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THE ROLE OF MAJOR LIFE EVENTS AND BRAIN DEVELOPMENT ON PERSONALITY TRAIT CHANGE IN ADULTHOOD

Insights from personality neuroscience

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Abstract

The relationship between personality trait change and major life events is currently undergoing extensive investigations within the field of personality psychology. A debate has risen regarding whether or not major life events can bring about trait change, and how typical trait change patterns over the adult lifespan can be explained. It is valuable to understand how traits change because they predict important future outcomes. The Five-Factor Theory described by McCrae and Costa (2008a) states that traits are purely biological entities, and trait change is explained to result from processes of intrinsic biological maturation, unaffected by life events. This thesis reviewed the literature regarding the relationship of trait change and life events, and the research of potential biological bases of traits in the brain together with a brain developmental perspective of intrinsic maturation. Gaining an insight in the relationship between personality traits and the brain is a goal within a young field of research called personality neuroscience, and an agenda of the Five-Factor Theory. Major life events do cause trait change, but the relationship is complex. A brain developmental perspective of intrinsic maturation did not entirely correspond with patterns of typical trait change in young adulthood. The Five-Factor Theory is challenged and modifications are suggested. Neurobiological correlates of five-factor traits reveal issues and potentials for future research.

Keywords: Five-Factor Model, Five-Factor Theory, trait change, major life event, personality, neuroscience, brain development

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Major Life Events and Personality Trait Change

Romantic relationships, parenthood, one's first job, and periods of unemployment are major events one can expect over a lifetime. Few would argue that they can have a great impact on one's life circumstances, but whether they can lead to lasting changes in personality has been a more controversial issue. The trait perspective of personality emphasizes the stability of personality traits and defines them as *relatively* stable patterns of cognition, emotions, and behavior that characterize people and distinguish them from one another (Roberts, Wood, & Caspi, 2008).

One main focus in the field of personality psychology has been to describe personality traits (McCrae & Costa, 2008b). A recent debate, called the *person-situation debate*, questioned the usefulness of having a trait approach to personality (e.g., Fleeson, 2004). This was based on findings indicating larger variances in behavior across situations than would be expected if stable traits determined behavior. According to some researchers, the debate can now be considered to be largely over (Fleeson, 2004). Having a trait approach to study personality was justified when it became generally accepted that traits described people's average way of acting over time, not how people acted in specific situations.

A commonly used classification system of traits is the *Five-Factor Model* (FFM; McCrae & Costa, 2008b) which comprises the traits; *Extraversion*, *Conscientiousness*, *Agreeableness*, *Openness*, and *Neuroticism*. Investigations of the stability of traits (that a person's trait levels stay largely the same over time) have resulted in vast numbers of scientific literature that imply traits are subject to change. The evidence comes primarily from measures of the average change in trait levels of a group over time (mean-level change), the relative ranking of individuals in a group on a given trait (rank-order change), and the deviation of individual trait levels from the group mean (intra-individual differences in change).

General patterns of trait change in adulthood have been found that generalizes across populations (e.g., Caspi, Roberts, Shiner, 2005; Helson, Kwan, John, & Jones, 2002; Roberts, Walton, & Viechtbauer, 2006). A meta-analysis (Roberts et al., 2006) showed that self-reports of trait levels tend to result in increasingly higher levels of conscientiousness, agreeableness, emotional stability (the reverse of neuroticism), and social dominance (an aspect of extraversion) over their lifespan. The patterns of development observed for openness and social vitality (the second aspect of extraversion) was different. They showed increased mean levels in early adulthood, followed by more or less stable levels in middle adulthood, and decreased levels into old age. Rank-order stability varies over one's lifetime with relatively low test-retest correlations in childhood followed by increasing stability up to the age of 50-70 before then declining (Roberts & DelVecchio, 2000). This thesis will refer to the typical patterns of trait change in adulthood found in the majority of people as *normative trait change*.

Moreover, normative trait change patterns are believed to be related to major life events, i.e. trait change coincides with major life events, such as graduation from school, entry into work life, romantic relationships, parenthood, and retirement (Bleidorn et al., 2018). Major life events not only correlate with trait change, but are also suggested to bring about changes in traits (e.g., Bleidorn, Hopwood, & Lucas, 2018; Denissen, Luhmann, Chung, & Bleidorn, 2019; Specht, Egloff, & Schmukle, 2011). However, there is an ongoing debate regarding the degree to which normative trait change can be explained by intrinsic maturational processes; predisposing traits to develop in certain ways (Costa & McCrae, 2006), as opposed to resulting from experiences from major life events (Roberts et al., 2006). This may first appear as a nature vs. nurture debate but most theories on either side of the debate include both biological and environmental aspects to some degree. The debate is rather about which aspect influences personality trait levels the most.

One side of the debate is represented by McCrae and Costa's *Five-Factor Theory* (2008a). It is a theory of personality and considers traits to be exclusively based in biology. Normative trait change is explained as resulting from biological maturation (p. 167) and trait change can only occur through biological processes. Life events are not supposed to cause trait change unless they affect the biological bases of traits (p.168). Behavior (the output of the personality system) can be influenced by the environment.

This thesis will primarily refer to McCrae and Costa's theory when using the term Five-Factor Theory, and acknowledges that not all researchers within the five-factor paradigm share their perspective of a Five-Factor Theory. Besides, McCrae and Costa distinguish between the FFM and the Five-Factor Theory, but not all researchers do. Some will consider the FFM a theory and may use the terms Five-Factor Theory and Five-Factor Model interchangeably.

The opposing side of the debate emphasizes the role of life events on trait change. An alternative perspective of normative trait change is found in the *social investment* perspective, which states that commitment to adult social roles such as creating a family and establishing a career, followed by experiences associated with these roles, is the driving force of normative trait change (Lodi-Smith & Roberts, 2007).

Many researchers would agree that traits are to some extent based in biology and encourage studies of the biological basis of traits. McCrae and Costa (2008a, p.168) view traits as completely based in biology, a controversial position not shared by all researchers within the FFM paradigm. The Five-Factor Theory does not specify the underlying biology of traits, but suggests the identification of biological bases of the five-factor traits as one of its agendas (McCrae & Costa, 2008a, p. 172). *Personality neuroscience* is concerned with identifying the neurobiological underpinnings of personality traits in order to understand how gene-environment interactions give rise to personality traits (Allen & DeYoung, 2017).

Relatively stable patterns of behavior, cognition, and emotion (personality) are assumed to be the product of relatively stable patterns in brain functioning. According to the personality neuroscience perspective, the development of the neural structures underlying personality-related brain functioning is shaped by long-term gene-environment interactions. Personality traits are thus believed to originate from the brain. Therefore, attempts have been made to discover how traits relate to the brain. A number of brain correlates of the five-factor traits have been reported, though the findings are not completely congruent with one another. From a personality neuroscience perspective, it is reasonable that normal brain maturation would account, at least in part, for the idea of intrinsic maturation. Grey matter and white matter volumes continue to change throughout most of the lifespan, with greater change occurring before age 20 than afterward with regionally different rates of change (Sowell, Thompson, & Toga, 2004). Grey matter volume tends to decrease with age, and white matter tends to increase from early childhood to middle adulthood. Brain maturation in regions associated with each five-factor trait could explain normative trait change if the regions correspond to patterns of brain development. Important to mention here is that mapping higher-order cognition, personality in this case, in the brain is a complex issue and might not even be achievable.

Understanding how people change in trait levels is important since traits have been demonstrated to be valid predictors of important future outcomes in domains such as health, work and romantic relationships (Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007).

The primary aim of this thesis is to contribute to resolving the debate of whether biological processes or experiences from major life events are the primary explanation for normative trait change by investigating the issue from a personality neuroscience perspective. Sub-aaims include to describe the relationship between major life events and trait change, and to consider the notion of intrinsic maturation by relating it to typical brain development from

adolescence to adulthood. This will be done by reviewing the literature on the topic. A second aim is to investigate how the Five-Factor Theory put forward by McCrae and Costa (2008a) explains trait change and to evaluate its biological assumptions in light of the results from the review.

