
Extraversion	Self-discipline	3.30	0.65	3.37	0.61	3.37	0.55	3.40	0.63	0.83*	0.84*	0.82*
	Openness to action	3.24	0.59	3.37	0.50	3.39	0.60	3.27	0.54	0.78*	0.84*	0.73*
	Total	3.29	0.63	3.37	0.58	3.38	0.55	3.37	0.61	0.82*	0.81*	0.81*
Neuroticism	Self-discipline	2.85	0.85	2.62	0.81	2.70	0.75	2.65	0.78	0.78*	0.82*	0.78*
	Openness to action	2.64	0.78	2.46	0.75	2.42	0.71	2.51	0.77	0.68*	0.71*	0.64*
	Total	2.80	0.83	2.57	0.79	2.62	0.75	2.61	0.78	0.76*	0.79*	0.75*
Agreeableness	Self-discipline	3.80	0.72	3.84	0.66	3.79	0.72	3.77	0.69	0.86*	0.85*	0.82*
	Openness to action	4.02	0.62	4.09	0.59	4.16	0.56	4.02	0.70	0.70*	0.76*	0.74*
	Total	3.86	0.70	3.91	0.65	3.90	0.69	3.84	0.70	0.83*	0.84*	0.80*
Desire to change	Self-discipline	4.41	0.56	4.17	0.59	4.10	0.61	3.97	0.74	0.41*	0.39*	0.36*
	Openness to action	4.03	0.35	3.98	0.54	3.85	0.66	3.91	0.53	0.19*	0.28*	0.24*
	Total	4.31	0.54	4.12	0.58	4.03	0.63	3.95	0.69	0.39*	0.39*	0.34*
Value of change	Self-discipline	12.75	1.38	12.35	1.60	-	-	-	-	0.36	-	-
	Openness to action	11.80	1.48	11.86	1.75	-	-	-	-	0.50	-	-
	Total	12.50	1.46	12.22	1.65	-	-	-	-	0.43	-	-
Feasibility of change	Self-discipline	8.74	2.52	10.56	2.81	-	-	-	-	0.48	-	-

Openness to action	10.12	2.71	11.31	2.37	-	-	-	-	0.40	-	-
Total	9.10	2.64	10.77	2.71	-	-	-	-	0.44	-	-

Note. Self-discipline group: T1: $n = 189$, T2: $n = 151$, T3: $n = 130$, T4: $n = 87$; openness to action group: T1: $n = 66$, T2: $n = 60$, T3: $n = 53$, T4: $n = 32$. Potential range for personality facets, traits, desire to change: 1-5; [a] = three behaviors were combined into a sum score with a potential range from 1-15; [b]= three behaviors were combined into a sum score with a potential range from 3-18; * $p < .01$.

Table 10. *Effect Sizes Across Intervention Groups and Time in the Combined Studies 1 and 2*

	Effect size across groups				Effect size across time		
Outcome	d_{T1}	d_{T2}	d_{T3}	d_{T4}	$d_{T1, T2}$ (S/O)	$d_{T1, T3}$ (S/O)	$d_{T1, T4}$ (S/O)
Self-discipline	1.22	0.99	0.98	0.68	0.76/0.43	0.83/0.37	0.96/0.26
Openness to action	0.51	0.10	0.39	0.27	0.15/0.69	0.05/0.74	0.12/0.46
Conscientiousness	0.84	0.68	0.77	0.45	0.56/0.37	0.51/0.31	0.69/0.27
Openness to experience	0.05	0.01	0.06	0.22	-0.05/-0.14	-0.12/-0.34	-0.14/-0.68
Extraversion	0.10	0.00	0.03	0.22	0.19/0.33	0.17/0.45	0.26/0.46
Neuroticism	0.26	0.20	0.38	0.18	-0.41/-0.29	-0.29/-0.37	-0.36/-0.20
Agreeableness	0.33	0.40	0.57	0.36	0.11/0.15	-0.03/0.33	-0.07/0.00
Desire to change	0.81	0.34	0.39	0.09	-0.40/-0.11	-0.50/-0.43	-0.69/-0.28
Value of change	0.66	0.29	-	-	-0.26/0.04	-	-
Feasibility of change	0.53	0.29	-	-	0.71/0.40	-	-

