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The Development of Mindfulness in Young Adults: the Relationship of Personality, Reinforcement Sensitivity, and Mindfulness

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Abstract

Objectives We report a pre-registered longitudinal study of emerging adults which examined the links between facets of mindfulness with Big Five and reinforcement sensitivity personality traits with the aim of exploring possible origins of individual differences in trait mindfulness.

Methods We investigated the relationship between personality, reinforcement sensitivity (including Behavioral Inhibition System (BIS) and Behavioral Approach System (BAS)), and mindfulness in a sample of 227 undergraduate students across 8 months, using a random-intercept cross-lagged panel model.

Results Mindfulness, in general, exhibited stronger longitudinal effects on personality than the other way around. We found reciprocal effects between reinforcement sensitivity and mindfulness facets: higher BAS-Goal-Drive Persistence positively predicted increased Acting with Awareness over time ($B = 0.369$ [.044, .693], $p = .026$) and higher Acting with Awareness predicted an increase in BAS-Goal-Drive Persistence ($B = .173$ [.041, .305], $p = .010$). Higher Non-Reacting Mindfulness predicted a reduction of BIS over time ($B = -.132$ [$-.247, -.017$], $p = .025$), with individuals with more skills to stay calm in emotional situations decreasing their reported levels of anxiety and emotional lability. Additionally, we found that higher Non-Judging mindfulness facets predicted an increase in Conscientiousness ($B = .147$ [.014, .280], $p = .031$). Finally, higher levels of Describing Mindfulness predicted an increase in Neuroticism over time ($B = .200$ [.034, .366], $p = .018$).

Conclusions Overall, our research findings indicate that mindfulness and personality share developmental trajectories over a 4-month period, suggesting avenues for possible personality development via Mindfulness interventions.

Keywords Personality · Mindfulness · Reinforcement sensitivity · Longitudinal · BIS/BAS · FFMQ

Mindfulness practitioners argue that mindfulness needs to be cultivated through careful and prolonged practice and may not change without focused interventions (Kang and Whittingham 2010). At the same time, the ability to pay attention to the present, in a non-judgmental way may be part of a larger personality trait complex. Indeed, mindfulness could be thought of as being systematically related to personality dimensions focused on emotion regulation, attention to detail, and openness to sensual experiences (emotional stability, conscientiousness, and openness), associations that have been reported in previous studies. The five factor model (FFM) of personality (McCrae and Costa 1997) proposes that behavioral differences between individuals are organized along five higher order dimensions: Openness (a desire for stimulating external and internal experiences), Conscientiousness (the ability to delay rewards and follow rules), Extraversion (the desire for social interaction), Agreeableness (the ability to maintain social relationships through empathy, respectfulness, and trust), and Neuroticism (the tendency to experience anxious or depressive moods, as well as emotional volatility).

These five dimensions are thought to be rooted in global neurobehavioral systems that vary between individuals, such as sensitivity to reward and punishment proposed in the revised Reinforcement Sensitivity Theory (Corr et al. 2013). This theory proposes a number of basic systems, including the Behavioral Approach System (BAS), the Behavioral Inhibition System (BIS), and a Fight-Flight-Freeze System. These systems are thought to be driven by genetically derived predisposition which are in turn being calibrated and updated

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in response to environmental stimuli during crucial phases of a person's development (Corr and Matthews 2020). The BAS orients individuals towards rewards and aids in obtaining those rewards through four main pathways: Reward Interest, Reward Reactivity, Goal-Drive Persistence, and Impulsivity. Individuals can be habitually motivated to direct their attention to potential rewards by either increasing the physical pleasure felt from rewards (Reward Reactivity) or by expressing an increased interest in rewards, which is associated with greater exploration of possibly rewarding stimuli (Reward Interest). There are also individual differences in the tendency to seek to obtain temporally or spatially immediate rewards, labeled Impulsivity, or delay obtaining immediate rewards to obtain larger rewards in the future, labeled Goal-Drive Persistence (Corr and Matthews 2020; Corr and McNaughton 2012). In contrast, the BIS is characterized by greater punishment sensitivity and monitoring of possible goal conflict, commonly expressed as worry about future threats and anxiety (Corr and Cooper 2016; Gray 1970). Although there are currently no direct measures of BIS/BAS at physiological or neurobiological levels, there are validated instruments that allow self-report measurement of the psychological and behavioral expressions of these two systems.

The interplay between these two major systems is thought to give rise to the behavioral traits as captured by the Big Five. Specifically, Neuroticism is thought to originate from differences in the sensitivity of the BIS. In contrast, Extraversion is thought to originate from individual differences in the sensitivity of the different BAS components (Gray 1970). These two personality traits have been most consistently associated with BIS/BAS, but the other three Big Five traits have also been linked to BIS/BAS in theory (Corr et al. 2013; Fischer 2017) and through empirical investigations (Fischer and Karl 2020). Openness summarizes aspects of personality aimed at obtaining external rewards (e.g., money) and internal rewards (e.g., positive affect, excitement) and has been linked to BAS Reward Interest/ Reactivity (Corr et al. 2013). Similarly, Conscientiousness, aimed at obtaining temporally distant rewards, is thought to be related to high BAS Goal-Drive Persistence (Corr and Cooper 2016). Finally, Agreeableness is more complex in its relationship to BIS/BAS (Corr et al. 2013) and might be linked to both BIS and BAS through an interplay of maintaining rewarding social connections (related to BAS), but also the need for restricting one's behavior to fit social rules (a core component of BIS, see Fischer 2017). Evidence seems to suggest relative consistent positive relations of Agreeableness with BAS, but both positive and negative correlations with BIS, which could be due to instrument and sample effects (Corr and Cooper 2016; Smits and Boeck 2006). Importantly, while BIS/BAS are thought to underly individual differences in the Big Five, they do not completely overlap (Corr et al. 2013; Fischer and Karl 2020). For example, while BIS is thought to underly Neuroticism, it is more

closely linked to the anxiety and rumination components of Neuroticism, rather than to the emotional volatility aspects (Slobodskaya and Kuznetsova 2013). Therefore, including both models of personality simultaneously allows us to examine their unique temporal associations with dispositional mindfulness, which can also open opportunities for a better targeting of future mindfulness interventions.