The research question of this thesis is as follows: can personality trait change in adulthood be explained by intrinsic maturation of the brain rather than by major life events, if not, can the Five-Factor Theory be modulated to account for the evidence? It is hypothesized that major life events do have some effect on trait change, although the exact nature of this relationship is not clear. Brain development measured by a change in neural tissue is hypothesized to be weakly linked to normative trait change due to the complexity of psychological functions involved in personality traits. A third hypothesis states that traits are more related to white matter change than grey matter change due to the white matter increase between young adulthood and middle adulthood. If the first two hypotheses are supported, it means the Five-Factor Theory cannot account for the evidence. This would call for suggestions of how the theory can be modified to account for the evidence, while at the same time maintaining its biological perspective.

The thesis begins with a short summary of a previous debate within personality research concerning the relevance of taking a trait approach to studying personality, before introducing the FFM and the Five-Factor Theory. The literature review then begins by explaining different types of trait change, including mean-level, rank-order, and intra-individual differences in change. General trends in research on trait change in adulthood are identified and theoretical explanations for normative trait change are provided. The review then turns its focus to major life events and their effects on trait change. In the final part, the thesis reviews literature on brain development and possible neurobiological underpinnings of the FFM to evaluate the notion of intrinsic maturation. It then summarizes the main results of the thesis

and discusses the implications of the results together with an evaluation of how the Five-Factor Theory can or cannot account for the results and how it might be modified. The thesis ends with a conclusion where limitations and suggestions for future research are addressed and the research question is answered.

Method

The thesis picked out a few restrictions to guide the selection of articles for the literature review. First, research had to include the FFM. Second, each article must have been cited a reasonable number of times, depending on the year of publication.

Articles were searched for in academic databases concerned primarily with research disciplines of psychology, personality psychology, developmental psychology, cognitive neuroscience, and neuroscience. Keywords used for initial article searches included; traits, the Five-Factor Model, major life events, trait change, trait development, brain correlates, and neurobiology. Secondary selections were made by tracing cited and citing articles of those from the first selection. The thesis focused mainly on recent research published after the year 2000. Articles evaluated as most important for the aim of the thesis constituted the final selection.

One topic this thesis intentionally left out from the review was the potential for gender differences in trait change. Previous research had found little to no support for gender differences (Roberts & DelVecchio, 2000; Roberts et al., 2006).

The thesis chose to study the research question by conducting a literature review instead of an empirical study based on the fact that life events cannot be manipulated experimentally. Besides, investigations of event-related trait change often require studies with longer durations of time than were within the scope of this thesis.

A Trait Approach to Personality

The Person-Situation Debate

The trait perspective of personality describes people's normal way of acting across time and situations. According to some studies, people vary a lot in behavior from one situation to the next; this is called within-individual variability (Fleeson, 2004, p. 83). The assumption that traits are predictive of behavior has been questioned – the so-called person-situation debate. The main points of this debate are summarized in a paper by Fleeson (2004). The debate concerned the issue of deciding which factors were most important in describing behavior across different situations; was a person's traits a better determinant of behavior than the situation surrounding the person, or vice versa? The high variability in behavioral responses to different situations was interpreted by the situation side to be primarily determined by the specifics of the situation. The person side emphasized the predictive usefulness of traits as shown by vast numbers of earlier studies; researchers reasoned that traits are a valid determiner of behavior across situations; otherwise, these consistent trait-outcome associations would not be found. It turned out that both sides were right.

Traits remain stable over longer time periods and are predictive of people's general way of acting. The average was derived from frequency distributions of people's display of moment to moment responses in everyday situations that could be associated with a specific trait (Fleeson, 2004). When all responses were taken together they clustered around a central point along the traits dimensions. The variability around those central points was not high, indicating some patterns in people's behavioral repertoire. The variation from the central points could account for the observed variability in how people acted in different situations, reflecting transitory states. Situations are useful for describing behavior in the short term, while traits describe patterns in behavior over time. According to Fleeson (2004), the person-situation debate is at an end because both aspects are valuable for personality research, but in

different ways. Researchers interested in people's average way of acting over longer stretches of time might benefit more by applying a trait approach and researchers interested in people's responses in a specific situation may benefit more by applying a situation approach.

This thesis will cover research development in personality psychology that followed. How situations (life events) and traits relate to trait change, and how an integrated view of these is necessary to understand processes of personality trait change fully, are investigated in the remainder of this thesis.

Five-Factor Model of Personality

The FFM classification system was developed through factor analysis of large collections of words used in everyday life to describe individual differences in characteristics (McCrae & Costa, 2008b). The model categorizes traits, also called facets, according to how they correlate with each other. For example, a person described as competent is often described as achievement oriented and self-disciplined. Correlated traits are grouped together to form broad categories or dimensions. Five distinct sets of correlating traits have consistently been found. The FFM labels them as extraversion, agreeableness, neuroticism, openness, and conscientiousness. Descriptions of traits from various other personality scales and models have been shown to overlap with these five factors, which supports the model's empirical validity and its utility.

The five sets of correlating traits are referred to as higher-order traits. Each has contrasting poles; for instance, extraversion is the *high* pole with the contrasting *low* pole of introversion; neuroticism is the opposite pole to emotional stability. Each is represented by six lower-order facets that are descriptive of them (McCrae & Costa, 2008b). These are not the only lower-order facets of personality, but they are the most important ones. Extraversion consists of the facets of *warmth*, *gregariousness*, *assertiveness*, *activity*, *excitement seeking*, and *positive emotions*. Agreeableness consists of *trust*, *straightforwardness*, *altruism*,

compliance, *modesty*, and *tender-mindedness*. Neuroticism consists of *anxiety*, *angry hostility*, *depression*, *self-consciousness*, *impulsiveness*, and *vulnerability*. Openness consists of *fantasy, aesthetics, feelings, actions, ideas,* and *values*. Finally, conscientiousness consists of *competence, order, dutifulness, achievement striving, self-discipline*, and *deliberation*.

Personality psychologists have studied traits because of their usefulness in predicting important outcomes (McCrae & Costa, 2008b). Each of the FFM traits is associated with certain outcomes, a few are presented here. Extraversion is linked with social success, higher lifetime income, and higher happiness compared to introversion. Agreeableness is associated with better social relationships as a partner. Neuroticism is associated with a tendency toward unhappiness regardless of present life situation and a higher risk for depression. Openness/intellect is associated with creative achievement and its low pole counterpart *closedness* with a tendency for conservatism and fundamentalism. Conscientiousness is a strong predictor of work performance. One meta-analysis (Roberts et al., 2007) demonstrated that personality traits are strong predictors of future success in romantic relationships, work-related attainment and health outcomes to approximately the same degree as socioeconomic status (occupational status, income- and education level) and cognitive ability (often measured as IQ). The possibility to link the Big Five traits to future outcomes relies on the notion that traits are stable constructs.

Personality traits are commonly assessed by self-reports through questionnaires, such as the NEO personality inventory (NEO-PI). The obtained trait levels on each of the Big Five dimensions provide an estimate of people's personality profiles. The FFM is assumed to provide stable estimates of personality over time since relative stability is a basic assumption of trait theory; e.g., an agreeable individual tends to stay agreeable over time.

The trait approach to personality builds on the notion that traits are heritable. McCrae and Costa believe that traits are substantially heritable (McCrae & Costa, 2008b, p. 288).

However, researchers have recently reported varying estimates of heritability for the FFM, from mean values of .18 to around .40, with some traits being more heritable than others (McCrae & Sutin, 2018, p. 155). A suggested explanation for the various results may be that studies differ in their ability to detect different types of genetic effects, depending on if the samples included twins or not (p. 155). Another explanation points to potential errors associated with self-report assessments of personality. When multi-method approaches are used, heritability estimates tend to rise. Besides, traits are by nature abstract entities with no clear boundaries while genes are very concrete. Certain genes may be involved in several different psychological functions, which may not relate to one trait alone. Judgments of the heritability of specific traits are not straightforward.

Stable individual differences in behavior during childhood are not described in terms of personality traits, but rather as temperament (Caspi et al., 2005, p. 454). However, temperament and traits are more or less referring to the same structure of individual differences in personality but are used by different sets of researchers who conceptualize them differently. Some researchers distinguish them by explaining that childhood temperament precedes adult personality traits and are described as more narrow and basic than traits seen in adulthood. Nevertheless, current research indicates that the two aspects are more similar than different. As with adults, *positive emotionality* is associated with extraversion, *negative emotionality* with neuroticism, and a child's ability for effortful control or *constraint* relates to conscientiousness. Temperament, like personality traits, is commonly considered malleable and influenced by environmental factors. What happens in childhood clearly affects the development of adult personality traits. Though this thesis will focus on personality traits in adulthood as described by the FFM, childhood temperament is important in fully understanding personality development throughout the lifespan.

