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## Environmental influences on neuroticism : a story about emotional (in)stability

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# Chapter 4

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## **Environmental Influences on Adult Neuroticism: A Systematic Review**

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## ABSTRACT

Behavioral-genetic studies show substantial non-genetic influences on variance of neuroticism within a population. Longitudinal studies show a small but steady drop in test-retest correlations with increasing time intervals. This suggests environmental effects on neuroticism, but a systematic overview of which environmental determinants account for change in neuroticism is lacking. We review (specific or unique) environmental influences that modify the neuroticism setpoint in adulthood and therefore individual life trajectories. Results are interpreted in light of the so-called ‘mixed model’ in which within-person changes in neuroticism are subdivided over short term perturbations around the setpoint of neuroticism versus more persistent changes in the setpoint itself. To account for genetic confounding and shared environmental influences studies of monozygotic (MZ) twin pairs discordant for neuroticism and longitudinal studies that report on environmental factors that predict within-individual change in neuroticism are reviewed. Our results indicate that the neuroticism setpoint is consistently touched by experiences that affect central aspects of one’s identity and status, mainly role transitions as partner (marriage/divorce) and employee (job loss/promotion). Especially interpersonal stress, conflict, and major events that were unpredictable, uncontrollable, unexpected, undesirable, and ‘off time’ from a life history perspective were followed by changes in neuroticism that persisted more than six months, which suggest setpoint change. Most change after severe SLEs persisted over a decade. Long-term and detailed studies are required to elucidate the details of the ‘mixed model’ of change in neuroticism. An understanding of the specifics of the events that lead to persistent changes in neuroticism may enable us to craft prevention strategies to tackle the vulnerability for mental disorders inherent in high neuroticism, rather than to wait for their manifestation.

## INTRODUCTION

*“After fixing upon some particular class of persons of similar age, sex, and social condition, we have to find out what common incidents in their lives are most apt to make them betray their character.”*  
Francis Galton, *Measurement of Character* (1884, [127]).

*“By changing the inner attitudes of our minds, we may change the outer aspects of our lives.”* William James (1842-1910 [2]).

In this paper we review environmental influences on neuroticism, a broad superordinate-dimension of behavioural variation in all major theories of temperament and personality. The core of neuroticism is to perceive the world as threatening, and to experience various negative emotions including anxiety, fear, sadness, anger, frustration, irritability, loneliness, worry, self-consciousness, dissatisfaction, hostility, guilt, shyness, distress, self-reproach, and reduced self-confidence [46,51,63]. High neuroticism is among the strongest predictors of physical and mental health problems [53,166,281], and forecasts important life outcomes such as occupational attainment, divorce, and mortality [64-68,77]. The total economic costs of high neuroticism to society have been estimated at twice that of the common mental disorders combined [55].

### Environmental Influences

Historical nature-versus-nurture debates of neuroticism have given way to the convention that both are important. Studying genetically identical (MZ) twins reared together and apart indicate that about half of the variance in neuroticism does not root in genetic factors [81-93]. Longitudinal studies show that the intra-individual temporal stability of neuroticism, as indexed by test-retest correlations, drops steadily over increasing intervals to plateau between  $r = .30$  to  $.50$  after 40 years [53,93,164,232,236,328,411,432]. Moreover, substantial intra-individual changes in neuroticism have been observed along the lifespan [163,164,411,433-435]. Though neuroticism is of clear importance to societal health [52-54,166], remarkably little is known about environmental influences that underlay individual differences and change in neuroticism [94,95,100]. This paper aims to fill this gap with a review of experiential influences that modify adult neuroticism, but this aim is muddled by person-environment correlation.

### Person-Environment Correlation

With age we become mutually accommodated with the changing environment in which we live and grow [64,248,249]. For example, we select a spouse, friends, vocation,

or hobby (or not), and select ourselves into specific situations, but avoid others, a constellation of choices that tend to intensify the propensities that drove us up there in the first place [64,248,263,411,436-441]. Twin studies show that 20-80% of the individual differences in various measures of our environment - from social support to life stress - is driven by genetic differences [248,256,263,412,437,442]. A substantial part of this variance is mediated by neuroticism [235,412,443,444], and many behavioural genetic and longitudinal studies show mutual reciprocity between neuroticism and life stress [100,125,222,223,235,239]. Both environmental influences on neuroticism and the rank-order between individuals become increasingly stable along the lifespan, which suggests that increasing gene-environment correlations ( $r_{GE}$ ) stabilize both our environment and our personality [85,91,93,163,164,234,236,247,253,445].

Our environment also changes in pace with a biosocial life script that is manifest in the occurrence, timing, sequencing, duration, and interaction of many social processes and normative life events along our life span [100,103,227,235,249,253,264,445-447]<sup>46</sup>. For example, we live and grow in a social convoy that escorts us as fellow travelers through time, with our family, spouse, and friends at the core, and acquaintances, neighbors and colleagues at the periphery [204,445,448]. This social convoy reaches its maximum size during young adulthood, followed by a shrinkage with age [204,445]. These social processes influence the kind of events we experience, part of their impact, and how we regulate our emotions [204,264,445,448].

Most positive life events (PLEs) occur during young adulthood (age 20-45), for example, because PLEs tend to relate to the acquisition of social roles, *e.g.* go live on one's own, graduation, a new friend, a first job, promotion, falling in love, marriage, or giving birth [249,367,389,446,449]. The associated social role changes and pressures drive a maturational mean-level decrease in neuroticism of about  $d=0.80$  between age 10 and 40 [163,165,227,450,451]. Negative life events (NLEs), in contrast, tend to be "unscripted" or refer to deviations from the normative timing and sequencing of the biosocial life script, *e.g.* divorce, widowhood, or unemployment

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46. In chapter 10 we discuss this in terms of the Red Queen Personality Principle, after the Red Queen in Lewis Carroll's book 'Through the Looking Glass' who describes her country as a place where "it takes all the running you can do, to keep in the same place" [1074]. Leigh van Valen used this metaphor to explain that organisms have to continually change and adapt to compete with co-evolving species in order to retain their ecological niche and pace within an increasingly deteriorating environment [1075]. In analogy, our development must keep pace with our changing environment and bioecological clock that shapes the fabric of our personal atmosphere [100]. For example, we have to co-develop with our aging birthcohort to keep our rank-order the same [163,164], as many peers and friends simultaneously experience the same life changes, *e.g.* graduation, a first job and partner, or children [99,264]. In Germany the mean ages (statistical norm) for a first job is 21.2 ( $SD = 4.9$ ), birth of a child (31.1,  $SD = 6.7$ ), marriage (34.2,  $SD = 10.2$ ), separation from partner (35.6,  $SD = 11.2$ ), children leaving home (49.7,  $SD = 7.7$ ), death of spouse (65.9,  $SD = 10.3$ ), see [249,340].

[249,251,449,450,452]<sup>47</sup>. Consequently, NLEs tend to be more uniformly distributed over the life cycle, although their incidence tends to increase slightly from midlife onwards [367,389,449].

### The Current Study

A strict demarcation between the individual and the environment is largely based on statistical methodology [25,95,255,263,427,453]. When we aspire to review environmental influences on neuroticism we have to rule out genetic confounding of environmental influences. The best approach seems the application of a neuroticism-discordant monozygotic (MZ) twin design, which has the extraordinary advantage of a control person with a virtually identical DNA sequence. MZ-twins grew up together in the same family environments, tend to share most peers, and share most indirect genetic effects, resulting in close to parallel lives. As a result, most within-MZ-twin pair differences in neuroticism are due to unique environmental influences [258,454-457]. Hence, a review of studies on MZ-twin-pairs discordant for neuroticism seems the best approach to study environments that elicit change in neuroticism, as this design inherently controls for most genetic confounding.

Unfortunately, as we will show, the literature with regard to neuroticism-discordant MZ-twin pairs is strikingly limited. This review therefore additionally includes studies with, a methodologically less strong, within-person longitudinal design to evaluate developmental patterns. However, in population samples, genetic and environmental variance cannot be disentangled and results may be influenced by selection effects or selective subject attrition and, in particular when the time interval between measurement waves is short, be confounded by reciprocal influences or measurement of concurrent relations (potential test-retest carry-over effects). As a notable advantage, the repeated measurements in a longitudinal study, however, enable the observation of the temporal order of experiences. Moreover, time quantifies the rate of intra-individual change. In addition, longitudinal studies have the benefit of excluding time-invariant unobserved individual differences, as individuals serve as their own controls. However, the many longitudinal studies on personality (see for a bibliometric portrait [458]) force us to limit ourselves to specific topics.

In this review we focus on longitudinal studies of major PLEs and NLEs i.e. time-discrete transitions that bring about a major change in social, economic or financial sta-

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47. Departures from these norms may not only stressful because of (prescribed) social norms and pressures, but also because they are unexpected, which impedes anticipatory rehearsal and coping [446,452,1238]. Moreover, individuals who are “off time” cannot benefit from the social and institutional structures that smooth the way for those who are “on time” [472,1239], e.g. support from peers with similar experiences. Finally, some constraints increase with age, e.g. stigmatization is stronger for singles of age 40 than age 25 [491].

tus, sources of affection, or social roles [244,366]. Such natural noxious circumstances or events place a stress (burden or strain) upon individuals that tax their psychological capacities to adapt [100,459,460]. While most life events shall result in short-term state fluctuations of negative affect (< 6 months), some major events or social role modifications can change the setpoint (or personal average) of the neuroticism density distribution [100,114,223]. This regulation mechanism has been called the mixed model of change in neuroticism, and has been described in detail before (see chapter 2 and 3, and [94]). In this review we focus on studies with a span of at least one year such that our events occurred on average at least 6 months before follow-up, in order to explore the long-term dynamics of setpoint change [100].

We also focus on experiences that took place in the three core systems in which we are embedded: our nuclear family, social network, and occupational life [100,103]. These systems are characterized by regulated patterned activities, social roles, and interpersonal relationships, and form the enduring environments that become most colored by recurrent person-environment interactions [21,103]. Moreover, the age-graded enactment in these social roles as partner, parent and employee are theorized to drive the mentioned mean-level decrease in neuroticism between age 20 and 40, estimated at  $d=0.20$  per decade [163,433]<sup>48</sup>. These choices mean, however, that changes in neuroticism after childhood abuse and adversities before age 18 [18,222,461], effects of diet, hobbies and sports [143,144], daily hassles and uplifts [462], inter-cultural differences [463], and psychological interventions and medication [351,353,354], among others, fall outside the scope of this review. In sum, we review major environmental influences that modify the neuroticism setpoint during adulthood, and therewith individual life trajectories.

## METHOD

### MZ-twin approach

Articles between 1950 and 2015 were searched for in the databases of PsychINFO, PubMed, and the ISI Web of Knowledge. The search strings consisted out of two components, with as first string the keywords ‘neuroticism, negative emotionality, negative affectivity, trait anxiety or emotional stability’. The last five keywords were included because these domains are constructs closely related to neuroticism. Trait-anxiety

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48. Known as ‘absolute continuity’, this reflects the assessment of group averages at certain age-points, which shows normative biosocial-maturational changes when a generation matures [434]. Notably, closely related primate species show similar age-related maturational decreases in emotionality [1240,1241].

refers to long-term and stable personality construct, defined as the tendency to respond with state-anxiety in the anticipation of threatening situations, akin to neuroticism [464]. Negative affectivity roughly corresponds to neuroticism, but is often measured on shorter time scales [94,286]. If results refer to trait-anxiety or negative affectivity this shall be explicitly noted.

The second component of the search string consisted of the terms ‘MZ twins, monozygote, monozygotic twins or identical twins’. Two reviewers screened the search results. The reviewers first screened the title and abstracts of the papers on inclusion criteria. We aimed at papers about MZ-twin pairs that explain within-pair differences in neuroticism. For this paper we selected papers focusing on determinants of the discordance in neuroticism ( $k=5$ ). Papers without neuroticism-measures or zygosity determination were excluded ( $k=60$ ). From the remaining papers about neuroticism-discordant MZ-twins, we extracted the cohort name and its characteristics. We recorded, where possible, the sampling population, recruitment strategy, response rate, the actual or eligible age range of the twins, the mean age (SD) of the twins, the proportion women in the sample and significant inclusion and exclusion criteria used in the studies. We further collected the name of the first author, year of publication, type of neuroticism measure, number of participants, zygosity determination and outcome regarding neuroticism. We also noted the criteria used to determine neuroticism, *viz.* the name of the measurement instrument, the administration format (self-report, interview, observer ratings) and the number of items of the instrument that was used. Cross-linked searches were made taking the lead from key articles.

### Longitudinal Studies

We searched for articles published between 1950 and 2015 in all databases of ISI Web of Knowledge, PubMed, and PsychINFO. The same first search-string was used as with the search for MZ-twin studies (neuroticism, negative emotionality, negative affectivity, trait anxiety or emotional stability), complemented by the terms ‘Longitudinal or prospective’. The results were screened with our fourfold a-priori selection criteria: The study (a) had to contain a measurement of neuroticism (or negative emotionality or trait-anxiety) *before* the experience of interest (*e.g.*, divorce); (b) had to contain another measurement of neuroticism (or negative emotionality, trait-anxiety, emotional stability) *after* the occurrence of the experience; (c) a minimum follow-up time of 12 months; (d) had to be written in English, Dutch, German or French; (e) needed a minimum sample ( $N > 150$ ) to gain sufficient statistical power. From the selected articles we extracted the sampling population, mean age (SD), proportion women, and significant inclusion and exclusion criteria. The same information as described above for the MZ studies were extracted from the selected articles



### Statistics

The heterogeneity of the outcome measures precluded a formal meta-analysis of the environmental influences on neuroticism. However, in order to improve on comparability, outcomes were converted into standardized difference or change score units Cohen's  $d$  [465]. An effect size  $d$  of zero means that both groups are exactly the same, whereas 0.50 indicates that the average person in the group who experienced a particular event scored half a SD on neuroticism above the average control. We used conversion formulas derived from Borenstein [420] and Peterson [466]. As a heuristic to guide interpretation of findings, the convention is that a  $d$  of 0.20 is regarded a small effect, 0.50 as medium, and 0.80 as large [373]. For correlations .10-.29 is considered small, .30-.49 medium, and from .50 large [373]. We encountered many studies which did not provide enough information to calculate a Cohen's  $d$ , and for these studies the review lacks an effect size in the text.