To date, the relationship between mindfulness, personality, and reinforcement sensitivity has been examined in cross-sectional studies (e.g., Giluk 2009; Hanley and Garland 2017; Karl and Fischer 2019), which unfortunately do not allow any inferences about temporal relationships and possible causality. Currently, personality researchers tend to make claims about directionality (e.g., BIS influencing Non-Judging) based on theoretical assumptions that responses to BIS/BAS scales represent underlying neuroanatomical differences in emotion and cognition (Dolatyar and Walker 2020). Consequently, correlations of BIS or BAS with mindfulness are interpreted as the influence of more basic neurobiological systems on mindfulness-based emotional experience and response (Corr and Cooper 2016). Given the presumed biological determination of the Big Five (McAdams and Pals 2006), similar claims could be made about correlations of mindfulness with Big Five measures. Seen from this perspective, personality changes are thought to be driving changes in mindfulness over time.

Recent theories and empirical evidence suggest that personality is dynamic and responds to situational and developmental cues, with major transitions taking place during early adulthood (Bleidorn et al. 2013; Kandler 2012; Roberts et al. 2006). Early adulthood is a particularly interesting period because it is marked by a convergence of biological changes, normative expectations, and social maturation effects related to identity and self-perceptions (Fischer 2017; Roberts and Davis 2016). First, early adulthood is a time of substantial neurobiological development involving a wide net of neurological systems assumed to underlie personality dynamics (Costa and McCrae 2006). Second, during early adulthood, individuals typically assume new social and work roles in their life, moving away from their parents to further their education (study) or secure paid employment, seek to find a stable life partner, and start forming a family. These new roles are accompanied by a range of expectations about appropriate behavior. Conforming to these normative expectations tends to be rewarded (e.g., academic achievement), whereas failure to adhere role-related expectations might be punished (e.g., social exclusion). Conforming to these social norms and associated expectations is typically linked to changes in personality traits in a socially normative fashion (Bleidorn et al. 2013; Lodi-Smith and Roberts 2016). Finally, changes in self-perceptions and identity development during this period might play a substantial role in trait changes. Transitory periods with challenges and associated success or failure to adjust to those

challenges may create feedback loops that shape personality. For example, if a university student views herself as studious and her studies are central to her identity, she is likely to dedicate an increased time to study. In case of academic achievements, this view might be validated and then reinforces an emerging trait-like behavioral predisposition of working hard (Göllner et al. 2017). Alternatively, failure may lead to a need to re-evaluate self-perceptions and associated behaviors (Roberts and Davis 2016).

Wrzus and Roberts (2017) developed the TESSERA framework to explain the mechanisms of personality change. Their model distinguishes short, medium, and long-term developmental processes. The period when individuals are leaving their parental home and assume new roles and responsibilities as university students is exceptionally rich in processes that are likely to induce personality processes that will lead to personality changes in the short-term, which can then crystallize and become stabilized in the following years. Crucial processes in this period include increased personal reflections in reaction to environmental stimulation, role modeling by peers, feedback and reinforcement of novel behaviors in response to changed roles and responsibilities, self-regulation, accommodation, and assimilation to new behavioral demands.

In line with these theoretical processes, Roberts et al. (2006) reported a meta-analysis of 92 longitudinal studies (total $N = 50,120$) which indicated that our focal age of 18 to 22 years was characterized by some of the most profound personality trait changes observable during the life span. The largest developmental changes were observed for aspects of Extraversion and Openness, and the weakest and non-significant changes for this age group were observed for Agreeableness and Conscientiousness. Personality may even systematically change over a period of 2 weeks provided individuals are motivated to change their personality and receive daily reminders (Stieger et al. 2020). In summary, personality during early adulthood is relatively malleable and likely to change depending on the individual's social environment and normative role expectations. Given these personality dynamics during this age period, the current research aims to examine how personality traits and mindfulness may relate to each other during a formative period of young people's lives.

In contrast to personality traits, dispositional mindfulness has been conceptualized as a relatively stable individual difference variable, but with some malleability due to practice and life events (Baer et al. 2008). Young adults might experiment with alternative life experiences and may take up new habits while transitioning from home to a more independent adult life. The opportunities and challenges during the first year of university create multiple situations in which individuals need to regulate their emotional and behavioral impulses and may become aware of their thoughts, feelings, and perceptions to successfully navigate novel environments. Given

the above-noted processes at biological, social, and subjective levels that have a likely impact on personality development, one might expect that similar changes could occur for individual differences in dispositional mindfulness. Research on the developmental trajectories of mindfulness has largely focused on the role of attachment styles (Stevenson et al. 2017). Less is known about other developmental influences on mindfulness. Given the well-documented patterns of change in personality in young adults (Roberts and Davis 2016) and the consistent cross-sectional link of personality and reinforcement sensitivity traits to mindfulness (Hanley et al. 2018; Reese et al. 2015), it is especially important to examine the role of personality and reinforcement sensitivity in the development of mindfulness during early adulthood.

The BIS system is geared towards the evaluation of risk and the rapid activation of (emotional) reaction without necessarily passing through conscious awareness. Hence, this automatic evaluation component would interfere with the various facets of mindfulness that require conscious awareness, acceptance of negative thoughts, and downregulating strong emotional responses. In line with these expectations, previous cross-sectional studies (Hanley et al. 2018; Karl and Fischer 2019) reported negative correlations between BIS and mindfulness facets expressing present-moment awareness of one's behavior and emotions, as well as judgment of one's emotional reactions. This suggests that individuals with higher activation of BIS tend to engage in fast, automatic behavior aimed at avoiding negative stimuli due to increased punishment sensitivity (Gray 2004; Keune et al. 2012), which conflicts with the conscious processing necessary to be aware of one's emotions and actions and, crucially, to non-critically consider them.