Five-Factor Theory

According to McCrae and Costa (2008b), the FFM is only a description of personality traits and cannot explain their everyday functioning. Instead, they developed the so-called Five-Factor Theory with the purpose of providing an explanatory account for trait functioning within a personality system framework (McCrae & Costa, 2008a). The FFM constitutes the main part of the theory and is placed within a *basic tendencies* component (McCrae & Sutin, 2018). The basic tendencies are only affected by biology such as genes and other biological processes with the potential to alter the development and the functioning of the brain and thus shape personality. Traits are affected only if their underlying biological bases are affected (McCrae & Costa, 2008a). Basic tendencies affect the rest of the personality system, while other components of the system do not affect basic tendencies. This means that the position of the Five-Factor Theory is that *external influences* (including life events) cannot be a direct cause of trait change. McCrae & Costa (2008b) maintain this assumption because of a lack of evidence for the opposite position. They do allow that psychotropic medications, psychotherapy, and damage to the brain can affect basic tendencies and so cause changes in trait levels (McCrae & Costa 2008a).

McCrae and Costa (2008a, p. 163) do not view traits as patterns of behavior; traits are deep psychological entities that are not directly observable but whose existence can be inferred from behavior. Costa and McCrae (2008a) argue that self-reports and observer ratings (a common supplement to self-reports) primarily capture expressions of traits, not the actual trait.

Patterns of behavior, cognition, and emotions are rather a description of the next component of the personality system, called *characteristic adaptations.* These are psychological mechanisms that are shaped by the interaction of basic tendencies and external influences (McCrae & Costa, 2008b). Interventions aimed at creating a desired change in

emotion, cognition, or behavior would be better off if they were based on modulating characteristic adaptations instead of trait levels (McCrae & Sutin, 2018). Skills, beliefs, and habits are all characteristic adaptations that people acquire. In contrast to basic tendencies, characteristic adaptations change depending on the environment (McCrae & Costa, 2008b). "*Characteristic*" refers to how the adaptations reflect an individual's underlying traits. "*Adaptation*" means that the individual adapts to fit in better with the environment – though maladjustments can occur (McCrae & Costa 2008b).

Behavior for McCrae and Costa (2008a) is part of the *objective biography* and is the product of interactions between external influences and characteristic adaptations. The tendency to smile at strangers is an acquired characteristic adaptation indicative of a basic tendency of extraversion. The external influence may be that smiling at strangers is an accepted behavior in the individual's environment.

It might be tempting to infer causal effects from correlations of traits with outcomes. Consider though that, if an individual with high extraversion tends to go to parties, it does not mean that the trait *caused* the individual to go to the parties, though that is of course a possibility (McCrae & Costa, 2008b). If the extraverted people in a population all go to parties more often than introverts, the inference that extraversion causes people in general to go to parties may be supported, even though it need not be true on the individual level.

Interventions aimed at creating desired changes in emotion, cognition, or behavior do sometimes lead to changes in trait levels (Roberts, Luo, Briley, Chow, Su, & Hill, 2017). Why this occurs is not clear. Extraversion and neuroticism are often targeted by interventions, so it is not surprising that they tend to change the most (p. 14).

McCrae and Costa (2008b) suggest that studying traits and their associations with outcomes on the population level is more meaningful than studying it on the individual level. The person-situation debate made clear that a trait approach is more useful for studying

average behavior in people and less useful for understanding how an individual acts in a certain situation. It is acknowledged that trait change in specific individuals can be informative as well, but since the general trends in personality trait change over the lifespan have been found at the group level and not the individual level, this thesis will look at personality trait change primarily at the group level. It will address average individual differences in change but makes no attempt to address trait change in particular individuals.

Trait Change

Different types of trait change can be investigated by measuring rank-order, mean-level, or intra-individual differences in change (Roberts & DelVecchio, 2000). All are independent measures; perfect rank-order stability (indicating no change) can exist together with significant mean-level changes (indicating change); individual differences in change may reveal that a substantial proportion of individuals diverge from the mean-level change patterns (Roberts et al., 2006). Roberts et al. (2008, p. 376) organized these types of changes according to whether they capture changes in relative positions in a given population or absolute change, and whether they examine change at the individual or population level. In this sense, rank-order is categorized as a measure of relative change at the population level, mean-level as a measure of absolute change at the population level, and intra-individual differences as a measure of absolute change at the individual level. The fourth type of change called *ipsative change/continuity* can be categorized as a measure of relative change at the individual level and refers to whether or not the trait levels on each trait for a specific individual (her personality profile) change their relative ordering over time (Roberts et al., 2008). This type of change has not been studied as much as the other types (Schwaba & Bleidorn, 2018) and will not be covered in this thesis.

Rank-order stability, as opposed to rank-order change, reflects that the relative ordering of individual trait scores within a group does not shift positions over time. Rank-order stability is thus represented by high test-retest correlations.

Mean-level change, as opposed to mean-level stability, measures whether the average trait levels of a group increase, decrease, or stay the same over time. Significantly increasing or decreasing mean levels are generally interpreted as indicating that most individuals in a population are changing in the same direction.

The third form of trait change captures intra-individual differences in change. Focusing solely on mean-level changes can conceal the existence of individual differences in change. Some people within the group may increase while other decreases in trait levels on a given trait, which may result in a no significant mean-level change. Mean-level change shows the average trend in change, while the variation around this trend is reflected in individual differences (Schwaba & Bleidorn, 2018).

To organize the research findings related to trait development in adulthood, Caspi et al. (2005) put forward three principles. The *maturity principle* views increasing levels of agreeableness, conscientiousness, emotional stability, and social dominance as reflecting increased psychological maturity and better functioning within society. Maturity – especially early maturity – has been linked to beneficial outcomes in health, work, and love. The Five-Factor Theory, as described by McCrae and Costa (2008a), regards maturity as the product of biological processes (McCrae & Sutin, 2018, p. 155) rather than psychological growth. This claim is hard to test since age cannot be manipulated experimentally, so the claim may only be confirmed by ruling out other explanations (p.158).

The *cumulative continuity principle* considers findings indicating increasing trait stability with age (Caspi et al., 2005). Rank-order stability increases with age up to middle age (Roberts & DelVecchio, 2000). Caspi and colleagues (2005) mentions four factors

proposed to be responsible for increased stability with age; *genetic research* suggests that a large part of trait stability can be attributed to genes; while *niche-building processes* cause an individual to create, seek out, or otherwise end up in trait-correlated environments; *identity development* leads to trait stability through the motivation to maintain one's sense of identity; and the achievement of psychological *maturity* further contributes to stability with increasing age.

The *corresponsive principle* concerns the interaction between traits and environment; traits cause people to put themselves into situations that deepen those traits: i.e., higher levels of a trait predict the occurrence of certain life events (selection effects), while the response further increases the same trait (socialization effects). The corresponsive principle implies that the occurrence of life events is often not random.

With these principles in mind, it is time to consider the typical development of traits throughout the lifetime.

Normative Trait Change Patterns

Development of personality traits from adolescence to old age is normally determined by measuring the average change in traits (mean-level change) between two or more assessment occasions either by sampling several age groups (cross-sectional) or by following one sample over time (longitudinal) (Caspi et al., 2005). Rank-order stability varies over one's lifetime with relatively low test-retest correlations in childhood followed by increasing stability up to the age of 50-70 before then declining (Roberts & DelVecchio, 2000).

Roberts and colleagues (2006) conducted a representative meta-analysis of 92 studies of average change across the lifespan that further established the existence of normative change patterns; including both cross-sectional and longitudinal approaches. They examined trait change over time for each of the Big Five. The result showed generally increasing trait levels of conscientiousness, agreeableness, and emotional stability over the course of a lifetime.

Roberts and colleagues (2006) divided extraversion into two subcomponents since earlier studies had found significantly different patterns of development for each. One of these, *social dominance*, showed generally increasing trait levels over time, reflecting how people often become more independent, self-confident, and dominant as they grow older. The other component *social vitality*, comprises sociability, energy level, gregariousness, and positive affect. Change here was modest, with slightly increasing mean levels up to adolescence and early adulthood, followed by a small decline around age 30, after which stability was high until old age when social vitality slightly decreased again.

