Running Head: PERSON-ENVIRONMENT RELATIONS

**Capturing Interactions, Correlations, Fits, and Transactions:
A Person-Environment Relations Model**

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Abstract

To understand personality dynamics, processes, and functioning better, knowledge on the relations between persons and environments needs to advance. First, this chapter outlines basic elements of persons (short-term $\mathbb{P}$ as states and long-term $\mathbb{p}$ as traits) and environments (short-term $\mathbb{E}$ for situations and long-term $\mathbb{e}$ for niches) along with their respective properties in a re-specified and extended Lewinian formula. Second, a generic Person-Environment Relations Model (PERM) is presented that specifies the different relations and important effect paths between person, environment, and outcome variables. Within the PERM, four central types of person-environment relations are distinguished and subsequently discussed in detail: *interactions* (person and environment variables moderate each other's effects on outcomes), *correlations* (person and environment variables are concurrently associated), *fits* (person and environment variables match with each other), and *transactions* (person and environment variables affect each other across time). Here, person-environment fit is distinguished as either a special effect pattern (involving an interaction) or a correlation, respectively. Third, focusing on the different ways in which persons and environments calibrate themselves towards each other, different navigation mechanisms are systematized, with a special emphasis on how persons navigate environments. Lastly, suggestions and recommendations for future lines of theory, methodology, and empirical research are provided.

Keywords: persons, personality, traits, states, environments, situations, niches, person-environment interactions, person-environment correlations, person-environment fit, person-environment transactions

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1. Introduction

As psychologists, we want to describe, explain, predict, and sometimes even change the psychological structures, processes, dynamics, and functioning of persons. To do so, we need to understand how persons and environments are related to each other. Indeed, different literatures acknowledge the intricate, complex, and dynamic interplay between persons and their social or non-social environments (e.g., Allport, 1961; Altman & Rogoff, 1987; Asendorpf & Rauthmann, 2020; Back et al., 2011; Balliet, Tybur, & van Lange, 2017; Baltes, 1997; Bandura, 1978, 1982; Baumert et al., 2017; Beck & Jackson, 2020; Benet-Martínez, Chapter 10; Blum & Schmitt, 2020; Bowers, 1973; Briley et al., 2019; Buss, 1987; Caspi, 1988; Caspi & Bem, 1990; Caspi, Bem, & Elder, 1989; Caspi & Roberts, 1999, 2001; Craik, 1994, 2000; Cramer et al., 2012; Denissen & Penke, 2008; DeYoung, 2015; Fleeson, 2012; Fleeson & Jayawickreme, 2015; Fournier, Moskowitz, & Zuroff, 2008, 2009; Fraley & Roberts, 2005; Funder, 2001, 2006, 2008, 2009; Hankin & Abramson, 2001; Hogan & Roberts, 2000; Holleinstein & Loughheed, 2013; Ickes, Snyder, & Garcia, 1997; Jayawickreme, Zachry, & Fleeson, 2019; Laceulle & van Aken, 2018; Laland, 2004; Law et al., 1996; Lerner, 1978; Little, 1987; Magnusson, 1990; Magnusson & Endler, 1977a,b; Markus & Kitayama, 2010; Meagher, 2020; Mischel, 1977; Mischel & Shoda, 1995, 1998, 2008; Molho & Balliet, 2020; Pettigrew, 1997; Pincus, Hopwood, & Wright 2020; Plomin et al., 1977; Rauthmann, 2015a; Rauthmann & Sherman, 2016, 2020; Roberts, 2018; Roberts, & Pomerantz, 2004; Roberts & Nickel, in press; Ross & Nisbett, 2011; Runyan, 1978; Ryff, 1987; Saegert & Winkel, 1990; Sameroff, 1975; Scarr, 1996; Stokols & Shumaker, 1981; Tett et al., 2013; Turkheimer, 2000; Walsh, Craik, & Price, 2000; Wrzus, Chapter 5; Wrzus & Roberts, 2017; Zaccaro et al., 2018). Further, many chapters in this handbook reference or even declare person-environment relations as central to personality psychology. From that vantage, personality dynamics and processes (e.g., Blum, Baumert, & Schmitt, Chapter 2; Revelle, 1995, Chapter 1; Hampson, 2012; Hopwood, 2018) can only be properly understood if we advance our knowledge on person-environment relations.

Consider Anna whose level of outgoing behavior (e.g., making eye contact with other persons, talking to them, sending open non-verbal cues) has been measured across 34 occasions (Figure 1). Additionally, the kind of situation Anna was in was also measured at each occasion. This allows segmenting the measured snippets of Anna's life stream into different situational episodes. As can be seen, five episodes were sampled for Anna, and these episodes could be grouped into "Situation Class A" (blue dots; e.g., tasks need to be done), "Situation Class B" (green boxes; e.g., friend is talking to her), and "Situation Class C" (yellow triangles; e.g., friend helps her with tasks) according to their cues or psychological characteristics (Rauthmann, 2015b). To provide an account of Anna's consistency or variability (Beck & Jackson, Chapter 4; Geukes et al., 2017), one could compare Anna's behavior within each episode (how does it fluctuate within an episode?) and across episodes (how does it fluctuate when similar episodes occur, and when different ones do?). This is an intra-individual perspective and an exercise in idiographic modeling. By also sampling corresponding information from several other participants, we could compare persons to each other or use nomothetic modeling from an inter-individual perspective. Idiographic and nomothetic approaches are not mutually exclusive and can be integrated (Wright & Zimmermann, 2019), but for simplicity the current example is just framed for one person, Anna. Apart from quantifying consistency and stability versus change in Anna's behaviors, other questions may also be interesting: Why is Anna in these situations in the first place? Why do her situations change? How do her behaviors and her situations relate to her mental functioning, her personality traits, and her relationships, country, and culture? How does Anna influence her situations, and how do they influence her? Does Anna craft herself a certain niche by the way she influences her situations, and does that niche have implications for Anna's development? How well does Anna fit into her environment, and does that fit have consequences for her well-being, identity, and social standing?

– Figure 1 –

These and many more questions can be answered from the perspective of relating persons to environments (and vice versa) across time. Towards this end, this chapter first outlines basic elements and their properties based on a re-specified Lewinian formula. Next, a basic and generic Person-Environment Relations Model (PERM) is presented that systematizes the different relations and effect paths between person and environment variables. Within that model, central types of person-environment relations are distinguished: interactions, correlations, fits, and transactions. It will also be shown that person-environment fit can be understood in terms of interactions or correlations. Zooming in on the different ways in which persons and environments calibrate themselves and each other, different navigation mechanisms are outlined that help understand processes and dynamics involved in person-environment relations better. Lastly, several suggestions and recommendations for future lines of theory, methods, and empirical research are made. Throughout the chapter, the PERM is also made more concrete at various instances to showcase its flexibility and how it can be adapted to capture more nuanced phenomena. A summary of this chapter's contents can be found in Table 1 to help readers locate the topics and information contained in this chapter better.

– Table 1 –

2. Re-specifying the Lewinian Formula

It has become almost a truism to state that behavior results from the interplay of person and environment variables. Over eight decades ago, Lewin (1936) coined a now seminal formula capturing this idea:

$$B = f(P, E) \quad \text{Equation 1}$$

In this formula, behavior (B) is a function of a person's current mental states (P) and the current environment (E). In Lewin's (1936) words, "every psychological event depends upon the

state of the person and at the same time on the environment, although their relative importance is different in different cases” (p. 12). The Lewinian formula in Equation 1 can also be condensed to $B = f(S)$ – where behavior is a function of the psychological or whole situation (S) of a person. Further, because P and E are interdependent, it also holds that $E = f(P)$ and $P = f(E)$.¹

Lewin’s simple formula – describing an actualgenetic process (i.e., something that unfolds at a circumscribed and usually shorter moment in time) – has been misunderstood, reconceptualized, or extended several times (Bond, 2013; Funder, 2006, 2008, 2009; Wagerman & Funder, 2009). For example, P has been interpreted as momentary behavioral states, behavioral patterns, personality, traits, or even genes and nature, and E as the psychological situation, perceived environment, context, socio-ecological niche, or even nurture. Undeniably, all of these “elements” are important in understanding human conditions, psychological functioning, daily dynamics, and developmental trajectories. However, they were not explicitly included in Lewin’s simplified formula.² Further, different issues are mixed, obscured, or even confused with each other, such as (1) overt behavior vs. covert mental operations, (2) structures vs. processes, (3) objective (actual) vs. subjective (perceived) accounts of the elements, (4) actualgenetic short-term, momentary, fast-changing vs. ontogenetic long-term, enduring, slow-changing timescales of elements, (5) predictors (*explanantia*) vs. outcomes (*explananda*), and (6) systematic vs. unsystematic variance in the elements. A more inclusive and nuanced understanding of the basic elements and their relations will have to take these issues into account. The following revised formula and its concretizations in this chapter attempt to be a first step into such a direction:

$$\mathbb{O} = f(\mathbb{P}, \mathbb{p}, \mathbb{E}, \mathbb{e}) \quad \text{Equation 2}$$

¹ These formulae simplistically assume that one variable can be fully explained by the other variable. Of course, such full explanation would be rare and residual components R (e.g., unexplained systematic and unsystematic variance) would also need to be distinguished: $E = f(P, E_R)$ and $P = f(E, P_R)$, where the residual components E_R and P_R are independent of each other. Residual components are omitted from further equations.

² They may have been implied in Lewin’s concept of a person’s “life space” which are all inner and outer influences on a person.

where $\mathbb{O}$ = set of outcomes variables, $\mathbb{P}$ = set of person state variables, $\mathbb{p}$ = set of person trait variables, $\mathbb{E}$ = set of momentary situation variables, $\mathbb{e}$ = set of enduring niche variables.³

2.1 Ingredients

2.1.1 Basic Elements: Person and Environment Variables. Table 2 contains an overview of the *basic elements* in Equation 2 and which forms they can each take. Generally, two broad types of variable groups can be distinguished (Asendorpf & Rauthmann, 2020): *person* ($\mathbb{P}$, $\mathbb{p}$) and *environment* ($\mathbb{E}$, $\mathbb{e}$) variables.⁴

– Table 2 –

$\mathbb{P}$ denotes, in line with the original Lewinian formula, any momentary person conditions that can change rapidly or at least in short periods of time. Somewhat as a deviation from Lewin, however, $\mathbb{P}$ can be *any kind* of momentary person state (e.g., physiological, sensory, perceptual, cognitive, affective, motivational, volitional, intentional, regulatory, behavioral), not just “mental” ones. $\mathbb{p}$ denotes any regular, recurrent, or only slowly changing person variables. Such variables have been broadly related to morphology (e.g., body mass index, physical health, longevity), dispositions (e.g., Big Five, intelligence), characteristic adaptations (e.g., goals, values, attitudes, well-being), and narratives (e.g., self-concepts, identity) in the literature (McAdams & Pals, 2006). $\mathbb{P}$ variables have elsewhere been referred to as *states* and $\mathbb{p}$ variables as *traits* (e.g., Cattell, Cattell, & Rhymer, 1947; Fleeson, 2001; Roberts, 2018; Steyer, Ferring, & Schmitt, 1992; Steyer, Schmitt, & Eid, 1999), and this chapter follows this tradition. Importantly, traitness vs. stateness may reside on a continuum, and any person variable may lie on said

³ The letters with double lines ($\mathbb{O}$, $\mathbb{P}$, $\mathbb{p}$, $\mathbb{E}$, $\mathbb{e}$) denote sets of variables regardless of their “flections” (see 2.1.2 *Differentiations: Flections of Measurement*). They are thus undifferentiated placeholders that could be any form of a specific variable. For example, $\mathbb{P}$ refers to any kind of momentary person variable (and could denote $\mathbb{P}$, $\bar{\mathbb{P}}$, $\ddot{\mathbb{P}}$, or $\ddot{\bar{\mathbb{P}}}$; see Table 2), while a $\mathbb{P}$ refers to a specific momentary person variable measured once.

⁴ Of note, Asendorpf and Rauthmann (2020) reversed what capitalized and decapitalized letters meant. There, and in contrast to this chapter, capitalized letters denoted more stable, long-term, or slowly changing variables, while decapitalized letters denoted less stable, short-term, or fast changing variables. Because Lewin’s concepts have precedent, I decided to keep capitalized letters for the short-term variables he described and use decapitalized letters for the long-term ones instead. This also creates greater consistency with other literatures.

continuum (Leising et al., 2014) and could potentially even be operationalized as both a trait and a state (Fleeson, 2001). Indeed, any measured variable (e.g., even a body mass index) may contain both state and trait components (Steyer et al., 1999), and it also depends on the properties of measurement whether traits can be feasibly extracted (e.g., from repeated measurements).

$\mathbb{E}$ denotes, in line with the original Lewinian formula, any momentary environment conditions that can change rapidly or at least in short periods of time (labeled here: *situations*). These $\mathbb{E}$ variables can be measured in more objective terms (e.g., attending to the actual cues in an environment) or in subjective/perceived terms (e.g., asking persons to rate psychological characteristics of an environment). $\mathbb{e}$ denotes any regular, recurrent, or only slowly changing environment conditions (labeled here: *niches*). Terms for $\mathbb{E}$ and $\mathbb{e}$ have not been used precisely or consistently throughout the literature (Rauthmann, Sherman, & Funder, 2015a). For example, $\mathbb{E}$ variables have elsewhere been referred to as situations, events, occurrences, or episodes, and $\mathbb{e}$ variables as environments, niches, or contexts (Rauthmann, Sherman, & Funder, 2015b). While $\mathbb{E}$ and $\mathbb{e}$ variables can be qualitatively different, it is often a matter of operationalization and measurement whether one can distinguish more enduring $\mathbb{e}$ components from more variable $\mathbb{E}$ components in assessments of the environment – similar to how trait and state components are inherent in every measurement of a person variable. Environment variables can be quite heterogeneous. For example, they could represent (1) circumscribed ecological phenomena or elements (e.g., nutrition, toxins, resource scarcity, natural hazards, catastrophes, weather conditions, flora, fauna, architecture), (2) discrete life events (e.g., graduation, new job, marriage, child birth, divorce, partner death, abuse, lottery win), (3) situational episodes (e.g., being at a party), (4) social niches (e.g., one's online and offline social networks, friends, romantic partners, work colleagues, groups), (5) institutions (e.g., vocations, occupations, organizations), (6) culture (e.g., norms, traditions, rules, laws, roles, games), or even (7) history (e.g., epoch, zeitgeist).

$\mathbb{O}$ can be any outcome variable of interest, which will usually reside either at the person level ($\mathbb{P}$, $\mathbb{p}$) or at the environment level ($\mathbb{E}$, $\mathbb{e}$). Some research tends to structure outcomes into individual (intrapersonal), interpersonal, and social-institutional domains (Ozer & Benet-Martínez, 2006; Soto, 2019). To a certain extent, designating which person or environment variable serves as an outcome variable and which as a predictor may be arbitrary. Therefore, theory and conceptual reasoning as well as appropriate methods (e.g., experimental and longitudinal designs) should be used to establish clear predictor-outcome relations (see also Hampson, Chapter 3; Möttus, 2016; Wessels, Zimmermann, & Leising, 2016).