In contrast, highly Reward-Reactive individuals (part of BAS) are generally oriented towards experiencing positive stimuli and emotions (Corr and Cooper 2016), which in turn should decrease their focus on negative stimuli and making it easier for them to be non-judgmental towards their own experiences. Patterns in line with these theoretical predictions have been observed in previous cross-sectional studies (see: Hanley et al. 2018; Karl and Fischer 2019).

Focusing on the Big Five, individuals high in Conscientiousness are typically motivated to obtain future rewards through self-discipline and restraining rash impulses that may interfere with longer term-goals. These behavioral tendencies necessitate sustained present-moment attention. In line with this reasoning, Acting with Awareness has been found to be positively related to Conscientiousness in cross-sectional observations (Haliwa et al. 2020). Openness represents a drive towards curiosity and being open-minded about new ideas, as well as an interest in deep philosophical thoughts (Soto and John 2017). Therefore, individuals higher in openness might be more likely to engage with and pay attention to both internal and external stimuli, as this is consistent

with the greater sensitivity towards sensory and intellectual stimulation. Conforming to these patterns, mindfulness dimensions expressing openness and awareness towards both internal (Describing) and external stimuli (Observing) have been consistently found to be positively related to Openness (Spinhoven et al. 2017). Neuroticism expresses emotional fragility and is characterized by emotional volatility, depression, and anxiety (Soto and John 2017) and overlaps strongly with BIS (Fischer and Karl 2020). Individuals higher on Neuroticism might find it difficult to remain non-reactive towards negative events and regulate negative emotions because they are more sensitive to emotions and more likely to experience emotional disturbances. In line with this, Non-Reacting has shown negatively correlations with Neuroticism (Fischer and Karl 2020; Hanley et al. 2018).

Extraversion captures both a high energy state in social contexts and greater orientation towards positive emotionality. The high sociability of Extraversion is expressed in the tendency of extraverts to talk more about abstract concepts and emotions (Beukeboom et al. 2013) and use more positive and less negative emotion words (Pennebaker and King 1999; Yarkoni 2010). In order to be able to express emotion terms in social interactions in both abstract and situation appropriate ways, it is necessary for extraverts to accurately perceive and describe their emotions. In line with this, past cross-sectional research reported positive correlations between Extraversion and Describing (Haliwa et al. 2020; Karl and Fischer 2019).

Our current study extends previous studies by (a) explicitly testing the links among mindfulness, Big Five, and BIS/BAS using (b) longitudinal data during early adulthood and (c) accounting for inter-individual differences in personality and mindfulness, meaning that our patterns can be interpreted as intra-individual changes over time. Our hypothesis is that changes in personality will be associated with changes in mindfulness over time. Specifically, we hypothesized that over time BIS is associated with decreased mindfulness, especially Non-Judgment, Acting with Awareness and Describing (Hypothesis 1), BAS is associated with increasing Non-Judgment (Hypothesis 2), Consciousness is associated with increasing Acting with Awareness (Hypothesis 3), Openness is associated with increasing Describing and Observing (Hypothesis 4), Neuroticism is associated with decreasing Non-Reacting (Hypothesis 5), and Extraversion is associated with increasing Describing (Hypothesis 6), see the Supplement for further information on proposed mechanisms and sources, and the Open Science Framework for pre-registered hypotheses and additional research questions.

Methods

Participants

The sample were first year students enrolled in a New Zealand University. They voluntarily took part in the study in exchange for course credits as partial fulfillment of course requirements in a two-part introductory course to psychology. Our final sample was representative of this group in age (M = 18.57, SD = 2.39) and gender (75.33% female).

Procedure

The current study was offered at four time-points throughout the academic year to all enrolled psychology students, but participation in each wave was voluntary and not contingent on previous participation. Because of the way that the degree is structured, this procedure resulted in different participant pools at each time-point, with changing populations across the 4-month period depending on enrolment patterns. The current study only includes participants that filled out the three-initial time-points. Time-point one (N = 715) was collected at the start of the academic year. Time-point two (N = 604) was collected about 2 months later (M = 57 days, SD = 5). Finally, time-point three (N = 617) was collected at the start of the second trimester (M = 70 days, SD = 5). Across these three time-points, 227 participants were matched using their unique student identification numbers, representing the current sample of the study. We also collected an additional fourth time-point (N = 151) at the end of the second trimester, but only 50 participants were matched across all time-points due to overall low response rate at this final time-point (which coincided with exam periods and reduced participation rates). Therefore, the fourth time-point was omitted from our analysis, but the data is available on the OSF for interested readers together with the data of all participants who were not matched across the initial three time-points. The time period (Time-point 1 to Time-point 3) captures the crucial first 4 months of university life of a cohort of young adults.

Measures

Mindfulness Dispositional mindfulness was measured using the FFMQ-SF (Bohlmeijer et al. 2011). This scale measures the five facets of mindfulness using 24 items on a 1 (*Never or very rarely true*) to 5 (*Very often or always true*) Likert scale. Example items are "I'm good at finding words to describe my feelings." or "I can easily put my beliefs, opinions, and expectations into words".

Personality To assess the Big Five personality structure the BFI-S was used (Soto and John 2017). This scale measures the five personality dimensions with three subscales each. The

overall scale is composed of 30 items and participants reported their agreement with each item on a 1 (*Disagree strongly*) to 5 (*Agree strongly*) Likert scale. Example items are "I am someone who is outgoing, sociable" (Extraversion) and "I am someone who is compassionate, has a soft heart" (Agreeableness).