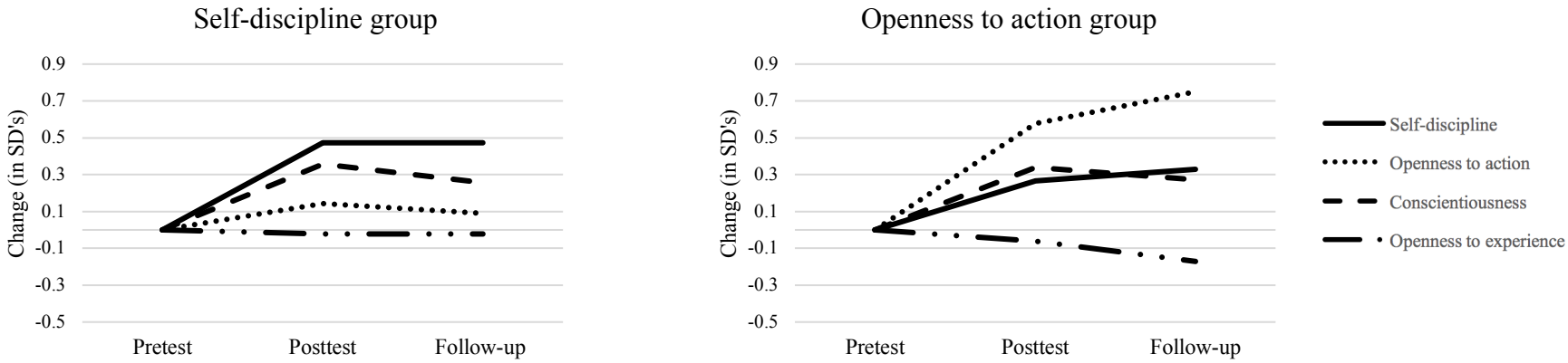
Note. S = self-discipline group; O = openness to action group; the effect size across groups was a standardized mean difference and was calculated by subtracting the mean of the outcome scores of the self-discipline group from the mean of the outcome scores of the openness to action group at the same measurement occasion and dividing this raw mean difference by the pooled standard deviation. The effect size across time was a standardized mean difference and was calculated by subtracting the mean of the T2 (posttest), T3 (follow-up assessment), and T4 (follow-up assessment 2) from the mean of the T1 (pretest) scores and dividing this raw mean difference by the standard deviation of the raw scores at T1 and taking the correlation between T1 and T2 and T3, and T4 into account (Morris & DeShon, 2002).

Table 11. *Fixed Effects Parameter Estimates for the Logarithmic Models with Logarithmic Slope by Group Interaction for the Combined Studies 1 and 2*

Fixed effects	Personality facets			Personality traits			
	Self-discipline	Openness to action	Conscientiousness	Openness to experience	Extraversion	Neuroticism	Agreeableness
Intercept							
Estimate (*SE*)	3.66*** (0.09)	2.86*** (0.07)	4.06*** (0.08)	3.73*** (0.10)	3.26*** (0.07)	2.62*** (0.10)	4.04*** (0.08)
95% CI	3.49; 3.82	2.73; 2.99	3.91; 4.21	3.53; 3.92	3.12; 3.41	2.43; 2.82	3.88; 4.20
Logarithmic slope							
Estimate (*SE*)	0.10 (0.05)	0.18*** (0.04)	0.05 (0.04)	-0.07 (0.04)	0.07 (0.04)	-0.16** (0.05)	0.06 (0.04)
95% CI	-0.00; 0.19	0.10; 0.25	-0.03; 0.14	-0.16; 0.02	-0.00; 0.13	-0.26; -0.06	-0.02; 0.14
Group							
Estimate (*SE*)	-0.86*** (0.10)	0.24** (0.08)	-0.51*** (0.09)	-0.03 (0.11)	0.05 (0.09)	0.19 (0.11)	-0.23* (0.10)
95% CI	-1.05; -0.66	0.08; 0.39	-0.69; -0.34	-0.26; 0.19	-0.12; 0.22	-0.03; 0.42	-0.42; -0.05
Logarithmic slope by group							
Estimate	0.24*** (0.06)	-0.12** (0.04)	0.13** (0.05)	0.06 (0.05)	-0.01 (0.04)	-0.01 (0.06)	-0.07 (0.05)
95% CI	0.12; 0.35	-0.21; -0.04	0.03; 0.22	-0.04; 0.16	-0.09; 0.07	-0.13; 0.10	-0.15; 0.02