To give an example of how person, environment, and outcome variables come together, being approached by others at a social event (here, $\mathbb{O}$ is defined as an $\mathbb{E}$) could be described or explained as a function of currently being in a good mood ($\mathbb{P}$), being generally outgoing ($\mathbb{p}$), being in easy-going and pleasant social interactions ($\mathbb{E}$), and already having a supporting social network of friends ($\mathbb{e}$). Because terms have been used haphazardly and inconsistently throughout the literature (Asendorpf & Rauthmann, 2020) and this chapter cannot engage in a full and balanced treatise of terminologies, I will henceforth simply refer to the basic elements as person variables $\mathbb{P}$ (*states*) and $\mathbb{p}$ (*traits*) as well as $\mathbb{E}$ (*situations* and their cues or characteristics) and $\mathbb{e}$ (*niches* and their cues or characteristics).

2.1.2 Differentiations: Flections of Measurement. As can be seen in Table 2, several *measurement flections* of $\mathbb{P}$, $\mathbb{p}$, $\mathbb{E}$, and $\mathbb{e}$ – which are used here as placeholders to be specified more clearly – can be differentiated based on measurement, distinguishing between (1) variable-oriented (with no diacritics) vs. person-oriented (with “”) and (2) single-moment (with no diacritics) vs. repeated measurements (with “”). In all instances, person variables may be assessed by different BIOPSIES data sources (actual Behavior and behavioral residues, Indirect measures, Observation, Physiological and biological measures, Strangers’ impressions,

Informants' knowledge, Experience sampling and ambulatory assessments, Self-ratings; see Rauthmann, 2017), while environment variables can be measured, for example, by human raters or sensors (Rauthmann, Sherman, & Funder, 2020). However, these distinctions – often also boiling down to more objective vs. consensual vs. subjective accounts of the variables – will not be notified here to avoid even further complexity. However, they could be easily integrated by using subscripts, such as, for example, P_{self} for a self-rating of a single person state at one point in time (e.g., how extraverted a person believes she or he is at a given moment of measurement).

First, P , p , E , and e are “simple” variable-oriented measurements at one measurement occasion – one variable is sampled at a specific point in time. Second, $\bar{P}$ and $\bar{E}$ are derived from repeated variable-oriented measurements (such as in ambulatory assessment or experience sampling) of several P and E variables, respectively. Such data make it possible to construct different new scores from repeatedly measured variables. For example, density distributions of these variables can be formed which are described by certain parameters (e.g., arithmetic mean, median, mode, standard deviation, minimum, maximum, skewness, kurtosis; see Fleeson, 2001 and Fleeson & Gallagher, 2009 for an application to P s). Further, latent variable modeling (such as forms of latent state-trait models; e.g., Geiser et al., 2017; Steyer et al., 2015) can be used to derive different scores (e.g., a latent trait, state, change score, etc.). Thus, density distribution parameters or latent scores could thus represent $\bar{P}$ and $\bar{E}$, respectively (e.g., the average of P s, the standard deviation of P s, the latent covariance shared among all P s across all measurement occasions, etc.). Note here that the source of the data comes from repeated P and E measurements defined as momentary, state-like elements, but the resulting scores of $\bar{P}$ and $\bar{E}$ may also represent longer-term, trait-like elements depending on the parameters or models chosen.⁵ Theoretically, $\bar{p}$

⁵ Some models, such as those from latent state-trait theory, decompose the observed variance in variables (here from repeatedly measured P s and E s) into trait- and state-like components. Thus, sometimes $\bar{P}$ and $\bar{E}$ could represent both state- and trait-like entities.

and $\bar{e}$ could represent repeated measurements of p and e variables, respectively (e.g., in longitudinal or measurement burst designs; Sliwinski, 2008), but it is not common to construct density distributions around such enduring variables. Still, latent variable modeling may be used to derive a latent mean or change score across time.

Third, $\ddot{P}$, $\ddot{p}$, $\ddot{E}$, $\ddot{e}$ represent person-oriented profile measurements where several variables (measured at one time-point), as a profile, are nested within persons or environments. For $\ddot{P}$ and $\ddot{E}$, multiple different short-term person or environment variables constitute a profile for each person or environment, respectively (or only one person or environment in an idiographic case study design) at one single measurement occasion. For $\ddot{p}$ and $\ddot{e}$, multiple long-term person and environment variables, respectively, constitute the profiles. Lastly, $\ddot{\ddot{P}}$ and $\ddot{\ddot{E}}$ are profiles of short-term person and environment variables, respectively, that have been sampled repeatedly at several measurement occasions. While profile elements may in fact be any kind of density distribution parameters or latent scores, most likely aggregated values across measurement occasions would be used for $\ddot{\ddot{P}}$ and $\ddot{\ddot{E}}$. Again, theoretically, $\ddot{\ddot{p}}$ and $\ddot{\ddot{e}}$ are also possible as profiles of repeatedly measured and aggregated long-term person and environment variables, respectively; but these are practically rarely if ever used. As explained previously, for all of these flections, different data sources may have been used to measure the variables.

2.1.3 Combinations. Equation 2 can be seen as the full four-element equation that subsumes several truncated one-, two-, and three-element equations (see overview in Table 3). For the four basic elements, there are thus 15 possible combinations. However, because $\mathbb{O}$ can take the form of any of the four basic elements, there are actually 60 different combinations.

Notably, the complexity of possible models can be increased even further by using (1) multiple variables at once for each element and/or (2) multiple measurement occasions. First, in multiple-predictor models, several variables may have been simultaneously measured for the same element. To give an example:

$$\mathbb{O} = f(\mathbb{P}_i) = f(\mathbb{P}_1, \mathbb{P}_2, \mathbb{P}_3, \dots, \mathbb{P}_i) \quad \text{Equation 3}$$

Second, the variables may have been measured at different time-points, thus enabling time-sensitive analyses (see *4.4 Person-Environment Transactions*). For example, a later (future) outcome variable at time n may be predicted from concurrent variables also at time n and prior (past) variables at time $n-1$. To give an example:

$$\mathbb{O}_n = f(\mathbb{P}_n, \mathbb{P}_{n-1}) \quad \text{Equation 4}$$

2.2 Functional Configurations

The previous section on elements, flections, and combinations focused only on the person and environment ingredients of Equation 2 and how they could be measured and combined. However, their relations to an outcome variable as well as to each other – both within a given time-point and across time-points – have not been touched upon so far. This relation question also concerns the exact nature and form of the function f . For example, functions can be additive, multiplicative, proportional, or exponential, among others, but often the exact function relating person and environment variables is left unspecified (Schneider, 2001, p. 145). The section *4. Person-Environment Relations* will concretize different functions that have been proposed in extant personality, social, developmental, and industrial/organizational psychological literature. Briefly, most research conceptualizes the function f in linear and additive ways or in multiplicative ways (see different effect patterns in *4.1 Person-Environment Interactions*), and some research also includes correlations (*4.2 Person-Environment Correlations*), fits (*4.3. Person-Environment Fit*), and time-lagged analyses (see *4.4 Person-Environment Transactions*).

3. A General Person-Environment Relations Model (PERM)

Keeping the different ingredients and their functional configurations in mind, Figure 2 presents a formalized account of a generic and general Person-Environment Relations Model (PERM). As can be seen, several paths (a-t) representing different *effects* are distinguished in the PERM, which may additionally exist at several time-points (making it possible to examine their intra-individual stability and change as well as possible inter-individual differences therein). A summary of the effects and their meanings can be found in Table 4.

– Figure 2 –

– Table 4 –

Person variables may be associated with outcome variables⁶ (path a), as may environment variables (path b). However, both (as products) may also “interact” and thus have an interactive effect on an outcome, such that a person variable moderates the effect of an environment variable on an outcome variable (path c') and also vice versa (path c"). This effect is termed here a statistical *person-environment interaction*. Additionally, person and environment variables may be associated with each other concurrently (path d), which is termed here a *person-environment correlation*. This correlation (or individual differences therein) may, in turn, itself be associated with an outcome variable (path e). Person-environment correlations may exist due to different reasons (paths f', f"), and these reasons are subsumed under the label of *navigational mechanisms*. Some of these mechanisms originate from the person and thus are tied to either $\mathbb{P}$ or $\mathbb{p}$ (path g'). Other mechanisms may, however, originate from or be tied to environment variables $\mathbb{E}$ or $\mathbb{e}$ (path g"). Additionally, mechanisms may also be directly associated with an outcome variable (paths h',

⁶ Outcome variables could be sampled before, at the same time, or after the sampling of predictors (person and environment variables). If concurrently sampled, outcome variables cannot be seen temporally as consequences (for a nuanced discussion about consequences, see Wessels, Zimmermann, & Leising, 2016). However, some variables are nonetheless considered “outcomes” in a conceptual sense and thus also distinguished from their predictors in a statistical modeling sense (e.g., when using regression analysis).

h"). So far, all elements and their relations have been examined at one time-point of measurement (T1). However, there may be multiple time-points. The PERM in Figure 2 depicts another time-point, T2. This allows also specifying stability effects between prior elements (T1) and later elements (T2) for navigation mechanisms (paths i' , i''), person variables (path j), environment variables (path k), and outcome variables (path l). Additionally, there may also be a stability of the person-environment correlation (path m). Further, there can be cross-lagged effects between person and environment variables, respectively, such that prior person variables predict later environment variables (path n) and prior environment variables later person variables (path o). This will be termed here a *person-environment transaction*. Prior outcome variables may also predict later navigation mechanisms (paths p' , p''), person variables (path q), and environment variables (path r). Lastly, later person-environment correlations can also be predicted by prior outcomes (path s) and prior navigation mechanisms (paths t' , t'').

It is important to note that *not* all possible relations are depicted in the in the PERM (Figure 2) for simplicity (e.g., there are no direct or lagged paths from person-bound navigation mechanisms to the environment variables but only to the person-environment correlations). There may also be feedback (across time), self-organization and autopoiesis, and non-linear effect patterns (e.g., with quadratic or cubic effects), but these are not explicitly marked in Figure 2 and would need to be inferred from the exact f functions when specified (e.g., using differential or polynomial equations). Further, relations among $\mathbb{P}$ with $\mathbb{P}$ and among $\mathbb{E}$ with $\mathbb{E}$, respectively, are also not depicted in Figure 2 but should also be considered. If subscribing to causal analysis, this could make it possible to distinguish six essential links between persons (i.e., with $\mathbb{P}$ and $\mathbb{P}$) and environments (i.e., with $\mathbb{E}$ with $\mathbb{E}$), most notably social ones, as outlined in Ryff (1987) and Pettigrew (1997). Specifically, (1) persons may influence specific situations (e.g., by selecting or changing one's situations; see 5.2.1), (2) specific situations may influence individuals (e.g., abuse

as a traumatic experience; see 5.2.2), (3) situations may influence social structures (e.g., repeated interactions may lead to a certain social network), (4) social structures may influence situations (e.g., within a social network, several different interactions are possible), (5) individuals may influence social structures (e.g., one's social network could be dependent on one's personality; 5.2.1), and (6) social structures may influence individuals (e.g., one's social network may change one's personality via repeated interactions over time; 5.2.2). In general, all relations in Figure 2 – including the ones not depicted for simplicity – are multi-determined, multi-functional, and constantly ongoing on short- and long-term timescales in a dynamic person-environment macro-system. Thus, there are complex multivariate relations, some of which constitute moderations (paths c', c'') and many mediations (e.g., path j may also flow via paths a and q). As such, the PERM already contains several hypotheses to be tested in future research. To what extent, when, why, or for whom the effects (paths) exist remain open empirical questions.

4. Person-Environment Relations

The PERM in Figure 2 contains four general person-environment relations:

1. Interactions (path c' or c'', keeping paths a and b in mind)
2. Correlations (path d)
3. Fits (special cases involving interactions or correlations)
4. Transactions (paths n and o in conjunction)

Unfortunately, these terms have been used rather haphazardly or even synonymously throughout the literature. This is especially true for the term “person-situation interaction” which has come to be used as an umbrella term for different phenomena. The term has become conceptually blurry as it is currently being used at least in the following four ways (Lilienfeld et al., 2015; Olweus, 1977; Rauthmann, 2018a): (1) both persons and situations shape behavior together; (2) relations between person and situation variables are bidirectional (i.e., persons shape

situations and situations shape persons); (3) persons and situations are interwoven in complex ways (i.e., their effects on behavior cannot be separated properly); and (4) statistical effects of person variables depend on situation variables and vice versa in the prediction of an outcome variable (i.e., moderation).

To gain conceptual and methodological clarity, it is paramount to clearly distinguish different person-environment relations and consistently use precise terminology to label them. To do so, this chapter maintains that (1) *interactions* concern how effects of person and environment variables on outcome variables depend on each other, (2) *correlations* concern how person and environment variables are associated concurrently, (3) *fits* concern the matching of person and environment variables to each other, and (4) *transactions* concern how person and environment variables are related⁷ to each other across time. It will also be shown how person-environment fit can be captured either by attending to certain effect patterns (which include person-environment interactions) or to person-environment correlations. As such, interactions and correlations can also signify fit in certain instances.

4.1 Person-Environment Interactions

The idea of an interaction between person and environment variables (the latter being historically mostly operationalized as “situation” variables) in predicting outcome variables of interest was born out of a consequence of the person-situation debate. The person-situation debate – which can be considered resolved today – has revolved around several issues (Fleeson & Nofle, 2008a,b; Kenrick & Funder, 1988). A notable idea was that the level, consistency, or stability of behavior was more strongly (or even solely) determined by environmental variables (such as the cues or characteristics of situations) than by person variables (such as personality

⁷ The PERM is currently phrased to be rather agnostic about whether these across-time-relations should represent causal explanations or mere predictions (but see 6.4 *Explanation vs. Prediction and Causality*). This will depend on the framework and the design within which a study on those relations is conducted.

traits). This resulted in efforts that pitted the person and the environment (situation) against each other. Consequently, an implicit assumption was that person and environment variables predicted outcomes independently of each other and that the prediction from person variables would be negligible. As a counter to such a simplistic understanding, interactional psychology (Ekehammar, 1974; Endler & Magnusson, 1976; Magnusson & Endler, 1977a,b) maintained that there can also be an interaction between person and environment variables. That interaction has often been interpreted in statistical terms such that (after controlling for the respective main effects of both the person and environment variables) the effect of the person variable on an outcome variable depends on the environmental variable and, vice versa, the effect of the environment variable on the outcome variable depends on the person variable. Statistically, this describes a moderation effect (see paths c' and c'' in Figure 2). Conceptually, it means that persons with certain levels on their person variables respond differently to (or show different levels of outcome variables in) environments with certain levels on their environment variables. Conversely, it also means that environments with certain levels on their environment variables elicit different responses for persons with certain levels on their person variables. This basic notion of an interaction can also be found in educational (aptitude-by-treatment interactions: ATI; e.g., Snow, 1989), applied (Trait Activation Theory: TAT; e.g., Tett et al., 2013), clinical (diathesis-stress models; e.g., Zuckerman, 1999), and behavior genetic literatures (gene-environment interactions; e.g., Briley, 2020; Caspi et al., 2002; Johnson, 2007).