Openness increased in adolescence and stayed mostly stable until it decreased in old age. The patterns of change in openness and social vitality were somewhat similar, except that openness showed greater change. Overall, the change patterns found in the meta-analysis add to earlier findings of similar patterns of change and are in line with the maturity principle.

The highest magnitudes of change across all traits were found in the age span from age 20 to around age 40, comprising young adulthood (Roberts et al., 2006). Other researchers have defined this period differently. Schwaba and Bleidorn (2018) argue for a distinction between emerging adulthood and young adulthood, and allocate the highest magnitudes in rank-order and mean-level change to the period of emerging adulthood, around ages 18 to 30. They consider individuals to belong to this stage of life if they do not have a home of their own, or do not live on their own due to insufficient income, and are without children. Emerging adulthood is a period during which different worldviews and lifestyles are tested and is separated from periods of young and middle adulthood (ages 30-64) which instead involves beginning and continuing commitment to normative social roles related to work and family. Later studies on mean-level changes are largely consistent with the meta-analysis of Roberts and colleagues (e.g., Lucas & Donellan, 2011).

Roberts et al. (2006) report that the changes they found were generally small. The importance of trait change may therefore be questioned, but the authors believe that even a small change might be important. The authors estimate that the upper bound for trait change over a lifetime is around a half standard deviation from the mean, while the lower bound reaches a full standard deviation. They conclude that this is a significant amount of change (p. 14).

Theoretical explanations. Several explanations for normative trait development have been put forward, of which this thesis will consider two. The first is provided by the Five-Factor Theory, which emphasizes biological influence on traits; trait change over the lifetime is considered the result of intrinsic maturation; i.e., biological developmental processes largely unaffected by life events. Simply stated, the development of traits is largely preprogrammed. From an evolutionary perspective, this implies that normative trait change must facilitate survival of the human species either directly or indirectly: i.e., normative trait change could be a byproduct of something else that facilitates survival (Costa & McCrae, 2006, p. 27).

The other explanation is provided by the *social investment principle*, which regards the commitment to social roles – adopted by people in all parts of the world – to be the cause of normative trait change (Roberts, Wood, & Smith, 2005). These social roles relate to such typical tasks as finding a long-term partner, starting a family, and contributing to society through employment (Lodi-Smith & Roberts, 2007). Experiences related to social roles, and expectations of how people should act in these roles, lead in time to change in those traits associated with the role, in line with the corresponsive principle. Changes in demographic variables do not imply investment of a new social role, investing in social roles means viewing them as part of one's identity (Lodi-Smith & Roberts, 2007). This psychological investment is necessary for traits to change. The social roles an individual invests in are

chosen based on her current personality profile. Normative trait change in young adulthood (maturity) is explained to arise because adult social roles involve maturity-related traits to a larger degree than other traits. Agreeableness, emotional stability, and conscientiousness are desirable traits within most adult social roles and are therefore expected to increase the most.

Comparing the two perspectives, Roberts et al. (2005) found stronger evidence in support of the social investment view, although most of it comes from preliminary research. The authors consider the Five-Factor Theory to be unable to account for a wide range of evidence. McCrae and Costa's assumption that environmental influences do not have any effect on trait change is not supported. Nevertheless, Costa and McCrae (2006, p. 27) continue to argue that there is not enough evidence for environmental effects on trait change; replicable effects in particular.

Another study (Bleidorn, Klimstra, Denissen, Rentfrow, Potter, & Gosling, 2013) comparing the two perspectives was a cross-cultural study on personality maturation in young adulthood. Researchers found strong evidence supporting the universality of personality maturation, in line with both perspectives. Some cultural differences did emerge though that stood in conflict with the assumption of the Five-Factor Theory that genetically determined trait change is universal so that the timing of trait change is largely the same in all populations. Researchers found cultural differences related to the timing of work-related transitions. Cultures with earlier onset of working life showed earlier maturity-related changes in emotional stability, conscientiousness, and agreeableness. Such cultural differences were small but significant. The authors considered social investment to better account for these findings. That said, the findings are not strong enough to rule out intrinsic maturation.

All things considered, each of the two perspectives on normative trait change is supported to some degree by empirical evidence (Denissen et al., 2019). At the same time, it is problematic to assume that evidence favors one explanation over the other.

Individual Differences in Trait Change

Average change does not necessarily reveal the direction of change in particular individuals, and individuals showing small or no change blend in with individuals showing greater change (McAdams & Olson, 2010). One group may decrease in trait value while another increases giving the illusion of stable mean levels. Individual differences may reveal information regarding the nature of trait change and to what extent people deviate from the normative pattern.

Roberts, Caspi, and Moffitt (2001) examined individual differences in trait change during the transition from adolescence to young adulthood. Personality assessment was done twice, at the ages of 18 and 26. The direction of change, positive or negative, was analyzed and compared with no change using the Reliable Change Index (RCI). Results showed that a large proportion of participants (72.2-89.8 %) did not change levels on any given trait over the eight-year period. Nevertheless, the change that *did* occur was still significant and reliable according to the RCI analysis (p. 675). The largest change (- 20.7 %) was found for *negative emotionality*, a factor similar to neuroticism, for which the comparable percentage of increased levels was 7.1. The highest change percentage for increased levels was found for *agentic positive emotionality* (25 %), similar to extraversion. Control, a subcategory of constraint which overlaps with conscientiousness, showed increased levels in a portion of 13 % of the participants, as compared to the 5.1 % of people who decreased. Mean-level changes in these three trait factors for all participants were also significant. In contrast, a similar amount of participants changed in a positive (11.3 %) or negative (9.6 %) direction for the factor of *stress reaction*, a subcategory of negative emotionality. These significant and reliable individual changes would have been concealed if only the non-significant population mean-level change of this component was considered.

This study indicates that traits are highly stable during the transition to young adulthood, despite substantial evidence pointing to this period as a time when the greatest trait change tends to occur. Participants changed approximately a quarter of a standard deviation on average (Roberts et al., 2001, p. 679). The observed change was explained in terms of maturity. Individuals showing less change over time were those who already had matured psychologically. These individuals did not require further psychological growth; they were already capable of handling the demands of becoming young adults. Individuals who had not yet matured psychologically tended to show more change, generally directed towards maturity. This evidence for reliable individual differences is significant even though the majority showed stable trait levels.

Vaidya, Gray, Haig, Mroczek, and Watson (2008) used growth curve analysis to investigate individual differences in trait change trajectories. Results showed significant variability in individual growth trajectories. Individuals differed in both magnitude and direction of change. All traits, except conscientiousness, were found to increase for some individuals and decrease for others. Growth trajectories for conscientiousness were either stable or increasing, with individual variability in the rate of change. Growth trajectories for the sample as a whole largely corresponded with the normative change patterns reported by Roberts et al. (2006); conscientiousness, agreeableness, and openness tended to increase, while neuroticism decreased. Small increases in extraversion were also found.

Another study (Mroczek & Spiro, 2003) used growth modeling to analyze change trajectories in a sample of men ranging from middle to old age. The researchers reported significant variability in extraversion and neuroticism trajectories (the only traits included in the study) as compared to the sample's mean trajectories. Such differences can be explained to some degree by life events and birth cohort. Neuroticism levels decreased a year after the men married or remarried, and increased after the death of a spouse until rapidly dropping

again. Rate of change after life events differed for neuroticism and extraversion. Neuroticism seemed more affected by life events, while extraversion remained mostly stable. The era in which people grew up also seemed to affect trait development. Separate birth cohorts showed significant differences in growth trajectories for extraversion over the same five-year span (age 70-75). The older cohort stayed stable or slightly declined, while the younger cohort significantly increased in extraversion levels.

Schwaba and Bleidorn (2018) reported small but significant individual differences in change over the lifespan (from ages 16-84). Deviations from the mean were largest around emerging adulthood (between adolescence and young adulthood), less so in young and middle adulthood, and smallest in old age for all traits except emotional stability, for which individual differences remained largely constant over the lifespan.