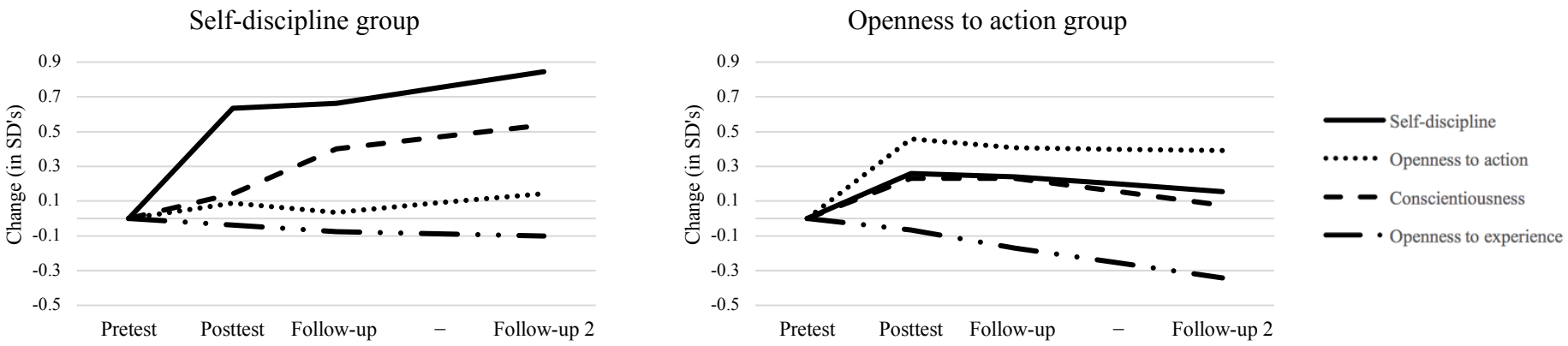
Note. Number of observations = 768; *SE* = standard error; group: 0 = openness to action, 1 = self-discipline.
*$p < .05$, ** $p < .01$, ***$p < .01$