Behavioral Approach vs. Avoidance Motivation We used the Reinforcement Sensitivity Theory Personality Questionnaire (RST-PQ; Corr and Cooper 2016). The RST-PQ assesses a general BIS factor, a factor measuring Fight, Flight, Freezing Systems (FFFS), and four factors of BAS (Goal-Drive Persistence, Impulsivity, Reward Reactivity, and Reward Interest). All 42 items are measured on a 7-point Likert scale ranging from 1 (*Not at All*) to 4 (*Highly*). Example items are "I am an avoidant sort of person" (BIS) and "I often find myself not wanting to touch certain objects" (BIS).

All our measures yielded acceptable α and ω reliability across the three waves and showed at least metric invariance across waves (Full details of the analysis of temporal invariance are given in the supplementary material). The internal reliabilities of the measures can be found in Table 1.

Data Analyses

We investigated the longitudinal relationships among mindfulness, personality, and behavioral inhibition/activation using a Random Intercept Cross-Lagged Panel Model (RI-CLPM, for an introduction to this model see: Hamaker et al. 2015).This model has been shown to allow for more accurate estimations of the random effects by allowing random intercepts to be estimated for subjects, which parcels out between-subjects variance. Our analysis therefore controls for individual differences between individuals and only models within-person temporal changes, independent of stable trait-like individual differences, a characteristic particularly relevant for a longitudinal study of personality traits (Mund and Nestler 2019). For comparison purposes, we also ran this model as regular CLPM by forcing the variances and covariances of the random intercepts to 0. This model showed substantially worse fit compared to the RI-CLPM ($F(136) = 440.68$, $p < .001$), and this result supports our choice of the RI-CLPM analytical model. Nevertheless, we report the CLPM on the OSF for the interested reader. For each wave, the five mindfulness facets (Observing, Describing, Acting with Awareness, Non-Judging, and Non-Reacting), the five dimensions of personality (Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism), the BIS, Fight Flight Freeze Sensitivity, and the four sub-facets of BAS according to the revised RST were included. A simplified conceptual representation of the model adopted from Hamaker et al. (2015) can be found in Fig. 1. Due to the option for participants to not respond to individual items at waves 1

and 3 each model was fitted with full information maximum likelihood (FIML) to replace missing data and a maximum likelihood estimator with robust (Huber-White) standard errors (MLR) to adjust for multi-variate non-normality. As specified in our pre-registration, all auto-regressive and cross-lagged effects were included. This resulted in a very conservative model which might lack the power to detect smaller effects (Masselink et al. 2018). Therefore, we also ran separate models for mindfulness and personality, mindfulness, and reinforcement sensitivity. We report these models on the OSF.

In our model, all variables at one timepoint predicted all variables at the next time point. This model allows us to co-vary out between-subject variation and only examine the within-subjects effects of the variables over time (Hamaker et al. 2015). Overall, all regression coefficients reported by this model represent change over time, rather than stability or rank order. Prior to testing the hypotheses, we investigated whether the instrument properties were invariant across time points (see Fischer and Karl 2019). Because our data were found to be metrically equivalent over time (identical factor loadings of items on latent variables across time), we decided to constrain all paths (auto-regressive and cross-lagged) to be equal across timepoints to reduce the interpretative complexity.

Results

We first examined the rank-order stability over time as well as the relative changes from wave to wave, which are reported in Table 2. As can be seen there, the average stability for the Big Five traits is quite high, ranging on average from .67 for *Agreeableness* to .83 for *Extraversion*. For RST, the rank-order stability is somewhat lower, ranging from an average of .60 for *BAS-Reward Reactivity* to .70 for the *Fight-Flight-Freeze-System*. Focusing on the important results related to mindfulness facets, the overall rank-order stability was somewhat lower, ranging from .50 for *Non-Judging* to .64 for *Describing*. Therefore, mindfulness appears to be more flexible and dynamic compared to personality traits, especially within the Big Five tradition. The cross-sectional correlation between the measures in the full samples at each wave, together with descriptive information on mean and standard deviation, is shown in the Tables 1, 2, and 3 of the supplementary material.

We then examined the wave-to-wave mean changes within our sample. For mindfulness, *Non-Reacting* increased from time 2 ($M_{T2} = 2.896$) to time 3 ($M_{T3} = 2.982$, $p < .05$ Tables 1, 2 and 3; $d = -.121$). *Non-Judgment* also changed significantly from time 2 to time 3 ($M_{T2} = 2.813$; $M_{T3} = 2.978$, $p < .01$, $d = -.209$). For the Big Five, the means of *Agreeableness* ($M_{T1} = 3.726$, $M_{T2} = 3.810$, $M_{T3} = 3.704$; $p < .05$; $d_{T1-T2} = -.134$; $d_{T2-T3} = .158$) and *Extraversion*