### Reporting

The information extracted from the selected articles is ordered within four broad themes or foci of empirical inquiry; (a) romantic relationships (relationship initiation, properties, and dissolution); (b) social environments (nuclear family, friends); (c) occupational environments; and (d) major non-normative positive and negative stressful life events. In the result section we introduce each theme with a short outline of known neuroticism-driven selection effects in existing meta-analysis and reviews, followed by the studies we encountered, and a synthesis of each theme. This review is restricted

**Table 10.**

<b>Romantic Partnerships</b>		Page	<b>Occupational Environment</b>		Page
A1	Selection effects	82	C1	Selection effects	93
A2	Relationship initiation	82	C2	Occupation, status, and salary	94
A3	Stable partnered and stable single	83	C3	Occupational Satisfaction	95
A4	Relationship properties	84	C4	Occupational Life	95
A5	Relationship dissolution	85	C5	Person-environment fit	96
A6	Widowhood	87	C6	Retirement	96
A7	Conclusion	87	C7	Conclusion	97
<b>Social Network</b>			<b>Stressful Life Experiences</b>		
B1	Selection effects	88	D1	Stress generation	98
B2	Cohabitation	88	D2	Positive experiences	98
B3	Nuclear family	89	D3	Negative experiences and timing	99
B4	Parenting	90	D4	Event chains	100
B5	Social networks	91	D5	Clustering	101
B6	Conclusion	92	D6	Gender differences	120

to studies conducted in adults, because parenting effects on neuroticism (in the range of normal family-to-family variation) seem to wash out in late adolescence [195,259,467-469], while genetic control over the environment increase with age [195,259,467]. The results have been arranged over the topics given in Table 10, but note that our choice for these topics was partly influenced by the availability of literature. Moreover, these topics and the broad themes in which they have been arranged show overlap, especially romantic partnerships and social network.

## RESULTS

### Search Results

The systematic search for MZ-twin studies yielded 371 potentially relevant papers, of which 218 were unique (59%). As a next step only the papers handling about environmental influences on neuroticism in MZ-twin pairs were selected. References of original articles and related reviews were hand searched for additional papers. We excluded 213 studies because they did not meet the *a priori* selection criteria listed above. Finally, five twin studies were included in the review study. The systematic searches of longitudinal studies identified 6592 studies, among which 3960 were unique (60%). The bibliographical lists of all included studies were searched for possible additional studies. Overall 60 longitudinal studies met the criteria and were included in the review study. A file with the excluded studies is available on request.

**Table 11.** Search results

	Twin studies		Longitudinal	
	Total	Unique	Total	Unique
Total	371	218	6592	3960
Excluded		213		3900
Included		5		60

## REVIEW OF EMPIRICAL FINDINGS

### Section A: Romantic relationships

Romantic relationships are the closest and most important relationships in nature after motherhood [246,471]. We review the effects of a transition into a romantic partnership or marriage on neuroticism, followed by the effects of different relationship properties, and the impact of relationship dissolution or divorce, respectively. While some of these events expand our social system (*e.g.*, a new relationship) others are characterized by

a loss within the system (*e.g.*, death of a spouse or divorce) [100,445]. We first provide a short outline of some neuroticism-driven selection effects.

### ***Selection Effects (A1)***

The selection of a mate is one of the most salient examples of environmental selection [472]. Moreover, divorce, separation, and loss of a spouse are considered the three most stressful life events in adulthood [223,366,473]. Most variance in divorce risk can be explained by genetic differences, somewhat more for men than women [474,475], and high neuroticism predicts a substantial part of this “relationship load” [156], at least more than SES or IQ [66]. Neuroticism does this via cognitive and emotional processes that color how individuals perceive and construe their environment [32,125]. In short, individuals high (*vs.* low) on neuroticism tend to select themselves into marital instability ( $d= 0.45$ ), dissatisfaction ( $d= 0.35$ ), conflict ( $d= 0.60$ ), abuse ( $d= 1.15$ ), and dissolution ( $d= 0.35$ ) [156,476-478]. Moreover, high (*vs.* low) neuroticism predicts both the most common cause of marital dissolution, *viz.*, infidelity ( $d= 0.91$ ) [479-481]<sup>49</sup>; and the third universal cause, maltreatment [156,482]. For example, women who partner with high (*vs.* low) neurotic men are four times more likely to be abused [156]. In the next paragraphs we explore the influences of factors in the romantic relationship domain on neuroticism.

### ***Relationship Initiation (A2)***

Unfortunately, no twin studies of transitions into romantic partnership or marriage were encountered, nor studies of cohabitation of romantic partners and neuroticism. Most longitudinal studies showed decreases in neuroticism after partnering [331,338,344,408,483,484], although not all [222,339]. Studies that focused on young adults showed that single 20 year-olds who partnered over the next decade decreased in neuroticism,  $d= 0.30$  to  $0.50$  [338,483,484]. This decrease was observed irrespective of the duration of the relationship, gender, age [338,483,484], marital status, whether individuals cohabited with the partner, lived on their own, or still lived with their parents [485]. Middle-aged men (age 39-45) also decreased in neuroticism after marriage in middle-age ( $d= 0.40$ ), compared to controls who did not marry [331,408]. Saliently, women did not [408]. However, divorced men (aged 43-91) who *remarried* also decreased in neuroticism over the next decade after remarriage ( $d= 0.50$ ), compared to men who did not remarry [331].

Alas, no information was available for the average rate of adaptation to a new partnership or marriage (“the honeymoon effect”), thus how long the decrease in

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49. Neuroticism predicts the annual prevalence of infidelity after control for gender, age, race and education ( $d= 0.91$ ), and even after control for marital dissatisfaction,  $d= 0.59$  [156,480].

neuroticism persists. Although it is known that subjective wellbeing is increased for about two years [486]. After partnering young adults decreased primarily in terms of negative affectivity (depression/anxiety) rather than emotional reactivity (impulsivity and anger) [483,487,488]. In sum, a new romantic relationship tends to be followed by a decrease in neuroticism, most likely for at least a decade; and at least for men, this effect is not limited to first relationships and young adulthood, but can take place along the life cycle.

### ***Stable Partnered and Stable Single (A3)***

Young adults who were stable single or stable partnered between age 20 and 30 showed fairly stable neuroticism levels [338,483,484]. However, young adults who continued their relationship decreased more in neuroticism than their peers who separated,  $d = -0.36$  vs.  $-0.22$  [338,344]. Notably, the latter decrease aligns with the normative decrease in neuroticism (of about  $d = 0.20$  per decade) between age 20 and 40 [163]. Adults who changed partner between age 20 and 30 showed a lower temporal stability in neuroticism ( $r = .46$  vs.  $.65$ ) and smaller decreases in neuroticism than their stable settled and even stable single peers [338,343,344,483,484]<sup>50</sup>. These results suggest that relationship continuers (~30% of the participants) show the stereotypic normative maturational decreases but that changers (~70%) follow more differential developmental patterns [343,344].

Arguably, partnership dissolution (and re-partnering) may have different implications for different individuals. While some shall be relieved, others may be frightened [489], and these perceptions may result in either a decrease or increase in neuroticism [249,343]. More differential patterns for changers align with the argument in the introduction that normative experiences facilitate the normative maturational changes in personality (*viz.*, decreases in neuroticism), while non-normative experiences evoke responses in line with previous neuroticism levels, thus more differences in response [249,451]. Finally, the larger changes in the stable partnered young adults aligns with the idea of romantic relationships as transaction systems, which show a reset after a change of partner [338,338,343,411,484].

Partnered individuals decreased most in negative affects like sadness and anxiety but not much in emotional reactivity dimensions such as impulsivity and anger [483,487,488]. Finally, two longitudinal studies observed comparable neuroticism levels for married and unmarried adults from age 20 to 30 [484], or for single and stable cohabiting couples in their thirties, even in retrospect, when both groups were 15 years old [490]. This suggests that relationship-transition effects are transient, and that levels gravitate back to their setpoint over a period of adaptation and reorientation [331], a

50. Notably, in contrast, one four-year study reported equal rank-orders of  $r = .58$  [344].

homeostatic process, which in previous studies has been called the dynamic equilibrium model [94,155,403,405,486]. The reviewed studies are by no means conclusive about the effects of partnering, *e.g.* stable singles may start to increase in neuroticism when their deviation from the biosocial life script becomes more salient with age [491], as implied in our introduction. Moreover, the conflicting studies lacked information about past relationships, while divorces may undo some of the initial benefits of partnering [99,482], a topic we come to after the next paragraph.

### ***Relationship Properties (A4)***

Neuroticism is for both genders associated with unstable marriages [492], and also the strongest personality predictor of marital (dis)satisfaction [493]. Satisfying partnerships buffer spouses from psychological distress and negative life events, whereas marital distress and instability forecasts negative outcomes over the life course [156,477]. The pendulum for neuroticism appears to swing under the influence of relationship-properties [343,411,484]: We already concluded that individuals who enter a romantic partnership tend to decrease in neuroticism, but this process is faster in high quality, satisfying, affectionate, and secure relationships [333,342-344]. Even high dependent individuals decrease in neuroticism after partnering, albeit it takes them more time in their partnership to do so [343]. Furthermore, also individuals who increased in relationship closeness over 8 years decreased in neuroticism, but the decrease over the next 7 years did not reach significance [246].

Increases in neuroticism were observed for individuals in unhappy and maladaptive partnerships, especially when they were exposed to repeated negative states [344], relationship stress [494], dissatisfaction [333,342,344,484], insecurity [246,333,342,344,484], conflict [246,344], abuse [344], and negative sexual experiences [339]. Moreover, the reported dose-response association [344] between maladaptive relationships and negative affect suggest causality [495], *viz.* the disposition towards neurotic distress probably *results* from recurrent negative states or acts of aggression [95,344,496]. Results also indicate that individuals who reported negative relationship-experiences became (on average) more hostile and irritable (mistrusting/self-critic) than their peers [344]. Finally, one study reported that more conflicts with a romantic partner predicted subsequent decreases in neuroticism [246].

The reviewed studies indicate enduring dynamics [497], *e.g.* relationship properties had stronger effects in stable-partnered adults than among relationships changers [344], in keeping with the relationship as transaction-system perspective. Moreover, a stable relationship does not mean higher personality stability, *e.g.* men who had highly satisfied marriages over a 24-year interval between high school and midlife reported more personality change [254], in line with observations that neuroticism levels decrease more in a happy marriages [333,342-344]. Third, men who married a spouse who was

high on trait-anxiety tended to increase in negative affect (at all four waves) over 13 years of marriage ( $r = .33$  [498]), which suggests emotional contagion. Surprisingly, the reverse association, *viz.*, between the husbands' level of trait-anxiety at  $T_1$  and the wives' negative affect 13 years later, was not significant [498]<sup>51</sup>. Fourth, young adults often reported comparable relationship experiences with different partners, indicative of cross-relationship generalization of neuroticism effects on partner selection and relationship quality [344,472]<sup>52</sup>. In sum, it seems likely that highly neurotic young adults select themselves in partnerships that over time lead to relationship insecurity and increased neuroticism [338], in accord with the corresponsive principle.

Virtually all observed effects were bidirectional (correlated change), and pure relationships effects on neuroticism were rare [343]. These results support transactional models of human behavior [472,499], and the characteristic tendency of individuals high on neuroticism to select themselves into situations that foster negative affect, via the selection of specific partners [156], interaction-styles [498,500]<sup>53</sup>, and conflicts [36,39]. Furthermore, in 40-60% of the romantic relationships the partners break-up and renew their relationship at least once, called cyclicity [501]. Cycling in cohabiting and marital relationships is associated with more uncertainty and lower relationship satisfaction [502], and cross-sectional with higher neuroticism levels [503], but we encountered no longitudinal study of this phenomenon. Finally, the most influential relationship variables on neuroticism were conflict frequency and to a lesser extent also feelings of insecurity [246,338,488,504,505].

### ***Relationship Dissolution (A5)***

Dissolution is an eminent aspect of the romantic relationships domain, if only because most marriages end in divorce [156,506], or the eventual death of one of the partners. MZ-twin pairs discordant for divorce showed for both genders higher neuroticism scores for the divorced twin of a pair [239]. One study of male twins reported on higher neuroticism for divorced *vs.* married ( $d = 0.18$ ), single, or widowed counterparts [172]. Moreover, four longitudinal studies reported small increases in neuroticism ( $d = 0.15$ ) after divorce [222,254,408,507]. However, another four longitudinal studies observed no effects of dissolution on neuroticism [338,340,438] or trait-anxiety [498]. For example, divorce within a six-year span was not associated with change in

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51. This is reminiscent of a study of adults over age 50 which reported a modest boost in health for women who were partnered to men who were highly neurotic and conscientious, while no benefit for being with highly neurotic and conscientious wives was seen in men [185].
  52. Notably, reports of how individuals experience their partner-relationship seem more characterized by one's own personality than that of the partner [560].
  53. Five processes reliably predict relationship dissolution: criticism, defensiveness, contempt, belligerence, and stonewalling or listener withdrawal [500].

neuroticism for both genders - though men increased slightly in the depression facet [408] - whereas a study of married couples reassessed on neuroticism, 13 years after their divorce, reported no effect of divorce on trait-anxiety nor negativity [498]. Furthermore, divorce predicted decreases in personality stability in women over a 24-year interval (between high school and midlife), but observed no effect of divorces on men [254].

However, as mentioned, two twin studies [172,239], four longitudinal studies [254,408,507,508], and a meta-analysis of longitudinal studies [41]<sup>54</sup> reported associations between divorce and neuroticism (for both genders [508]). The differences between these studies suggest that homeostatic processes in the aftermath of divorce mask the (initial) impact of divorce [345], perhaps because most subjects passed their most distressing phase before researchers collected their data. This is not unlikely in two-wave-snapshot studies, because then the study length must cover the time course of the underlying causal process to avoid spurious results [333,509]. Moreover, some may anticipate (and prepare for) a divorce with increases in negative and fights *before* divorce, which would mask the effects of divorce [156,510]. In addition, as mentioned, differences in how individuals respond to divorce (*e.g.*, relief *vs.* fear) may mask effects [343,489], though not so much for the MZ-twins [172,511]. Furthermore, some inconsistencies may reflect (gender) differences in the meaning divorce conveys over the lifecycle [78,156]<sup>55</sup>.

One longitudinal study showed intriguing support for the effects of divorce on neuroticism [507]. Kiernan and colleagues followed a cohort of women from their teens - before their marriages - into adulthood. Although divorced women had scored higher on neuroticism as teenagers ( $d = 0.27$ , thus assortment), they also increased significantly in neuroticism after divorce (till  $d = 0.63$ ). More importantly, women who scored low on neuroticism at age 16 increased in neuroticism after divorce, and the proportion women who scored low on neuroticism dropped from 36% to 5% after a broken marriage [507]. Notably, these results suggest that the association between neuroticism and divorce is not necessarily a reflection of preexisting psychological

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54. Divorce rates and mean-neuroticism levels a decade later correlated 0.48 for males and 0.39 for females (both  $p < .001$ ) over 170 studies and 40192 participants, whereas the reverse association (*i.e.* between mean-neuroticism and divorce rates 10 years later) was nonsignificant for both genders. This suggests that change in environments (*i.e.* the divorces) precede the change in neuroticism [41].

55. Women remarry increasingly less often with age because sex ratio and mate-value changes favor men, known as the marriage squeeze phenomenon [78,156]. In addition, 90% of the single parents are women [78]. Furthermore, discord and dissolution are typically perceived as signs of failure [156], and may incur severe cost like loss of extended kinships, essential resources, and missed mating opportunities [482]. The price thereof may increase with age as partners have invested more time and energy, have more to lose, and fewer opportunities to repartner. Such factors may (partly) account for the observation that more divorces associate with less personality stability among women, but not among men [254]. However, emotional stability is also more sexually attractive in men than women [156-159].

problems, but rather of secondary stressors [512] in the period around (simultaneous with) a relationship dissolution [513-515]. Note that this interpretation aligns with the diverging effects of divorce for MZ-twins [172,239]. Finally, the results were probably attenuated because the consequences of divorce were limited for the disproportional young, wealthy, educated, intelligent and Caucasian samples studied [163,516]<sup>56</sup>.