Figure 1. *Changes in Standard Deviations Over Time in Study 1*



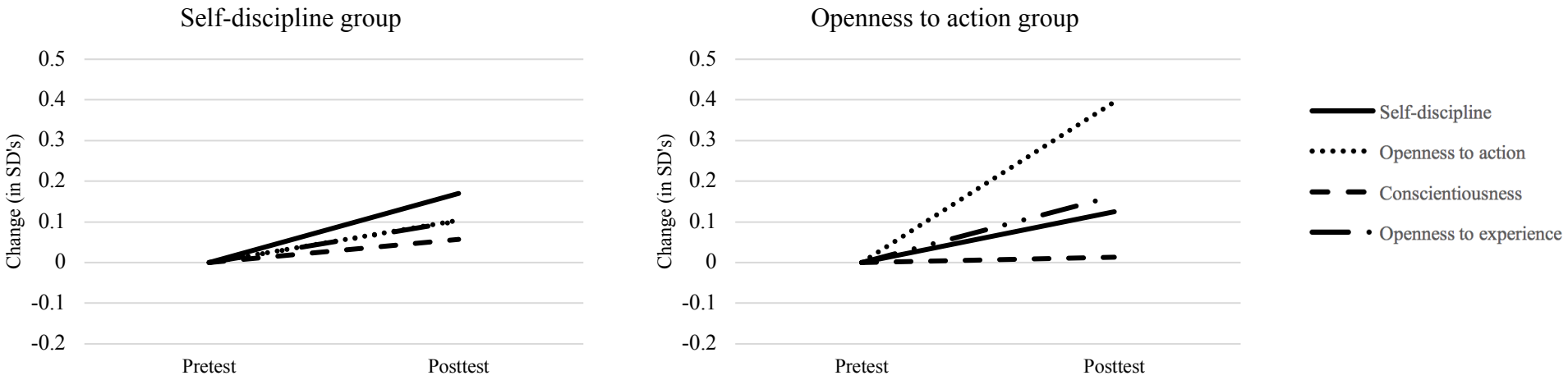
Note. Average change in outcome from pretest to follow-up. The y-axis is the change in the outcome variable measured in standard deviation units. Estimates for each time point for each outcome were calculated by subtracting the pretest mean from the mean of the outcome at a specific time point and dividing by the standard deviation of that outcome at pretest. Positive values indicate an increase in the outcome variable and negative values a decrease in the outcome. The x-axis is scaled in two-week periods.

Figure 2. *Changes in Standard Deviations Over Time in Study 2: Self-Reports*



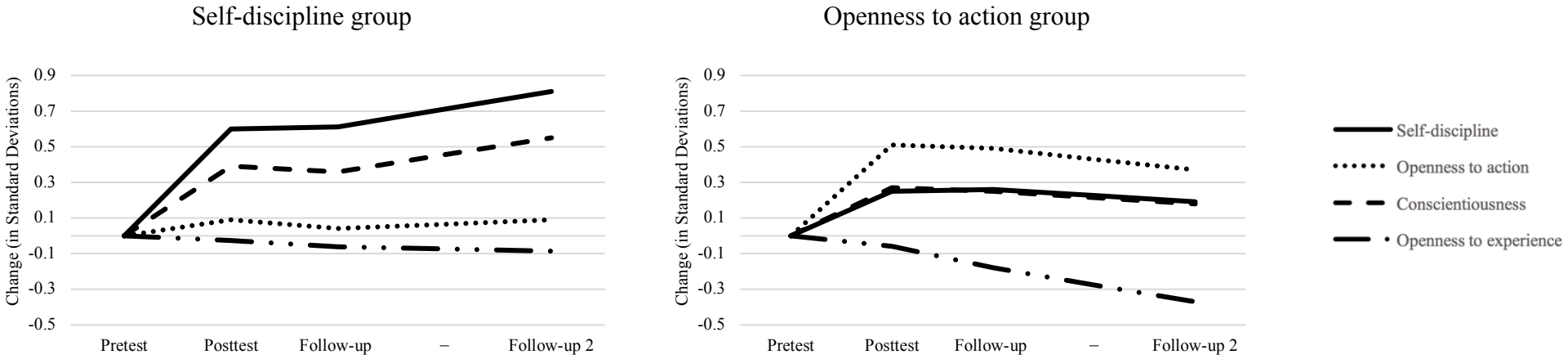
Note. Average change in outcome from pretest to follow-up and follow-up 2. The y-axis is the change in the outcome variable measured in standard deviation units. Estimates for each time point for each outcome were calculated by subtracting the pretest mean from the mean of the outcome at a specific time point and dividing by the standard deviation of that outcome at pretest. Positive values indicate an increase in the outcome variable and negative values a decrease in the outcome. The x-axis is scaled in two-week periods.