Table 1 Reliability of the measures in the study

	α	ω	GLB	H
Time 1				
Non-Reacting	.746 [.716, .776]	.751 [.722, .780]	.757	.772
Non-Judging	.757 [.729, .786]	.768 [.741, .795]	.803	.822
Observing	.675 [.637, .714]	.676 [.637, .715]	.692	.682
Describing	.821 [.800, .842]	.824 [.804, .845]	.866	.85
Acting with Awareness	.729 [.698, .761]	.727 [.695, .759]	.802	.802
BIS	.926 [.918, .934]	.927 [.919, .935]	.932	.935
Fight Flight Freeze Sensitivity	.769 [.743, .795]	.771 [.746, .797]	.817	.781
BAS-Impulsiveness	.759 [.732, .786]	.763 [.736, .789]	.816	.786
BAS-Reward Reactivity	.802 [.780, .824]	.804 [.783, .826]	.843	.826
BAS-Goal Drive Persistence	.858 [.842, .875]	.863 [.847, .878]	.861	.877
BAS-Reward Interest	.821 [.801, .842]	.824 [.804, .844]	.872	.84
Extraversion	.760 [.732, .787]	.771 [.745, .797]	.813	.808
Agreeableness	.721 [.689, .753]	.736 [.705, .766]	.789	.747
Conscientiousness	.738 [.709, .768]	.750 [.722, .779]	.742	.767
Neuroticism	.825 [.805, .845]	.826 [.806, .846]	.830	.843
Openness	.677 [.641, .714]	.686 [.651, .722]	.719	.727
Time 2				
Non-Reacting	.757 [.726, .788]	.761 [.731, .791]	.769	.782
Non-Judging	.785 [.758, .813]	.793 [.767, .820]	.807	.833
Observing	.708 [.670, .746]	.709 [.671, .747]	.723	.711
Describing	.821 [.798, .844]	.824 [.802, .846]	.869	.846
Acting with Awareness	.784 [.757, .811]	.787 [.760, .814]	.807	.836
BIS	.925 [.917, .934]	.926 [.918, .935]	.917	.935
Fight Flight Freeze Sensitivity	.800 [.776, .824]	.803 [.780, .827]	.860	.821
BAS-Impulsiveness	.751 [.721, .780]	.754 [.725, .784]	.812	.778
BAS-Reward Reactivity	.789 [.764, .814]	.793 [.768, .817]	.857	.818
BAS-Goal Drive Persistence	.831 [.810, .851]	.837 [.817, .857]	.830	.860
BAS-Reward Interest	.786 [.760, .812]	.791 [.765, .816]	.846	.813
Extraversion	.744 [.713, .776]	.754 [.723, .784]	.819	.791
Agreeableness	.741 [.710, .771]	.745 [.713, .777]	.831	.761
Conscientiousness	.715 [.679, .750]	.725 [.691, .759]	.781	.755
Neuroticism	.841 [.821, .860]	.842 [.823, .862]	.892	.850
Openness	.710 [.674, .746]	.720 [.685, .754]	.777	.786
Time 3				
Non-Reacting	.755 [.722, .787]	.761 [.730, .792]	.784	.798
Non-Judging	.797 [.769, .824]	.812 [.787, .836]	.851	.871
Observing	.759 [.726, .792]	.761 [.728, .793]	.785	.764
Describing	.822 [.798, .845]	.823 [.800, .846]	.847	.867
Acting with Awareness	.755 [.723, .788]	.761 [.730, .792]	.807	.839
BIS	.923 [.914, .933]	.924 [.915, .934]	.958	.932
Fight Flight Freeze Sensitivity	.807 [.783, .831]	.809 [.785, .833]	.848	.820
BAS-Impulsiveness	.740 [.708, .773]	.743 [.711, .775]	.780	.767
BAS-Reward Reactivity	.808 [.784, .831]	.810 [.786, .834]	.874	.838
BAS-Goal Drive Persistence	.858 [.840, .876]	.862 [.845, .880]	.875	.875
BAS-Reward Interest	.819 [.796, .842]	.822 [.800, .845]	.871	.845
Extraversion	.749 [.717, .782]	.757 [.726, .788]	.834	.779
Agreeableness	.763 [.732, .794]	.775 [.746, .805]	.812	.781
Conscientiousness	.734 [.699, .768]	.744 [.711, .777]	.793	.762
Neuroticism	.844 [.824, .865]	.846 [.826, .866]	.895	.865
Openness	.732 [.697, .766]	.736 [.702, .770]	.736	.755

($M_{T1} = 3.102$, $M_{T2} = 3.167$, $M_{T3} = 3.099$; $p < .05$; $d_{T1-T2} = -.083$; $d_{T2-T3} = .089$) changed over time. For RST, the means of *BIS* ($M_{T1} = 2.707$, $M_{T2} = 2.648$; $p < .05$; $d_{T1-T2} = .108$), *BAS-Impulsivity* ($M_{T1} = 2.589$, $M_{T2} = 2.510$; $p < .01$; $d_{T1-T2} = .139$), *BAS-Reward Reactivity* ($M_{T1} = 2.848$, $M_{T2} = 2.785$; $p < .05$; $d_{T1-T2} = .132$), *BAS-Reward Interest* ($M_{T1} = 2.649$, $M_{T2} = 2.543$; $p < .001$; $d_{T1-T2} = .184$), *BAS-Goal Drive Persistence* ($M_{T1} = 2.941$, $M_{T2} = 2.870$; $p < .05$; $d_{T1-T2} = .132$), and *FFFS* ($M_{T1} = 2.499$, $M_{T2} = 2.367$; $p < .001$; $d_{T1-T2} = .228$) all changed over time. The full results are reported in Table 3.