### ***Widowhood (A6)***

In middle aged men (43 to 90) the death of their spouse predicted both level and rate of change in neuroticism, on average an increase  $d= 0.72$  [331]. However, these elevations were followed by an accelerated decrease in neuroticism ( $d= 0.40$ ) over the subsequent decade [331]. This suggests a homeostatic system, wherein individuals return to their setpoint [94]. Moreover, the loss of a spouse is reportedly one of the most stressful experiences in adulthood [366,378]<sup>57</sup>. The observation of adaptation processes to such a stressful event suggests that adaptation to much less severe events is likely, such as those discussed in section D.

### ***Conclusion (A7)***

The studies in the romantic partnership section showed that marriage and partner investments result in decreases in neuroticism, in line with normative developmental patterns. Men who selected a spouse high on neuroticism tended to increase in neuroticism over time [498], in line with transactional models [95,472,499,517]. Results align with the corresponsive principle insofar that life events that are associated with change in neuroticism were often selected for as well. The results suggest that romantic relationships have separate positive and negative dimensions, which associate with decreases or increases in neuroticism, respectively, *cf.* [100,518-520]. Alas, few studies focused on transactions beyond emerging adulthood (age 30), however, while spouses may become ever more important resources for dealing with everyday problems in

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56. Many factors may moderate the association between divorce and neuroticism, *e.g.* income [477,507,1242], availability or loss of supportive networks [78,477,507,1243,1244]; culture and ethnicity [516,579,1245]; education [507,616], health, employment, length of marriage, conflict with the ex-partner, number and severity of negative experiences, if you initiated the divorce [156,269,379, 482,514,1243,1246,1247], individual variables [378,379,473], and so on. For example, women whose marriages have broken down have on average more children to support [507]. Moreover, divorced individuals have more often both divorced parents and come from poorer families, which may experience difficulties to cope with the financial and emotional strain their adult children may well engender on them [507]. Hence, divorce may have repercussions for the wider family group - which may in turn associate with more guilt and distress. Nevertheless, the costs of remaining in an unhappy marriage have been discussed.

57. Note that the death of a spouse means one cannot win her back (although repartnering is possible), and does not require a reassessment of strategies, which might enable a return to pre-existing neuroticism levels [156].



old age, when social networks shrink. Though it is often argued that most relationship effects are confined to emerging adulthood [504,521], the reviewed studies demonstrate that relationship effects on neuroticism occur along the lifespan [246,522]. It remains largely unknown *how* and *why* specific contexts or relationship properties change neuroticism, and the specific rate of adaptation to these events. Finally, the family is not a static institution, thus effects possibly differ over generations, given that within decades marriage rates have fallen, divorce rates have risen, and the defining characteristics of marriage have changed [506,523].

## **Section B: The Social Network**

Social networks refer to the set of people with whom an individual is directly involved, such as family members, friends and acquaintances, and which are crucial for personality development [103,445]. Aspects of this social network show normative developmental changes [445], but not much is known about how such changes impact on changes in neuroticism [125,246], and also the trajectories of these effects are not very well understood [249,445]. In this section we review effects of sibling cohabitation, interactions in the nuclear family, or interactions within our social networks, on change in neuroticism. However, before doing so, we outline some neuroticism-driven selection effects that shape our social network.

### ***Selection Effects (B1)***

Twin research indicates that most (40-80%) human variance in social networks and support is explained by genetic influences [256,437,524]. These effects are probably mediated by personality differences, via which individuals select, evoke, and shape their habitual environments [66,249,525]. High neuroticism predicts lower (perceived) social support for both genders [302,437,526-528], lower family satisfaction ( $r = -.19$ ,  $p < .01$  [529]), more problems to get along with relatives and friends ( $d = 0.28$ ), fewer confidants, less interpersonal relationships and social integration [222,437,478], and more loneliness [530], death, illness, and crises in the core network [478]. Little of these effects seem due to reporting bias [38,478]. Finally, there seems no neuroticism-driven selection for living arrangement (*e.g.*, with parents, alone, with roommates, or with partner) in young adulthood [531], possible effects at other age ranges are not studied yet. In the following we focus on effects of cohabitation, and interactions in the nuclear family and social networks, followed by a conclusion.

### ***Cohabitation (B2)***

Twins who cohabited with their co-twin at baseline showed no interindividual change in neuroticism over a six-year interval, while twins who had started to live apart (*e.g.*, left parental home) showed significant divergence in neuroticism levels [532]. Another

study showed heritability estimates of neuroticism to be 0.54 among cohabiting male twins, but 0.39 among males who lived apart [172]. A lower number of social contact seems to antedate (possibly even causally) the suggested decreased intra-pair similarity for neuroticism [532]. This perspective is supported by a meta-analysis of MZ-twin studies [336]. Finally, a study of 5000 male MZ-twin pairs indicated that a change in residence for negative reasons tended to associate with higher neuroticism scores [172].

### ***Nuclear Family (B3)***

Prospective studies indicate that changes in interpersonal relationships - such as family ties and peer contacts - associate with changes in neuroticism [342,344,408,484,505,521,533-538]. The nuclear family proved the most influential social context, *e.g.* young adults (age 17-23) who perceived conflict with fathers or mothers often increased in neuroticism ( $d= 0.60, 0.50$ , respectively [521]). Similarly, parents who reported more conflict with their children [484] or adolescents also increased in neuroticism ( $d= 0.26$  [539])<sup>58</sup>. One study of middle-class two-parent two-child families showed that perceived change in social support had no effect on the parents or oldest child, and only the youngest child increased in neuroticism [538]. Arguably, this reflects that decreases in support are most threatening to a child that is more dependent [78,540,541]. In accord, changed support from father or mother between age 17 and 23 was unrelated to change in neuroticism among young adults [521]<sup>59</sup>.

The stress of having a newborn baby associated with increases in neuroticism of  $d= 0.56$  [539], especially for parents who already had high levels of neuroticism [542]. Also parents who became more insecure with their children increased in neuroticism [484], just as women with negative mothering-experiences [543]<sup>60</sup>. In contrast, positive mothering-experiences associated with decreases in neuroticism [543], just as increased security with family members [338]. Increases in neuroticism associated also with more dissatisfaction with one's interpersonal network [342,344], abusive interpersonal relationships [342,344], and perceived declines of family and social life over time [408]. Such declines in contact predicted increases in the facet traits anxiety, depression, and vulnerability for stress [408]. Young women exhibited an accelerated increase in emotional stability (decrease in neuroticism) when they moved

58. This may be interpreted in terms of potential fitness costs [471,615]. Notably, perceived parenting self-efficacy was not associated with changes in neuroticism [539].

59. It remains unknown whether the adolescents lived with their parents or independent over this period.

60. Women with negative mothering-experiences tend to increase in vulnerability, *viz.*, hypersensitivity, fearfulness and dependence [543]. However, this is a reciprocal effect, because neuroticism also predicts more insecurity [246].

out of their parental home [340]. This effect was not observed among men [340]. Albeit independent living is a rite of passage to adult status [264], this observation may reflect ‘daughter guarding’, because daughters tend to experience more constraint in the parental home [544].

Finally, a division of 1000 twin-pairs in quartiles based on increasing levels of family dysfunction (negative emotional tone, *e.g.* low support, or anger) showed that both the mean and variance of neuroticism increased steadily with more family dysfunction [533], which accounted for about 3% of the variation in neuroticism [533]. Notably, the increase in neuroticism was approximately the same in twins with low versus high genetic liability for high neuroticism [533], indicating environmental canalization, *viz.*, with or without a genetic predisposition, all obtain high scores. This process has also been observed for high levels of parental conflict [545]. Similar processes underlie the observation that neuroticism is more heritable in individuals without religious upbringing [546], another example of how heritability differs over different environmental contexts [248,336,545,547], which stresses prudence about inheritance [86,548-551], and support a sociogenomic perspective on personality development [93,95].

#### ***Parenting (B4)***

Becoming a parent is often cited as the most important turning point in one’s life, particularly among women [552]. One study showed no change (*vs.* controls) in neuroticism for individuals who transitioned to parental status over a four-year interval [484]. This may seem counterintuitive, and in discord with social investment predictions [251], but fits the notion that decreases in neuroticism after partnering aid the rearing of a child, *before* it is born [156,439,553]. Perhaps the decrease in neuroticism due to investment is balanced by an increase due to stress of a child. Moreover, lack of change may also reflect a homeostatic process, when neuroticism scores that deviated from the setpoint had already returned to baseline due to too low frequent neuroticism measurements. It may also be that young adults who became parent do not show the normative decrease that their peers show (because parenthood may also be stressful), which would manifest in rank-order stabilities [94,244]. Lastly, there was no relation between the number of children an individual begets and personality stability over time [254], which does not support the idea that young parents fail to change.

Nevertheless, in a 9-year follow-up study was found that high (*vs.* low) emotional individuals were less likely have a second and third child [554]. And interestingly, individuals who were high (*vs.* low) on emotionality at baseline *and* got two or more children increased in emotionality over 9 years (from  $d = 0.13$  to  $d = 0.36$ ), while emotional stable individuals in similar conditions did not [554]. Over these 9 years individuals who had no children remained relatively stable on emotionality, while in-

dividuals who had one or more children increased in emotionality [554]. Finally, high neuroticism associates with childbirth complications [555], whereas giving birth to a pre-term child increases maternal trait-anxiety measured at 14 days and at 14 months postpartum [430]<sup>61</sup>. Pre-term birth appears to represent a long-term difficulty for the parent, which is an ongoing environmental influence [100]. In sum, results suggest that the distress associated with childbirth is larger in individuals high on neuroticism before pregnancy [554].

### *Social Networks (B5)*

Most human functioning is socially situated. The neuroticism setpoint must thus be socially embedded. The social convoy that travels with us in time is broader than parents, siblings and spouses, and also contains our friends, acquaintances, and neighbours, albeit these contacts tend to fluctuate more [445,448], and decrease in number and importance with age [204,445]. Studies about the influence of broader social networks on neuroticism were scarce. Decreases in neuroticism were reported when peer contacts increased between age 18 to 30 [338], or after befriending new people [222], but in another study no effect was found [246]. Insecurity in the presence of peers showed a correlated change with neuroticism [246,338]. Nevertheless, young adults' perceived conflict with best friends or peers [521] or changed support from best friend [521] were unrelated to change in neuroticism. In another study no effect was reported of changes in number of conflicts, quality of contacts with peers, or closeness with friends on change in neuroticism [246]. Third, all associations between relationship variables and neuroticism were non-significant in an 18-month longitudinal study of first-year students [505]. However, elderly women who reported declines in social support between age 74-80 (fewer available friends, visits, and social contacts) increased in neuroticism over this six year period [536]. One large study reported increases in neuroticism one year after the break-up of a longstanding relationship with a friend or relative ( $d=0.20$ ), or after serious problems with a close friend, family member or neighbour ( $d=0.14$  [222]). Furthermore, individuals who cared for elderly chronically ill family members decreased in anger and anxiety over two years (arguably an emotional adaptation), albeit guilt and depression persisted [556]. Even so, caregivers who placed their family member in a nursing home decreased also significantly in guilt, when periods just prior and after placement (8 months apart) were compared [556].

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61. Mothers ( $N=50$ ) of children with a very low birth weight (<1500 grams) and/or birth before 32 completed gestational weeks *v.s.* a control group of mothers ( $N=30$ ) of term infants born around the 40th gestational week with an average birth weight of 3500 grams; all spontaneous pregnancies [430]. Conversely, pre-term born children or children with low birth weight score themselves higher on neuroticism, shyness, and inhibition as emerging adults [1248,1249], even after control for age and SES [1248].

### ***Conclusion (B6)***

Changes in neuroticism associated most with problems in the proximal social network, especially in terms of deteriorating ties. Moreover, perceived conflict and perceived deterioration of family life associated more with change in neuroticism than changes in perceived support [408,521,533]. This suit of results is in keeping with conceptions of neuroticism as sensitivity to threat and punishment [557] and the notion that threats to belongingness or dissolution of social bonds are the primary sources of negative affect [558,559]. However, neuroticism levels appear to be largely unaffected by social relationships beyond family life [246,488,521,538], and although all studies were restricted to young adults [505,521]<sup>62</sup>, this observation aligns with the literature [471].

Theoretically, it may seem likely that neuroticism has a stronger influence on relationship quality than vice versa (*cf.* extended phenotype): Not only has neuroticism higher stability over time - resulting in persistent and cumulative effects on our social networks, relationship experiences are also likely to have more time-limited effects [484,505,560], to fluctuate more, and to cancel each other out [505,521]. It has therefore been noted that relationship properties and broad traits like neuroticism have a different level of abstraction which results in unfair comparisons, which leads to a preponderance of personality effects [246,484]. Indeed, in line therewith the authors of a 15-year follow-up study on the facet level of neuroticism reported the effects of facet traits on relationship effects and vice versa to be equally likely [246].

An important limitation of the reviewed studies was that mainly samples of young adults were assessed during developmental stages on which important changes in friendship-status occur [561], such as when they start a study, which happens in encapsulated environment that are utterly atypical from the social environments of the population as a whole [107]. It remains therefore unknown if these findings generalize to adults in midlife. This is, however, an important issue, because social networks change over the life cycle, *e.g.* with age individuals report fewer conflicts, a decline in the number of friends, and less contact with family and friends in general [338,445]. Moreover, social networks differ along the time course [331,333,334,562-564], and have a socioeconomic gradient [107,463,547,565-568]. Furthermore, social networks tend to have a gender-specific make-up, as women tend to have more kin and fewer co-workers in their social networks than men do [78,569,570], and to report fewer conflicts and fewer close friends, but more intimate dyads, prefer smaller groups, experience marriage and family as more central than men do, and profit more from partner

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62. Asendorpf and colleagues [505] concluded that “whether students’ peer network grew quickly or slowly, whether they experienced increasing or decreasing conflict with parents or peers, whether they fell in love or not, whether their perception of available support from parents or peers increased or decreased had no effect on their neuroticism score.”

support [11,78,156,338,570,571]. Third, women seem more affected on their neuroticism score by stressful events in their proximal network (*e.g.* death of a loved one, problems getting along) than men, and report more events [222,473,572]. However, not one study accounted for gender difference in what counts as social capital [78,569]. In sum, the social network section showed that the vast majority of environmental influences on neuroticism take place within the proximal family. Given the patchy nature of the available data, this is unsurprising, and many questions are not addressed.

### Section C: Occupational Environments

Besides from their social relationships most humans also derive their identity from their professional relationships in their occupational environments [573]. Most likely because most awake hours between age 20 and 65 are spent in occupational environments, which, compared to the social and romantic environments, are characterized by more formalized behavior, roles and routines [123]. The occupational environment provides many resources, in terms of status, behavioral confirmation, stimulation, and money, and therewith access to activities and endowments [445,574].