Figure 3. *Changes in Standard Deviations over Time in Study 2*: Observer-Reports



Note. Average change in outcome from pretest to follow-up. The y-axis is the change in the outcome variable measured in standard deviation 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 standard deviation of that outcome at pretest. Positive values indicate an increase in the outcome variable and negative values a decrease in the outcome.

Figure 4. *Changes in Standard Deviations Over Time in the Combined Studies 1 and 2: Self-Reports*



Note. Average change in outcome from pretest to follow-up and follow-up 2. The y-axis is the change in the outcome variable measured in standard deviation 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 standard deviation of that outcome at pretest. Positive values indicate an increase in the outcome variable and negative values a decrease in the outcome. The x-axis is scaled in two-week periods.

Supplementary Table 1. *Model Selection Based on AIC/BIC from the Multilevel Models Studies 1 and 2*

	Study 1					
	Intercept Only		Linear		Logarithmic	
	AIC	BIC	AIC	BIC	AIC	BIC
Outcome	Self-discipline group - Self-reports					
Self-discipline	213.96	222.37	195.99	212.81	189.50	206.32
Openness to action	118.57	126.98	122.95	139.77	122.14	138.96
Conscientiousness	166.00	174.41	160.15	176.98	157.68	174.51
Openness to experience	197.05	205.46	199.31	216.14	198.23	215.05
Extraversion	159.26	167.67	155.03	171.85	155.49	172.31
Neuroticism	216.94	225.35	218.02	234.85	216.70	233.52
Agreeableness	169.39	177.80	173.87	190.69	174.05	190.87
	Openness to action group - Self-reports					
Self-discipline	90.46	96.53	84.70	96.85	79.58	91.74
Openness to action	73.79	79.87	57.73	69.88	53.26	65.41
Conscientiousness	59.39	65.47	64.66	76.81	64.07	76.22
Openness to experience	75.11	81.19	79.14	91.29	79.67	91.82
Extraversion	80.61	86.68	81.36	93.51	80.94	93.09
Neuroticism	87.95	94.02	91.32	103.47	89.49	101.64
Agreeableness	70.35	76.42	75.45	87.60	74.85	87.00
	Study 2					
	Intercept Only		Linear		Logarithmic[1]	
	AIC	BIC	AIC	BIC	AIC	BIC
Outcome	Self-discipline group - Self-reports					
Self-discipline	750.02	762.24	681.18	705.63	645.54	669.99
Openness to action	381.58	393.81	376.19	400.65	376.10	391.55
Conscientiousness	568.14	580.37	536.51	560.96	521.62	546.08
Openness to experience	608.55	620.78	598.89	623.35	595.34	619.80
Extraversion	435.10	447.33	437.56	462.01	435.65	460.10

Neuroticism	733.68	745.90	716.86	741.31	706.95	731.41
Agreeableness	462.48	474.71	460.61	485.06	452.03	476.48
Openness to action group - Self-reports						
Self-discipline	148.05	157.18	149.98	168.25	147.87	166.13
Openness to action	143.16	152.29	140.82	159.08	134.16	152.42
Conscientiousness	131.98	141.11	136.38	154.64	133.98	152.24
Openness to experience	181.49	190.62	181.98	200.23	176.75	195.01
Extraversion	93.33	102.46	95.24	113.50	93.10	111.36
Neuroticism	257.10	266.22	255.13	273.39	249.95	268.21
Agreeableness	172.31	181.44	173.93	192.19	171.58	189.84
Self-discipline group - Observer-reports						
Self-discipline	209.56	218.56	204.38	216.37	-	-
Openness to action	123.17	132.17	122.71	134.70	-	-
Conscientiousness	241.78	250.77	243.40	255.39	-	-
Openness to experience	203.46	212.45	204.06	216.05	-	-
Extraversion	269.48	278.48	271.37	283.35	-	-
Neuroticism	308.51	317.58	298.03	310.13	-	-
Agreeableness	257.95	266.95	259.27	271.26	-	-
Openness to action group - Observer-reports						
Self-discipline	39.90	46.08	40.95	49.19	-	-
Openness to action	51.85	58.03	44.16	52.40	-	-
Conscientiousness	53.15	59.33	54.55	62.78	-	-
Openness to experience	54.54	62.78	89.87	98.12	-	-
Extraversion	101.41	107.59	101.61	109.85	-	-
Neuroticism	144.70	150.98	141.54	149.92	-	-
Agreeableness	89.95	96.13	90.52	98.77	-	-

Note. AIC = Akaike information criterion; BIC = Bayesian information criterion; [1] Logarithmic change models could not be examined for observer-reports because there were only two measurement occasions.