In the available literature dealing with statistical interactions between person and environment variables, there are actually three distinct strands of interactionist research: (1) variance decomposition, (2) linear interaction, and (3) non-linear approaches. However, these three can be seen as special cases of (4) more general effect patterns when predicting outcomes from person and environment variables, which also subsume (5) an outcome-based, variable-

oriented definition of person-environment fit. The following paragraphs give an overview of these five strands where interactions are key.

4.1.1 Analysis of Variance. The variance decomposition approach examines variance associated with persons, situations, and person $\times$ situation interactions in ANOVA-type designs (Bowers, 1973; Furr, Chapter 28). To do so, a set of persons needs to be exposed to a set of situations, and their experiences (e.g., perceptions, affect) and/or behavior need to be recorded. This creates a design where persons and situations are fully crossed and variance in dependent or outcome variables (e.g., perceptions, behavioral responses) can be decomposed into different sources: persons, situations, and person $\times$ situation interactions (mixed with error if multiple items have not been used to measure the outcome variable). An example of this line of thought is the anxiety S-R inventory from Endler and Hunt (1966) where persons indicate how anxiously they would react (R) to a set of situations (S). Variance in anxious reactions can then be decomposed into stemming from the two main effects of persons (= inter-individual differences between persons in generally reacting anxiously) and situations (= inter-situational differences between situations in their general tendency to elicit anxious reactions), plus the two-way interaction of person $\times$ situation (= uniquely anxious reactions of specific persons to specific situations, beyond the two main effects). A typical finding of variance decomposition research is that the person $\times$ situation interaction is quite sizable (Lakey, 2016). However, measurement error has often not been taken into account (which is often confounded with interaction variance; Kenny, 1994; Rauthmann & Sherman, 2019), and estimates of explained, reliable variance depend crucially on the selection of persons, situations, and reactions as well as the methods used to assess and analyze them (Cooper & Withey, 2009; Geiser et al., 2015; Judd, Westfall, & Kenny, 2012).

4.1.2 Linear Interaction Effects. All too often the term “statistical interaction” is treated in a monolithic fashion, when in fact there can be different forms or shapes of interaction (Widaman et al., 2012), as shown in Figure 3. For example, at least ordinal interactions (e.g., in the diathesis-stress model; Zuckerman, 1999) and disordinal interactions (e.g., in the differential-susceptibility model: Ellis et al., 2011) should be distinguished. For example, in the ordinal interaction form as hypothesized by the diathesis-stress model (upper left side of Figure 3), the quality of environments only plays a role for at-risk persons (e.g., with genetic vulnerability) whose outcomes are worse in “bad”⁸ environments. In contrast, resilient persons seem impervious to the effects of environments. Further, “good” environments confer no differential benefits to either resilient or at-risk persons. In the disordinal interaction form as hypothesized by the differential-susceptibility model (lower left side of Figure 3), malleable persons profit strongly from “good” environments, but also suffer greatly from “bad” ones. In contrast, non-malleable persons are again impervious to effects of environments. Thus, the malleable persons will show worse or better outcomes, respectively, than the non-malleable persons.

Figure 3 additionally shows on the right side some other hypothetical interaction forms. These could each be interpreted from the perspective of either persons or environments, depending on what units of analysis researchers are interested in. For example, a linear synergistic interaction approach considers how person and environment variables “work together” (synergy) in a linear way to explain an outcome variable. A “full linear crossing” (a disordinal interaction) is also displayed. The type of interaction captured is one of amplification (or if viewed conversely, of suppression or attenuation): the effect of a person variable on an

⁸ Environments (and also outcomes) are of course not per se “good” or “bad.” Rather, some environments are more, and others less conducive with regard to a predicting a certain (often socially desirable or undesirable) outcome. What is good” or “bad” may thus depend on the research, cultural, and historical context.

outcome is amplified (or attenuated) by an environment variable. This idea has been applied to different affective domains (e.g., anxiety: Endler, 1975; anger: Spielberger, 1988) and justice behavior (Schmitt, Eid, & Maes, 2003; Schmitt & Sabbagh, 2004).

– Figure 3 –

Most conceptualizations and studies examining linear interactions have focused on the following version:

$$P = f(p, E) = p + E + p \times E (+ \text{residual error}) \quad \text{Equation 5}$$

To give an example, persons with higher levels on p (e.g., trait anxiety) show a higher increase in their levels of P (e.g., intensity of anxious feelings or behaviorally expressed fear) from lower to higher levels of E (e.g., quantity and/or quality of anxiety-inducing stimuli) than do persons with lower levels on p who show a smaller increase in P levels. This means that persons with higher p levels are more attuned or differentially sensitive to E levels than persons with lower p levels. In other words, p amplifies the effect of E on P in this example. Alternatively, one may also flip this interpretation and state that E amplifies the effect of p on P (this would be an environment perspective). While conceptually and statistically straightforward, this strictly linear interpretation of an interaction suffers from unrealistic assumptions, most notably that the level of an outcome, such as behavior, could increase (or decrease) infinitely (which is not possible as there are natural or measurement-related upper and lower boundaries of most variables).

4.1.3 Non-linear Effects. As a remedy of issues associated with linear interactions, more recent non-linear approaches have been proposed (e.g., Traits as Situational Sensitivities = TASS: Marshall & Brown, 2007; Nonlinear Interaction between Person and Situation = NIPS: Blum et al., 2018; Schmitt et al., 2013). For example, the NIPS model posits that the non-linear effect follows the shape of a logistic regression which is achieved because both persons and environments can be either “weak” or “strong” (see last panel on the right side of Figure 3; e.g.,

Blum et al., 2018; Cooper & Withey, 2009; Dalal et al., 2014; Leising & Müller-Plath, 2009; Meyer, Kelly, & Bowling, 2020; Meyer & Dalal, 2009; Meyer, Dalal, & Hermida, 2010; Schmitt et al., 2013). There are different ways to conceptualize the strength of a situation or environment (Rauthmann, 2018b; for a review, see Meyer et al., 2020). However, one way is to surmise that strong environments have extreme scores on their variables (e.g., extremely anxiety-inducing vs. extremely calming) where inter-individual differences between persons matter less to the manifestation of some outcome such as behavior (i.e., variance between persons in their reactions or reaction levels is restricted). This would mean that persons with different trait anxiety levels would *not* show pronounced differences in their behavioral displays in strong environments (i.e., more trait-anxious and less trait-anxious persons react with similar amounts of fear or calmness, respectively). Thus, environment variables can, under such circumstances, have more power over an outcome than person variables. In contrast, weak environments have moderate scores on their variables where individual differences in the outcomes manifest more readily and thus become salient. This would mean that persons with different trait anxiety levels would show corresponding differences in their behavioral displays (i.e., more trait-anxious persons will react with more fear than less trait-anxious persons). Thus, person variables can, under such circumstances, have more power over an outcome than environment variables.

The preceding ideas pertain only to the environment side, but they could also be applied to the person side. Thus, in a similar vein, there can be “strong” persons with extreme values on a trait (e.g., extremely low vs. extremely high trait anxiety) that react in certain trait-corresponding ways (e.g., with fear or calmness) regardless of the levels of environment variables. Thus, under such circumstances, their traits may matter more than the environment in the prediction of an outcome. In contrast, “weak” persons do not show extreme trait values, and thus the levels of the environment variable will be stronger predictors of their behavior. Hence, under such circumstances, the environment may matter more than the traits in the prediction of an outcome.

Combining the idea of weak vs. strong environments and persons, respectively, necessarily yields non-linear effects on outcomes which have already been empirically tested for circumscribed construct domains (e.g., aggression and jealousy: Blum et al., 2018). An example is given in Figure 3 (bottom panel), which can be seen from the perspective of either person or of environment variables. However, the general operation of the NIPS model (which makes far more assumptions than just non-linear effects), specific instantiations of non-linear interactions, and the generalizability to other construct domains remain to be examined. Further, parts of the NIPS model (i.e., non-linear effects of person and environment variables) can also be situated within different effect patterns (see next section, *4.1.4 Effect Patterns*) that themselves may be viewed as specific instances of a full, second-order polynomial regression.

4.1.4 Effect Patterns. Given the possible linear and non-linear effects of person and environment variables on outcomes (see paths a, b, and c'/c" in Figure 2), different *effect patterns* can be distinguished. In roaming the literature (see Krueger, 2009), three historically consecutive statistical perspectives on effect patterns can be identified (which are, of course, also based on or informed by theoretical considerations): Linear, interactionistic, and non-linear perspectives. Of these, the linear and some of the interactionistic patterns have already been empirically examined, while the non-linear patterns rarely receive attention and have yet to be examined in full detail. Each of these perspectives, and the different positions encapsulated within each of them, entails different ramifications for how the function f relating person and environment variables to outcome variables is specified. The perspectives are compiled in Table 5, and the prototypical prediction patterns or effects they would produce can be found in Figures 4a-c. These figures thus demonstrate which shape person-environment relations *could* take in the prediction of outcomes. Notably, a variable-oriented perspective is employed here where effects pertain to certain variables of interest across sampled persons and/or environments, respectively.

– Figures 4a, b, c –

First, four linear patterns can be distinguished (see Table 5, Figure 4a): *Zero* (neither the person nor the environment variable predict the outcome), *Person-only* (only the person variable predicts the outcome), *Environment-only* (only the environment variable predicts the outcome), and *Additive* (both the person and the environment variable predict the outcome independently).

Second, another four interactionistic patterns can be distinguished (see Table 5, Figure 4b):

Interaction-only (only the interaction effect of the person and environment variable predicts the outcome), *Person plus Interaction* (the person variable as well as the interaction between the person and environment variable predict the outcome), *Environment plus Interaction* (the environment variable as well as the interaction between the person and environment variable predict the outcome), and *Additive plus Interaction* (the person variable, the environment variable, and the interaction between the person and environment variable predict the outcome).

Though any of the previously summarized eight patterns (linear and interactionistic, respectively) could be equipped with quadratic effects of person and environment variables, respectively, only four “extremes” of non-linear patterns are presented here (see Table 5, Figure 4c): *Person Strength* (only the quadratic person variable predicts the outcome), *Environment Strength* (only the quadratic environment variable predicts the outcome), *Non-linear Additive* (both the quadratic person variable and quadratic environment variable predict the outcome independently of each other), and *Non-linear Additive plus Interaction* (the quadratic person variable, quadratic environment variable, and the interaction of the person and environment variable predict the outcome).

The 12 overly simplified effect patterns outlined here are just a selection, as with five predictors (i.e., two main effects of person and environment variables, their respective quadratic effects, and their interaction effect) actually 30 distinct effect patterns are possible if at least one

or maximally five predictors actually predict an outcome. However, to conserve space and only show general tendencies, the 12 most important, interesting, or salient patterns have been compiled in Table 5 and Figures 4a-c. These can be contrasted against another effect pattern, termed *Full Complexity* here, that is essentially an unconstrained, full second-degree polynomial regression equation where all predictors meaningfully predict the outcome (Edwards, 2002). For example, if we used as predictors a short-term person (P) and a short-term environment variable (E) to predict a momentary outcome variable (O), then we would use following equation:

$$O = f(P, E) = P + E + P^2 + P \times E + E^2 \quad \text{Equation 6}$$

Figure 4d contains two examples for such a Full Complexity effect pattern where the regression coefficients of all predictors are statistically significant or sizable. Specifically, the full polynomial regression in Equation 6 predicts an outcome variable simultaneously from a person variable (b_1), an environment variable (b_2), the square of the person variable (b_3), the person variable $\times$ environment variable interaction (b_4), and the square of the environment variable (b_5). The resulting regression weights b_{1-5} can, in turn, be used to compute four response surface parameters a_{1-4} that describe a three-dimensional plot (Box & Draper, 1987; Edwards, 2002; Edwards & Parry, 1993), facilitate visual inspection and understanding of effect patterns, and allow the testing of nuanced hypotheses (Humberg et al., 2019; Schönbrodt, 2016a,b). Confidence intervals and inferential statistics with p -values are also available for these response surface parameters. Polynomial regression and response surface analyses allow testing quite nuanced hypotheses, most notably pertaining to fit (see 4.1.5 *Outcome-based, Variable-oriented Person-Environment Fit*). Further details on polynomial regression and response surface analysis can be found in Box 1.

– Figure 4d –

– Box 1 –

4.1.5 Outcome-based, Variable-oriented Person-Environment Fit. Polynomial

regression models and subsequent response surface analyses have been used to understand outcome-based person-environment fit (e.g., Edwards, 2002, 2008; Edwards & Shipp, 2007; Edwards et al., 1998). “Outcome-based” means that “fit” between predictor variables is defined here always in terms of predicting an outcome, and hence a “fit” may mean different things for different outcomes even if the same predictors are used in the same dataset. Roughly, there are two operationalizations of such outcome-based fit. First, there are strict and lax patterns of fit that can be identified from the polynomial regression and response surface parameters (see Humberg et al., 2019 for six conditions that need to be met to conclude an actual fit pattern). Three such patterns are presented exemplarily in Figure 4d. Most notably, these fit patterns all contain non-linear terms – quadratic effects and interactions. Interactions thus are key to this kind of fit.

Second, more pragmatically, person-environment fit could also be operationalized as the local “optimum level of outcome achieved” at a certain combination of measured values of the person and environment variable. For example, though not numerically congruent, the combination of the scores 2.3 on the person variable and 4.1 on the environment variable (both on a scale from 1 to 5) may together yield the highest scores on the outcome variable. In other words, it is at 2.3 and 4.1 when the person and environment “fit” to have produced the highest levels of an outcome.⁹ Such an interpretation of fit, however, begs the question whether any (optimal) prediction of an outcome by person and environment variables could be considered person-environment fit. On the one hand, proponents of the commensurability idea (e.g., Caplan, 1987) would require the person and environment variables to be “similarly measured” in terms of

⁹ In principle, one could also be interested in the lowest or any other most valuable level of an outcome. What “fit” means is always outcome-dependent here, and the desirability of the outcome variable (e.g., life-satisfaction, depression, salary, unemployment, divorce) then plays a crucial role in how we approach and interpret person-environment fit.

content (e.g., person variable: sociability; environment variable: sociality) and graded response scales¹⁰— only then would it be sensible to examine fit. On the other hand, others (e.g., Kristof, 1996) have taken a laxer approach where certain forms of fit (e.g., supplementary vs. complementary: Cable & Edwards, 2004; Muchinsky & Monahan, 1987) may require more commensurability and others less (for details, see *4.3 Person-Environment Fit*).