#### *Selection Effects (C1)*

Normative development into adulthood, such as graduation and economic independence, associate with emotional stability [251,264,575-577], as well does social investments in the occupational environment ( $n = 5188$ ,  $k = 24$ ,  $r = .11$ ,  $d = 0.22$  [450]). However, such associations in the occupational system are easily confounded, because neuroticism is inversely associated with socioeconomic status (SES which refers to social class and educational attainment, *e.g.* 25<sup>th</sup> vs. 75<sup>th</sup> SES percentile,  $d = 0.21$  [67])<sup>63</sup>. Moreover, high (*vs.* low) neuroticism levels forecast specific job-environments [172,578-580], downward mobility, job-loss, and lower academic achievement, lower income, occupational prestige, job-satisfaction [27,99,222,410,472,478,581-585], and less growth in cognitive achievement ( $r = -.18$  over 68 years,  $R^2 = 1\%$  after correction for gender and prior ability [108,586]).

Most studies, also twin studies, reported negative associations between neuroticism and intelligence ( $r = -.10$  to  $.15$  [108,211,587]), but some find no association [588]. Furthermore, both high SES individuals and higher educated individuals report more job satisfaction *and* more problems at - and worries about - their job [473,589]. Finally, a meta-analysis of longitudinal student samples showed no association between economic conditions and change in trait-anxiety *after* control for social connectedness and threat [41]. In sum, effects in the occupational environment are difficult to interpret in

63. For example, over a 10-year interval SES explained about 8% of the mortality risk associated with neuroticism, but neuroticism 11% for SES [67].

isolation, because they are markedly shaped by neuroticism-driven selection effects. In adults higher neuroticism associated over two years with a lower likelihood to finish formal education or a course [222]. In the following section we explore influences in the occupational environment that associate with stability and change in neuroticism.

### ***Occupation, Status, and Salary (C2)***

The first study of 5000 male twin pairs reported differences in neuroticism levels in different occupations [172], arguably a selection effect. Unemployed twins reported higher neuroticism scores ( $d= 0.15$ ), just as twins who worked at night or shiftwork schedules ( $d= 0.10$ )<sup>64</sup>. Moreover, vocations and neuroticism lay on a continuum from low-neurotic farmers and upper-professionals ( $d= -0.16$ ) via sedentary occupations to higher scores for twins with heavy physical occupations (in the mines or industry,  $d= 0.07$ ). Neuroticism weakly associated inversely with income ( $d= 0.08$ ) and level of education ( $d= 0.12$ ), such that the difference in neuroticism between twins educated to secondary school versus higher educated twins (university) was  $d= 0.15$  [172]. The twin studies thus indicate that neuroticism levels can (partly) be predicted by unemployment, status, income, and education [78,528,590].

A two-year study reported decreases in neuroticism ( $d= 0.20$ ) after a new job and for young adults who obtained promotion or more prestigious occupations [27,222,410], especially in alienation, angry hostility, and vulnerability to stress [27,410]. Moreover, increases in salary associated with accelerated decreases in neuroticism, especially in angry hostility, depression, and impulsiveness [410]. Fourth, young adults who achieved financial security between age 18 to 26 experienced an accelerated decrease in negative affect, markedly in stress reaction and alienation, compared to peers who were unable to do so [27]. Notably, the relationship between higher income and the decrease neuroticism [410,591] lasted over a 10-year period ( $n= 304$ ,  $d= 0.40$ ), but post-hoc significance was only observed in a subgroup aged 30 to 40 ( $n= 142$ ,  $d= 0.90$ ), and not in older individuals ( $\geq 41$  years,  $n= 162$ , age range 41-62) [410]. Although this are small groups, the results suggest that income-effects overlay with the accelerated decrease in neuroticism for the young adults who became financial independent [27], an “important hurdle to leap” in order to see oneself as an adult [592]. However, individuals who reported *decreases* in economic status over the life course (*vs.* no change) increased in neuroticism, and this was also observed during midlife [408,428].

Occupied women showed more stable personalities than unemployed peers in a 24-year follow-up study, *after* control for other family and occupational variables [254]. This latter observation aligns with notions of environment selection as a stabilizing

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64. These observations overlay with cross-sectional reports of high neuroticism scores among shiftworkers [1250,1251].

factor for personality development [100,472]. All observations in this paragraph fit the social investment principle (social expectations) and mating preferences. Albeit resources are likely to remain important across the lifespan, strikingly, we encountered only one (supporting) study beyond young adulthood: Elder women who reported more unmet needs over the years between age 74 and 80 (*e.g.*, income, health care, housing, transportation, nutrition and leisure time activities) reported increases in neuroticism [536].

### ***Occupational Satisfaction (C3)***

A study of women reported an association between work satisfaction and a decrease in neuroticism over a 30-year interval [27,342]. This inverse association between work satisfaction and neuroticism is emphasized by findings from meta-analyses [593,594]<sup>65</sup> of longitudinal studies ( $d=0.35$ ) in both genders, and has been reported for negative affect ( $d=0.63$ ), trait anger ( $d=0.49$ ), and trait-anxiety ( $d=0.37$ )<sup>66</sup> as well, see [593,595]. It may be that high neurotic individuals (of both genders) allow their negative moods to affect their job satisfaction [596], in line with their reactivity to and focus on negative stimuli observed in cognitive tasks in lab studies [31,32,597].

### ***Occupational Life (C4)***

A study of 5000 male MZ-twin pairs showed that individuals who changed jobs for negative reasons tended to score higher on neuroticism [172]. A longitudinal study [408] showed increases in neuroticism after negative changes in the occupational environment (over six years), compared to individuals who reported no change. Similarly, being fired associated with increases in neuroticism ( $d=0.30$ ) compared to peers who were promoted [408]. Individuals who lost their job became more anxious, depressed, and vulnerable for stress [408]. Surprisingly, individuals who reported more work autonomy in their jobs became slightly more alienated, whereas work involvement was not associated with change in neuroticism [27]. In a two-year study of families increases in work stress led to more increases in neuroticism in fathers ( $R^2=.04$ ) than mothers ( $R^2=.01$ ), and these correlated change suggests dose-responses, *viz.* the more stress the more emotional instable individuals became [535].

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65. Cross-sectional over 24 studies and 9183 individuals; longitudinal over 6 studies and 1799 individuals [593].

66. Cross-sectional over 46 studies and 12834 individuals; longitudinal over 6 studies and 905 individuals, from 2 weeks to 7 years [593].



### ***Person-Environment Fit (C5)***

The neuroticism setpoint captures a balance between the person and his environment (see chapter 10), such as the fit with the characteristics of a given job or organization [598], as outlined in the previous paragraph. Young adults who felt growing fit with their work environment decreased in neuroticism over four years [339],  $d= 0.28$  [598]<sup>67</sup>. Students who reported positive interactions with their university and positive feelings about their grades at  $T_2$  decreased in neuroticism between age 18 (at  $T_1$ ) and 22 [599]. In contrast, indicators of low fit, such as counter-productive work behaviors (*e.g.* norm-violations, deviant or unsafe behaviors, absenteeism, conflict with colleagues, stealing, feigning sickness to take days off, and doing drugs at work), associated with increases in neuroticism [600,601] and negative emotionality between age 18 and 26 [602], especially in stress reaction and aggression ( $d= 0.37, 0.47$ , respectively), but decreases in harm avoidance ( $d= 0.20$ ) [602]. These behaviors are the functional opposite of social investment, and the observed increase in neuroticism is in line with investment predictions [450,603].

### ***Retirement (C6)***

The journey from working to retiring is one of life's great transitions, often regarded to be a SLE, which requires adaptation [604,605]. About 30% of the elder males report retirement problems [605], and it was therefore surprising that two longitudinal studies found no effect of a retirement transition on neuroticism [331,346]<sup>68</sup>. One study reported increases in trait-anxiety in the months before retirement, but not thereafter [606], thus short-term fluctuations. Retirement satisfaction associated with emotion-related aspects of neuroticism like depression and vulnerability, which associate with different stress-coping strategies [346]. Though we should be warily with only four studies available, it is salient that retirement-related loss of work roles and declines in activity were unrelated to changes in neuroticism, while unemployment stands out as a major life change and antedated increases in neuroticism [172,408]. When people are forced to retire, unexpected or involuntarily, the effect on neuroticism may be comparable. Arguably, retirement has less resource-related consequences, and its effects on status and behavioral confirmation may be easier to substitute (*e.g.*, with more affection or other activities), because retirement is a normative part of our social script, and is perhaps the second longest anticipated event (after death).

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67. At least for Alpha fit defined as the match between the subjective values and desires of the person and a consensus judgment of resources provided by the environment. This was not so for Beta fit, that is, subjective resources of the environment as perceived by the person [598].

68. This was supported by one study of 200 men, excluded because there was no follow-up neuroticism measure, which showed that baseline neuroticism was not predictive for problems in the following transition year [605].

**Conclusion (C7)**

Young adults who increased in prestige (status), financial security, and satisfaction associated with their occupational environment showed accelerations of the normative decrease in neuroticism [27,339,342,408,410,607]. Perhaps because most studies focused on young adults (age 20 to 30) positive changes were more influential than negative changes in the occupational environment. This balance may be different for older individuals, and increases in neuroticism after decreases in economic status were also observed during midlife [408,428]. More long-term effects have time to capture the association between wealth and the incidence of negative life events along the lifespan [608]. Nevertheless, aspects of our occupational environment, in terms of status or satisfaction, predicted changes in neuroticism over 10 to 30 years in multiple studies [27,254,342,410].

In the population studies occupational experiences and neuroticism were reciprocal over time, but the effects on neuroticism seem smaller than vice versa [341]. This is in line with the corresposive principle. This selection hypothesis is supported by the small differences in neuroticism between event-discordant MZ-twins, compared to the larger effects reported in the population studies. The twin studies, most robust against selection, indicated that neuroticism levels can (partly) be predicted by unemployment, status, income, and education [78,528,590].

It has been noted that occupational troubles and income loss are more stressful for men than women [473,572,609]. Neuroticism was inversely associated with social status for men [610,611]. This gender difference has to be established in younger samples, in which men are not the natural breadwinners. Nevertheless, such gender differences align with theories in which men strive for occupational status, power, and resources as mating budgets to successfully attract the women most men prefer [11,157,612-615]. Finally, retirement stood out as having no effect on neuroticism, while unemployment consistently predicted increases in neuroticism. Perhaps because retirement is normative, and as such does not signal something about our social position.

**Section D: Stressful Life Events**

One potent way to study the temporal dynamics of neuroticism is to focus on stressful life events (SLEs), which are able to alter developmental trajectories [331,339,408,616]. We defined SLEs as time-discrete transitions that bring about a major change in social, economic, or financial status, sources of affection, or social roles.

### ***Stress Generation (D1)***

Up to half of the individual variance in SLE occurrences can be explained by genetic differences [155,223,248,412,442,443,617-624]<sup>69</sup>. These selection/evocation effects seem relatively stable along the lifespan [93,625-627], and explain more variance for PLEs (~50%) compared to NLEs (~40%) [235,617,628], and unsurprisingly, more for endogenous (controllable or self-caused, 30-50%) than exogenous life events (uncontrollable or chance-events, 0-25%), see [155,235,248,412,442,443,617-623]<sup>70</sup>. Neuroticism is observed to mediate part of this association, and the prevalence of many specific SLEs increases along the neuroticism-continuum [155,222,339,340,629-631] vs. [616]. For example, individuals from the highest quartile of neuroticism report three times more interpersonal-SLEs than those in the lowest quartile [340,444,626,631], and this association remains after adjustment for mental health [425]. While most studies report prospective associations between neuroticism and the subsequent occurrence of dependent *and* independent NLEs ( $d= 0.20$  to  $0.50$ ) or difficulties ( $d= 0.32$ ) [222,302,339,340,425,444,478,626,629-632], this is not the case for PLEs [222,339,340,629,630]. Selection effects are not observed for all specific SLEs, probably because they differ in their controllability [235,340]<sup>71</sup>. It may also be that other predictors have an (potentially stronger) impact than personality, albeit it remains unknown which that might be [66,340]. Albeit most SLEs are likely to have relatively time specific effects, stress often begets further stress, forming event chains [633,634], which were discussed in section D4. In sum, individuals high on neuroticism conduct their lives in ways that (unwittingly) encourage interpersonal stress.

### ***Positive Experiences (D2)***

Most studies only assessed negative (stressful) events. Studies in which both NLEs and PLEs were measured showed decreases in neuroticism after PLEs [222,339,543,635]. For example,  $d= 0.23$  over one year [222], and  $d= 0.50$  over a 4-year period [339]. Moreover, when our personal surroundings change for the better our neuroticism seems to decrease ( $d= 0.25$ ), and this effect lasted more than four years [100]. One two-year study reported even a slightly stronger effect for PLEs than NLEs on neuroti-

69. Notably, most of these “one-snapshot studies” are even likely to underestimate the genetic contributions [248]; see also [437,1252]. See for absence [100,442,623] versus presence [617,689] of personality effects on exogenous SLEs. Bemmels [442] reported that environments not shared by siblings explained 33% of the variance of endogenous SLEs and 57% of the exogenous SLEs. One study reported that up to 30% of the variance in SLE-exposure could be explained by neuroticism and social disadvantage [444].

70. Though the tendency to report SLEs has a heritable component as well [248,619], little of the observed association between neuroticism and SLEs seems due to reporting bias [235,478].

71. PLEs that are rated as uncontrollable seem rare (*e.g.* lottery win), and most PLEs are rated as controllable [235,870,1253]. This is supported by the general stronger genetic influences on PLEs than on NLEs [235].

cism ( $n= 2981$ ,  $d= 0.23$  vs.  $0.19$  [222]). However, two other studies found no effect of PLE-aggregates on neuroticism [100,340], although one observed effects of positive life changes [100]. Relative increases in the number of PLEs, however, are associated with decreases in neuroticism [635]. Reports of specific PLEs that associate with a decrease in neuroticism are remarkably scarce (beyond those already discussed, *e.g.* a new romantic partner and promotion at work). Students who reported PLEs during a travel abroad decreased in neuroticism [339,636]: their trait-anxiety increased over the first six months abroad, but was followed by a marked decrease until 12 months, at the end of their travels [636]. Individuals who felt they learned a lesson from an experienced life event also reported a decreased in neuroticism, especially in the depression facet of neuroticism [339]. Finally, whereas NLEs are nearly always undesirable, PLEs may vary widely in their desirability [494].