Supplementary Table 2. *Fixed Effects Parameter Estimates for the Logarithmic Models for both Intervention Groups in Study 1*

	Personality facets				Personality traits		
Fixed effects	Self-discipline	Openness to action	Conscientiousness	Openness to experience	Extraversion	Neuroticism	Agreeableness
			Self-discipline group				
Intercept							
Estimate (*SE*)	2.83*** (0.11)	3.16*** (0.08)	3.50*** (0.10)	3.67** (0.13)	3.33*** (0.11)	2.69*** (0.13)	3.94*** (0.11)
95% CI	2.61; 3.04	3.00; 3.32	3.30; 3.70	3.41; 3.92	3.12; 3.54	2.44; 2.94	3.72; 4.16
Logarithmic slope							
Estimate (*SE*)	0.37*** (0.08)	0.07 (0.05)	0.19** (0.06)	-0.03 (0.07)	0.12 (0.06)	-0.14 (0.07)	-0.06 (0.06)
95% CI	0.21; 0.52	-0.03; 0.17	0.06; 0.31	-0.20; 0.11	-0.00; 0.24	-0.29; 0.01	-0.18; 0.05
			Openness to action group				
Intercept							
Estimate (SE)	3.51*** (0.20)	2.85*** (0.11)	3.93*** (0.13)	3.79*** (0.17)	3.18*** (0.15)	2.51*** (0.18)	4.01*** (0.14)
95% CI	3.11; 3.91	2.63; 3.07	3.67; 4.18	3.44; 4.13	2.88; 3.49	2.15; 2.88	3.74; 4.28
Logarithmic slope							
Estimate (SE)	0.25 (0.13)	0.35** (0.09)	0.07 (0.08)	-0.04 (0.08)	0.20* (0.09)	-0.13 (0.10)	0.07 (0.08)
95% CI	-0.01; 0.52	0.16; 0.53	-0.08; 0.26	-0.20; 0.12	0.02; 0.40	-0.34; 0.07	-0.09; 0.25

Note. Number of observations: Self-discipline group = 122, openness to action group = 66; *SE* = Standard error.
*$p < .05$, ** $p < .01$, ***$p < .01$

Supplementary Table 3. *Fixed Effects Parameter Estimates for the Logarithmic Models for both Intervention Groups in Study 2*

	Personality facets				Personality traits		
Fixed effects	Self-discipline	Openness to action	Conscientiousness	Openness to experience	Extraversion	Neuroticism	Agreeableness
			Self-discipline group				
Intercept							
Estimate (*SE*)	2.79*** (0.06)	3.07*** (0.05)	3.57*** (0.05)	3.70*** (0.07)	3.31*** (0.05)	2.86*** (0.07)	3.76*** (0.06)
95% CI	2.68; 2.90	2.98; 3.16	3.46; 3.67	3.57; 3.83	3.21; 3.40	2.73; 2.99	3.65; 3.88
Logarithmic slope							
Estimate (*SE*)	0.32*** (0.04)	0.05 (0.03)	0.18*** (0.03)	-0.00 (0.03)	0.05* (0.02)	-0.18*** (0.03)	0.00 (0.03)
95% CI	0.25; 0.40	-0.00; 0.10	0.13; 0.24	-0.01; 0.06	0.00; 0.09	-0.24; -0.12	-0.05; 0.06
			Openness to action group				
Intercept							
Estimate (SE)	3.72*** (0.08)	2.85*** (0.08)	4.12*** (0.07)	3.69*** (0.12)	3.29*** (0.07)	2.68*** (0.10)	4.05*** (0.08)
95% CI	3.56; 3.88	2.69; 3.02	3.98; 4.27	3.47; 3.92	3.15; 3.44	2.48; 2.88	3.89; 4.22
Logarithmic slope							
Estimate (SE)	0.07 (0.04)	0.13** (0.04)	0.05 (0.04)	-0.07 (0.04)	0.04 (0.04)	-0.17* (0.07)	0.06 (0.05)
95% CI	-0.01; 0.16	0.04; 0.21	-0.04; 0.13	-0.16; 0.01	-0.03; 0.11	-0.30; -0.04	-0.03; 0.15