In summary, individual differences in trait change exist and are significant. They are likely not due to chance or error. At the same time, personality traits remain relatively if not highly stable for most people. Life events and birth cohort account for individual differences in older men, while differences in young adulthood seem to reflect the level of maturity. Most participants could be described by normative change patterns. Still, a considerable number of people diverged from these patterns.

Major Life Events

The definition of traits presented in the beginning of the thesis implies that lasting changes in people's typical patterns of thinking, behaving, or feeling reflects trait change. In this sense, anything that alters a person's typical ways of acting should eventually lead to changes in trait levels. A change in one's life circumstances (often as a result of major life events) is believed to be able to cause such changes (Luhmann et al., 2014). Researchers interested in personality change may therefore focus their attention on major life events or role transitions from which lasting changes in people's life circumstances are likely to occur. Minor life events (daily

events), will not likely cause any meaningful change in people's general way of thinking, behaving, or feeling.

Other types of life events are believed to change people, e.g., religious conversions or spiritual transformation, near-death experiences. The number of people experiencing these types of life events is likely to be too few to be able to draw any conclusions of their effect on trait change, if such was found. For example, there is little evidence of change in personality trait levels as a result of religious conversion or spiritual transformation in contrast to what one might believe (Emmons, Barrett, & Schnitker, 2008). They are however suggested to affect personality at a hierarchically different level than personality traits (level one). Religious conversion leads to a change in people's meaning system and more evidence of change in personality at the level of a person's goal striving (level two) and life narrative (level three) are found for this type of life event. Perhaps initial personality trait profiles predispose some individuals to experience religious conversion or spiritual transformations and select them into religious environments.

Major *negative* events are believed to cause a change in life circumstances. Löckenhoff et al. (2009) assessed major adversive or traumatic events by interviewing the participants and asking for the most horrifying or frightening event they had recently experienced (within the latest two years).

Lüdtke, Roberts, Trautwein, and Nagy (2011) assessed life events through a survey that included items from pre-existing life experience questionnaires. This method allowed the researchers to investigate the accumulated number of positive vs. negative life events, and the effects of single life events on trait change. The method is limited though by having a large gap between the actual experience of a life event and the moment participants rated the positive or negative valence of those events that occurred in the previous two years. People

might rate a life event differently if they rated it at the time of the event compared to months later.

Luhmann and colleagues (2012) formulated a definition of life events as reflecting a change of a current status (e.g., transition from unemployed to employed status) that occur under a discrete time-frame with a clear beginning and end.

Life events can be classified as *normative events*, *non-normative events*, and *non-events* (Luhmann et al., 2014). These types of events are believed to have different effects on traits. Normative events are events that typically occur at certain life stages, i.e., it is normative to enter employment for the first time in young adulthood. Events are called non-normative when they occur at stages of life when such events do not normatively happen according to any societal timetable, i.e., becoming widowed in early adulthood. When a normative event that is desired by an individual does not occur at a stage of life when it typically would, it is called a non-event; i.e., not finding a partner when it is desired. It is not clear if non-normative, non-events, or normative events influence trait change to the same degree. One may have stronger effects than the others. Although it is suggested that normative events are more likely to lead to trait change due to their association with well-known expectations of how people should act in response to them; e.g., when entering employment it is according to the norm to be more organized, follow instructions, and be self-disciplined. This point is offered as an explanation for why normative trait change patterns exist, unless you are a proponent of the Five-Factor Theory, in which case any event-related changes are rather viewed as resulting from processes of intrinsic maturation.

Effects of Major Life Events on Trait Change

Löckenhoff et al. (2009) found that people reported to having experienced an extremely negative life event, such as a life-threatening event, loss of someone close, or witnessing of an accident, showed increased neuroticism, particularly in terms of angry hostility. They showed

decreased levels in the *compliance* facet of agreeableness and the openness facet *values* (p. 55). Negative life events were found primarily to influence these facets, with small effect sizes. Other personality traits were largely unaffected, though pre-existing high levels of conscientiousness and extraversion were associated with better mental health afterward, indicating a protection effect from these traits (p. 57). No selection effects were found: pre-existing trait levels did not predict the occurrence of extremely negative life events. That said, the life events described in the study do not seem to be under the person's control, and so trait-based life choices might not be directly related to the occurrence of such traumatic events as compared to commonly occurring and less dramatic negative events more directly related to people's life choices. For example, the death of a family member is (in most cases) not under one's control, while breaking up with a partner might be more clearly related to a person's typical way of behaving.

Accumulated numbers of life events over time have been associated with baseline trait levels, as well as trait change (Lüdtke et al., 2011). Lüdtke and colleagues (2011) found evidence for selection and socialization effects when an individual's total number of life events was classified as negative, positive, or neutral and analyzed separately. Negative life events were more frequently present for individuals with high levels of baseline neuroticism (i.e. initial trait levels of the individual when entering the study, not necessarily their true baseline). Negative life events tended to be followed by increased neuroticism. One might reason from this that low levels of neuroticism at baseline would be predictive of number of occurring positive events, but this was not found. In contrast, individuals with high levels of baseline extraversion experienced positive life events more frequently, and negative life events less frequently over time. Experiencing positive life events tended to lead to increased extraversion. This shows that selection effects can be followed by socialization effects, a possibility allowed for by the corresponsive principle; i.e., the traits that lead people to

experience life events are the same traits that change most in response to the events (Caspi et al., 2005).

Dennissen et al. (2019) conducted a longitudinal study (9 years) in which life events were defined in terms of status changes. They examined the influence of gain-based and loss-based events on trait change. Life events defined as status changes are reflected by shifts in demographic variables. Dennissen and colleagues assessed status changes by monthly surveys that solicit information on primary occupation, marital status, and number of children living at home. Personality was assessed once per year or every second year. Events are coded as gain (e.g., marriage) or loss (e.g., divorce). Traits were hypothesized to relate differently to gain vs. loss-based events. Selection effects seem to account for a great deal of the association between trait change and life events. About two-thirds of significant trait-change effects could be explained by pre-event trait levels (p. 627). Openness increased the likelihood for divorce, while marriage was more likely for individuals low in neuroticism and openness and high in conscientiousness. That leaves one-third of the effects to be associated with life events. Observed socialization effects were small. Trait change was sometimes found to begin a time before a major life event, such as decreased neuroticism before childbirth (although neuroticism tended to increased again after childbirth) or increased openness before employment (p. 628). Unemployment was preceded by increased neuroticism (p. 629).

The way stressful events are perceived is suggested to be an important indicator that people with different personality profiles modulate whether or not an event will have an effect on trait levels or not (Sutin, Costa, Wethington, & Eaton, 2010). Sutin et al. (2010) report that whether a stressful event is perceived as a turning point (life changed direction) or a lesson learned (something was learned that increased wisdom) is associated with trait levels before the event and any subsequent increases. Neurotic individuals tended to view the events as turning points and showed increased neuroticism after the event. Extraverted individuals

tended to perceive the events as an opportunity or lesson and showed increased extraversion and conscientiousness afterward. However, the direction of causality cannot be determined, the participants could already be changing in a certain direction, and thus it is not clear whether the interpretation of the event as a turning point or a lesson learned is causing the subsequent changes.

Life events have been assessed in different ways and so findings are not directly comparable. That said, some general trends can be identified regarding associations between life events, baseline trait levels, and trait change. The studies above indeed suggest that traits change in response to life events and do so in specific ways, but traits are also predictive of life events.

Selection and Socialization Effects

Findings on different effects of life events on trait change point to some general trends. These trends primarily involve selection effects and socialization effects. Traits have been found to increase the likelihood that certain life events will occur; i.e., selection effects are present. People exhibiting higher levels of extraversion are likelier to start a romantic relationship and move in with a partner as a young adult compared to others (Specht, Egloff, & Schmukle, 2011). Being high in conscientiousness increases the likelihood to get a job; conscientious and emotionally stable individuals are likelier to get married (Denissen et al., 2019). The evidence implies that traits are somewhat responsible for why people are exposed to certain life events. Traits also relate to how events are interpreted (Sutin et al., 2010). The corresponsive principle combines both selection effects and socialization effects; people select themselves into environments that correspond to their personality profiles, and major life events that are brought about from this environment are more likely to further strengthen the personality profile.

Socialization effects occur when traits change due to experiencing or anticipating an event (Specht et al., 2011). Individuals who enter employment show increased emotional stability after the transition (Denissen et al., 2019). First-time employment has been associated with a sharp increase in conscientiousness, while retirement is associated with a drop in conscientiousness (Specht et al., 2011).