### *Negative Experiences and Timing Effects (D3)*

Population studies show that up to 90% of the participants report a significant SLE over the past decade [473]. For example, 25% witnessed an accident, and 50% experienced the death of a close other [473,616]. Moreover, individuals who experienced an extreme SLE tended to increase in neuroticism ( $d= 0.30$ ) at threefold the normative rate of change in midlife [616,637]<sup>72</sup>. Adults who reported an ‘extreme horrifying or frightening event’ over the two years prior to follow-up ( $T_2$ , 25% or  $n= 115$ ) tended to increase in neuroticism, especially in two specific neuroticism facets, *viz.*, angry hostility and depression [616]). However, an 8-year follow-up study in individuals in their midlife (age 42 to 50) observed no change in mean-level neuroticism for those who experienced a severe trauma (*vs.* controls), though their trait stability was lower [638]. A third of participants reported that they were still not adjusted to changes resulting from a SLE that they experienced over the past two years [616]. This self-reported adjustment associated with higher educational levels ( $d= 0.50$ ), but, interestingly, not with  $T_1$  personality [616].

Most longitudinal studies with aggregated NLE measures show that their incidence predicts increases in neuroticism [222,223,339,543,635]. However, increases in negative affect three months later ( $d= 0.63$ , [222,345]) are not the lasting changes we conceive of as change in the setpoint of neuroticism [94,100,222,223]. Some studies observed increases in neuroticism 12 months after the SLE-occurrence [222] or even after four years ( $d= 0.60$  [339]), but other studies failed to observe changes in neuroticism at 6 to 36 months follow-up [100,345]. These inconsistencies are probably due to the specifics of the SLEs, because some of the SLEs that occurred more than four years before  $T_2$  *did* associate with higher negative affect [345]: the death of a

72. Three *t*-score points instead of the average of one (a *t*-score has a mean of 50 and SD of 10).

close family member, parental divorce and abortion ( $d=0.43$ ). Arguably these are more personal and severe SLEs [100,345]. In a 16-year five-wave study life event aggregates had no (persistent) effect on neuroticism, while long-term difficulties and deteriorated life quality predicted lasting (> 13.5 years) increases in neuroticism [100]. Moreover, changed life quality and endogenous long-term difficulties accounted for up to 10% of the observed individual change in neuroticism [100].

Individuals who described a life event as a turning point in their life, or construed the event as negative or mixed positive/negative, tended to increase in neuroticism as well [339]. Generally death and dying of significant others are the most potent of all NLEs in adulthood [366,378,473], and most frequently mentioned [389]. Health-care issues come second, *e.g.* (life threatening) illness and injury, which seem to increase in incidence over the life course [339,378,389]. Their relevance to neuroticism has been indicated by exposure-discordant MZ-twins [239]. Finally, the third most potent SLEs are contacts with the criminal justice system, followed by financial issues [339,378]. In sum, neuroticism seems most sensitive to the type of SLEs that can be categorized as traumas as described in the DSM-V for post-traumatic stress disorders [639]: first-hand exposure, witness, or confrontation with actual or threatened death, serious injury, or sexual violence, or a threat to the physical integrity of self or others (close family member or friend).

### ***Event Chains (D4)***

Besides their independent effect, PLEs and NLEs are also part of so called event chains, *e.g.* unemployment (or divorce) may lead to serious financial problems, which leads to a move to more affordable housing (in a poorer neighbourhood), and a decrease in PLEs. Although single events generally have frequencies below 10% [408], NLE-scores tend to associate over time ( $r>.20$  over 7 years [626]). Most studies are pretty bad suited to address such interrelations. Moreover, long-term difficulties predicted positive life changes 9-years later ( $r=.19$  [640]), and PLEs and NLEs show complementary longitudinal relationships ( $r>.30$  [381,629,640]), *e.g.* divorce and marriage. In addition, one study of students reported a positive association ( $r=.26$ ) between baseline neuroticism and the individual rate of change, indicating that high-neurotic individuals increased more in neuroticism (over 4 years) after an event than their low-neurotic peers [339], although women appeared to change less than men did [339]. However, another study in adult twins did not observe an effect of baseline neuroticism [223]<sup>73</sup>.

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73. One study over 5 months, and therefore not included in this review, showed no effect of baseline neuroticism on the post-traumatic stress response after a severe stressful event [812].

We evaluate our surroundings constantly for simply feeling good or bad, roughly because positive affects permit approach of incentives, and negative affects motivate avoidance of threats [21,22,124,641-643]. Though positive and negative life changes are inversely related with each other (*e.g.*,  $r = -.49$  [100]), positive and negative life events are moderately associated within individuals,  $r = .11$  to  $.47$  [100,222,235]. Individuals differ in how many life events they experience, both positive and negative [100,222]. Moreover, we seem to be more variant in our responses to aggregates of PLEs than to NLEs [387,494], which is often explained with the ‘broaden-and-build theory’ of positive emotions [387,644]. PLEs are proposed to broaden individual’s behavioral and thought repertoire (via positive affect) which leads to greater affective complexity [387,494,644-646] and resilience [582,647]. Ancestral responses to NLEs have probably been more constrained [22].

Depending on conditions, NLEs and PLEs may be reciprocally, nonreciprocal, or independently activated [648], *e.g.* (relatively) unrelated during times of low stress, but associated in high stress contexts, when individuals process negative information at the expense of positive information [494]. PLEs may also buffer for the impact of NLEs on neuroticism [269,382-384,387,644]. After control for the opposite valence, negative affect is reported to be influenced by both PLEs and NLEs [345]. Likewise, after control for the opposite valence of life events and change in symptoms of depression and anxiety PLEs may be more predictive for change in neuroticism than NLEs [222].

### **Clustering (D5)**

The common clustering on valence (PLEs/NLEs) has its drawbacks. Traumatic experiences (accidents, an angry tiger) may be clustered with less severe events (going to the dentist, having your paper rejected), or ambiguous and divergent experiences [245,268,340,408,572,616,629,630]. Moreover, it is rather arbitrary; other researchers cluster on categories, like single events, collective events, network events, occupational, financial or health events [341]. In addition, some LEs may confound with symptoms of psychopathology [386], such as conflicts with others, or worries about one’s life situation. Arguably, changes in habits of sleeping or eating, or sexual difficulties, which are reported to associate with change in neuroticism [178,339], might be better conceptualized as (early) symptoms of illness (*e.g.* depression) than as life events. Moreover, their relation with stress is often bidirectional [649], *e.g.* sleep deprivation elates negative affect in response to mild stressors ( $d = 0.50$  to  $0.90$ ) [650], and increases in impulsivity associate with increases in eating [178]. The same yields for increases in doctor visits across college which tend to be accompanied by an increase ( $d = 0.82$ ) in neuroticism [599].

**Table 12.** Environmental influences that prospectively predict change in neuroticism scores, or are a source of discordance for neuroticism in studies of twin pairs

First Author	Year	Sample	N	% ♀	Age range (R) or Mean (M, SD) at T <sub>1</sub>	Years Neuroticism and T <sub>1</sub> -T <sub>2</sub> (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's d (♀, ♂)	ΔN ♀ ♂
Jeronimus	2014	Population Netherlands	296	47	R= 16-63 M= 34.3 (11.8)	16 ABV	Endogenous long-term difficulties	0.49	0.49	↑
							Exogenous long-term difficulties	0.19	0.19	↑
							Negative life events			-
							Positive Life events			-
							Deterioration of life quality	0.46	0.46	↑
							Improvement of life quality	0.25	0.25	↓
Mund	2014	Population German	654	54	M= 24.4 (3.7)	15 NEO-FFI	Relationship conflict (over 7 years)	$\gamma = -.36^b$	0.67	↑
							Negative affect facet			-
							Self-reproach facet			-
							Relationship insecurity (over 7 years)			-
							Negative affect facet			-
							Self-reproach facet			-
							Conflict with friends (over 7 years)	$\gamma = -.36^b$	0.67	↑
							Negative affect facet	$\gamma = -.42^b$	0.76	↑
							Self-reproach facet	$\gamma = -.29^b$	0.55	↑
							Decrease in closeness with friends (over 7 years)			-
							Negative affect facet			-
							Self-reproach facet	$\gamma = -.26^b$	0.49	↑
Ogle	2014	Population	670	3.5	M= 42 (2.9)	8 NEO-PL-R	Severe trauma during midlife			-
							Having a child			
Hutteman	2013	Population Germany	625	100	R= 19-45 M= 31.5 (5.4)	4 BFI (3-items) Emotional stability		$b = -.22^b$	0.56	↑

First Author	Year	Sample	N	% ♀	Age range (R) or Mean (M, SD) at T <sub>1</sub>	Years Neuroticism and T <sub>1</sub> -T <sub>x</sub> (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's d (♀, ♂)	ΔN ♀ ♂
Hutteman	2013	Population Croatia	1008	54	42.6 (6) R= 27-65	3 IP1P-pool Emotional stability	Parent-child conflict	B= -.08 <sup>b</sup>	0.26	↑
Jeronimus	2012	Population Netherlands	2981	67	R= 18-65 M= 42 (13.1)	2 NEO-FFI Neuroticism  (Δ anxiety and depression)	Negative life events	b	0.19 <sup>a</sup>	↑
							Positive life events	c	-0.23 <sup>a</sup>	↓
							Family member seriously ill, wounded, or victim of violence	c	0.15	↑
							Separation of partner	c	0.15	↑
Kandler	2012	Twins Germany	338	R= 22-74 M= 39.6 (SD=13.5)	10 NEO-PI-R	Broke up longstanding relationship with a friend/relative	c	0.20	↑	
						Family member recovered from serious illness	c	0.15	↓	
						Befriended new people	c	0.17	↑	
						Started a new job or was promoted	c	0.13	↓	
						Formally finished school/course	c	0.19	↑	
						Holiday	c	0.17	↓	
						Controllable positive life events	r= .02		—	
						Controllable negative life events	r= .15 <sup>c</sup>	0.30	↑	
Lütke	2011	Population Germany (students)	1908	62	M= 19.5 (0.8)	4 NEO-FFI Neuroticism (ΔN)	Uncontrollable negative life events	r= .09		—
							Sexual problems	r= .15 <sup>a</sup>	0.30	↑
							Started new job (neg.)	r= .13 <sup>a</sup>	0.26	↑
							Change in university studies (neg.)	r= .12 <sup>a</sup>	0.24	↑
							Changed accommodation (neg.)	r= .12 <sup>a</sup>	0.30	↑
							Increased working hours (neg.)	r= .09 <sup>a</sup>	0.18	↑
							Failed important exam	r= .09 <sup>a</sup>	0.18	↑
							Negative change in financial situation	r= .09 <sup>a</sup>	0.18	↑
							Started psychotherapy (neg.)	r= .08 <sup>a</sup>	0.16	↑
							Started psychotherapy (pos.)	r= .17 <sup>a</sup>	0.35	↓



First Author	Year	Sample	N	% ♀ Age range (R) or Mean (M, SD) at $T_1$	Years Neuroticism and $T_1$ - $T_x$ (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's $d$ (♀, ♂)	$\Delta N$ ♀ ♂
						Own injury or illness	$r = .08^a$	0.16	↑
						Illness or injury of a friend	$r$		—
						Death of a family member	$r$		—
						Death of a friend	$r$		—
						Went abroad (pos.)	$r = -.11^a$	0.22	↓
						Got promoted at work	$r = -.08^a$	0.16	↓
						Began regular work (pos.)	$r = -.07^a$	0.14	↓
						Quit a job (neutral).	$r$		—
						Joined a student association	$r$		—
						Moved out of home (pos.)	$r$		—
						Broke off a relationship with boyfriend/girlfriend	$r$		—
						Entered a new relationship (of at least 1 month)	$r$		—
						Parents broke up or divorced	$r$		—
						Got married	$r$		—
						Failed the high school diploma	$r$		—
						Got pregnant (self or partner)	$r$		—
						Had an abortion (self or partner)	$r$		—
						Change in sleeping habits	$r = .17^a$	0.35	↑
						Change in eating habits	$r = .15^a$	0.30	↑

First Author	Year	Sample	N	% ♀	Age range (R) or Mean (M, SD) at $T_1$	Years Neuroticism and $T_1$ - $T_x$ (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's $d$ ( $\uparrow, \downarrow$ )	$\Delta N$ ♀ ♂
Specht	2011	Population Germany	14718	52	R= 16-96, M=47.21 (16.3)	4 BFI-S (3 N-items) Emotional stability Adj. for demographic variables	Slope (mean)	$b = 0.101^a$	↑	↑
							Marriage	$b = -0.68^{ns}$	—	—
							Sex*marriage	$b = -0.182^{ns}$	—	—
							Moved in with partner	$b = -0.054^{ns}$	—	—
							Divorce	$b = 0.035^{ns}$	—	—
							Separation of partner	$b = 0.070^{ns}$	—	—
							Sex*separation from partner	<i>nescio</i>	—	—
							Death of a spouse	$b = 0.018^{ns}$	—	—
							Sex*death of a spouse	<i>nescio</i>	—	—
							Leaving parental home	$b = 0.089^{ns}$	—	—
							Sex*leaving parental home	$b = -0.468^b$	↓	↓
							Child that leaves home	$b = -0.002^{ns}$	—	—
							Birth of a child	$b = 0.023^{ns}$	—	—
							Death of a parent	$b = -0.018^{ns}$	—	—
Unemployment	$b = 0.021^{ns}$	—	—							
Retirement	$b = -0.025^{ns}$	—	—							
First job	$b = 0.089^{ns}$	—	—							
Positive LEs	$b = -0.006^{ns}$	—	—							
Negative LEs	$b = 0.020^{ns}$	—	—							
Lehnart	2010	Population	703	71	All 20	8 Negative Emotionality Transition to partnership	Impulsivity $T_1$ - $T_2$	$b = 0.43$	↑	↑
							Impulsivity $T_2$ - $T_3$	$b = 0.43$	—	—
							Anger $T_1$ - $T_2$	$b = 0.37$	—	—
							Anger $T_2$ - $T_3$	$b = 0.37$	—	—
							Depression $T_1$ - $T_2$	$b = 0.37$	—	—
							Depression $T_2$ - $T_3$	$b = 0.37$	↓	↓

First Author	Year	Sample	N	% ♀	Age range (R) or Mean (M, SD) at $T_1$	Years Neuroticism and $T_1$ - $T_x$ (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's $d$ ( $\uparrow, \downarrow$ )	$\Delta N$ ♀ ♂
Sutin	2010	Population USA	297	57	R= 30-62, M= 52.3 (6.4)	10 NEO-PLR	Depression $T_2$ - $T_3$	g	0.38	↑
							Social anxiety $T_1$ - $T_2$	g	0.23	↓
							Social anxiety $T_2$ - $T_3$	g	0.42	↓
Sutin	2010	Population USA	533	65	M= 45.1 (10.4)	10 NEO-PLR	Occupational experiences;			
							Decision latitude	d		—
							Psychological demands	d		—
							Physical demands	d		—
							Hazardous work	d		—
							Perceived the LE as a turning point in life	b	0.20 <sup>c</sup>	↑
Sutin	2010	Population USA	533	65	M= 45.1 (10.4)	10 NEO-PLR	N1 Anxiety	b		—
							N2 Angry hostility	b		—
							N3 Depression	b		—
							N4 Self-consciousness	b	0.22 <sup>b</sup>	↑
							N5 Impulsiveness	b		—
							N6 Vulnerability	b		—
							Learned a lesson from experienced LE	b		—
							N1 Anxiety	b		—
							N2 Angry hostility	b		—
							N3 Depression	b	0.22 <sup>b</sup>	↓
							N4 Self-consciousness	b		—
							N5 Impulsiveness	b		—
N6 Vulnerability	b		—							
Construed LE as negative	b	0.14 <sup>c</sup>	↑							
Construed LE as mixed	b	0.20 <sup>c</sup>	↑							
N4 Self-consciousness	b	0.30	↑							