Outcome-based person-environment fit is variable-oriented and defined as a pattern of effects (Humberg et al., 2019) – as opposed to person-environment correlations that can be examined in a person-oriented manner and have also been conceptualized as fits (see *4.2 Person-Environment Correlations*). Usually, no individual differences in this kind of fit can be derived (but see Nestler, Humberg, & Schönbrodt, 2019)¹¹, which also means that typically no nomological network is cast around it to examine its correlates (e.g., causes/antecedents, concomitants, and consequences). Further, also no (inter-individual differences in intra-individual) stability and change can be established.¹² However, this form of fit still allows testing quite nuanced hypotheses for how an outcome variable is predicted conjointly by person and environment variables. Notably, it has been repeatedly emphasized that these kinds of analyses can only yield meaningful findings and actually test the nuanced hypotheses when the person and environment variables are conceptually, methodologically, and numerically commensurate (Schönbrodt, 2016a,b). If this is not the case, then the hypotheses cannot be tested directly, but the patterns of effects (i.e., the regression coefficients in the full polynomial regression) and the

¹⁰ The mere fact that the same response scale (e.g., from 1 to 5) has been used would likely not suffice to conclude strong commensurability. For example, a “3” may mean different things on a trait scale for sociability and a situation scale for sociality despite perfect numerical commensurability. Their scalability likely differs.

¹¹ An exception would be multi-level polynomial regressions and response surface analyses where person, environment, and outcome variables at level 1 are nested within persons at level 2. In such a case, variance in slopes and also response surface parameters could be examined as individual differences. For details, see Nestler et al. (2019).

¹² It is still possible to quantify the stability of the response surface parameters a_{1-4} across time-time points (essentially asking whether they remain the same across time).

overall shape of the response surface may still be revealing and of interest; however, strong caution is warranted with fit interpretations and conclusions. For example, such a cautious approach has been used in personality and social-psychological research to understand the relations of income with the fit between personality traits and job demands (Denissen et al., 2019); of self-esteem with the fit between one's own personality traits and those from one's home city (Bleidorn et al., 2016); of perspective-taking with the fit between one's own and one's community's ideological orientations (Chopik & Motyl, 2016); and of peer-victimization with the (mis-)fit between one's own personality traits and those from one's peer group (Boele et al., 2017). More complex analyses have also examined moderators, such as the study of Ilmarinen et al. (2017) where friendship homophily in traits and cognitive abilities (i.e., persons with similar personalities nominate each other as friends) was examined as a function of classroom sizes and children's gender. Further, polynomial regressions and response surface analyses have been used in numerous industrial/organizational and work-psychological studies examining person-team, person-job, and person-organization fit, among others (e.g., Edwards & Shipp, 2007).

4.1.6 Summary and Findings. What is the evidence for the occurrence, size, and shape of person-environment interactions? The answer to this question crucially depends on how the person and environment variables are defined and operationalized as well as which research design is used. For example, variance decomposition approaches usually find sizable interaction effects (Lakey, 2016; see also Furr, Chapter 28). In contrast, there seem to be barely any consensually agreed upon and replicable molecular gene $\times$ environment interaction effects (Briley et al., 2019; cf. Caspi et al., 2002). However, gene-environment interactions remain popular in behavior genetics (Manuck & McCaffery, 2014), with distinct patterns of effects proposed (Belsky & Pluess, 2009; Briley, 2020; Roisman et al., 2012), such as diathesis-stress (genetic predispositions only manifest under certain environments), vantage sensitivity

(environments override genetic predispositions in phenotypic manifestation; removing them leads to genetic differences gaining influence), and differential susceptibility (some persons are specifically attuned to and others immune to certain environmental influences). There seems to be some (replicable) evidence for diathesis-stress and vantage sensitivity effects, but less for differential susceptibility (see Briley, 2020). Further, in work contexts, interactions between traits (p) and organizational or work variables (mostly e) have been found repeatedly and noted to be substantial and meaningful (for a cursory overview of industrial/organization-psychological studies, see Table 6.2 in Tett et al., 2013, pp. 93-94). In contrast, however, experience sampling data in daily life have suggested that interaction effects between personality traits (p) and momentarily perceived situation characteristics (E) predicting momentary personality states (P) were very small, if they could be detected at all (Sherman et al., 2015; cf. Breil et al., 2019). More recently, Sherman and Pashler (2019) estimated the magnitude of interactions between person and environment variables in five studies, with 42 to 542,700 effects per study. The averaged incremental *R*s (computed across all possible models within each study) beyond the main effects of the person and environment variables ranged from .019 to .131 for those five studies. These effect sizes thus seem rather miniscule although even supposedly small effects can be practically meaningful, consequential, or accumulate across time (Funder & Ozer, 2019).

These disparate findings can be reconciled when considering several issues. First, person-environment interactions derived from experience sampling data in daily life may look differently than those from experimental designs. Specifically, the signal to noise ratio may be different (with more noise in repeatedly measured field data) so that interactions – which are notoriously subtler than main effects – may be more difficult to detect. Second, detecting interaction effects reliably not only requires adequately powered studies but also a careful (e.g., representative) selection of persons and environments. Violating these principles may lead to Type I and II errors

(i.e., either spuriously finding interactions or missing actual interactions). Third, and associated with the previous point, researchers need to attend to balances and symmetries in their data and predictive models (see Table 3). For example, examining $P = f(p, E)$ may be balanced (there is one p and one E predictor), but not symmetrical (a short-term P is supposed to be predicted from a long-term p with a short-term E). Given that there likely is covariance shared among P , p , E , and e (see 4.2 *Person-Environment Correlations*) and that said covariance may be differentially distributed according to short- vs. long-term timescales, attending to balances and symmetry is important. For example, short-term P and E may be differently correlated to each other than long-term p and e , and those time-scale symmetrical correlations may differ from asymmetrical ones such as P with e and E with p . Fourth, the type of measurement of both person and environment variables – especially with which data sources they are tapped (e.g., self-ratings of P and *in situ* ratings of E) – may also account for the differences observed in the literature. Lastly, by focusing only on linear interactions, potentially interesting and important patterns in the data may be missed. Specifically, non-linear terms may yield a fuller picture and even allow examining nuanced hypotheses about person-environment fit in relation to outcomes variables (see 4.1.4 *Effect Patterns* and 4.1.5 *Outcome-based, Variable-oriented Person-Environment Fit*).

4.2 Person-Environment Correlations

A downstream net result of the many effects and transactions going on in the PERM is the correlation between person and environment variables. This means that certain persons are non-randomly assorted into certain social and non-social environments. Table 6 compiles 32 different forms of person-environment correlations that are possible depending on which person and environment variables or profiles serve as input (for options, see Table 2).

As can be seen in Table 6, a broad distinction can be made between (1) variable-oriented R correlations (e.g., a single person and a single environment variable are correlated across a person sample) and (2) person- or profile-oriented Q correlations (e.g., a profile of person variables is correlated with a corresponding profile of environment variables within single persons). Another important distinction concerns (3) the symmetry regarding the person and environment variables' respective timescales. For example, a PE correlation is symmetrical (both the person and environment variables are defined as short-term variables; e.g., Rauthmann et al., 2016), while a pE correlation is not (one variable is defined as long-term, the other as short-term; e.g., Rauthmann et al., 2015c). Lastly, a person-environment correlation can be interpreted simply as a meaningful or statistically significant association between a person and environment variable or as person-environment fit. The latter is a special interpretation of person-environment correlations, and some may argue it is only warranted when there is commensurability between the person and environment variables (i.e., at least in terms of content, measurement, and scalability; see also *4.1.5 Effect Patterns*, *4.1.5 Outcome-based*, *Variable-oriented Person-Environment Fit*, and *4.3 Person-Environment Fit*).

4.2.1 Variable-oriented Correlations. If persons and environments are non-randomly intertwined, then single person and environment variables should be correlated to some extent. Such correlations, if statistically significant, sizable, or meaningful, can be a result of ongoing transactions or, more specifically, how persons find themselves in and navigate their environments (see *5. Person-Environment Calibrations and Navigation Mechanisms*). There are several reasons why single person and environment variables may become associated or synchronized across time. For example, one such reason is that persons, to a certain extent, select, evoke, modify, and create their environments. If this happens in person-congruent ways (e.g., according to one's traits or to one's momentary goals), then person and environment variables

will show correlations to some extent (Fraley & Roberts, 2005; Ickes et al., 1997). This may be the case for both symmetrical (two long-term or two short-term variables being correlated) and asymmetrical correlations (one short-term and one long-term variable being correlated).

Details on the quantification of variable-oriented person-environment correlations can be found in Box 2. The following is a necessarily eclectic snapshot of a myriad of studies that have quantified concurrent person-environment correlations. However, studies from the six domains of (1) behavior genetics, (2) work, (3) relationships, (4) social investments, (5) daily life, and (6) simulations are singled out here because they showcase a broad range of topics studied and were substantively interested in person-environment correlations.

– Box 2 –

4.2.1.1 Behavior Genetics. The behavior-genetic literature has already catalogued ways in which persons with a certain set of genes (p) are non-randomly found in certain environments or niches (e) (Kandler et al., Chapter 7; Plomin, DeFries, & Lohelin, 1977; Scarr & McCartney, 1983). Such gene-environment correlations are non-negligible as they have implications for estimates of specific model parameters in behavior-genetic analyses (Briley et al., 2019), such as the analysis of twin data (Purcell, 2002). An interesting downstream effect of genotype-environment correlations (i.e., two correlated long-term variables) is that measures of the environment (e.g., self-perceptions, informant-perceptions, and observations) also show genetic contributions (7-39%; Kendler & Baker, 2007). In this vein, Plomin et al. (1990) have also found genetic influences on life events, which may be mediated by personality traits (Saudino et al., 1997). This means that even the environments we find ourselves in likely are, at least partly, also driven by our genotypes and personalities. This nicely exemplifies what person-environment correlations conceptually capture: The person and the environment are inextricably concatenated in complex ways which means that person variables will contain variance from environments and

environment variables variance from persons – even if person and environment variables can be theoretically and even measurement-wise neatly segregated.

4.2.1.2 Work. For demands in work environments, Denissen et al. (2014) examined, among other things, for each of the Big Five domains how self-reported personality trait scores (p) of persons working in certain vocations were correlated with personality-related role demands (e) of those vocations (as rated by students and experts). They termed this person-environment correlation the “kernel of truth” because it conveys that “occupations that score high on a particular personality norm demand are also carried out by persons who actually score high on the corresponding trait” (p. 1936). Those correlations ranged from $-.14$ (conscientiousness) to $.69$ (openness) and were particularly high for openness, extraversion, and agreeableness. Thus, on average, persons reported trait levels that were concordant with consensual role demands of their jobs.

For stressors in work environments, Ford et al. (2014) conducted a meta-analysis on synchronous (same-time) stressor-strain effects, where “stressors” are environmental variables (e.g., workload, conflicts) and “strain” person variables (e.g., psychological and physical symptoms, such as exhaustion, irritation, depression, illness). They used studies that measured stressors and strains at least at two time-points so they could examine to what extent stressor-strain correlations increased across time. Stressors were correlated meta-analytically with psychological strain at $.35$ (Time 1) and $.37$ (Time 2) and with physical strain at $.12$ (Time 1) and $.14$ (Time 2).

4.2.1.3 Relationships. Turning to social environments, one could view assortative mating and friendship homogeneity effects as person-environment correlations. For example, if trait levels of friends and/or romantic partners are similar to persons’ own trait levels, then such person-person similarity indexes person-environment correlations. In such cases, the environment is defined as other persons, their behaviors, their personalities, or the relationships or

interpersonal dynamics with them (Asendorpf, 2020; Back, Chapter 8; Clark, Lemay, & Reis, 2020; Roche & Cain, Chapter 25; Pincus et al., 2020; Molho & Balliet, 2020).

A recent study with several thousand Facebook users examined assortative person-environment correlations for friendships and romantic partners using status updates and likes which were algorithmically converted to Big Five scores (Youyou et al., 2017). Additionally, the authors had self-reports on the Big Five and thus were able to also quantify self-report-based similarities. In all instances, similarities (expressed in r units) were – on average across all Big Five traits – rather small to moderate for self-reported scores, likes-derived scores, and language-derived scores from status updates for friends (.06, .14, .24) and couples (.10, .24, .38). Thus, this research demonstrates that there is some, though likely small non-random assortment among persons (i.e., personality homophily: correlations between a person's trait levels and others' trait levels). The evidence for the implications and consequences of such personality homophily seems to be mixed, however. For example, Weidmann et al. (2017) used concurrent and longitudinal dyadic polynomial regression analyses and found only little evidence that the similarity of heterosexual couples in their Big Five traits conferred benefits for relationship satisfaction.

Whether persons select others who are more similar to themselves (niche selection or construction) and/or actually become similar to each other across time (e.g., via social influences) is often not disentangled. However, recent studies showed that friendship similarity seems to be mainly driven by niche construction mechanisms (Bahns et al., 2017). Such questions concern in fact dynamic person-environment transactions (see 4.4) as well as calibrations and navigation mechanisms (see 5.). Person-environment correlations, as presented here, are defined to be non-dynamic and stationary but dynamic mechanisms can explain their occurrence.

4.2.1.4 Social Investments. Looking at social investments into different life domains, experiences, and social roles, Lodi-Smith and Roberts (2007) conducted a meta-analysis on the

relations between the three “maturity” Big Five traits (agreeableness, conscientiousness, emotional stability) and social investments into work, family, religion, and volunteerism in cross-sectional studies. These findings can thus be relevant to person-environment correlations insofar as actual environment and not person variables (e.g., experiences, performance, behaviors) have been sampled in the studies that went into the meta-analysis. Meta-analytical correlations between the three maturity traits and social investment categories ranged from .11 to .19 for work, from .15 to .16 for family, from .00 to .16 for religion, and from .02 to .15 for volunteerism. Together, the meta-analysis provided evidence for small to moderate relations between mature traits and social investments in different life domains.