Note. Number of observations: Self-discipline group = 435, openness to action group = 155; *SE* = Standard error.
*$p < .05$, ** $p < .01$, ***$p < .01$

Supplementary Table 4. *Fixed Effects Parameter Estimates for the Linear Models for both Intervention Groups in Study 2 - Observer-reports*

	Personality facets				Personality traits		
Fixed effects	Self-discipline	Openness to action	Conscientiousness	Openness to experience	Extraversion	Neuroticism	Agreeableness
				Self-discipline group			
Intercept							
Estimate (*SE*)	3.67*** (0.07)	3.04*** (0.06)	4.20*** (0.08)	4.02*** (0.06)	3.47*** (0.09)	2.37*** (0.11)	4.04*** (0.07)
95% CI	3.52; 3.81	2.93; 3.15	4.05; 4.35	3.89; 4.14	3.28; 3.65	2.16; 2.58	3.90; 4.18
Linear slope							
Estimate (*SE*)	0.12** (0.04)	0.05 (0.03)	0.03 (0.06)	0.06 (0.05)	-0.02 (0.05)	-0.18*** (0.05)	-0.06 (0.07)
95% CI	0.03; 0.20	-0.01; 0.11	-0.08; 0.14	-0.04; 0.16	-0.12; 0.09	-0.28; -0.08	-0.19; 0.08
				Openness to action group			
Intercept							
Estimate (SE)	4.14*** (0.07)	2.86*** (0.08)	4.59*** (0.08)	3.98*** (0.10)	3.39*** (0.15)	2.21*** (0.16)	4.00*** (0.11)
95% CI	3.99; 4.29	2.70; 3.01	4.44; 4.74	3.78; 4.18	3.09; 3.68	1.89; 2.54	3.78; 4.22
Linear slope							
Estimate (SE)	0.05 (0.05)	0.18** (0.05)	0.05 (0.07)	0.09 (0.09)	0.10 (0.07)	-0.28* (0.12)	0.10 (0.08)
95% CI	-0.05; 0.15	0.07; 0.28	-0.08; 0.19	-0.10; 0.28	-0.05; 0.24	-0.53; -0.04	-0.07; 0.27

Note. Number of observations: Self-discipline group = 148, openness to action group = 58; *SE* = Standard error.
*$p < .05$, ** $p < .01$, ***$p < .01$

Supplementary Table 5. *Model Selection Based on AIC/BIC from the Multilevel Models for the Combined Studies 1 and 2*

	Intercept Only		Linear		Logarithmic	
Outcome	AIC	BIC	AIC	BIC	AIC	BIC
Self-discipline	1272.67	1286.61	1186.40	1214.26	1129.48	1157.34
Openness to action	710.57	724.50	697.24	725.11	676.60	704.50
Conscientiousness	952.01	965.94	913.40	941.26	887.91	915.78
Openness to experience	1050.82	1064.75	1034.38	1062.24	1023.81	1051.68
Extraversion	764.22	778.15	761.38	789.24	754.01	781.87
Neuroticism	1291.11	1305.04	1261.92	1289.78	1246.04	1273.90
Agreeableness	873.25	887.18	873.56	901.42	864.13	891.99

Note. AIC = Akaike information criterion; BIC = Bayesian information criterion; bold numbers denote best fitting models.