Viewed from a Five-Factor Theory perspective, associations of major life events and trait change may just as well be explained by intrinsic maturation. McCrae and Sutin (2018) believe that since the direction of causality is not established – it is not clear if the event *caused* the trait change – it cannot be ruled out that naturally occurring trait changes may simply co-occur with life events, such as transition into first job or retirement.

The Five-Factor Theory explains that life events must affect the biological bases of traits in order to cause trait change (McCrae & Costa, 2008a). Whether or not a particular life event affects the underlying biology of traits is difficult to know – unless an accident causing brain damage is considered a life event (it is at least an external influence) – but the Five-Factor Theory does not distinguish between types of life events, nor does it define what a life event is compared to other external influences. McCrae and Costa (2008a, p. 168) do acknowledge that psychotherapy can lead to trait change since it can cure depression, which they considered a brain disease, and in that way affect the biological bases of traits.

Brain Development and Intrinsic Maturation

Intrinsic maturation, the primary cause for normative trait change according to the Five-Factor Theory, should correspond to the patterns of normative brain development over the lifespan. The theory offers only general statements about the origin and development of traits; they are based in biology and develop from biological processes (McCrae & Costa, 2008a). The biological bases of traits primarily include brain structures and genes. Genes are believed to control processes of aging (McCrae & Sutin, 2018). Thus, it should be informative to look at

the effect of age on brain maturation and degeneration over the lifespan to explore if this type of biological process relates to normative trait change. In this thesis, the patterns of normative personality trait change are limited to the age span between adolescence and old age, which will be the age span of interest in this section as well.

The effect of age on brain development is commonly assessed by measuring volumetric changes in the brain for grey matter, white matter, and brain weight over the lifespan (Sowell et al., 2004). Grey matter consists mainly of neuronal cell bodies and unmyelinated axons. Grey matter volume generally decreases with age. Between adolescence and young adulthood (age 30), reductions in grey matter are more prominent in dorsal, mesial, and orbital frontal cortex (Sowell et al., 2004). The parietal lobes and other cortical structures show less reduction during this time. In contrast, localized brain growth of the same age span assessed by distance from center (DFC) measure (the radial tissue expansion from the center of each subject's brain) showed growth in dorsal areas of the frontal lobe, in the inferior, lateral temporo-occipital junction, and in the left orbitofrontal cortex (Sowell et al., 2004). Interestingly, regions showing significant grey matter loss overlap with regions of DFC growth.

White matter volume mainly consists of myelinated axons beneath the cortical structures of the brain. It connects brain regions with each other and larger white matter integrity is associated with more efficient information transmission between these regions (Jackson, Balota, & Head, 2012). Increased white matter volume is mainly explained by increasing myelination of the axons and is viewed as an important aspect of brain maturation. Axons can be divided into projection fibers (connecting the cortex with the ventral parts of the brain and the spinal cord), commissural fibers (connecting the two hemispheres), and association fibers (connecting various cortical areas within the same hemisphere). Lebel & Beaulieu (2011) studied white matter change in the brain from childhood to young adulthood

and found that association fibers showed significant changes from adolescence to young adulthood (ages 19-32) while projection and commissural fibers showed little or no change. Association fibers increased in parameters of fractional anisotropy (FA; axon packing and myelination) in white matter tracts of superior and inferior fronto-occipital fasciculus, and in inferior longitudinal fasciculus. These fasciculi connect frontal lobes to occipital and temporal lobes, and temporal lobe to occipital lobe respectively. The same fasciculi showed decreasing parameters of mean diffusivity (MD), which reflects water content and density. The opposite; decrease in FA and increase in MD, is generally viewed as a negative effect in elderly aging (Lebel & Beaulie, 2011).

In general, myelination begins early in life and continues well into the age of fifty, but is more prominent up to age 20 than it is after age 20 (Sowell et al., 2004). White matter volume begins to decline in middle age, with more prominent loss in frontal regions relative to other regions, such as the temporal lobes. Frontal regions are also the last to myelinate, that is, the last regions to mature and the first to show declines. Overall volumetric changes (including white and grey matter changes) in the brain due to aging are more prominent in dorsal cortices of the frontal and parietal regions, and less so in the ventral cortices of the temporal and occipital regions (Sowell et al., 2004).

Postmortem studies of brain weight have shown that it reaches a peak around the age of 20 and stays largely stable until around the age of 50 before it begins to gradually decline, with more dramatic declines after the age of 80 (Sowell et al., 2004). Since grey matter reductions begin already in early childhood and continue throughout the lifespan, it is believed that overall brain weight can be primarily accounted for by myelination that tends to peak around the time when brain weight starts to decline.

Reduction in grey matter volume does not necessarily mean a reduction in cognitive function (Park & Reuter-Lorenz, 2009). Nevertheless, it seems more likely that intrinsic

maturation of normative trait change, at least in young adulthood, relates more to white matter than to grey matter. In addition, Jackson et al. (2011) studied the relationship between regional brain volume and personality traits in healthy aging (ages 44 to 88) and concluded that white matter volume was a more consistent mediator of the relationship than grey matter volume. It is however acknowledged that focus on one type of tissue does not exclude potential importance of the other. Normative trait change and rank-order change in personality trait levels show greater change between 20 and 40 years of age as compared to later adulthood and old age. In comparison, myelination occurs during this same period. To make further inferences about the role of brain development in intrinsic maturation of personality traits, it is necessary to consider correlates of grey matter and white matter volume with the Big Five personality traits.

Neurobiological Underpinnings of the Five-Factor Model

Biological bases of the Big Five traits have been studied with neuroscience methods (DeYoung, Hirsh, Shane, Papademetris, Rajeevan, & Gray, 2010). According to personality neuroscience, relatively stable patterns of behavior, cognition, and emotions reflect relatively stable brain functioning. Efficient brain functioning is often, but not always, associated with greater brain tissue volume in brain regions associated with certain cognitive functioning. It is therefore of interest to personality neuroscience to explore the associations between regional grey and white matter volume with the FFM. However, better functioning does not necessarily entail larger structural volume in the brain. Brain correlates of personality traits should be interpreted with caution since it is a complex matter to link brain structures with psychological functioning (Bjørnebekk, Fjell, Walhovd, Grydeland, Torgersen, & Westlye, 2013). One personality trait incorporates many different psychological functions, and one brain area might be involved in several functions associated with more than one trait. Any suggested brain-trait relationships are first and foremost hypothetical.

Allen and DeYoung (2017) consider the FFM to be the best available taxonomy for organizing findings within personality neuroscience. They also claim that any theory of personality should include a description of neurobiological substrates of traits from which to generate testable hypotheses. The Five-Factor Theory does not specify what the exact nature of the relationship between the traits and their underlying brain mechanism is, though it is understood that anything causing a change in the brain can potentially shape personality (McCrae & Sutin, 2018, p. 155). Brain structure correlates of the Big Five – if such exist – are not considered important in *explaining* traits and are not specified within the Five-Factor Theory. McCrae and Costa (2008a, p. 172) do however encourage the study of the biological bases of the five-factor traits to increase our understanding of how traits develop from biological processes. Likewise, Allen and DeYoung (2017) argue that, by identifying brain structures for each of the Big Five personality traits, it becomes possible to gain a better understanding of how they originate from gene-environment interactions. It will be useful to consider the neurobiology associated with each of the Big Five traits.

Extraversion

Extraversion is linked to grey matter volume of the medial orbitofrontal cortex, a region involved in reward processing. Bjørnebekk et al. (2013) found that high extraversion is associated with thinner cortex in the left ventromedial prefrontal regions (inferior frontal gyrus); an area involved in the production of language. Another potential function linked to this region is inhibitory processes. Bjørnebekk and colleagues have suggested that a thinner IFG could reduce inhibition of speech in extroverts, leading them to be more talkative and less concerned with what they say. Sensitivity to reward has been implicated in extraversion and is believed to play a central role (Allen & DeYoung, 2017). This function is mediated by the dopaminergic system, which is related to extraversion. The dopaminergic system is part of the brain's reward system. Extraversion reflects the *wanting* aspect of the dopaminergic

system, while the *liking* aspect is implemented in the opiate system. Allen & DeYoung (2017) suggest that wanting can be assigned to one part of extraversion they call *assertiveness*, and the liking aspect to another part, named *enthusiasm*. Assertiveness (also called agentic extraversion) comprises traits such as leadership, initiative, activity, and drive. Enthusiasm comprises traits of gregariousness, positive emotionality, and sociability.