4.2.1.5 Daily Life. The previous studies all concerned *pe* correlations between enduring variables, but what about *PE* correlations between momentary variables? For example, Fleeson (2007) found contingencies between Big Five state enactments and momentary situation characteristics (anonymity, task orientation, others’ friendliness, others’ status) to range between -0.10 to 0.67 in his Study 1 and between -0.18 to 0.30 in his Study 2¹³, with some inter-individual differences in those contingencies (*SDs* = 0.07-0.25 in Study 1 and *SDs* = 0.10-0.20 in Study 2). Sherman et al. (2015) and Rauthmann et al. (2016) examined in self-reported experience sampling data, among other things, concurrent associations between 10 personality states (*P*; Big Five states, plus honesty/humility, dominance, self-esteem, happiness, and authenticity) and 8 momentary experiences of situation characteristics (*E*; DIAMONDS: Rauthmann et al., 2014). On average across all possible 80 pairings of person and environment variables (Rauthmann et al., 2016), absolute cross-sectional associations amounted to 0.09¹³ (*SD* = 0.08). Looking at only 23 pairings that were a priori specified as conceptually plausible and sensible, the average

¹³ As with most multi-level model analyses, these are unstandardized effects. This means: For every one-point increase in the predictor, the criterion increases in the amount of the unstandardized effect.

absolute effect size was higher at 0.16 ($SD = 0.07$). It seems that when it comes to more short-term timescales (i.e., hours in the case of experience sampling methodology), then momentary person-environment correlations may be smaller. However, even if they are small momentarily, they could accumulate to impressive effects across longer periods of time (see Funder & Ozer, 2019 for a discussion). Furthermore, Sherman et al. (2015) also estimated the amount of inter-individual differences in contingencies (ranging from 0.08 to 0.26) which were barely related to personality traits (i.e., only small and often statistically non-significant cross-level interaction effects in multi-level modeling). Thus, taken together, there appear to be small to moderate actual genetic person-environment correlations (“contingencies”) but their nomological networks are poorly understood so far. The surveyed findings await replication, and person-environment correlations deserve a more systematic and broader examination.

4.2.1.6 Simulations. Using computational modeling with simulations, Fraley and Roberts (2005) examined person-environment relations across ages. In their model, the correlation between individual differences in a psychological or person variable and an environment variable increased sharply from age 0 to 7 and then reached a plateau of approx. $r \approx .35$ around age 8 and later (see their Figure 4 on p. 69). They termed this correlation “coherence” (for a full overview on this term, see Fournier, Chapter 17) and linked it to person-environment fit. However, whether or not a variable-oriented person-environment correlation represents “fit” is likely more a conceptual question. Regardless, it is interesting that this finding reflects the empirical person-environment correlations cursorily reviewed above relatively well. This additionally lends credence to Fraley and Robert’s (2005) model and its operationalizations.

4.2.2 Person-oriented Profile Correlations. “Fit” can generally be defined as the match, similarity, correspondence, or congruence between person and environment variables (Caplan, 1987; Edwards et al., 1998; Kristof-Brown & Guay, 2011). More precisely, Harrison (2007, p.

391) defines fit as “a state of compatibility of joint values of one or more attributes, $a, b, c, \dots j$, of a focal entity (P), and a commensurate set of attribute values, $a, b, c, \dots j$, of the entity’s environment (E)”. This definition can be expanded to a profile approach which, according to O’Reilly, Chatman, and Caldwell (1991), “(...) comprehensively assesses individuals and situations using a common language, allows for the ipsative measurement of individual characteristics by arraying attributes in terms of their salience to the individual, and provides a direct measure of person-situation fit” (p. 491). Empirical research has already adopted such a profile approach to fits between enduring $\ddot{p}$ and $\ddot{e}$ profiles (e.g., need-reinforcer correspondence: Rounds, Dawis, & Lofquist, 1987; person-job fit: Caldwell & O’Reilly, 1990; organizational goal congruence: Vancouver & Schmitt, 1991; work value congruence: Meglino, Ravlin, & Adkins, 1992; person-organization fit: Cable & Judge, 1996; O’Reilly et al., 1991; value-resource fit: Roberts & Robins, 2004; need-press fit: Harms et al., 2006). Usually, the person variables represent different forms of enduring $\ddot{p}$ (e.g., values, needs, goals, abilities), and the environment variables different forms of enduring $\ddot{e}$ (e.g., presses, affordances, demands, or supplies from another person or group, team, job, vocation, organization, neighborhood, city, region, or culture). In essence, most person-environment fit theories and models thus consider the person variables to be traits and the environment variables to be a rather enduring socio-ecological niches. However, as Table 6 alerts us, there could be also several other forms of person-environment fit that rely on different interpretations of the person and environment variables.

Details on profile analyses can be found in Box 3. While person-environment fit has been studied mainly in industrial/organizational psychology, there is also already some research from social and personality psychology. This section serves to just briefly highlight findings especially (though not exclusively) from the latter strings of research.

– Figure 5 –

In terms of the stability of person-environment fit (path m , Figure 2), previous studies have demonstrated that there is almost no or only little mean-level change (with somewhat increasing means) and substantial rank-order stability (r_s between .30s to .60s) across years (Chatman, 1991; Harms et al., 2006; Richards, 1993; Roberts & Robins, 2004). These studies, however, all concern fit between trait and niche variables in academic or organizational contexts, and thus the generalizability of their findings to other forms of fit (Table 6) and different context domains remains open. More recently, Rauthmann and Sherman (in prep.) examined the levels, stabilities, correlates, and cross-method generalizability (across self- and other-ratings) of patterned person-environment correlations (which they interpreted as “fit”). To do so, the computed q -correlations across 31 items for $\check{p}\check{E}$ (asymmetrical) and $\check{P}\check{E}$ fits (symmetrical) from four waves of data, each days to weeks apart. Several findings stand out. First, the normative person and environment variable profiles were substantially correlated ($q_s = .64-.77$), suggesting relatively high normative person-environment fit. Indeed, overall fits were, on average, higher, more reliable, more strongly intercorrelated, more temporally rank-order stable, and more strongly correlated in nomologically sensible ways with self-reported intrapersonal adjustment variables (depression, happiness, ego-control, well-being) than distinctive fits. This means that, at least in this study, the links between patterned person-environment fit and adjustment could be traced back to normativity. Second, in almost all cases, there was sizable variance in individual q -correlations, thus suggesting the presence of inter-individual differences in patterned person-environment fits. Third, $\check{P}\check{E}$ fits were somewhat stronger than $\check{p}\check{E}$ fits. Lastly, because different rating sources were used for personality traits (self vs. peer-ratings) and for situation ratings (*in situ* vs. *ex situ*), the cross-method generalizability of the patterns of findings could also be

examined. While most patterns held up, there was evidence for common-method biases (e.g., higher intra-source and lower inter-source correlations). Taken together, this study demonstrated that patterned person-environment fit in daily life is at least moderately sizable and that there are inter-individual differences in overall and distinctive forms of such fit that are also somewhat stable and correlated mostly due to normativity with adjustment variables.

4.3 Person-Environment Fit

4.3.1 Important Distinctions. The concept of person-environment fit dates back to Plato (Dumont & Carson, 1995), Parson's (1909) matching model of career decision-making, Lewin's (1936, 1943) field theory, and Murray's (1938) need-press model (see Edwards, 2008 for a review). Today, it is deeply entrenched in industrial/organizational and work psychology (Caplan, 1987; De Cooman et al., 2019; Edwards, 2008; Edwards, Caplan, & Harrison, 1998; Edwards & Shipp, 2007; Harrison, 2007; Kristof, 1996; Kristof-Brown & Guay, 2011; Pervin, 1968; Schneider, 2001; Schneider, Goldstein, & Smith, 1995; Spokane, Meir, & Catalano, 2000), while less often studied in personality and social psychology (cf. Bleidorn et al., 2016; Denissen et al., 2018; Harms, Roberts, & Winter, 2006; Rauthmann, 2013; Roberts & Robins, 2004). Schneider (2001) even elevated person-environment fit to one of the most important concepts in entire psychology, noting that "[o]f all the issues in psychology that have fascinated scholars and practitioners alike none has been more pervasive than the one concerning the fit of person and environment" (p. 141).

Despite or maybe even because of its importance, person-environment fit has been operationalized quite differently in the literature, both in conceptual and methodological-statistical terms. However, in each case, it may be expressed by, or at least involve, person-

environment interactions or correlations. As previously explained, one can broadly distinguish person-centered, profile-oriented from variable-centered person-environment fit.

The *person-centered view* (see 4.2.2) can model person-environment fit as a *q*-correlation between a profile of person variables and another profile of concordant environment variables. The resulting *q*-correlations are computed for each person which makes it possible to examine the extent of inter-individual differences in profile-level person-environment correlations, their stability, and their nomological correlations with other variables. Further, normative profiles of person and environment variables may also be controlled in such analyses. If such *q*-correlations are referred to as “fit”, then this fit concept essentially captures a person-environment correlation at the profile-based person level.

The *variable-centered view* can come in two forms (see 4.1.5 and 4.2.1). First, two variables – a person and an environment variable – may be correlated with each other. At the sample level, the resulting correlation coefficient (often Pearson’s *r*) is an index of a variable-based person-environment correlation. However, using Asendorpf’s (1990) approach (see Box 2), individual person-environment correlation scores can also be derived and thus inter-individual differences in such correlations correlated across time or with other variables. Second, polynomial regression with response surface analyses may be used to examine to what extent person-environment fit patterns are present when predicting an outcome from the linear main effects of person and environment variables, their respective quadratic (and sometimes even cubic) effects, and their interaction effect (see Box 1). In contrast to the previous conceptions of fit, this fit interpretation does not rely on a correlation between person and environment variables but is constituted by a specified effect pattern (see Humberg et al., 2019 for details on which conditions need to be tested and met).

Further, it is important to consider how an index of fit is derived and what it means.

According to Edwards et al. (2006), there is an atomistic, molecular, and molar approach. In the atomistic approach, person and environment variables are measured each separately, and then fit indices will be derived (e.g., via profile correlations, individual-level scores of sample correlations, or polynomial regression analyses). However, this also means that there can be many different kinds of person-environment fit (for *each* of those tabulated in Table 6), depending on which person variables (e.g., morphology, dispositions, abilities, goals, values, virtues, strengths, self-concepts, etc.) and environment variables (e.g., discrete life events, psychological situation characteristics, others' normative values, average neighborhood personality trait levels, organizational atmospheres, etc.) were measured in which fashion (e.g., self-reports vs. informant-reports). For example, Edwards and Cooper (1990) argued that the fit between persons' goals and values with supplies from the environments is a different type or version of fit than the fit between persons' abilities and environments' demands. Thus, for the understanding of what a given atomistic person-environment fit score or effect pattern means, it is crucial to clearly specify and operationalize the involved person and environment variables. In the molecular approach, persons are asked to report on their perceived discrepancies between person- and environment-level entities (e.g., whether their workload is too much for their abilities). In the molar approach, persons are asked to directly report on their own person-environment fit (e.g., how well they fit to an organization). It has been empirically shown that the atomistic, molecular, and molar approaches are not interchangeable and relate only modestly to each other at best (Edwards et al., 2006). As they do not seem to tap the same concepts, each of them provides a unique window into understanding different aspects of person-environment fit.

Apart from these more methodological considerations, there are also functional differences in person-environment fit. For example, a broad distinction can be made between supplementary vs. complementary fit of person and environment variables (Cable & Edwards,

2004; Muchinsky & Monahan, 1987). Supplementary fit can be said to occur when high or low “demands” from an environment meet high or low “supplies” from a person. For example, dutiful situations require high conscientiousness, and intellectual situations require high open-mindedness. Thus, person and environment variables supplement each other in these examples. In contrast, complementary fit can be said to occur when high or low “demands” from an environment meet low or high “supplies” from a person. For example, situations where other persons are dominant may require less dominance from an actor (i.e., submissiveness), and those situations where others are submissive more dominance from the actor. Thus, person and environment variables complement each other in this example. The distinction between different types of fit also has implications for the commensurability of person and environment variables (e.g., supplementary fit arguably requires stronger commensurability).

4.3.2. Processes and Consequences of Person-Environment Fit. If the correlation between a person variable and a conceptually, contentwise, or practically concordant environment variable, or between profiles of concordant person and environment variables, is interpreted as “fit”, then the generic PERM in Figure 2 can accommodate and guide more nuanced models. An example is given in Figure 6 that extends path e of the PERM, showcasing how person-environment fit may predict multiple proximal and distal outcomes that capture the duality of persons’ identity (the intrapersonal domain) and reputation (the interpersonal domain; Hogan, 1982).

– Figure 6 –

As explained in more detail below, unique hypotheses concerning the intrapersonal domain are that persons with higher person-environment fit should, on average, be more cross-temporally stable in their trait-relevant enactments, show less personality change, feel more authentic, experience more positive affect in daily life, and report higher life satisfaction.

Concerning the interpersonal domain, they should be easier to judge in their personalities (i.e., be good targets) and be more liked or valued by others in groups. Together, persons with higher person-environment fit could be expected to be well-adjusted and, as such, have more resources at their disposal which would enhance survival and reproduction. Given such crucial importance of person-environment fit, persons may be motivated to attain, and also monitor, specific fits to their environments.

To capture all of these complexities, the extended person-environment fit process model presented here is inspired by, and can tie together, diverse literatures (e.g., on identity, self, impression formation, group processes, niche construction, adjustment, adaptation, fitness, etc.). To my knowledge, no study has so far tested all the different effect paths proposed in Figure 6 simultaneously, though some isolated effects have already been examined (see cursory survey of the literature below).

As can be seen in Figure 6, a *person-environment correlation* (any form from Table 6), defined here as fit, may first proximally impact *trait expressions*: specifically, which kinds of affects, behaviors, cognitions, and desires (ABCDs; Wilt & Revelle, 2015) will be expressed how strongly and how consistently. In other words, person-environment correlations may constrain the repertoire and actualization of personality-relevant dynamics and processes in *content*, *level*, and *variation*. Those trait expressions, dependent upon person-environment correlations, then go on to yield more distal effects for the self (intrapersonal route) and for others (interpersonal route) in the three domains of *traitedness*, *evaluations*, and *adjustment*. In all cases, there can be direct effects (e.g., from trait expressions on adjustment) and more indirect or mediated effects (e.g., from the person-environment correlation to adjustment, via trait-expressions, traitedness, and evaluations). Further, intra- and interpersonal processes may also depend on and co-influence each other across time.

Intrapersonally, the ways in which traits are expressed habitually lead persons to develop a sense of their *self-predictability* (how well they know themselves and can anticipate how they react to certain circumstances). Self-predictability is of course also dependent on several other self- and identity-related variables and processes (Thagard & Wood, 2015; Morin & Racy, Chapter 15; Pasupathi & Adler, Chapter 16), such as (but not limited to) self-consistency, self-verification, self-concept clarity, self-insight, and schematicity of self-concept areas. Self-predictability, in turn, may be associated with own perceptions and feelings of *authenticity* (feeling in tune with and true to one's "real" self), and both may then lead to different indicators of *intrapersonal adjustment* (e.g., self-esteem, positive affect, flourishing, mental health, well-being, life-satisfaction, etc.). The degree to which perceived authenticity is tied to intrapersonal adjustment may depend also on persons' perceived valence of the ABCDs as a moderator (e.g., how personally important or consequential they deem certain ABCDs and/or how valuable they think they are to their socio-cultural reference group).

Interpersonally, the ways in which traits are expressed habitually lead others to develop a sense of targets' *predictability* (how well they can be "read" and their behaviors, or personalities, predicted). Knowing about targets' predictability may also be related to evaluations of their perceived *trueness* (how true to themselves they seem and to what extent they are acting "out of character"). Both, in turn, may affect how the target is accepted socially and thus also influence *interpersonal adjustment* (e.g., liking, status, prestige, leadership emergence, etc.). However, an important moderator will be the socio-cultural valence, normativity, and importance of the involved ABCDs.