Supplementary Table 6. *Fixed Effects Parameter Estimates for the Logarithmic Models with Logarithmic Slope by Group Interaction for the Combined Studies 1 and 2 – With Covariates*

Fixed effects	Personality facets			Personality traits			
	Self-discipline	Openness to action	Conscientiousness	Openness to experience	Extraversion	Neuroticism	Agreeableness
Intercept							
Estimate (*SE*)	3.52*** (0.16)	2.98*** (0.14)	3.81*** (0.15)	3.74*** (0.21)	3.31*** (0.15)	2.47*** (0.20)	4.18*** (0.17)
95% CI	3.20; 3.83	2.71; 3.25	3.52; 4.10	3.33; 4.15	3.01; 3.61	2.09; 2.86	3.84; 4.52
Logarithmic slope							
Estimate (*SE*)	0.10 (0.05)	0.18*** (0.04)	0.05 (0.04)	-0.07 (0.04)	0.07 (0.04)	-0.16** (0.05)	0.06 (0.04)
95% CI	-0.00; 0.19	0.10; 0.25	-0.03; 0.13	-0.15; 0.02	-0.00; 0.14	-0.26; -0.06	-0.02; 0.14
Group							
Estimate (*SE*)	-0.63*** (0.10)	0.33*** (0.08)	-0.39*** (0.09)	-0.05 (0.12)	0.11 (0.09)	0.02 (0.12)	-0.21* (0.10)
95% CI	-0.82; -0.43	0.17; 0.50	-0.57; -0.21	-0.30; 0.18	-0.08; 0.29	-0.22; 0.26	-0.41; -0.00
Logarithmic slope by group							
Estimate	0.23*** (0.06)	-0.12** (0.04)	0.13** (0.05)	0.06 (0.05)	-0.01 (0.04)	-0.01 (0.06)	-0.07 (0.05)
95% CI	0.12; 0.35	-0.21; -0.04	0.04; 0.22	-0.04; 0.16	-0.09; 0.08	-0.13; 0.10	-0.16; 0.02

Note. Number of observations = 768; *SE* = standard error; group: 0 = openness to action, 1 = self-discipline; the potential effects of age, desire to change, value of change, feasibility of change, and study were controlled (covariates in the models).
*$p < .05$, ** $p < .01$, ***$p < .01$

Supplementary Table 7. *Fixed Effects Parameter Estimates for the Logarithmic Models with Slope by Group Interaction for the Combined Samples Controlled for T1 Levels*

Fixed effects	Personality facets			Personality traits			
	Self-discipline	Openness to action	Conscientiousness	Openness to experience	Extraversion	Neuroticism	Agreeableness
Intercept	0.26*** (0.09)	0.24*** (0.06)	0.31*** (0.09)	0.08 (0.07)	0.29*** (0.07)	0.28** (0.08)	0.26*** (0.08)
Logarithmic Slope	0.10 (0.06)	0.20*** (0.04)	0.05 (0.05)	-0.07 (0.05)	0.08 (0.04)	-0.16** (0.06)	0.06 (0.04)
Group	-0.05 (0.03)	-0.01 (0.03)	-0.03 (0.03)	-0.02 (0.03)	0.01 (0.03)	0.00 (0.04)	-0.03 (0.03)
Group by Logarithmic slope	0.24*** (0.07)	-0.14** (0.05)	0.12* (0.06)	0.06 (0.06)	-0.01 (0.05)	-0.01 (0.07)	-0.07 (0.05)

Note. Number of observations = 768; *SE* = standard error; condition: 0 = openness to action, 1 = self-discipline; the potential effects of age, desire to change, value of change, feasibility of change, study, and T1 levels were controlled (covariates in the models).
*$p < .05$, ** $p < .01$, ***$p < .01$