Extraversion has not been reliably linked to regional white matter integrity (Bjørnebekk et al., 2013; Jackson et al., 2011; Xu & Potenza, 2012).

Neuroticism

Neuroticism reflects the tendency to experience negative emotions (DeYoung et al., 2010). Neuroticism is negatively associated with volume in the dorsomedial prefrontal cortex and left medial temporal lobe areas including the posterior hippocampus. It is further correlated with volume in the mid-cingulate gyrus (DeYoung et al., 2010). These regions correspond to associations that have been made between neuroticism and negative emotion as well as sensitivity to threat and punishment. Bjørnebekk et al. (2013) found the strongest and most reliable associations between brain structure and neuroticism, compared to the remaining Big Five traits. They found negative correlations between neuroticism and frontal and temporal surface area, white matter microstructure, and total brain volume.

Allen and DeYoung (2017) report a link between serotonin and neuroticism. Depression, anxiety and related disorders are often treated with serotonergic drugs, resulting in decreased neuroticism if treatment is successful. They report another link between increased activation in the hypothalamic-pituitary-adrenal (HPA) axis, which has a well-established role in the regulation of bodily stress responses, and neuroticism. The amygdala is believed to play a role in neuroticism, but findings from neuroimaging studies are inconsistent (Allen & DeYoung, 2017).

Neuroticism has been found to have an interaction effect with age on overall cerebral white matter volume, such that age-related decline in white matter volume was greater for people with high neuroticism than for those with lower neuroticism (Jackson et al., 2011). Neuroticism has been found to correlate positively with MD, the parameter that normally decreased in young adulthood, in white matter fasciculi including superior longitudinal, and inferior frontal occipital fasciculus, among others (Xu & Potenza, 2012).

Agreeableness

High agreeableness characterizes people that are generous, modest, and honest (McCrae & Costa, 2008b). Agreeableness is negatively correlated with volume in the posterior left superior temporal sulcus, involved in inferring the intentions of others from their physical movements (DeYoung et al., 2010). Agreeableness is further correlated with volume of the posterior cingulate cortex; a region suggested being involved in understanding the beliefs of others. In general, the brain regions associated with agreeableness are involved in processing social information. Bjørnebekk et al. (2013) found no relationship between agreeableness and brain structure.

Agreeableness correlated negatively with MD values in superior longitudinal fasciculus and corona radiata (Xu & Potenza, 2012). Corona radiata is a white matter sheet that radiates in the cortex and bundles up in the brain stem. It carries almost all of the information transferred to and from the cerebral cortex. Xu and Potenza (2012) interpret the negative correlation with MD to indicate better myelin integration in people scoring high in agreeableness compared to people scoring low.

Conscientiousness

Conscientiousness is high in people that are disciplined, hardworking, and purposeful (McCrae and Costa, 2008b). DeYoung et al. (2010) consider the ability to inhibit impulses to enable efficient goal-striving to be a primary function of conscientiousness.

Conscientiousness is associated with increased volume in large regions of the middle frontal gyrus in the left lateral prefrontal cortex (DeYoung et al., 2010). Functions involving these regions include the execution of planned behavior and maintenance of information in working memory. Associations between high conscientiousness and increased volume in the orbitofrontal region have also been found (Jackson et al., 2011), which was the region associated with extraversion in the study by DeYoung et al. (2010).

Low conscientiousness has further been linked to greater decreases in cerebral white matter volume with age (Jackson et al., 2011). However, correlations between conscientiousness and regional white matter integrity have not been reported (Bjørnebekk et al., 2013; Xu & Potenza, 2012).

Openness

Individuals with high openness are more prone to engage in creative, imaginative, and abstract thinking (Beaty et al., 2016). DeYoung and colleagues (2010) did not find any significant associations for openness with regional grey matter in their study. Another study (Beaty et al., 2016) found a correlation between high-level openness and a more efficiently functioning default network. The default network is generally associated with mind-wandering, creative idea generation, and other types of self-generated thinking, in line with the characteristics of open individuals.

Openness correlates with white matter integrity in several fasciculi distributed across cortical and subcortical regions, including e.g. corona radiate, superior longitudinal fasciculus, and anterior cingulum. Taken together, openness does not seem to be related to any specific brain region, it rather relates to overall connectivity in the brain.

Summary of the Biological Aspect of Normative Trait Change

Brain regions with accelerated grey matter decrease overlapped with brain regions showing most DFC growth. These regions include the dorsal areas of the frontal lobe, the inferior,

lateral temporo-occipital junction, and the left orbitofrontal cortex. Normative trait change includes increased levels of agreeableness, conscientiousness and social dominance facet of extraversion, together with decreased levels of neuroticism. Reported grey matter correlates of agreeableness do not overlap with any of these regions. Conscientiousness correlates with middle frontal gyrus which is structurally close to the dorsal areas of the frontal lobe. It was also associated with increased grey matter volume in the orbitofrontal region, which maps well with growth associated areas. No studies were found that assessed grey matter correlates of the social dominance facet, but the structurally close orbitofrontal and left ventromedial correlates of extraversion overlap with growth-related areas of the left orbitofrontal cortex. Finally, the regional grey matter volume that is negatively correlated with neuroticism does not overlap with growth-related areas, which otherwise is thought to reflect decreased neuroticism (or increased emotional stability). On the other hand, neuroticism was also negatively correlated with cortical surface area in frontal and temporal regions, which overlaps with the growth areas.

Neuroticism was negatively associated with white matter integrity in the superior longitudinal fasciculus while the opposite association was found for agreeableness. No association between white matter integrity and conscientiousness or extraversion was reported. Taken together, regional grey matter volume and white matter integrity partly correspond with a brain developmental perspective of intrinsic maturation, but findings of trait-brain correlates are inconsistent.

Results

The literature is congruent with the idea that traits do change over time. Measures of mean-level change show that self-reported ratings of agreeableness, conscientiousness, emotional stability, and social dominance increase over time. Measures of mean-level and rank-order change show that greatest change occurs around young adulthood, and that trait levels are

relatively stable during middle adulthood. Studies of individual differences in change demonstrate significant variances in growth trajectories of an individual's trait development.

Major life events have generally moderate, but significant effects on trait change. Specific life events do not lead to the same trait changes for all individuals. Anticipatory effects before events, socialization effects after events, and selection effects predicting the occurrence of some events are commonly found effects in the relationship between life events and trait levels.

Neurobiological correlates of the five-factor traits have been reported that partly overlap with a brain developmental perspective of intrinsic maturation believed to explain normative trait change patterns.

Discussion

The issue of whether major life events could lead to lasting personality trait change was investigated by reviewing the literature. The biological claims put forward by McCrae and Costa in their Five-Factor Theory called for a closer look at the current status of research on neurobiological underpinnings of the five-factor traits.

A trait approach is suitable when talking about the average responses within a population (Fleeson, 2004). This is important since the results of this thesis should be interpreted with this in mind. Individuals with high-level openness are more likely to get divorced, but this does not mean that a particular individual with high openness will eventually divorce.

The first part of the primary aim of this thesis was to investigate whether major life events can lead to lasting changes in the Big Five traits. To begin with, the evidence does suggest that major life events may produce change in traits, though the relationship is complex. Major life events have different effects on different traits, and not all events lead to changes in all individuals. Traits can change in anticipation of an event or as a result of

experiencing the event. In addition, a person's initial trait levels when entering a study are predictive of the number of negative or positive events (Lüdtke et al., 2011), as well as predictive of single major life events (e.g., Denissen et al., 2019; Specht et al., 2011).

The question of whether observed trait changes are lasting is not entirely clear. Life events are commonly occurring over the lifespan and change in a trait due to a specific life event may be followed by another event causing the same trait to change again in the same or another direction. This might lead to overestimating or underestimating the duration of the life event effect.