The process model in Figure 6 rests on several assumptions but also bears novel hypotheses. First, attaining person-environment fit should be a core concern of most persons, though there may of course be inter-individual differences in how strongly persons strive to

pursue fit (motivation) and how much energy and resources they invest (investment). Indeed, Erikson (1968) had already described finding a fitting niche as a task for identity development. It also seems that persons will be more engaged and interested in as well as invest more into environments (e.g., occupations, social roles) that fit with or afford their goals and values (for an application of this principle to women's aspirations for pursuing STEM careers, see Diekmann et al., 2017). Schmader and Sedikides (2018) have termed the underlying process of pursuing one's goals in an environment that affords those goals "motivational fluency" and surmised that it fosters perceptions or feelings of self-determination. Thus, persons should be motivated to approach goal-fitting environments and avoid others. Indeed, low person-environment fit may instigate selection effects (Holland & Nichols, 1964), and even after important life transitions, persons tend to create personality-fitting niches (e.g., Jonkmann et al., 2014; Lüdtke et al., 2011; Zimmermann & Neyer, 2013).

Second, if person-environment fit is normatively so important, then there may be monitoring systems that constantly gauge how well we fit to our environments. Indeed, this is the idea of sociometer theory (Leary et al., 1995; Leary & Baumeister, 2000) which builds on a fundamental need to belong (Baumeister & Leary, 1995): persons monitor social cues for acceptance versus rejection, and the resulting experiential outcomes of that monitoring are feelings of self-esteem. Correspondingly, it has been found that stronger forms of psychological fit may decrease uncertainties and increase social validation which then can lead to higher self-esteem (Hardin & Higgins, 1996; Leary, 1999). Further, persons may "feel right" when person and environment variables are synchronized (Cesario, Grant, & Higgins, 2004; for similar arguments in the domain of regulatory fit when the manner of activity engagement sustains motivational orientations, see Higgins, 2005). According to Schmader and Sedikides (2018), this may lead persons to actively seek environments that afford "interpersonal fluency" (being oneself

with others). Thus, if persons possess something like a “need to fit” and a corresponding generalized “fitometer” system monitoring the different ways in which they fit to their social and non-social environments, then the system’s output may result in feelings of positive affect, authenticity, and self-esteem – all indicators of intrapersonal adjustment. Interesting further questions are then to what extent persons’ subjective experiences of fit align with their actual fit (e.g., Edwards et al., 2006) and the extent of inter-individual differences in such fit insights.

Third, person-environment fit should be generally tied to both intra- and interpersonal adjustment.¹⁴ Indeed, person-environment fit itself has been related to and even interpreted as adjustment (French, Rogers, & Cobb, 1974; Thomas & Chess, 1977). For example, living in areas matching one’s personality has been shown to confer certain benefits and increased life-satisfaction (Bleidorn et al., 2016; Jokela et al., 2015). Additionally, such adjustment via person-environment fit may result in greater consistency or stability of personality (Wachs, 1994). Indeed, Roberts and Robins (2004) found in a longitudinal study that students with higher fit to their university environment showed overall less personality change across time.

Fourth, a consequence of the adjustment of persons with generally high person-environment fit is that, at least within the domains that the person-environment fit pertains to, this person may be more normative and easier to judge (good target; Funder, 1995, 1999) than persons with less person-environment fit. Indeed, well-adjusted persons seem easier to judge in terms of their personality traits (Human & Biesanz, 2013; Human et al., 2019), and this should also pertain to those with higher person-environment fits.

Lastly, a downstream effect of person-environment fit processes occurring at sub-population levels is the non-random assortment of persons to specific environments. This means

¹⁴ Per sociometer theory, this seems plausible just at face value because if other persons accept and like a person (interpersonal adjustment), then this person will feel good about themselves (intrapersonal adjustment).

that there will be spatial clustering of personality phenotypes (and even genotypes) in certain regions (see, e.g., research on geographical and spatial distributions of personality trait levels: Jokela et al., 2015; Rentfrow, 2013; Rentfrow & Gosling, in press; Rentfrow & Jokela, 2017, 2020; Rentfrow, Gosling, & Potter, 2008), which likely confer local fitness optima for “fitting” individuals. Such spatial clustering of personality can, in turn, help explain economic growth differences between regions (Garretsen et al., 2019). However, geographical personality distributions and regional variations have also been shown to be the product of societal and economic changes decades earlier (Obschonka et al., 2018). Historically important and large-scale changes can also contribute to selective migration, which in turn may be seen as a macroscopic process of a large amount of persons striving to attain better person-environment fit (i.e., leaving one environment for a another one; see also 5.2.1.1 *A Systematic Account*). Indeed, relations between personality traits and migration patterns have already been documented (e.g., Camperio Ciani et al., 2007; Jokela, 2014; Jokela et al., 2008), leading to drifts in both genotypes and personality phenotypes. Thus, the striving for person-environment fit, coupled with the affordances from regions, societies, cultures, countries, or nations, can also have implications for group and social identity (Schmader & Sedikides, 2018), mobility processes (Oishi, 2017), socio-cultural processes and person-culture fit (Benet-Martínez, Chapter 10), and population dynamics (Camperio Ciani et al., 2007; Ciani & Capiluppi, 2011).

4.4 Person-Environment Transactions

Several theories and models emphasize bidirectional transactions between person and environment variables across time, development, or age (e.g., Baltes, Lindenberger, & Staudinger, 2006; Baltes, Staudinger, & Lindenberger, 1999; Bandura, 1978; Briley & Tucker-Drob, 2014; Caspi, Elder, & Bem, 1989; Corker & Donnellan, 2020; Elder & Shanahan, 2006; Ford & Lerner, 1992; Lerner, 1978; Lerner & Walls, 1999; Magnusson & Stattin, 2006; Plomin

et al., 1977; Rowe, 1987; Scarr & McCartney, 1983; Shiner, 2009). These transactions take the form that prior person variables predict later environment variables and, vice versa, prior environment variables predict later person variables. Thus, *person-environment transactions* concern the phenomenon that person variables ($\mathbb{P}$, $\mathbb{p}$) and environment variables ($\mathbb{E}$, $\mathbb{e}$) may be related to each other across time, that is, one can temporo-sequentially and/or causally predict the other. Two issues need to be accounted for here:

1. The timescales of the variables used
2. The patterns of transaction effects across time

4.4.1 Timescales of Variables. As explained earlier, there are rather short-term ($\mathbb{P}$, $\mathbb{E}$) and rather long-term variables ($\mathbb{p}$, $\mathbb{e}$) on the side of the person and the environment, respectively (Table 2). This distinction corresponds to variables being different in their conceptualizations and measurement in terms of their proximity/distality, abstractness/specificity, and temporal resolutions. Thus, when relating person and environment variables to each other *across time*, their respective shorter- vs. longer-term timescales need to be taken into account. This is illustrated in Figure 7. Specifically, if earlier variables predict later variables, four types of *underlying processes* can be inferred from the predictions (Figure 7):

1. Longer-term variable predicts longer-term variable (*ontogenetic process*)
2. Longer-term variable predicts shorter-term variable (*manifestation/expression process*)
3. Shorter-term variable predicts shorter-term variable (*actualgenetic process*)
4. Shorter-term variable predicts longer-term variable (*accretion/accumulation process*)

– Figure 7 –

4.4.1.1 Ontogenetic Processes. A stable, long-term variable can predict another stable, long-term variable. Such ontogenetic transactions are symmetrical because both person and environment variables are defined as enduring or only slowly changing. For example, research

has especially examined how genetic variance ($\mathbb{P}$) becomes associated with environmental differences ($\textcircled{e}$) across time (Johnson, 2007; Kandler et al., Chapter 7) as well as how personality traits ($\mathbb{P}$) predict persons' personal, social, and occupational niches ($\textcircled{e}$) and/or vice versa (e.g., work niches: Hudson, Roberts, & Lodi-Smith, 2012; Mortimer & Lorence, 1979; Roberts, Caspi, & Moffitt, 2003; Wille & de Fruyt, 2014; Woods et al., 2013; relationship niches: Asendorpf & Wilpers, 1998; Deventer et al., 2019; Kiff, Lengua, & Zalewski, 2011; Laceulle & van Aken, 2018; Mund & Neyer, 2014; Neyer, Mund, Zimmermann, & Wrzus, 2014; Mund et al., 2016; Neyer & Asendorpf, 2001; Reitz, Motti-Stefanidi, & Asendorpf, 2016). The processes linking enduring person and environment variables across time are ontogenetic because they unfold over longer timescales or even across the lifespan. Usually, personality and developmental psychologists will be interested in such long-term dynamics and processes (Baltes et al., 1999, 2006; Ford & Lerner, 1992; Lerner, 1978; Lerner & Walls, 1999; Wrzus & Roberts, 2017).

Attending specifically to bidirectional transactions between long-term person and environment variables (see 4.4.2 *Transaction Effect Patterns across Time*), it has been argued that there can be selection and socialization effects. These effects occur because there are “two mutually supportive life-course dynamics: “social selection,” wherein persons select environments that are correlated with their personality traits, and “social influence,” wherein environmental experiences affect personality functioning” (Caspi et al., 2005, p. 470; Roberts & Wood, 2006). Thus, there are two concatenated or interlocked processes occurring, namely that (1) persons select and/or modulate their environments according to their traits (see Gosling et al., 2002 and Gosling, Gaddis, & Vazire, 2008 for personality-manifestation in personal environments) and that (2), in turn, these traits are consolidated by the selected environments (via socialization processes). In this vein, the corresponsive principle of personality development (e.g., Roberts, 2006; Roberts & Robins 2004; Roberts & Wood, 2006) states that traits lead

persons to select certain environments and make specific experiences in them, and then those experiences *change* (not stabilize) those initial traits. According to an overview in Roberts and Nickel (in press), several studies seem to already have yielded a corresponive pattern of findings in different person and environment domains (e.g., a large number of person and life experience variables in different domains: Lüdtke et al., 2011; Roberts et al., 2003, 2004; Roberts & Robins, 2004; alcohol-proneness in youth and peer-groups: Scalco, Trucco, Coffman, & Colder, 2015; impulsivity and substance use: Kaiser et al., 2016; traits and behavioral problems: Klimstra et al., 2010; neuroticism and stressful or negative life events or stress: Jeronimus et al., 2014; Laceulle et al., 2015; Luo et al., 2017; temperament and relational aggression: Atherton et al., 2017; effortful control and behavioral problems at school: Atherton et al., 2019; traits and goals: Bleidorn et al., 2010; Big Five traits and job characteristics: Denissen et al., 2014). However, there is also evidence for non-corresponive patterns (e.g., Wood & Harms, 2016). Indeed, not all ontogenetic transactions need to follow a corresponive pattern, and corresponive effects may not operate for longer periods of time (Roberts & Nickel, in press) as there must be some form of counter-regulative mechanism to prevent ever-more change occurring in the system *ad infinitum*.

There are at least three issues to keep in mind when examining the literature on corresponive effects. First, several studies did not actually measure environmental variables, but focused more on persons' experiences (which are thought of as the extensions of engaging with certain environments). Thus, indeed corresponive person → person transactions have been studied more often than actual person → environment transactions. Second, the corresponive principle is about change, but it can easily be confused as being about continuity or stabilization. Thus, the niche-picking principle has been introduced (Nye & Roberts, 2019; Roberts & Damian, 2017; Roberts & Nickel, 2017, in press) which maintains that persons with certain trait levels enter or create certain niches that, in turn, serve to deepen or *stabilize* (not change) their initial

traits. Indeed, this idea has already been brought forward by Bowers (1973) who noted that “persons foster consistent social environments which then reciprocate by fostering behavioral consistency” (p. 329). So far there is only indirect evidence for a niche-picking pattern (better person-environment fit results in less change: Harms et al., 2006; Roberts & Robins, 2004) as this principle has not yet been directly tested. Lastly, many studies could not properly disentangle within-person from between-person effects (and artifacts). It thus remains an open question to what extent findings will be replicable when employing different designs and data-analytical procedures.

4.4.1.2 Manifestive/Expressive Processes. Second, a stable, long-term variable can predict a more instable, short-term variable. Such manifestive transactions are asymmetrical because the person and environment variables are defined at different timescales. For example, personality traits ($\mathbb{P}$) may predict the characteristics of situations ($\mathbb{E}$) persons find themselves in (Rauthmann et al., 2015c) or more enduring characteristics of persons’ daily situations ($\textcircled{E}$) may predict personality states ($\mathbb{P}$). In such instances, one variable can be said to manifest in or be expressed by another variable at a smaller, more fine-grained timescale. The concrete underlying processes unfolding in such manifestive or expressive transactions can be manifold and depend on the variables being studied.

4.4.1.3 Actualgenetic Processes. Third, a more instable, short-term variable can predict another instable, short-term variable. Such actualgenetic transactions are symmetrical because both the person and environment variables are defined as fast-changing or momentary variables. For example, research has examined how prior self-reported personality states ($\mathbb{P}$) predict later perceived situation characteristics ($\mathbb{E}$) and vice versa in experience sampling data (Rauthmann et al., 2016). Further, a plethora of experimental and social-psychological research has linked momentary cues or characteristics ($\mathbb{E}$) of situations to different momentary thoughts, feelings,

motivations, and behaviors ($\mathbb{P}$) of persons (e.g., Reis, 2008; Richard, Bond, & Stokes-Zoota, 2003). The processes linking short-term person and environment variables across time are actualgenetic because they reflect ongoing dynamics and how the transaction unfolds in short-term timespans. While social psychology has been traditionally interested in such environment-to-person processes, personality psychology has recently become more invested in understanding more fine-grained timespans of personality dynamics, processes, of functioning (e.g., Baumert et al., 2017; Blum et al., Chapter 2; Dermody et al., 2017; Fleeson, 2001, 2012; Hopwood, 2018; Wright & Hopwood, 2016; Zimmermann et al., 2019), often employing idiographic or within-person perspectives linking short-term variables to each other (e.g., Beck & Jackson, Chapter 4; Fleeson, 2017; Vazire & Sherman, 2017).

4.4.1.4 Accumulative/Accretive Processes. Lastly, a more instable, short-term variable can predict a stable, long-term variable. Such accretive transactions are asymmetrical because the person and environment variables are defined at different timescales. For example, this would be the case when situation variables ($\mathbb{E}$) predicted personality traits ($\mathbb{P}$) or when personality states ($\mathbb{P}$) predicted niche variables ($\mathbb{E}$). These kinds of processes can, for example, be found in the literature on the effect of life events or trauma on later development. However, in most of personality psychology, these processes have received comparatively less attention than the other process forms outlined before. One reason (besides measurement issues) may lie in the timescale asymmetry: most scholars would not believe that a single momentary person or environment variable, respectively, could impact a more stable environment or person variable, respectively. However, there are at least two instances where this may be the case.