First Author	Year	Sample	N	% ♀	Age range (R) or Mean (M, SD) at T <sub>1</sub>	Years Neuroticism and T <sub>1</sub> -T <sub>x</sub> (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's d	
									(♀, ♂)	ΔN
Jokela	2009	Population	1839	58	R= 15-30	9 Buss-Plomin Emotionality	No child	d= 0.04		—
							Begot 1 child	d= 0.14 <sup>b</sup>	0.14	↑
							Begot 2 or more children	d= 0.20 <sup>a</sup>	0.20	↑
Löckenhoff	2009	Population	367	63	95% >44	10 NEO-PLR	Retirement transition	G		—
							N1 Anxiety			—
							N2 Angry hostility			—
							N3 Depression			—
							N4 Self-consciousness			—
							N5 Impulsiveness			—
N6 Vulnerability			—							
Löckenhoff	2009	Population	458	64	R= 31-88, M=47.2 (10.6)	8 NEO-PLR	Adverse life events	β= 0.10 <sup>b</sup>	0.30	↑
							N1 Anxiety	β= 0.06		—
							N2 Angry hostility	β= 0.12 <sup>b</sup>	0.35	↑
							N3 Depression	β= 0.07 <sup>c</sup>	0.24	↑
							N4 Self-consciousness	β= 0.06		—
							N5 Impulsiveness	β= -0.03		—
N6 Vulnerability	β= 0.05		—							
Sutin	2009	Population	302	59	M= 52.4 (6.4)	10 NEO-PLR	Personal income	d	0.39 <sup>b</sup>	↑
							N1 Anxiety	d		—
							N2 Angry hostility	d	0.37 <sup>c</sup>	↑
							N3 Depression	d	0.32 <sup>c</sup>	↑
							N4 Self-consciousness	d		—
							N5 Impulsiveness	d	0.37 <sup>c</sup>	↑
N6 Vulnerability	d		—							
Higher occupational prestige	d	0.22 <sup>b</sup>	↑							
N1 Anxiety	d		—							
N2 Angry hostility	d		—							

First Author	Year	Sample	N	% ♀	Age range (R) or Mean (M, SD) at $T_1$	Years $T_1$ - $T_x$ (and adjustments)	Neuroticism and (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's $d$ (♀, ♂)	$\Delta N$ ♀ ♂
								N3 Depression	d		—
								N4 Self-consciousness	d		—
								N5 Impulsiveness	d		—
								N6 Vulnerability	d	0.35 <sup>c</sup>	↑
							Job satisfaction	d			—
							N1 Anxiety	d			—
							N2 Angry hostility	d			—
							N3 Depression	d			—
							N4 Self-consciousness	d			—
							N5 Impulsiveness	d			—
							N6 Vulnerability	d			—
Middeldorp	2008	Twins	5782	67	R= 18-65	5	ABV	Life events (general)	g	0.38	↑
Sturaro	2008	Population	174	47	M= 17	6	at age 17: Big Five Emotional stability at age 23: NEO-FFI	Perceived conflict with mother	b	0.30	↑
								Perceived conflict with mother	b		—
								Perceived conflict with father	b	0.56	↑
								Perceived conflict with father	b	0.47	↑
								Perceived conflict with best friend	b		—
								Perceived support from mother	b		—
								Perceived support from father	b		—
								Perceived support from best friend	b		—
Neyer	2007	Population	339	55	R= 18-30, M= 24.4 (3.7)	8	NEO-FFI Correlated change slope	Insecurity with peers	b	1.32	↑
								Insecurity with family	b	2.87	↑
								Closeness to peers	b		—
								Closeness to family	b		—
								Conflict with peers	b		—
								Conflict with family	b		—

First Author	Year	Sample	N	% ♀	Age range (R) or Mean (M, SD) at $T_1$	Years $T_1$ - $T_2$ (and adjustments)	Neuroticism and (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's $d$ (♀, ♂)	$\Delta N$ ♀ ♂
Willemssen	2007	Twins	4369	67	R = >25	11	ABV	Religious upbringing	g	0.13, 0.21	↓
								Contact with peers	b	1.46	↓
								Contact with family	b		—
								Transition into a first partnership $T_1$ - $T_2$		0.45	↓
							Transition into a first partnership $T_2$ - $T_3$		0.54	↓	
Lehnaert	2006	Population Germany	253	61	R = 18-29, M = 25 (3.7)	8	NEO-FFI	Relationship status; continuers	$d$	-0.36	↓
								Relationship status; changers	$d$	-0.22	↓
								Relationship security $T_1$ - $T_2$ ; same partner	$r$	-0.26	↓
								Relationship security $T_2$ - $T_3$ ; same partner	$r$	-0.14	↓
								Relationship security $T_1$ - $T_3$ ; changed partner	n.a.	n.a.	n.a.
								Relationship security $T_2$ - $T_3$ ; changed partner	$r$	-0.22	↓
								Relationship dependency $T_1$ - $T_2$ ; same partner	$r$	-0.14	↓
								Relationship dependency $T_2$ - $T_3$ ; changed partner	n.s.	n.s.	—
								Relationship satisfaction $T_1$ - $T_2$ ; same partner	$r$	-0.15	↓
								Relationship satisfaction $T_2$ - $T_3$ ; same partner	$r$	-0.13	↓
							Relationship satisfaction $T_1$ - $T_2$ ; changed partner	n.a.	n.a.	n.a.	
							Relationship satisfaction $T_2$ - $T_3$ ; changed partner	$r$	-0.23	↓	
Roberts	2006	Population	907	48	R = 18-26	8	MPQ, NE	Counterproductive Workplace Behaviors	b	0.33	↑
								Stress reaction	b	0.27	↑
								Aggression	b	0.38	↑
								Alienation	b	---	—
Scollon	2006	Population Australia	1130	52	R = 16-70, M = 37.2 (13.3)	8	EPI	Work satisfaction	$r$	-0.64 <sup>b</sup>	↓
								Relationship satisfaction	(a)	0.92	↓

First Author	Year	Sample	N	% ♀ Age range (R) or Mean (M, SD) at T <sub>1</sub>	Years T <sub>1</sub> -T <sub>x</sub> (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's <i>d</i> (♀, ♂)	ΔN ♀ ♂
Van Aken	2006	Families	1152 (s)	mixed Fathers M= 43.9 (3.27) Mothers M= 41.7 (3.71)	3 Big Five Factors (30 adjectives) Emotional stability	Life satisfaction Work stress Father: Perceived partner support	b b b	---, .024 <sup>b</sup> 0.20 <sup>a</sup> , 0.41 <sup>a</sup> 0.14 <sup>c</sup> , ---	— ↓ ↑ ↑ ↓ —
Robins	2005	Population of students		59 M= 18	4 NEO-FFI	Higher college grades Feeling positively about grades Positive interactions with the university Increase in visits to the doctor	b b b b	0.77 0.30	— ↓ ↓ —
Steunenberg	2005	Population	2117	51 R= 55-85, M= 69.5	6 DPQ	Physical health related variables Presence chronic disease Cognitive functioning			— — —







First Author	Year	Sample	N	% ♀ Mean (M, SD) at T <sub>1</sub>	Age range (R) or T <sub>1</sub> -T <sub>2</sub> (and adjustments)	Years Neuroticism and T <sub>1</sub> -T <sub>2</sub> (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's <i>d</i> (♀, ♂)	ΔN ♀ ♂
							Work autonomy			
							Stress-reaction facet			
							Aggression facet			
							Alienation facet	0.20		↑
							Work stimulation			
							Stress-reaction facet			
							Aggression facet			
							Alienation facet			
Paris	2002	Population USA	48	100 M=21	6 CPI		Satisfaction of full-time mothering role	$\beta = -0.32$	0.68	↓
							Positive experience of mothering	$\beta = -0.30$	0.63	↓
Robins	2002	Population New Zealand	712	54 R= 18-26	6 MPQ		Being with the same partner over study	$d = -0.36^c$	0.36	↓
							Negative emotionality, Change of partner during the study	$d = -0.33^b$	0.33	↓
							Relationship quality	$r = -0.17^b$	0.34	↓
							with same partner	$r = -0.26^c$	0.54	↓
							changed partner	$r = -0.14^e$	0.28	↓
							Relationship conflict	$r = 0.16^b$	0.32	↑
							with same partner	$r = 0.24^c$	0.49	↑
							changed partner	$r = 0.14^b$	0.28	↑
							Partner abuse	$r = 0.16^b$	0.32	↑
							with same partner	$r = 0.19^b$	0.39	↑
							changed partner	$r = 0.16^b$	0.32	↑
Neyer	2001	Population	637	54 R= 18-30, M= 24.4 (3.7)	4 NEO-FFI		Transition to partnership		0.44	↓
							Partnership dissolution			
							Marriage			
							Transition from school to university			
							Transition from university to working life			

First Author	Year	Sample	N	% ♀ Mean (M, SD) at $T_1$	Age range (R) or Mean (M, SD) at $T_1$	Years $T_1$ - $T_2$ (and adjustments)	Neuroticism and (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's $d$ (♀, ♂)	$\Delta N$ ♀ ♂
								Transition to parenthood			-
								Insecurity with children		0.30	↑
										0.36	↑
Caughlin	2000	Newly married Couples	336	50 ♂ M=24, ♀ M=21		13 16 PFQ Trait-Anxiety		Married versus divorced couples; differences at 13 years			-
								Effect partners' trait anxiety at $T_1$ on negativity at 14 mo.		0.28, 0.72	↑ ↑
								Effect partners' trait anxiety at $T_1$ on negativity at 26 mo.		---, 0.92	- ↑
								Effect partners' trait anxiety at $T_1$ on negativity at 13 yrs.		---, 0.92	- ↑
Costa	2000	Prospective USA	2274	22 R= 39-45		9 NEO-PI		Marital satisfaction	g		
								Changes for the worse in family or social life	g	0.51	↑
								N1 Anxiety	g		↑
								N2 Angry hostility	g		-
								N3 Depression	g		↑
								N4 Self-consciousness	g		-
								N5 Impulsiveness	g		-
								N6 Vulnerability	g		↑
								Changes for the worse in work life	g		↑
								Changes for the worse in economic status	g		↑
								Being Fired	g	0.30	↑
								N1 Anxiety	g		↑
								N2 Angry hostility	g		-
								N3 Depression	g		↑
								N4 Self-consciousness	g		-
								N5 Impulsiveness	g		-

First Author	Year	Sample	N	% ♀ Age range (R) or Mean (M, SD) at T <sub>1</sub>	Years Neuroticism and T <sub>1</sub> -T <sub>X</sub> (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's d (♀, ♂)	ΔN ♀ ♂
						N6 Vulnerability	g		↑
						Marriage	g	---	0.40 ↓
						Divorce	g		—
						N3 Depression	g		—
						Change in marital tension age 27 to 52			↑
Roberts	2000	Population	104	100 M=21	30 Anxiety scale Psychoneuroticism	Anxiety Psychoneuroticism		0.87	↑
						Change in marital satisfaction age 43 to 52			—
						Anxiety Psychoneuroticism			—
						Change in work satisfaction age 43 to 52, on			—
						Anxiety Psychoneuroticism			—
						Crime rate		0.67, 0.72	↑ ↑
						AIDS cases		0.60	— ↑
						Suicide rate, age 15-24		0.92, 1.18	↑ ↑
						Women's Labor Force Participation		0.92, 1.28	↑ ↑
						College degrees awarded to women		0.47	— ↑
						Population index of social health (reverse)		0.72, 1.00	↓ ↓
						Unemployment rate		0.60, 0.95	↑ ↑
						Divorce rate		0.84, 1.09	↑ ↑
						Percentage of people living alone		0.74, 1.03	↑ ↑
						Women's age at first marriage		0.72, 0.98	↑ ↑
						Birth rate (reverse, in population		0.65, 0.87	↓ ↓
						Social connectedness + other threats		1.71, 2.33	↑ ↑
Twenge	2000	Cross-temporal meta-analysis of 134 ♀ and 148 ♂ samples	40192	53 College students	10 Neuroticism and trait-anxiety social indicators on population-level	Neuroticism and trait-anxiety			

First Author	Year	Sample	N	% ♀ Mean (M, SD) at T <sub>1</sub>	Age range (R) or Mean (M, SD) at T <sub>1</sub>	Years Neuroticism and T <sub>1</sub> -T <sub>x</sub> (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's d (♀, ♂)	ΔN ♀ ♂
Vollrath	2000	Students	119	55 M= 22.6 (3.6)		3 NEO-FFI	Concerns about academic capabilities	d	0.39	↑
Asendorpf	1998	Prospective Case- control	132	70 R= 18-22, ♀M= 20, ♂M= 20.4		1.5 NEO-FFI	Change in # peer relations Conflict with parents/ peers Falling in love Transition into relationship Perceived support parents/peers	b b b b b		- - - - -
Dunne	1997	Twins Australia	6463	66 R= 17-88		8 EPQ	Maintained versus decreased church attendance to twice a year Increased from yearly to at least monthly	F= 16.47*** F= 1.46	0.22	↑ -
Suh	1996	Population	115	63 R= 20-23		2 T <sub>1</sub> : NEO-PI T <sub>2</sub> : NEL-FFI T <sub>1</sub> : NEO-PI T <sub>2</sub> : NEL-FFI	Negative life events past 3 month Negative life events past 6 months Negative life events past 12 months Negative life events 24 months Negative life events 36 Negative life events >48 months before T2 Positive life events Positive life events, after control for negative			↑ - - - - ↑ - ↓
Andrews	1993	Prospective case-control	1042	Nescio M= 17.12, 17.2 for controls		1.5 Personality vulnerability index(m)	Exchange students after 12 months abroad		0.28	↓
Kurdek	1993	Population	1076	50		5 Symptom checklist 90-R	Unstable marriage (husband)	F <sub>(1,188)</sub> = 0.63 F <sub>(1,188)</sub> = 0.13		↑ ↑
Magnus	1993	Population USA	136	63 R= 22-26		4 NEO-PI-R	Objective positive events Objective negative events			- -