One major point resulting from this thesis is that traits *do* seem to change by other means than through purely biological processes. On the other hand, the effects of life events are generally small and findings of specific effects are diverse and preliminary. Several reasons can explain this. First, there is a lack of longitudinal studies in which individuals were followed for longer time periods (several years) and provided more than three personality assessments. More studies like this can provide better temporal accounts of event-based trait change. Longitudinal studies can more reliably detect whether individual trait levels eventually return to some form of baseline, or if certain life events tend to have long or short-term effects.

Second, there is no common understanding of what counts, and what does not count as a major life event. The recent and more precise definition of life events as time-discrete status changes, provided by Luhmann et al. (2012), is a promising start to resolve this problem because it excludes minor life events and slow status changes. However, getting a pet would count as a life event by this definition but no study that I know of included this type of life event. I believe that conscientiousness would increase from this experience because owning a pet often requires more planning than usual. In terms of selection effects, some initial trait levels may increase the likelihood that some people get a pet while others do not. Likewise,

many other life events people would consider *major* have probably been left out from most studies. The reason to do so is that the selection of life events is based on theoretical assumptions of which life events are most plausible to explain the well-established normative trait change patterns.

Third, the nature of life events is a possible mediating factor of trait change in response to the event. Employment can be of several types; e.g., full-time or part-time, temporary or permanent, with or without night shifts. These may have different effects on a person's life circumstances followed by different effects on patterns of thinking, feeling and behaving, potentially leading to trait change.

The other part of the primary aim was to explore how well neurobiological correlates of agreeableness, conscientiousness, extraversion, and neuroticism overlapped with patterns of brain maturation in young adulthood. Perfect overlap would be strong support for the role of intrinsic maturation in leading to normative trait change; increased agreeableness, social dominance, and conscientiousness, and decreased neuroticism. The overlap was far from perfect. As with the effects of major life events on trait change, connecting personality traits to specific brain regions, and relating change in brain tissue with a change in personality functioning is highly complex. The weak relationship between brain development and personality development in this thesis can have many interpretations whereof most are speculative.

Differences in personality are supposed to indicate differences in brain structure. However, the FFM may only reflect how people describe each other, and may not be directly applicable to explain how differences in personality can be found in differences in brain functioning or brain tissue. This thesis inclusion of an overview of brain-trait correlates illustrates the potentials and the issues with this endeavor. Neurobiological underpinnings of the Five-Factor traits have been suggested (e.g., DeYoung et al., 2010). If a life event was

indeed demonstrated to lead to changes in these brain structures, any conclusions in this regard would still be premature since the brain-trait correlations are not straightforward. It would be necessary to also include measures of personality. Nevertheless, brain-trait correlations are useful for generating testable hypotheses.

The secondary aim was to evaluate how the Five-Factor Theory, as described by McCrae and Costa (2008a), could be modified to account for evidence of trait change due to major life events, if such was found. The small effect sizes and the relative stability of traits over time do indicate that major life events are not associated with any dramatic changes in personality. The main point here is that they at least *are* closely related to trait change, which is enough to challenge the radical biological assumptions of the Five-Factor Theory. On the other hand, McCrae and Costa maintain their statement that external influences (including life events) cannot be a direct cause of trait change, partly because of a lack of convincing evidence for the opposite claim; that external influences *do* have an effect on trait change. This is a radical and illogical statement. They mean the effects of life events on trait change have not been replicated well enough. In addition, McCrae and Sutin (2018, p. 158) state that "the best evidence for the intrinsic maturation hypothesis comes from ruling out alternatives". They also state that an average expectable environment will not have a differential effect on trait change: traits will change in certain ways regardless of the psychological environment (how people think, feel and behave) (p. 156). Still, they do acknowledge that their point of view will almost certainly be wrong in "exceptional circumstances" (p. 156).

Even though I believe that life events do lead to trait change, I also believe that McCrae and Costa's controversial position spur research on the topic because researchers of opposing views are motivated to prove them wrong.

In line with the theory, life events can lead to changes in traits by means of affecting their biological bases. That said, it would be just as reasonable to assume life events can do

this, as it would be reasonable to assume that they have no impact on trait development at all (as the theory currently states). In this sense, the theory could be modified to more clearly allow for the possibility that life events lead to changes in e.g., the brain which affects the biological bases of traits and thus causes trait change. Interestingly, McCrae and Costa (2008a) consider successful psychotherapy (without the involvement of drugs) to be an example of when an external influence can lead to trait change by changing the biological bases of traits. The only reason for this claim is that they view depression as a brain disease, a view not shared by all researchers. If a brain disease is cured, and personality has changed, it means the underlying bases of traits have changed. However, worth noting is that it is currently not known if these life events actually do affect the underlying biology of traits. The weak support for a brain development perspective of intrinsic maturation to explain normative trait change allow for the possibility that external influences such as life events may play a role in shaping how the brain develops and in that way cause the weak associations.

Another review (Roberts et al., 2005) that examined the extent to which empirical evidence supports the Five-Factor Theory as compared to the social investment perspective looked at the intrinsic maturation and social investment tenets of personality maturation in young adulthood. They interpreted the Five-Factor Theory to explain maturation solely from genetic influences; while this thesis interpreted them to mean that any biological processes (not only genetic) would explain personality maturation. In addition, this thesis looked at potential biological bases of traits in the brain to provide a biological evaluation of the theory. Still, both reviews arrived at similar conclusions; the Five-Factor Theory is insufficient in explaining a wide range of non-biological evidence for trait change.

To sum up, the Five-Factor Theory is supposed to explain how personality works but it cannot account for individual differences in change that are related to life events. It is not useful for generating predictions of how people in general think, feel or behave, because the

components of the theory that interact to give rise to general patterns of behavior are not well specified. Characteristic adaptations (learned skills, habits, etc.) are, in practice, not easily distinguished from basic tendencies (traits), and how external influences (life events) interact with characteristic adaptations to give rise to behavior is not clear. McCrae and Sutin (2018, pp. 158-159) mention that it would probably be easier to study outcome associations at the trait level than on the level of characteristic adaptations, but also that traits are not directly accessible by any mean of personality assessment, their existence can only be inferred indirectly (p.152). It can thus not provide an explanation for the established associations between self-reported trait levels and future outcomes to any more degree than the associations alone.

Conclusion

The thesis investigated the relationship between major life events and changes in five-factor traits, explored if typical brain development and neurobiological correlates of five-factor traits corresponded with normative trait change patterns, and evaluated whether or not the Five-Factor Theory could account for the results and discussed how it could be modified to account for the results.

One limitation of this study was that it focused on literature about trait change, and might have missed out on important literature on trait stability, thus the literature selection might have led to a biased result. Also, the Five-Factor Theory appears to be inconsistent by dismissing external influence on trait change but at the same time allowing non-biological psychotherapy to cause personality change, or the theory has been misinterpreted by the author of the thesis, which in that case poses a strong limitation.

Assumptions of the Five-Factor Theory were evaluated in light of findings pointing to the potential effects of major life events on trait change. General trends in the research literature on trait change and the influence of major life events on such change were

presented. Whole brain, grey and white matter volume change with age showed weak relationships with brain regions associated with the five-factor traits.

The FFM is often implemented in other fields of research, and thus the contribution of this thesis may be relevant not only for personality psychology but also for other research that concerns the FFM.

Future research on trait change and major life events can look at how life events are related to any biological changes that can potentially affect personality, as Denissen et al. (2019) also point out. For example, if life events can be demonstrated to have lasting effects on the dopaminergic system (strongly linked to extraversion) or the serotonergic system (strongly linked to neuroticism) and relate these changes to changes in trait levels, the biological account of the Five-Factor Theory can be tested. In this case, a longitudinal study with several assessments of personality, brain imaging or assessment of other biological markers theorized to be part of the biological basis of traits, and assessments of major life events could be conducted.

Major life events can indeed bring about changes in trait levels; some of them lasting for at least a year and others are temporary and fade out within months. A brain development perspective of intrinsic maturation is considered unable to explain normative trait change in adulthood. The Five-Factor Theory cannot account for event-based trait change in its current form and its notion of intrinsic maturation is not supported. It is suggested to be modified. To be able to account for the results of the thesis and maintain its biological position, it should specify the biological bases of traits, and biological processes relevant for intrinsic maturation, and more clearly allow for the possibility that life events cause trait change by altering the biological bases of traits, *or* it should allow characteristic adaptations and personality traits to affect each other in both directions (as compared to the current one-way direction).

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