First, some *single* shorter-term life events ($\mathbb{E}$) can instill or represent “time-discrete transitions that mark the beginning or the end of a specific status” (Luhmann et al., 2012, p. 594) and afford changes in demands, roles, status, or relationships. These could be so important (e.g.,

first long-term romantic relationship, first job), consequential (e.g., marriage, divorce, new job, parenthood), or even traumatic (e.g., losing one's job, death of a partner, being abused, having a bad accident) that they engender changes in long-term person variables (Bleidorn & Denissen, in press; in some dire cases, even growth: Baltes et al., 1999; Jayawickreme & Blackie, 2014, 2016; cf. Mangelsdorf, Eid, & Luhmann, 2019). For example, Bleidorn, Hopwood, and Lucas (2018) concluded in their comprehensive review of the extant empirical literature that there is "some evidence that life events can lead to changes in Big Five personality traits and that different life events may be differently related to specific trait domains", though they cautioned at the same time that "a more general conclusion emerging from [the] review is that the evidence for the nature, shape, and timing of personality trait change in response to life events is still at a preliminary stage" (p. 83). Most studies use a discrete or nominal account of a life event (i.e., whether it occurred or not), while failing to account for the potentially moderating roles of persons' perceptions and anticipations of life events (e.g., their valence, importance, predictability, controllability, extraordinariness, etc.; see Luhmann et al., 2020 for a taxonomy and measure) and the processes unfolding before, during, and after the event that may lead to stabilization or destabilization of personality traits (Roberts & Nickel, in press). Further, some short-term person variables (P) may also be hugely consequential for one's later niche ($@$), for example, when single acts of delinquency or crime (e.g., murder) lead to imprisonment, or when a heroic act or a very creative idea may change someone's social status.

Second, *several* momentary variables may accumulate over time in their effects on a more enduring variable. In this vein, the repeated exposure to certain situations (thus, E becoming $\bar{E}$) may be accompanied by, or instill, changes in long-term personality traits (p) across time (e.g., repeated instances of daily hassles, partner conflict, or bullying could engender more neurotic or hostile trait levels; repeated environmental exposures manifest in epigenetic biomarkers). Further, recent research has examined how interventions, and especially forms of psychotherapy (Roberts

et al., 2017), may instill personality change (for a review, see Hudson, Chapter 50). Such interventions constitute repeated exposures to certain situations ($\bar{E}$), which, for example, is exactly the case in exposure therapy (e.g., Abramowitz, Deacon, & Whiteside, 2019). Conversely, the repeated enactment of certain person variables (thus, P becoming $\bar{P}$) could have profound impacts on the niches persons craft for themselves in their daily lives and across the lifespan.

4.4.1.5 Summary. Taken together, when examining transactions between person and environment variables across time, it is important to specify for each variable at which timescale it resides. Depending on the timescales of the transacting variables, different underlying processes or types of transactions are examined (i.e., ontogenetic, manifestive/expressive, actualgenetic, accretive/accumulative). Notably, even when examining only shorter-term or longer-term variables, respectively, there may still be differences in proximity/distality, abstractness/specificity, and temporal resolutions among them (e.g., within shorter-term variables: unfolding across seconds vs. minutes vs. days; within longer-term variables: e.g., culture is at a different level of abstraction than one's neighborhood, and both are different from one's usual social networks). Further, "shorter-term" vs. "longer-term" should be seen on a continuum rather than as discrete categories. Keeping these issues in mind, the next section (4.4.2) concerns the *patterns of effects* of persons on environments and environments on persons. *Each* of those effects may be ontogenetic, manifestive/expressive, actualgenetic, or accretive/accumulative depending on how the variables have been conceptualized and measured.

4.4.2 Transaction Effect Patterns across Time. Given a person and an environment variable each measured at two time-points, there are two stability paths (of the person and of the environment variable; see paths j and k in Figure 2) and two cross-lagged paths (from the person to the environment variable, and from the environment to the person variable; see paths n and o in Figure 2) in the PERM. Depending on which of these four effects are "present" (i.e.,

statistically significant, sizable, or meaningful) across time, 16 different kinds of transaction effect patterns can be identified. These patterns are summarized in Table 7 and depicted in Figure 8. Additional patterns could be identified when also considering the cross-sectional presence or absence of person-environment correlations; however, for simplicity, these were not included in Figure 8. Broadly, four different kinds of transaction effect patterns can be distinguished:

1. Non-transactions
2. Bidirectional transactions (persons → environments, environments → persons)
3. Monodirectional transactions of persons → environments
4. Monodirectional transactions of environments → persons

– Table 7 –

– Figure 8 –

First, there are four *non-transaction effect patterns*. These patterns have been termed “non-transactional” because there are no effects from person to environment variables or from environment to person variables. One pattern (Zero Transaction) does not contain any effects at all, and the other patterns (Person Stability, Environment Stability, and Bi-Stability) only contain certain stability paths. Although such patterns may exist (e.g., some evidence for a Bi-Stability pattern in experience sampling data with P and E: Rauthmann et al., 2016), they do not capture genuine transactions between persons and environments.

Second, there are four *bidirectional effect patterns* which capture “transactions” how they are traditionally conceptualized: as mutual, reciprocal, or bidirectional relations between person and environment variables across time. For all of these effect patterns, the two cross-lagged effect paths are present, and they are distinguished only regarding the presence of stability effects (both present: Full; none present: Reset; only person-stability: Person-tilted; only environment-stability: Environment-tilted). It is especially noteworthy that these bidirectional transactions will

lead to (higher) person-environment correlations across time (see Fraley & Roberts, 2005 for a simulation study), though not infinitely so as there are natural and measurement boundaries as well as likely counter-regulative mechanisms acting against an ever-increasing correlation (i.e., it will stagnate at some point, reaching its asymptotic maximum, or even reverse). Moreover, looking to transactions in person-culture processes (see Benet-Martínez, Chapter 10), Markus and Kitayama (2010) stated that “[i]n a cycle of mutual constitution, people are culturally shaped shapers of their environment” (p. 421). Even more macroscopically, gene-culture co-evolution may occur as a result of the chronic unfolding of, and bidirectional effects between, genes and culture in populations (for a review, see Laland, Odling-Smee, & Myles, 2010).

Lastly, there are eight *monodirectional transaction patterns* where effects flow only into one direction: four patterns concern person variables predicting later environment variables (but not vice versa), and four other patterns environment variables predicting later person variables (but not vice versa). While these patterns are also termed transactions here, the temporal and/or causal impacts are one-sided and not reciprocal.

All transaction effects in Table 7 and Figure 8 could potentially be ontogenetic, manifestive/expressive, actualgenetic, or accretive/accumulative depending on how the respective person and environment variables have been operationalized and which research designs have been used. However, some effect patterns may be more likely or more pronounced with certain variables than others. For example, Denissen et al. (2014) have found different transaction patterns (e.g., bidirectional and monodirectional ones) depending on whether participants were job beginners, job stayers, and job changers as well as which Big Five trait was examined (see corresponding transaction patterns in their Figure 1, p. 1936). Further, with more than two measurement occasions, different effect patterns can be concatenated and yield more complex ones. In addition, patterns may develop, evolve, or change across time, becoming weaker or

stronger (e.g., when more stabilization or destabilization occurs). This makes it possible to identify cascades and vicious cycles (which still do not continue indefinitely, though).

4.4.2.1 Findings. This section necessarily contains only a few selected findings from the vast literatures that have examined any form of lagged or even cross-lagged effects of person and environment variables. Details on the analysis of reciprocal or cross-lagged person-environment transactions can be found in Box 4. Importantly, many studies and meta-analyses have examined cross-lagged effects, but most did not situate their findings explicitly within a person-environment relations framework. Additionally, there are several studies that have quantified only one path (e.g., n in the PERM: prior traits p predict later situation characteristics E ; Mehl, Gosling, & Pennebaker, 2006; Rauthmann et al., 2015c; Wrzus, Wagner, & Riediger, 2016) and thus established one direction but not the other. Those will not be referenced here because they cannot be used to glean full information on the different transaction patterns in Table 7 and Figure 8. The following cursory summary intends to provide an impression of the effect sizes and transaction effect patterns found in the domains of (1) life events, (2) work, (3) relationships, and (5) daily life.

– Box 4 –

4.4.2.1.1 Life Events. In terms of various life events in general (which often are also work- and relationship-related, but not exclusively so), there may sometimes be full bidirectional transactions between person and environment variables (Bleidorn et al., 2018; Bleidorn & Denissen, in press; Roberts, & Nickel, in press). However, there generally seems to be a trend pointing towards stronger paths from persons to environments than vice versa. For example, Bleidorn et al. (2018) found only rare instances in which life events instilled lasting personality changes as a consequence. Further, Kandler et al. (2012) found in a longitudinal twin study that directionality primarily flowed from personality traits to life events, and that relations between

traits and life events were mostly genetically mediated. Nonetheless, once controlling for genetic associations, they found small environmental mediations for effects of life events on traits.

Some contextual personality (development) theories, such as Social Investment Theory (SIT; Roberts, Wood, & Lodi-Smith, 2005), claim that “experiences in (...) social roles, as well as expectations for role-appropriate behavior, contribute to changes in personality traits” (Lodi-Smith & Roberts, 2007, p. 81). In contrast, more endogenous or biologically oriented personality theories, such as Five-Factor Theory (FFT; McCrae & Costa, 2008), deny the influence of environmental variables on trait variables as “traits are immune to the effects of the psychological environment” (McCrae, 2019, p. 64). The only exception to this principle is that environmental influences (e.g., nutrition, physical trauma, physical activity, psychopharmacological treatment) may impact biological structures and functions which can, in turn, cause downstream effects in basic traits (McCrae, 2019; see also DeYoung, 2015). There is also evidence supporting this view as true long-term personality change after life events has been rarely demonstrated (Costa et al., 2000; Costa, McCrae, & Löckenhoff, 2019; McCrae et al., Chapter 23). Together, SIT posits profound socialization effects, while FFT does not; in contrast, FFT posits strong selection effects. The disagreement between contextual and endogenous theories lies thus in whether basic traits, such as the Big Five, can change enough and lastingly with the objective exposure to and/or subjective experience of life events; however, both agree that characteristic adaptations (such as goals) may be impacted by life events.

Despite scarce evidence for lasting personality change in the face of life events, there are some studies that suggest the power of life events to shape personality. For example, traveling abroad – and thus being exposed for a longer time to a new culture and many new experiences – may have effects on personality development (Lüdtke et al., 2011; Zimmermann & Neyer, 2013). Further, Denissen et al. (2019) also found in a large, nationally representative, and prospective

longitudinal study some small socialization effects (i.e., life events → traits), but two thirds of all effects were still identified as selection effects (traits → life events). Further, socialization effects can be either anticipatory (some life events can be anticipated) or reactionary (some cannot be anticipated and just have to be experienced and dealt with).

4.4.2.1.2 Work. In terms of work (e.g., employment/unemployment, vocation, salary, etc.), several studies point towards full bidirectional transactions. For example, Roberts et al. (2003) found a corresponsive pattern in that prior personality traits at age 18 predicted later (subjective and objective) work experiences at age 26, while the work experiences were related to personality changes from age 18 to 26. In a longitudinal design using job beginners, changers, and stayers, Denissen et al. (2019) could tease apart selection from socialization. Specifically, there were selection effects for job beginners and changers (i.e., prior trait levels predicted later job demands) and also socialization effects for job stayers (i.e., prior job demands predicted later trait levels). Ford et al. (2014) conducted a meta-analysis on studies using multiple measurements of job-related stressors and psychological or physical strains. They found small cross-lagged effects in both directions (stressors → psychological/physical strains: .03 and .05; psychological/physical strains → stressors: .01 and .04), which – if deemed practically important – may be interpreted in support of bidirectional transactions.

4.4.2.1.3 Relationships. In terms of social, romantic, and familial relationships (e.g., entering a certain type of relationship; relationship quality, quantity, conflict, etc.; social support from others), there may also be full bidirectional transactions, but most currently available findings point towards effects being more frequent and stronger for person(ality) → relationships paths than vice versa (e.g., Asendorpf & van Aken, 2003; Asendorpf & Wilpers, 1998; Deventer et al., 2019; Mund & Neyer, 2014; Neyer & Asendorpf, 2001; Neyer & Lehnart, 2007). Indeed,

81% of significant cross-lagged paths concerned effects from traits to relationship variables in Deventer et al.'s (2019) study, and about two thirds were related to trait facets (rather than trait domains). Nonetheless, there are also studies that demonstrate some sizable or important relationships → person(ality) effects (e.g., Sturaro, Denissen, & van Aken, 2008), especially when examining relations at the facet level of traits and using appropriate designs and modeling procedures (Mund & Neyer, 2014). Wrzus and Neyer (2016) provided a lifespan perspective in reviewing empirical studies on the co-development of traits and relationship variables across the lifespan. They also reported that selection effects were somewhat stronger than socialization effects. However, there were important developmental patterns for selection effects of personality on friendships (small to moderate in adolescence, moderate to large in young adulthood, small or negligible in middle and late adulthood) and on familial relationships (small in adolescence and young adulthood, moderate in middle and late adulthood). Further, socialization effects also showed age-graded changes (moderate during adolescence, small to negligible from young adulthood onwards). These findings suggest that transaction patterns need to be considered in conjunction with life phases in persons' development (Wrzus et al., 2016).

4.4.2.1.4 Daily Life. The preceding studies reviewed for life-events, work, and relationship domains concerned mostly long-term variables and thus ontogenetic processes. In an experience sampling study looking at actualgenetic transactions within the timeframe of hours, Rauthmann et al. (2016) predicted later perceived situation characteristics from prior personality states, and later personality states from prior situation characteristics. They could compare altogether 80 effects (i.e., all possible combinations between the sampled person and environment variables), of which 23 were deemed a priori as conceptually or prima facie plausible and 57 as not plausible. Across all 80 combinations, absolute situation characteristic → personality state

effects averaged to 0.03^{13} ($SD = 0.02$), and absolute effects were higher for plausible ($M = 0.05$, $SD = 0.02$) versus non-plausible combinations ($M = 0.03$, $SD = 0.02$). Similarly, across all 80 combinations, absolute state $\rightarrow$ situation characteristic effects averaged to 0.03 ($SD = 0.02$), and absolute effects were higher for plausible ($M = 0.04$, $SD = 0.02$) versus non-plausible combinations ($M = 0.02$, $SD = 0.02$). Thus, while the cross-lagged paths were comparable in magnitudes, they were relatively small in all instances. This pattern of findings would speak more for a Bi-Stability model (4 in Figure 8) where mainly the stabilities of the person and environment variables is present across time (in Rauthmann et al., 2016; person variables with $M = 0.20$, $SD = 0.03$; situation characteristic variables with $M = 0.22$, $SD = 0.07$).