First Author	Year	Sample	N	% ♀ Mean (M, SD) at T <sub>1</sub>	Age range (R) or Mean (M, SD) at T <sub>1</sub>	Years Neuroticism and T <sub>1</sub> -T <sub>x</sub> (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's d (♀, ♂)	ΔN ♀ ♂
Duggan	1991	Prospective case-control	34	70	R=16-67	18 EPI	Good vs. poor outcome groups (4 cat.) Length of admission (short, long) Number of weeks in hospital (few, many) Amount of depressive episodes (few, many)	3.94		— ↓ — —
Kaprio	1990	Twins	1078	52	R=18-25	6 EPI Co-twin resemblance	Cohabiting at T <sub>1</sub> and still so at T <sub>2</sub> (vs. twins who separated) Cohabiting at T <sub>1</sub> , separated but in frequent contact at T <sub>2</sub> Cohabiting at T <sub>1</sub> , separated but rare contact at T <sub>2</sub>	0.40, 0.43 0.40, 0.19 0.92, 0.29		↑ ↑ ↓ ↓ ↓ ↓
Rabins	1990	Prospective case-control	62	68	M=60.8	2 NEO	Caregiver whose relative with dementia is placed in a nursing home during the study vs. caregivers whose relatives stayed home. Negative mood Guilt			— ↓
Kierman	1986	Population Britain	1857	100	M=16	10 MPI	Divorced/separated vs. lasting marriages (at age 32) (q)	M (SD) 0.63		↑
Mullan	1986	Twins	112	mixed	R=21-81, M: 43.2.	—	Alcohol dependency/history	a	1.53, 1.45	↑
Sagy	1986	Population Israel	418	49	R=14-18	0.3 STAI Trait anxiety	Severe stress situation ; evacuation of one's home	M (SD)		—
Kessler	1984	Population	6919	mixed	R=>18	1 Psychological distress	Income loss	b=0.330, 0.342	0.24, 0.41	↑ ↑
		USA					Separation and divorce	b=0.263, 0.143	0.15, 0.09	↑ ↑
							Other Love Loss	b=0.354, 0.374	0.23, 0.22	↑ ↑

First Author	Year	Sample	N	% ♀	Age range (R) or Mean (M, SD) at T <sub>1</sub>	Years Neuroticism and T <sub>1</sub> -T <sub>2</sub> (and adjustments)	Predictor (higher/more)	Result Effect size	Cohen's d (♀, ♂)	ΔN ♀ ♂
Koskenvuo	1984	Twins	9912	0	R = > 18	— Eysenck's N-scale, modified by Floderus. Adj. for age	Death of a loved one	b = 0.193, r = 0.003	0.12	↑ -
							Ill Health	b = 0.245, r = 0.176	0.27, 0.22	↑ ↑
							Negative network event	b = 0.129, r = 0.028	0.25	↑ -
							Years of education	c	0.12	↓
							Income	c	0.08	↓
							Unemployment vs. working	f	0.14	↑
							Heavy physical work vs. sedentary work	f	0.07	↑
							Divorce	c	0.14	↑
							Changes of workplace for negative reasons	c	0.24	↑
							Changes of place of residence for negative reasons	c	0.22	↑
Brousseau	1981	Population	176	0	R = 25-45	7.44 GZTS Emotional stability (n)	Night- and shift-work schedules vs. day work	f	0.09	↑
							Service work vs. farming work	f	0.16	↑
							Monotony of work	c	0.28	↑
							Chronic bronchitis vs. no chronic bronchitis	f	0.37	↑
							Illness or disability pension vs. at work	f	0.24	↑
							Swedish speaking vs. Finnish	f	0.18	↓
							Heavy drinking	c	0.46	↑
							Stress of daily activities	c	0.95	↑
							Job characteristics: Skill variety		0.34	↑
							Task identity		0.30	↓
Task significance		0.56	↓							
Autonomy		—	—							
Feedback		0.36	↓							

First Author	Year	Sample	N	% ♀ Age range (R) or Mean (M, SD) at $T_1$	Years Neuroticism and $T_1$ - $T_2$ (and adjustments)	Predictor (higher/more)	Result Effect size	Colten's $d$ (♀, ♂)	AN ♀ ♂
Brousseau	1978	Population USA	116	0 R= 25-45	6 GZTS, Freedom from Depression Scale (n)	Job characteristics (r) Skill variety	$r = .23^b$ $r = .21^c$	0.47 <sup>b</sup> 0.43 <sup>c</sup>	↓ ↓
					Task identity		$r = .07^{ns}$	—	—
					Task significance		$r = .24^b$	0.49 <sup>b</sup>	↓
					Autonomy		$r = .07^{ns}$	—	—
					Feedback		$r = .19^c$	0.38 <sup>c</sup>	↓

*Note.* adj. = adjusted; **16PFQ**= 16 personality factors questionnaire; **ABY**= Amsterdamse Biografische Vragenlijst; **CPI**= California Psychological Inventory; **DSD**= Système de Description en Cinq Dimensions; **EPI**= Eysenck Personality Inventory; **EPQ**= Eysenck Personality Questionnaire; **GZTS**= Guilford-Zimmerman Temperament Survey; **MID**= major depression; **N**= neuroticism; **NE**= negative emotionality;  $r$ = correlation coefficient; **STAI**= State-Trait Anxiety Index;  $T_1$ = baseline;  $T_2$ = follow-up; **USA**= united states of America. (a) Correlated change (of slopes); (b) standardized regression coefficient beta, (c) partial correlation; (d) cross-lagged coefficient; (f) Odds-ratios of means; (g) t- or f-tests; (h) Valence-ratings were made on a 5-point scale with 1=high negative impact till 5=very positive impact; (i) For example, income, health care, housing, transportation, nutrition, activities; (j) Hypersensitive, fearful and dependent; (k) general estimating equations; (l) The assaultiveness and irritability subscales; (m) Personality Vulnerability index:  $0.6 * EPI-N\text{-scale} (= \text{trait-anxiety index}) + 0.2 * \text{locus of control (LCB)} + 0.3 * \text{Defense Style}$ ; (n) emotional stability is the low pole of neuroticism, and reported effects are therefore presented in reverse i.e. applied to neuroticism; (o) Depressed mood and Psychophysiological distress scales; perceptions or bodily feelings associated with anxiety and depression; (p) person-environment fit is the match between subjective values and desires of the individual and for Alpha fit a consensus judgment of the resources provided by the environment, and for Beta fit the subjective resources of the environment; (q) the effect must be strongly inflated because the initial (pre-marriage) difference was already  $d = 0.57$ , suggesting that the effect of divorce on neuroticism is merely  $d = 0.06$ ; (r) the mean of the five other job dimension scores for each respondent; (s) 288 middle-class two-parent Dutch families with at least two adolescent children between age 11 and 15 from the Nijmegen Family and Personality Study; (t) Psycho-education, breathing and relaxation strategies, monitoring and challenging thoughts, and social skills training; (u) interaction term sex\*variable is used to examine gender-effects. Significance, <sup>a</sup> $p < .001$ , <sup>b</sup> $p < .01$ , <sup>c</sup> $p < .05$



### *Gender Differences in SLEs (D6)*

Life event inventories tend to represent typical male experiences best, and often lack experiences such as abortion or rape [156,572], albeit studies who do so report comparable results [339]. However, gender differences should be bore in mind when interpreting evidence about sex differences in exposure, as most gender divergence in distress scores may be explained by differential response rather than differential exposure, *e.g.* stronger female reactivity [572]. Moreover, studies often find no gender differences in the report of specific life events [651,652], though some do [340,572,653]. However, when asked to report the most important SLE over the past decade, women tend to report network events (problems with close other), whereas men are more likely to report problems with their own health or trouble at work [378,473,653], which, as discussed, appear to align with their reproductive aspirations.

## DISCUSSION

We reviewed the literature for environmental influences on neuroticism, paradoxically one of the most stable aspects of personality and most susceptible to change as well [62,438]. Most individuals seem able to maintain stable neuroticism equilibria under stable life circumstances, given a normal level of education, a stable social network, a stable partnership, and a satisfying job. Evidently, neuroticism levels change during more turbulent times, when individuals adapt to environmental change and new roles. Our results show that the neuroticism setpoint can and does change over time in response to a wide range of environmental factors, primarily in the context of partner relationships, proximal family, and work properties, and often (but not always) in accord with social investment perspectives. Most observed effect sizes align with the modus in psychology [66,654,655]. Our results support the literature that characterizes neuroticism as enhanced sensitivity and reactivity to events that are unpredictable, uncontrollable, unexpected, undesirable, and non-normative from a life history perspective [24,54,100,249,415,451,656,657] and to interpersonal stress and conflict (social cues), rather than to physical threat [27-40,658]<sup>74</sup>. In the following we reflect upon our results in the light of the mixed model of change in neuroticism, the corresponsive principle, the social investment theory, and revive bioecological systems theory to provide structure to the study of environmental effects.

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74. Most variance in human anxiety revolves around social fears such as being criticized or rejected [37,1254] and separation anxiety [98,1255]. Moreover, removal from the group is universally the primary human punishment [573]. Interestingly, the salience of social exclusion seems to result in short-term mating strategies in women while social inclusion does this for men [1256,1257].

### Mixed Model of Change in Neuroticism

To discuss environmental effects on neuroticism we distinguish three temporal levels, in terms of hours, weeks, and years. At the most momentary level we experience affective states in response to environmental stimuli (*e.g.*, anger, frustration, fear, sadness) that last for several hours at best [22,124,659-662]. High neuroticism is characterized by more and more persistent negative affect [46,50,51,56-63].

More long-term temperament-like frameworks capture balances (*e.g.*, subjective wellbeing) or consistencies in such affective-emotional expressions across multiple contexts over the months, which form personal density distributions of affective-emotional expression [13,15,22,110]. At this secondary temporal level we also encounter persistent episodes of mood [78,94,222,663], specific symptoms [53], and episodes of anxious or depressive illness [114,222]. Life events that trigger an anxious/depressive episode do this typically within maximal three months [345,356-358], and most major depressive episodes recover within three months [664]. Moreover, most life event effects on neuroticism have also receded within six months [100,222,223], which led us to review studies that span one year at least.

At a third temporal level we conceptualize neuroticism setpoint change, *viz.* the person characteristic (trait-like) average of the negative-affective density distribution [94,114,222,223]. Some reviewed studies showed event-driven changes in neuroticism that persisted over a decade [100,246,331], in line with the mixed model of change in neuroticism [94]. It remains unknown how long changes in the neuroticism must persist before we can speak of setpoint change (*viz.*, where do the second and third temporal levels border). For example, the literature suggests that grief or bereavement after the loss of a loved one can persist for up to two years [639]. In prior work we argued that experience-driven changes in neuroticism that persist for more than 6 months indicate setpoint change [100], and based upon this review this position seems reasonable.

Two studies showed that major increases in the neuroticism setpoint measured about two years after a negative environmental change ( $d = 0.50$  to  $0.70$ , *e.g.* death of a spouse) receded by about 60% over the next decade [100,331]. Furthermore, adaptation seems faster after PLEs than NLEs, *e.g.* the magnitude of setpoint change in neuroticism after changed life situation was 25% stronger for increases versus decreases after 4 years, but already 65% after 6 years [100]. In sum, we take these results to suggest that changes in neuroticism that persist for 6 months indicate setpoint change, but that setpoint change may decay over years to decades [223,244]. Neuroticism setpoint change may serve to balance our inner and outer worlds (the Red Queen Personality Principle), and to adapt to (or cope with) specific changes in our personal environment, and are perhaps followed by slower external adaptation (*e.g.*, via substitution processes [665]). This would enable the neuroticism setpoint to gravitate slowly back

(in terms of years) towards the – generally more normative - equilibria to which one was accustomed [94,100].

### **Corresponsive Principle**

Neuroticism appears sensitive to “unscripted” events [449,567]. We tend to respond to non-normative events in line with our pre-existing neuroticism-levels [38,399,626,666,667], resulting in a widening of intrinsic differences via reciprocal causality [27,339,340,473,598]. SLE-prevalences follow a neuroticism-continuum [155,222,339,340,629-631] such that the quarter with the highest (*vs.* lowest) neuroticism levels experience up to three times more interpersonal-SLEs [340,444,626,631]. Moreover, neuroticism levels moderate the association between SLEs and mental-health problems [38,399,626,666,667], in line with conceptions of neuroticism as the vulnerability to destabilize when exposed to environmental-stress [385,668-671].

Additionally, a twin study observed a neuroticism versus ‘type-of-vocation’ gradient that suggests selection forces and higher neuroticism scores for individuals with night and shift work schedules [172]. Finally, high (*vs.* low) neurotic adults tend to select themselves in neuroticism-promoting relationships [156,338,507], report more distress after childbirth [554], and more relationship dissolution [249,343], which lead to more neuroticism.

We use the concept of severe trauma to outline a few additional points with regard to the corresponsive principle. Severe trauma associates with higher neuroticism scores along the lifespan [222,638], but childhood trauma seems more predictive for high neuroticism in midlife than severe trauma in midlife (age 42-50), despite the recency of the latter [638]. The corresponsive principle holds that autocatalytic processes (selection and evocation effects) magnify pre-existing differences in neuroticism, accumulations that could explain heightened neuroticism at midlife [64,251,672]. However, children and adolescents also have a more flexible neuroticism setpoint [93,164,253] because they live in less stable personal atmosphere [85,91,164,234,236,247,445], which aligns with the corresponsive principle. Third, severe trauma may impact less at midlife, because by then individuals tend to be more emotional stable – thus less reactive [38,399,626,666,667], in line with the corresponsive principle.

The corresponsive principle functions as a kind of “verbal magic” [102] that is difficult to falsify and applies (post-hoc) to most observations, but not all [222,223,673]. For example, one large twin study observed no stronger impact of SLEs on neuroticism for individuals who were high (*vs.* low) on neuroticism at baseline [223]. One two-year population study ( $n= 2981$ ) observed that childhood trauma amplified the decrease in neuroticism after PLEs but dampened increases in neuroticism after NLEs [222], in contradiction to the corresponsive principle. Finally, accumulating gene-environment correlations, also known as the Dickens-Flynn effect [106,427], affect most personality

traits and other traits alike, and may also magnify cultural phenomena [674,675]. For example, in one 3-year study blacks were more often exposed to physical assault than whites [653]. It remains therefore unknown how and why people develop as they do, and more specific theories than the corresposive principle seem required to explain changes in neuroticism in response to specific environmental influences, both in terms of mechanisms and timing.

### **Social Investment Theory**

The social investment hypothesis holds that age-graded social roles drive functional personality maturation via associated societal expectations and contingencies (such as becoming a reliable partner, a nurturing parent, or a cooperative colleague) and promote a reward structure that facilitates emotional stability [24,27,142,227,251,433,450]. In this review we observed (accelerated) decreases in neuroticism for individuals who transited into a (romantic) partner role, at least for men also in midlife, and after remarriage [246,331,338,344,408,483,484]. The increase in negative affect (depression/anxiety) rather than emotional reactivity (impulsivity and anger) [483,487,488] is reminiscent of changes that have been observed for elevations in social rank [676], which support the notion of partnering as a rite to adult status [78,264].

Young adults in stable relations (~30%) showed stereotypic normative decreases in neuroticism while those who changed partners (~70%) followed more differential developmental patterns [343,344]. However, we found no support for decreases in neuroticism after young adults begot a child [484], while partnership seems paramount to functional maturation [156,439,553]. Begetting a child is an exception to the general rule, perhaps because it is an epitome of anticipation (extremely “scripted” and often planned), which enables coping and environmental adaptation. It has been noted that pre-conceptions of a future identity (rather than direct experience) may change personality in anticipation of future roles [249,677,678], a rather complex intrapsychic influence. Alternatively, the stress of becoming a parent may counterbalance the decrease due to social investment. In the occupational domain we observed (accelerated) decreases in neuroticism for young adults who became financially independent [27,410], increased in occupational status [27,410,428], or experienced growing fit with their environment [339,598,599]. Salient was the absence of retirement-driven effects on neuroticism [331,346], perhaps because retirement is the second longest anticipated event (after death).