To contextualize our change data, the meta-analysis by Roberts et al. (2006) reported mean d values of .41 for social dominance facet of *Extraversion*, .06 for the social vitality facet of *Extraversion*, .05 for *Agreeableness*, .04 for *Conscientiousness*, .12 for *Emotional Stability*, and .37 for
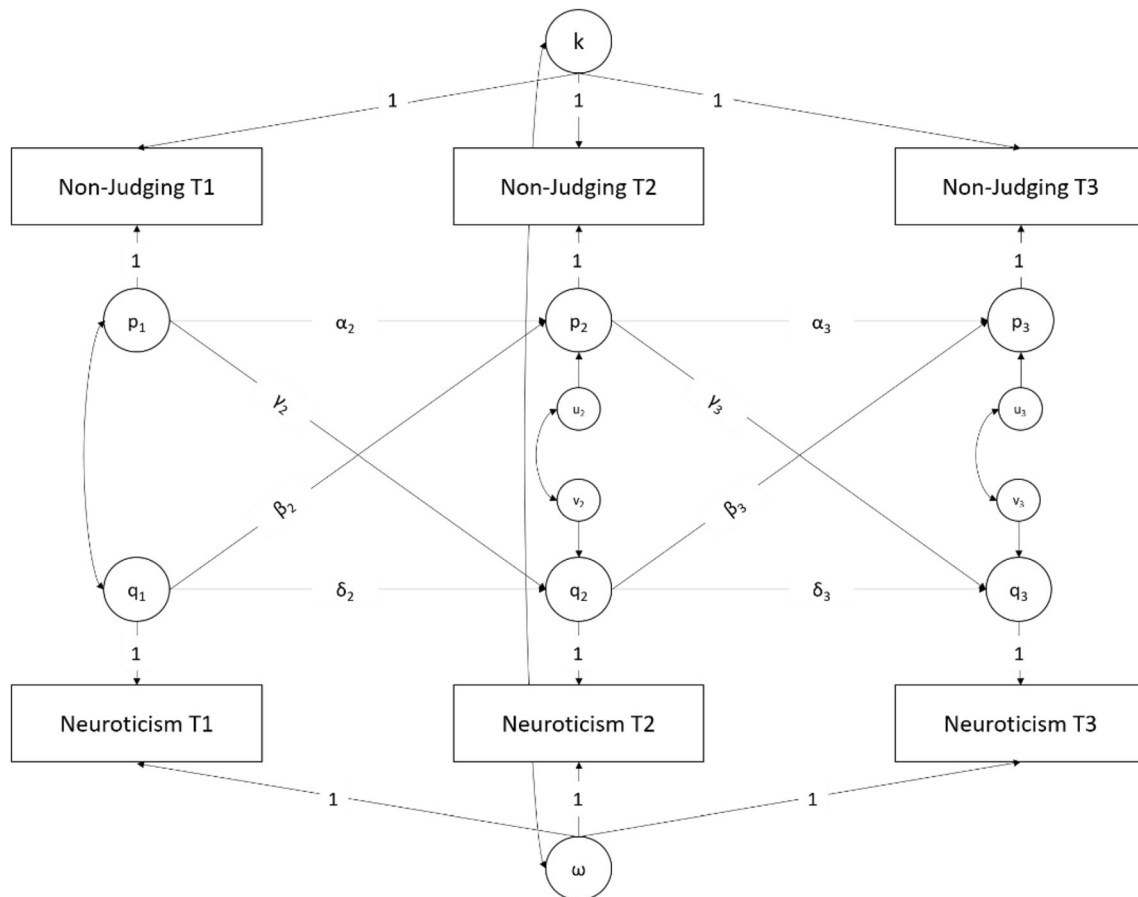
Fig. 1 Simplified conceptual model of the analytical model. In the model, ω and κ account for between subject stability, allowing for the estimation of the within-subjects carry-over effects (α, δ) and the crossed effects (β, γ). Our model included the five factors of personality (Openness, Agreeableness, Conscientiousness, Extraversion, Neuroticism), the components of the Reinforcement sensitivity theory (BIS, FFFS, BAS-Impulsiveness, BAS-Goal Drive Persistence, BAS-Reward Interest, BAS-Reward Reactivity) and the five facets of mindfulness (Observing, Describing, Non-Reacting, Non-Judging, Acting with Awareness)

Openness during the 18 to 22-year bracket. Hence, our changes are of smaller magnitude compared to the meta-analytic changes reported in other studies. The temporal changes in mindfulness facets, specifically for the Non-reacting and Non-judgment facets of mindfulness, were larger than those for any of the personality traits in our study.

To test the longitudinal within-subjects relationship of RST-R, BFI, and the FFMQ, we fitted a random intercept cross-lagged panel model with an MLR estimator to adjust for multivariate non-normal data. The model showed excellent fit to the data: CFI = .977, RMSEA = .040 [.033, .047], SRMR = .041. We examined the fitted model for support of our pre-registered hypotheses. Overall, none of the predicted effects that were observed in cross-sectional studies were replicated when examining change dynamics over time. Specifically, *BIS* did not significantly and negatively predict *Non-Judgment* ($B = -.127$ [$-.609$, $.356$], $p = .607$), *Acting with Awareness* ($B = -.038$ [$-.458$, $.382$], $p = .858$) or *Describing* ($B = -.145$ [$-.661$, $.370$], $p = .580$); *BAS-*

Reward-Reactivity did not positively predict *Non-Judgment* ($B = -.053$ [$-.441$, $.335$], $p = .790$); *Conscientiousness* was not positively associated with greater *Acting with Awareness* over time ($B = .155$ [$-.177$, $.486$], $p = .361$); *Openness* was not positively predicting *Describing* ($B = -.005$ [$-.305$, $.296$], $p = .976$) and *Observing* ($B = -.156$ [$-.504$, $.191$], $p = .378$) over time; *Neuroticism* was not negatively predicting *Non-Reacting* ($B = -.008$ [$-.299$, $.284$], $p = .960$); and finally, *Extraversion* was not positive related to *Describing* over time ($B = -.135$ [$-.501$, $.231$], $p = .469$).

Instead, higher *BAS-Goal-Drive Persistence* positively predicted increased *Acting with Awareness* over time ($B = .369$ [$.044$, $.693$], $p = .026$). Greater persistence in pursuing distant goals was associated with positive changes in this facet of Mindfulness. We additionally found significant effects in the opposite direction: mindfulness predicted within-person changes in personality traits over time. Higher *Non-Reacting* predicted a reduction of *BIS* over time ($B = -.132$ [$-.247$, $-.017$], $p = .025$), with individuals with more skills to stay

Table 2 Temporal stability of the facets in the analysis

	Stability from T1 to T2	Stability from T1 to T3	Stability from T2 to T3	Average
Non-Reacting	.530	.504	.593	.542
Non-Judging	.459	.507	.544	.503
Observing	.656	.596	.630	.627
Describing	.654	.613	.639	.635
Acting with Awareness	.538	.625	.601	.588
FFFS	.771	.695	.647	.704
BIS	.710	.663	.628	.667
BAS-Impulsivity	.747	.640	.653	.680
BAS-Reward Reactivity	.647	.562	.597	.602
BAS-Goal Drive Persistence	.703	.687	.653	.681
BAS-Reward Interest	.723	.704	.599	.675
Agreeableness	.694	.634	.679	.669
Conscientiousness	.728	.726	.763	.739
Neuroticism	.790	.759	.777	.775
Openness	.798	.738	.735	.757
Extraversion	.836	.821	.821	.826

calm in emotional situations decreasing their reported levels of anxiety and emotional lability. Also, higher *Acting with Awareness* predicted an increase in *BAS-Goal-Drive Persistence* ($B = .173$ [.041, .305], $p = .010$). Taken together with our finding that the personality-to-mindfulness relationship was also positive, this bi-directional pattern suggests that *Acting with Awareness* and *BAS-Goal-Drive Persistence* mutually reinforce each other over time.

Additionally, higher *Non-Judging* predicted an increase in *Conscientiousness* ($B = .147$ [.014, .280], $p = .031$): individuals who reported abstaining from judging their emotions and cognitions reported greater increases in *Conscientiousness* over time. Finally, higher levels of *Describing* predicted an increase in *Neuroticism* over time ($B = .200$ [.034, .366], $p = .018$). Individuals who were better able to accurately describe their emotions reported increases in emotional

Table 3 Means and mean differences in the longitudinal samples at each time-point

	M_{t1}	M_{t2}	M_{t3}	p_{t1_t2}	p_{t2_t3}	d_{t1_t2}	d_{t2_t3}
Acting with Awareness	3.014	2.967	2.981	.350	.687	.060	− .024
Non-Reacting	2.958	2.896	2.982	.182	.046	.086	− .121
Non-Judging	2.878	2.813	2.978	.213	.001	.086	− .209
Observing	3.559	3.543	3.543	.778	.955	.016	.003
Describing	3.091	3.129	3.117	.347	.716	−.052	.021
BIS	2.707	2.648	2.610	.033	.190	.108	.075
BAS-Impulsivity	2.589	2.510	2.557	.004	.121	.139	− .086
BAS-Reward Reactivity	2.848	2.785	2.827	.019	.185	.132	− .079
BAS-Reward Interest	2.649	2.543	2.560	.000	.629	.184	− .029
BAS-Goal Drive Persistence	2.941	2.870	2.855	.010	.594	.132	.030
FFFS	2.499	2.367	2.407	.000	.273	.228	− .061
Neuroticism	3.047	3.040	2.984	.904	.138	.005	.066
Agreeableness	3.726	3.810	3.704	.011	.003	− .134	.158
Conscientiousness	3.169	3.128	3.132	.267	.968	.055	− .002
Openness	3.611	3.602	3.630	.842	.496	.008	− .033
Extraversion	3.102	3.167	3.099	.029	.028	− .083	.088

All p values are based on paired sample t tests between adjacent time-points

instability over time. A simplified figure with all significant effects is presented in Fig. 2 and full results of all effects on mindfulness are reported in Table 5 in the supplementary material.

Discussion

In the current study, we report on the temporal relationship between mindfulness and personality traits during a crucial period during early adulthood. Contrary to our hypotheses, mindfulness facets predicted personality trait changes within the person over time. Two possible reasons why the predicted changes from personality to mindfulness were not supported by our data might be due to (a) the predicted development processes may occur over longer time-frames or (b) changes in mindfulness might occur as a result of important life-events that are influenced by personality, but that are not directly related to personality as such (Bleidorn et al. 2018; Lüdtke et al. 2011).

Focusing on the positive relationships first, in our sample, we found a positive feedback loop between Acting with Awareness and Goal-Drive Persistence. This indicates that the attainment of long-term rewards (the Goal-Drive Persistence component of the BAS) is enabled and supported by higher level conscious processes (Gray 2004), including those captured by the Acting with Awareness Mindfulness component, which in turn then further increases activation of Goal-Drive Persistence Personality components. Hence, goal pursuit and conscious awareness of one's pursuit of goals

mutually reinforce each other. For example, to lose weight (while we acknowledge that the success of these efforts is additionally dependent on age, SES, and a range of other home-life factors) both a long-term strategy (e.g., diet plan) as well as conscious situational awareness (mindful eating) are necessary and mutually reinforcing. The diet plan necessitates that individuals make conscious eating decision, in turn the awareness of one's behavior allows for effective long-term strategies to be put in place and the monitoring of progress towards reaching the desired goal. This finding provides a potential explanation why Acting with Awareness might be negatively related to behaviors such as smoking frequency (Adams et al. 2012) and eating disorders (Adams et al. 2012; Lavender et al. 2011) via both allowing for conscious decision making in contrast to automatic behavior and by fostering the ability to delay rewards. Our patterns imply that Acting with Awareness and Goal-Drive Persistence formed a feedback loop over time. This loop provides a potential explanation why Acting with Awareness within the mindfulness network is repeatedly found to impact behavioral change that requires both moment to moment awareness and long-term planning. Additionally, our finding that higher Non-Judging predicts greater Conscientiousness support the possibility that mindfulness facets expressing effective emotional regulation might buffer against perceived set-backs and facilitate greater goal pursuit and self-regulation (Hanley 2016).