The social investment hypothesis implies that individuals who develop in accordance with their sociocultural tide (‘assimilation’) benefit while the minority that cannot keep pace with the cultural life script (or swim against the current) “pay a price” (see the introduction). Individuals who report or show low fit with their environment (*e.g.*, dismissal [408]), and behaviours that are functional opposites of (social) invest-

ment, *e.g.* counter-productive work behaviors [600-602], unemployment [172,408], or breaking the law [603]), indeed associate with (relative) increases in neuroticism (this review). Furthermore, transitional events (*e.g.*, a first romantic partner, a first job, becoming a parent) are predictive for changes in neuroticism [227,450], but little is known about what these transitions actually mean for the individual [679], *e.g.* in terms of proximal processes [103], resource availability [665], or functional values [24,266]. Furthermore, high neuroticism is characterized by more awareness of - and sensitivity to - normative comparisons [680-682]. Finally, cross-cultural studies showed that individuals in Pakistan, China, Guatemala and Brazil transit at a much younger age into the labor force than their peers in Canada, Australia or the Netherlands (the timing of their biosocial life script), and also show the normative decrease in neuroticism ( $d=0.20$  per decade) at an earlier age [163,227,576], which can be seen as support for social investment as a prime drive behind the normative decrease in neuroticism.

### **Environments**

Many social events are instantaneously reflected in the structure of our personal environment, *e.g.* entrance events expand our personal atmosphere (or Metasystem) with a new romantic relationship, job, or friends. In each of these systems we play a specific role (as friend, employee, and partner/parent) and experience enduring patterned interactions with our surroundings [100,227,249]. Exit events, in contrast, contract the personal atmosphere, and tend to associate with increases in neuroticism (*e.g.*, divorce, death of a spouse, end of a friendship, or dismissal/unemployment). Moreover, each microsystem can be touched by “unscripted” more stochastic experiences, *e.g.* accidents, disease, and the like, events that associate with change in neuroticism. The derivation of a taxonomy for environmental influences (just as we did for personality) is an old problem that psychologists still struggle to solve [245]. Capturing the complex effects of multiple environmental factors on neuroticism is a daunting enterprise because we seek to understand them by the analysis of components that can only be understood in relation to the whole [25,103,243,447].

One promising framework to structure environmental influences on neuroticism is bioecological systems theory [103], conceptualized as a framework of interconnected nested systems. The sum of the family system, occupational system, and social systems of which we are part forms our personal atmosphere (Mesosystem), which in turn is shaped by a Chronosystem (outlined below). For example, reactions to normative events tend to be more scripted, but the content and timing of this script shall vary along sociohistorical contexts [17,249,264,683]. Culture can be seen as an extra somatic means of human adaptation to our ecological niche, called characteristic adaptations [16,24,101,110,111,113,114]. With an eye for detail we could discern time-and-space-specific differences in (a) the prominence of specific facet traits and (b) the impact of

life events (*e.g.*, parenthood, divorce, change in social support) on the neuroticism setpoint, *e.g.* for both genders along the life cycle, over generations, or in subcultures [24,608]. A consideration of these differences may deepen our understanding of how neuroticism and our (social) environment interact, and why the strength of neuroticism effects vary across situations, to enhance wellbeing.

### The Many Personalities of Neuroticism

Neuroticism has been described as a “hodgepodge of quite different person-qualities” that makes neuroticism “an over inclusive, easy-to-invoke societally evaluative wastebasket label” [3,684]. Our current taxonomies suffice to classify, integrate, and guide personality research, but lack a theoretical or empirical foundation to determine the exact facets that make up the neuroticism trait space [16-18,101,228]. Consequently, theorists disagree whether angry-hostility, aggression, irritability, impulsivity, inferiority, or dependency are core aspects of neuroticism [94,142,685]. The wondrous variety of measures and labels akin to neuroticism seem to boil down to three clusters in the neuroticism trait space: an anxiety-withdrawal cluster (“Fear”), a depression-unhappiness-distress cluster (“Grief/Sad”), and a vulnerability-stress-reactivity (“Anger”) cluster [18,22,54,198,487,557,685,686]. The fact that similar clusters have been distinguished for psychopathology, *e.g.* fear, anxious-misery (inhibition), and externalizing clusters, respectively, is taken as support [687-689]<sup>75</sup>.

The anxiety and depression clusters of neuroticism refer to the stable (lifelong) tendency to experience negative affect or aversive mood states including anxiety, depression, fear, anger, contempt, disgust, guilt, irritability, nervousness, distress, impulsivity, and un-pleasurable engagement [3,53,94,138,286,690]. Both domains merge in a neuroticism setpoint and personal density distribution of negative affect, with the specific emotions and behaviors variable over individuals, theories, and cultures [122,684]. There are differences as well (see also chapter 10), *e.g.* sadness is marked by negative valence and *low* arousal, while anxiety is marked by negative valence and *high* arousal [659]. Negative affectivity has been described as the more cognitive component of neuroticism, which decreases when young adults find themselves a romantic partner [483,487,488].

Emotional reactivity (impulsivity and anger), in contrast, decreases after young adults obtain promotion or more prestigious occupations [27,410]. This emotional reactivity or volatility cluster of neuroticism refers to the tendency to be easily upset

75. Or in the tripartite model, Anxious Arousal, Anhedonic Depression, and General Distress [284,1258,1259]. Notably, Fear, Grief/Sad, and Anger also make up the mammalian negative-affective super factor [22]. Another large twin study showed that covariance between internalizing and externalizing clusters disappears after accounting for genetic and environmental influences shared in common with neuroticism and novelty seeking [1260].

[487,684] and to destabilize after exposure to environmental stress [35,38,385,668-671,691,692]<sup>76</sup>. This emotional instability results in heightened sensitivity to environmental factors (a low threshold of arousal) and unexpected, intense, and rapid changes in emotion, thus the amplitude of the personal density distribution [58,192,199,693]<sup>77</sup>. Reactivity is often operationalized as individual differences in the thresholds of reaction, latency, intensity, peak-intensity, duration, and recovery of negative affects/emotions [22,123,192,199]. The neurotic volatility cluster may underlie the consistent associations between neuroticism, mood variability [663,694,695,695-697], and mood disorders [52,53,53,281].

Finally, frustration/anger versus anxiety/depression also differ in the type of behaviours they motivate, *e.g.* approach versus avoidance [689,698-700]. Anger and anxiety are also mediated by different neurological substrates [22] and have different implications for development and psychopathology [701-703]. Finally, facet traits can also differ in their sensitivity to environmental influences [230,246]. To conclude, the three clusters in the neuroticism concept may explain why neuroticism is both one of the most stable aspects of personality and most susceptible to change as well [62,438], and the sensitivity to environments is inherent in the conceptualization of neuroticism.

### **Limitations**

This review was limited by the range of available studies (also accounting for many inconsistencies), while measure-heterogeneity precluded formal meta-analyses. Consequently, this review became a qualitative synthesis of the relevant, representative, and evidence-based literature, and relied on the scarce MZ-twin studies, and criteria of consistency of the association, temporal order, and evidence of dose-response (correlated change) mechanisms. In the following we outline some challenging issues of measurement in terms of content, methods, and informants.

### ***Ipsative Stability***

Within this review we ignored changes in the stability in the configuration of other traits within the individual (ipsative stability), while there may be dynamic interactions between them [704,705]. We can only claim that neuroticism is uniquely related to the studied experiences if neuroticism is studied together with all other dimensions of personality. Life event occurrences are influenced by all traits, *e.g.* more extraverted, agreeable, and conscientious individuals tend to report more PLEs [630]. Second,

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76. *Cf.* the allostatic load model [268,670], and the sense of being out of control as a common feature of anxiety and fear [1261].

77. High neuroticism is characterized by more intense experience of negative emotions (such as fearful and sad), but the volatility facet of neuroticism also results in more extreme positive feelings (such as enjoyment [151,1262]).

after a SLE (with high event centrality) people tend to show a small (temporary) increase in neuroticism, but also in openness to experience and conscientiousness [706]. Third, there are indications for synergistic effects between high neuroticism and high conscientiousness that result in good health behaviours [99,185,186]. Though we acknowledge that typological approaches result in important information loss [707], perhaps traits configurations form “personality chords” (*e.g.* high neuroticism, conscientiousness, and agreeableness), which seem to render one vulnerable or resilient to specific events [18,705,708,709]<sup>78</sup>, or disorders [710,711].

### ***Methodological Concerns***

We observed methodological concerns, *e.g.* attrition was often associated with higher neuroticism levels [222,333], and rather high in relationship studies [477]. Second, the relative small sample sizes may partly explain the lack of separate models for both genders or failure to account for the divergent meanings events (being married/remarried/divorced/single, but also work and social network) may have for men and women [99,156,569,570]. Third, many longitudinal studies lean on associations or cross-lagged paths [509,712], which conceal the magnitude of the reciprocity (socialization *vs.* selection), *e.g.* the bidirectionality between neuroticism and divorce [484,713]<sup>79</sup>. In addition, most cross-lagged panel models and latent growth curve models do not allow changes in one domain (neuroticism or environmental factors) to predict changes in the other domain, thus do not study dynamic transactions directly [246].

Furthermore, it is often observed that neuroticism effects on the environment are stronger than vice versa [100]. This led some to argue that comparisons between neuroticism (as a broad domain) and environmental variables are unfair [484], and that facet traits are a more equal measurement level [246]. Fourth, all studies lacked a life-span perspective, and most had few measurement occasions over small spans (two-wave snapshots), which foreclose reflections on short- and long-term temporal dynamics [714], while earlier experience may form a dynamic moderator or have sequelae [99,715]. Life records capture the natural history of the person as no other data can, and are highly reliable due to aggregation of observations over a long period [99,472]. Finally, we may have encountered the ‘file-drawer problem’ because we found remarkably few studies with negative findings (no effect) [716-718].

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78. For example, some proposed an Alpha trait (or “chord”) to maintain stability, that captures emotional stability, agreeableness, and conscientiousness, and a Beta trait as tendency toward exploration and growth, with extraversion and openness [18,705,708].

79. In one study the authors therefore remained puzzled whether change in neuroticism “resulted from the interaction with (or nurturing by) a partner” or whether a transition into a partnership was a “characteristic adaptation” of intrinsic personality change [484,713].



### ***Instruments and Tools***

Important statistical tools like correlated change require large sample sizes in order to have sufficient statistical power, especially after control for  $T_1$ -values and Bonferroni adjustment, but may prove to be crucial tools to uncover mechanisms behind intra-individual change [333,719]. Furthermore, twin studies at least controlled for most confounding due to genetic factors and shared experiences [223]. In virtually all studies personality was assessed with self-report instruments [246]<sup>80</sup>, a strategy that is especially problematic for self-report life events (often with Likert-scales), because retrospection inherently incorporates response components, such as cognition and appraisal [268,720], and item interpretation or recall [269,377].

Interview-based methods are therefore the gold standard for assessing life stress [268-270,721], and data indeed suggests worrisome discrepancies between interviews and self-report [722,723]. Interviews are an incomplete solution, however, if only for the demands of time and cost, and few (< 2%) studies therefore use interviews [386]. In addition, interviews may be less likely to elicit embarrassing or consequential information, such as physical or sexual abuse [724]. Similarly, interviews about marital satisfaction may result in social desirability or self-presentation biases [344,508]. Even so, interviews would probably have broadened our knowledge [100], just as more dyadic analyses would [125,246]. Finally, it is tempting to argue for experiments to establish causality, but hitherto it is unethical to expose random individuals to divorce or pregnancy, and allowed stressors are unrepresentative of the life stresses that people encounter in the real world (either in intensity or duration). Furthermore, only specific people shall participate in experiments, while both experimenters and subjects shall know it's an experiment.

### ***Therapy***

The review did not focus on the context of therapy, although this provides one of the best opportunities to study the possibility of change in neuroticism (see chapter 10). Within therapy environmental influences are clearly defined and controlled, making intervention studies “a window into the organization of a system and the processes associated with transition” [725]. Given that neuroticism is a risk factor for - or may reflect subthreshold levels of - developing psychological disorders [53,272-275,281], a reasonable aim for clinicians developing prevention strategies may be to influence neuroticism, as decreases in neuroticism may improve resilience and health

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80. Albeit these are reliable measures they assessed only *perceptions* of the subject, thus reflect ‘beliefs’ of the participants, which are surely consequential, but not necessarily accurate. Studies should more often be dyadic. None of the studies included used behavioral observation (either ‘live’ or videotape) or informants, while this has been implemented before [731,1263].

[52,54,222]. Prior work has shown that interventions treating high neuroticism are feasible [351,354,355,391,726-728], both psychological and pharmacological ( $d=0.40$  to  $1.25$ ). We feel this complex topic deserves a review for itself.

### *Psychometrics*

Neuroticism measures are constructed via standard psychometric procedures, including high test-retest reliability, and focus on static aspects of neuroticism, not change [331,719]. Hence, responses in terms of ‘general feelings’ are less sensitive to intraindividual variability, and likely to underestimate trait change. Furthermore, most questionnaires discriminate good at the most disturbed high end of the neuroticism continuum, but rather poorly at the emotional stability side [729]. One solution may be additional observation studies of real-life trait-relevant situations that make people show their personality [245,730,731], as Galton argued [127]. Another solution may be to focus were possible on changes in the relevant facets [246,253]. Third, we should study the differences between personality instruments and those used to gauge mental health [732]. Moreover, the review would have been more informative if studies used personality measures with known scale properties (*e.g.* ratio scales). In addition, we hope for more cross-cultural evidence, because virtually all samples were western, educated, industrialized, rich, and democratic (WEIRD) populations [733], and a five factor structure seems less robust in non-educated individuals, *e.g.* Bolivian forager-horticulturalist [734].

## CONCLUSION

We reviewed environmental factors that foster stability and change in neuroticism. The key message is that neuroticism setpoint levels are consistently touched by normative experiences that affect core aspects of one’s identity and status, mainly role transitions as partner (marriage/divorce) and employee (dismissal/promotion). The neuroticism setpoint was most responsive to major interpersonal stressors that were unpredictable, uncontrollable, unexpected, undesirable, and ‘off time’ from a life history perspective. The magnitude of the observed effects range at the modal within psychological research. Increases in the neuroticism setpoint about two years after a major SLE were followed by a 60% decrease in size over the subsequent decade, which we take to suggest that the neuroticism setpoint has its own temporal dynamics. We propose that changes in neuroticism that persist over six months indicate setpoint change. Nevertheless, more lifespan studies and detailed dissections of environmental factors are required to understand the dynamics of setpoint change in neuroticism: paradoxically both one of the most stable and changeable personality traits.