Focusing on potentially negative patterns: The Describing facet of mindfulness predicted an increase in Neuroticism over time. This finding might seem counter-intuitive given the cross-sectional findings in some studies that these constructs
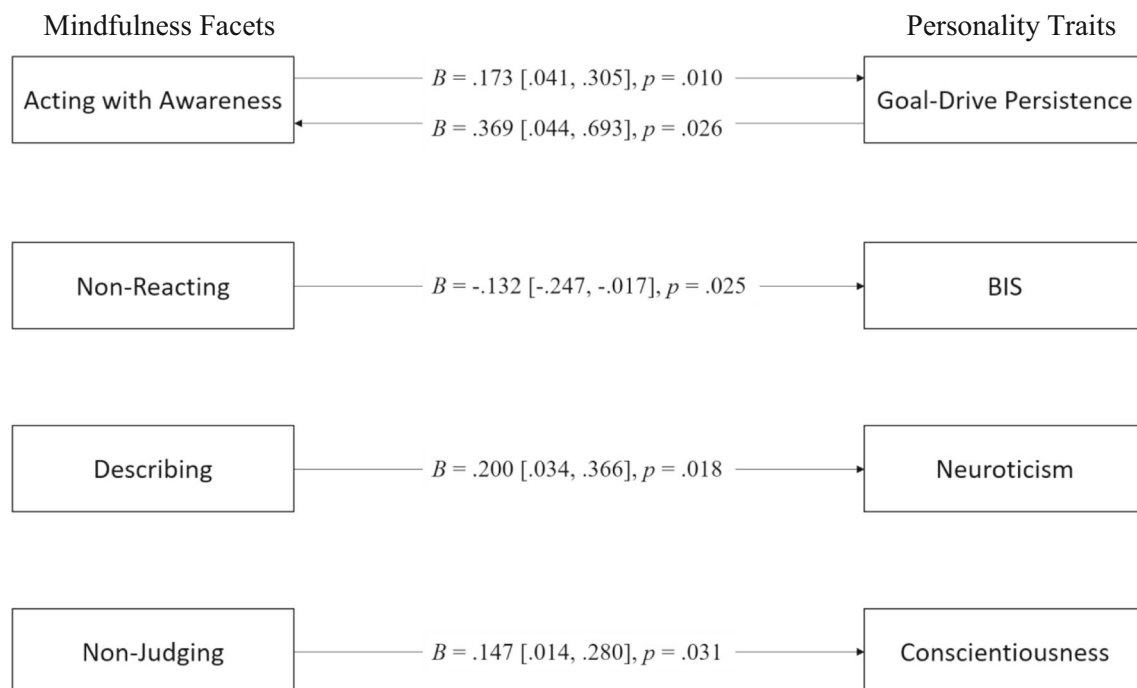

Fig. 2 Significant focal effects across time in the RI-CLPM

are negative related (Barnhofer et al. 2011; Iani et al. 2017) as well as general decreases of Neuroticism over time (Roberts et al. 2006). Nevertheless, theories such as the Monitor and Acceptance Theory (Lindsay and Creswell 2017) provide a potential explanation for this relationship over time. The Describing component does not contain a non-judgmental component, but rather represents momentary awareness of one's emotions. Increased awareness of one's emotions without the necessary skills to manage them might contribute to greater emotional volatility, depression, and anxiety, with the awareness of one's emotions thereby contributing to greater anxiety, depression, and emotional volatility over time rather than reducing them. This pattern fits in with current discussions that describe mindfulness as a complex set of independent processes which can be differentially aligned in a general population (Lindsay and Creswell 2017) and may lead to these within-person increases in Neuroticism that run counter to age-normative processes. Our finding therefore has potentially important implications for mindfulness practice. For example, when individuals describe their emotions through writing may induce negative affect for some individuals that are vulnerable or may not have the necessary emotion-regulation capacities, in the case that they recollect negative events (Pennebaker and Beall 1986). Engaging in activities that align with the Describing facet of mindfulness on its own might foster Neuroticism and potentially lead to increased rumination and depression, which requires attention to and interactions with other mindfulness skills that help with emotion regulation.

Overall, the patterns found highlight the need for further research to examine the disconnect between the relatively consistent cross-sectional relationships between mindfulness and personality traits reported across multiple studies (Fischer and Karl 2019; Giluk 2009; Hanley 2016), which were not replicated over time in our sample. One potential research direction would be to adopt a network perspective similar to those adopted in personality research to understand the core variables that affect within-person dynamics over time (Cramer et al. 2012). It is possible that while mindfulness and individual difference domains are cross-sectionally related due to consistency effects or measurement artifacts, the dynamic changes within-individuals may be governed by a different and potentially smaller set of more specific behaviors and emotion-regulation processes. Such research may also provide new insights for attempts to develop possible patient-centered or personalized mental health interventions, which may take into account the needs, preferences, and capacities of each individual.

Limitations and Future Research Directions

One clear limitation of our current study is the relatively short interval between measurement points (i.e., 2.5 months) and having data on only three time points.

It is possible that some personality and mindfulness changes manifest and unfold via different temporal dynamics. Clearly, more research using finer time sampling over longer periods is needed. One prediction based on our current patterns is that we expect stronger effects of mindfulness on personality and possibly vice versa over longer time frames. These longer-term within-person effects may approximate cross-sectional relationships. This is a hypothesis worth exploring in further research. Studies using longer timeframes would also allow testing the differential influence of general developmental trends vs significant idiosyncratic live events on the development of personality and mindfulness. One standard limitation of survey designs is that it relies on ratings, which raise common method bias issues (Podsakoff et al. 2003).We included method effects in our psychometric assessment in order to account for some of these effects (see the Supplementary Material), but future research using other non-rating-based methods or multimethod approaches to more explicitly examine method effects is needed. Furthermore, our current sample was made up from mostly female university students in a relative restricted age range, limiting generalizability of our findings. The current results cannot inform on temporal dynamics in different age cohorts or whether there are gender differences across different developmental periods. Nevertheless, our sample is similar in composition to previous studies that examined the cross-sectional relationships between mindfulness and personality (Hanley and Garland 2017). This clearly highlights the necessity of dispositional mindfulness research to diverse its sampling base. Future research, using a more diverse sample, could also address the question what role mindfulness practice plays in the longitudinal development of trait mindfulness and personality. We would predict that active mindfulness practice would amplify individual differences and hence, strengthen mindfulness effects on personality over time.

Compliance with Ethical Standards

participants provided consent to the current study by responding to a consent question presented as part of the study in the affirmative.

Open Science Statement This study was pre-registered prior to the end of the data collection and analysis and our time-stamped predictions made available on the OSF. The pre-registered code and data to reproduce the analyses, a table describing the proposed mechanisms and references, a full model table with all results including longitudinal relationships between all the personality trait variables and mindfulness variables on all time points is available on OSF (https://osf.io/8kufq/).

We also provided an additional data set containing a subsample of participants on the OSF that we used to validate the short version of the FFMQ against the long version. The data set contains several further scales that might be of interest to researchers on mindfulness or personality, and we invite interested readers to use this data in their own analysis.

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