4.4.2.2 Summary. For long-term variables and ontogenetic timescales, the following tendencies seem to crystallize across literatures. First, the stability of trait variables tends to be somewhat higher (path j) than that of niche variables (path k). Second, cross-lagged effects from person to environment variables (path n) tend to be stronger than from environment to person variables (path o). Third, combining both prior insights, full bidirectional transaction patterns (5 in Figure 8) are often hypothesized to occur, but the empirical evidence is currently somewhat stronger for the person-tilted monodirectional or even full person transaction pattern (9 and 10 in Figure 8, respectively). For short-term variables and actualgenetic timescales, transaction effects are often small. Nonetheless, these must exist (e.g., when cues in the environment are processed by a perceiver and elicit affective reactions), even if they are difficult to detect or disentangle. In general, however, these summary observations are all just broad-stroke descriptions across various effects in the literature, and of course other patterns have also been found.

There are several explanations for the apparent “ontogenetic power” of personality to shape niches more so than niches shape personality: (1) stability of variables, (2) breadth of variables, (3) transition points, (4) developmental periods, and (5) research methodologies. First,

traits are believed to be generally relatively stable variables, both in terms of mean-level (Roberts, Walton, & Viechtbauer, 2006) and rank-order stability (Roberts & DelVecchio, 2000). In contrast, environments or niches may be less stable. Indeed, there is considerable mean-level change of daily situation characteristics across the life-span (Brown & Rauthmann, 2016), and the studies examining personality-relationship transactions have also found relationship variables to be often less stable than the trait variables (e.g., Deventer et al., 2019; Mund & Neyer, 2014). More stable variables could perhaps be in a better position to impact less stable variables more strongly (than vice versa), which may explain why traits tend to predict relationship variables more often and more strongly than vice versa (Neyer et al., 2014; Wrzus & Neyer, 2016). More stable variables are by definition less malleable than more fluctuating variables, and their effects could be less time-dependent – thus ensuring stronger predictive power.

Second, environment variables often reside at a different granularity level than broad-stroke traits (e.g., the Big Five domains). It might be too difficult for broad and abstract variables to predict narrow and specific variables (bandwidth-fidelity dilemma or trade-off; Cronbach & Gleser, 1957; Hogan & Roberts, 1996), and this asymmetry may explain the lack of evidence for socialization effects (Mund & Neyer, Chapter 9). Further, domain-level traits are indeed less related to relationship variables than facet-level traits, and some relationship → personality effects can only be uncovered at the facet-level of traits (Mund & Neyer, 2014). Thus, the level of analysis and breadth of variables is important to consider.

Third, whether normative or non-normative life transition points (e.g., entering or exiting a relationship, entering the first or a new job, etc.) are included in the analyses may make a difference. For example, Caspi and Moffit (1991, 1993) have argued that strong or disruptive life events may – paradoxically – accentuate, reinforce, or even stabilize individual differences instead of changing them. This may, however, only hold for historical and large-scale events

(e.g., pandemics, wars, recessions) that affect an entire population or for age-graded events that rather uniformly affect a certain age slice of the population (e.g., schooling, retirement). If there are additionally barely any inter-individual differences in intra-individual stabilities and changes, then environment effects on trait levels or changes will be hard to detect. Further, transitive events may still offer the opportunity to create niches that are congruent with one's existing personality traits (see 4.3.2. *Processes and Consequences of Person-Environment Fit* and 5. *Person-Environment Calibrations and Navigation Mechanisms*). Together, studying person-environment or relationship transactions in times of transitions may actually make it harder to detect bidirectional transactions because individual differences may stabilize (Neyer et al., 2014). It is important to keep in mind that persons are often (though not always) neither randomly nor passively exposed to life events. As such, personality influences on the anticipation, occurrence, unfolding, and consequences of life events are to be expected.

Fourth, an even more differentiated picture on person-environment transactions can be obtained from a developmental lifespan perspective. Opportunities, possibilities, and constraints are age-graded (Baltes, 1987, 1997), and thus person-environment transactions should show differences across the lifespan (Lang, Reschke, & Neyer, 2006; Wrzus et al., 2016).

Lastly, on their treatise on personality-relationship transactions, Mund and Neyer (Chapter 9) raised attention to methodological issues that also take into account the preceding points. Such issues concern the research designs (e.g., using mixed environments, having transitions or not, obtaining dyadic data, having several measurement bursts, ensuring age homogeneity vs. heterogeneity of participants and attending to the age range, sampling facet-level data, etc.) and the data-analytical techniques employed (e.g., cross-lagged panel models and newer inventions; Mund & Nestler, 2019). It should be noted that these issues do not just pertain to personality-relationship transactions, but also to person-environment transactions in general.

5. Person-Environment Calibrations and Navigation Mechanisms

Persons constantly navigate environments, and those environments provide a rich smorgasbord of opportunities and obstacles. Hence, persons and environments can exert influences upon each other so that each of them may change in corresponding ways, and they can also become systematically correlated across time. These processes are summarily referred to here as *calibrations*, and they are different from simple stability or change in each of the person and environment variables. The time-lagged paths in Figure 2 (j and k, and n and o) contain all types of stability and change, but calibration more specifically refers only to change *in response to* something, often though not always also for a functional purpose (especially on the side of persons). Such calibrations may be achieved by different person and/or environment *navigation mechanisms* (NMs) and they may result in person-environment correlations via those mechanisms (see path f'/f'' in Figure 2). Notably, there can be mechanisms in or from the person (g') and in or from the environment (g''). This section outlines different types of calibrations and associated mechanisms which can help foster a more dynamic understanding of persons and environments in conjunction.

5.1 Calibration Types

At any given time-point, persons and environments may be inextricably interwoven such that influences come from all directions and go into all directions. Nonetheless, it still makes sense to distinguish between functionally different types of calibrations which each may exert influences upon $\mathbb{P}$, $\mathbb{p}$, $\mathbb{E}$, and $\mathbb{e}$ variables in isolation as well as on their effects or relations in a concurrent or lagged fashion. There are four different types of calibrations (see Table 8), which can be obtained when crossing two “active/sending” subjects (person vs. environment) with two “passive/reactive/receiving” objects (persons vs. environment):

1. Person → Person calibration
2. Person → Environment calibration
3. Environment → Person calibration
4. Environment → Environment calibration

– Table 8 –

For each of these four types of calibrations, again two instances can be distinguished.

First, in some way commensurate variables may be calibrated across time (e.g., for Person → Person: job satisfaction at different time points). Second, incommensurate variables may also be calibrated across time (e.g., for Person → Person: job satisfaction and family conflicts at different time points). It is thus always necessary to clearly specify which person and environment variables are involved in calibrations as well as why and how they are.

In a *Person → Person calibration* (mechanisms drive or moderate path *j* in Figure 2), a person changes something about themselves. Such autoplasic person-focused change has already been documented in the literatures on state fluctuations and their stabilizations (Fleeson, 2012, 2017), life management and selection-optimization-compensation (SOC) strategies (Baltes & Baltes, 1990; Freund & Baltes, 1998, 2000, 2002), self-regulated personality development (Hennecke et al., 2014), secondary control mechanisms (Heckhausen, 1997), emotion regulation strategies (Gross, 1998), and developmental regulation (Haase, Heckhausen, & Wrosch, 2013). For example, in the pursuit of autoplasic regulation, persons make use of life-management strategies composed of selection (i.e., setting, specifying, and focusing on goals), optimization (i.e., acquiring and investing of goal-relevant means), and compensation (i.e., using alternative means to preserve a function) (Freund & Baltes, 2002).

In a *Person* → *Environment calibration* (mechanisms drive or moderate path n in Figure 2), a person changes something about the environment. Such alloplastic change has already been documented in the literature on gene-environment associations (e.g., Johnson, 2007; Kandler et al., Chapter 7), evolutionarily informed person-environment transactions and adaptive conditional strategies (Buss, 1987, 1991; Buss & Greiling, 1999), person-environment fit (e.g., Kristof-Brown & Guay, 2011), primary control mechanisms (Heckhausen, 1997), situational self-control (Duckworth, Gendler, & Gross, 2016), complex patterns of personality development (Kandler et al., 2015; Roberts, 2018; Roberts & Caspi, 2003), and how persons' lives unfold when they construct their niches (Tesser, 2002). Specifically, a large body of literature suggests that personality (P) has the power to shape situations (E) and niches (N) (e.g., Allport, 1961; Bandura, 1978; Diener, Larsen, & Emmons, 1984; Emmons & Diener, 1986a,b; Emmons et al., 1985, 1986; Furnham, 1981; Holland, 1966; Scarr, 1996; Snyder, 1981; see Ickes et al., 1997, pp. 175-184 for a review), generally in motive- or need-congruent ways. Thus, it has been argued that "a person's selection and creation of environments is one of the most individuating and pervasive expressions of his or her personality" (Caspi et al., 1989, p. 377). Indeed, Allport (1961, p. 179) had already maintained that "... most persons do a good deal to create the situation to which they respond" so that "... the situations we find ourselves in are often the direct product of our previous (and continuing) personalities." Thus, persons' personalities could be understood by, or even as a special form of, their "imprints" on their environments (e.g., Gosling et al., 2002, 2008; Hopwood, 2018; Sullivan, 1953; see also 6.7 *A Transactional Perspective on Traits and Personality*).

In an *Environment* → *Person calibration* (mechanisms drive or moderate path o in Figure 2), an environment changes something about a person. Such "molding" has already been documented in the literature on effects of experimentally manipulated stimuli on psychological

functioning and behavior (e.g., Orne, 1962; Reis, 2008); affordances (Chemero, 2001, 2003; Gibson, 1977; Miller, 2007; Stoffregen, 2000a,b, 2003, 2004); subtle nudges (Hertwig & Grüne-Yanoff, 2017; Thaler & Sunstein, 2008; Sunstein & Reisch, 2017; e.g., food choices, dieting, healthy lifestyle: Arno & Thomas, 2016; policy and markets: Abdukadirov, 2016); processes of attraction-selection-transformation-manipulation-attrition (ASTMA; Nye & Roberts, 2019); life events, work, and relationships on personality development (e.g., Bleidorn et al., 2018; Mund & Neyer, Chapter 9; Nye & Roberts, 2019); situation strength (Cooper & Withey, 2009; Dalal et al., 2019; Judge & Zapata, 2015; Keeler et al., 2019; Meyer et al., 2020; Meyer & Dalal, 2009; Meyer, Dalal, & Hermida, 2010; Rauthmann, 2018c); traumata (e.g., Jayawickreme & Blackie, 2014, 2016; cf. Mangelsdorf et al., 2019); and psychotherapy and interventions (Hudson, Chapter 50; Roberts et al., 2017). For example, Ickes et al. (1997, p. 166) have stated that “environments provide opportunities for personal dispositions to be manifested and reinforced” and that the fact that persons “display ... behaviors in settings they have specifically chosen ensures a substantial degree of consistency in their behavior.” Thus, trait manifestation and behavioral consistency could also be seen partly as downstream products of environmental variables exerting their influences (see also Fleeson, 2007; Fleeson & Law, 2015; Sherman et al., 2015).

In an *Environment* $\rightarrow$ *Environment calibration* (mechanisms drive or moderate path k in Figure 2), an environment changes something about itself. Such an environment-focused change reflects the inherent dynamics of daily life over which persons sometimes do not have a direct influence (e.g., waiting for a bus where one cannot influence if or when the bus comes). For example, they have already been documented in the literature on chance encounters, events, and developments (e.g., Bandura, 1982; Hirschi, 2010). However, this does not mean that these processes or influences are random; they simply happen independent of a person and just concern intra-environment dynamics (e.g., passage of time, natural disasters, social and cultural changes

and shifts). Moreover, there can be different mechanisms linking different environment variables to each other (e.g., work and family), such as, for example, spillovers, compensations, segmentations, resource drains, congruence, and conflicts (see Edwards & Rothbard, 2000 for a review).

From this description of the four general types of calibrations, it becomes clear that they will likely differ in their actual and perceived agency and locus of control for persons. For example, the following relations seem plausible regarding persons' general levels of agency:

$$\text{Person} \rightarrow \text{Person} \geq \text{Person} \rightarrow \text{Environment} > \text{Environment} \rightarrow \text{Person} \geq \text{Environment} \rightarrow \text{Environment}.$$

However, these relations reflect as of yet untested hypotheses.

Interestingly, several empirical studies may suggest stronger person $\rightarrow$ environment than environment $\rightarrow$ person effects (see n and o paths, respectively, in Figure 2; see also 4.4.2.2 *Summary*). However, looking at experience sampling data that capture dynamics and processes unfolding in short-term timespans (e.g., hours), the effects of personality states (P) on perceived momentary situation characteristics (E) and vice versa are almost identical, though all small (Rauthmann et al., 2016). Notably, all surveyed studies only pertain to the effect paths found and did not sample any NMs. However, taken together, the currently available patterns of findings seem to suggest that – on average and especially across longer periods of time (as opposed to shorter timespans) – environment $\rightarrow$ person NMs may exert a smaller or less tractable influence than person $\rightarrow$ environment NMs. If this were the case, then this would be a powerful demonstration of persons' agency over their lives and their development. Still, no firm conclusions can be reached to date as the empirical quantification of NMs and their influences has not progressed so far (see 6.5 *Conceptualizing, Measuring, and Studying Calibrations and Navigation Mechanisms*).

5.2 Navigation Mechanisms

The different forms of calibration previously outlined happen and can be achieved via *navigation mechanisms* (NMs; see Table 8). The following two sections will only focus on alloplastic NMs for person → environment and for environment → person calibrations, with a stronger emphasis on the former (i.e., *how* persons get into and out of environments). The autoplasic NMs for person → person and for environment → environment calibrations will be left aside. Though these are, of course, also important to consider and to understand, they are beyond the scope of this chapter that is more concerned with person-environment relations than with relations within the person or the environment, respectively.

5.2.1 Navigation Mechanisms for Person → Environment Calibrations. Persons have been described as constantly striving to create equilibria between their personalities and environments (Cramer et al., 2012). To do so, they may employ – willingly and unwillingly – different person→environment NMs (Allport, 1937; Buss, 1987; Caspi & Roberts, 2001; Ickes et al., 1997; Plomin et al., 1977; Rauthmann & Sherman, 2016; Roberts & Caspi, 2003; Scarr & McCartney, 1983; Snyder, 1983; Snyder & Ickes, 1985). Via the habitual utilization of person→environment NMs, persons can try to gradually “optimize” their surroundings according to their personalities (especially, needs, values, and goals), and thus person and environment variables will become correlated or synchronized over time (Fraley & Roberts, 2005; see also 4.2 *Person-Environment Correlations*). This fundamental principle has been voiced in multiple, discipline-spanning literatures. Personality, social, and developmental psychological literatures have already detailed how persons structure and regulate their daily lives (e.g., Duckworth, Gendler, & Gross, 2016; Haase et al., 2013; Ickes et al., 1997; Rauthmann & Sherman, 2016; Tesser, 2002). Further, industrial/organizational and work psychology has also emphasized how

persons craft their jobs (e.g., Holland, 1959, 1987; Wrzesniewski, 2001). Lastly, biologically or genetically oriented disciplines have also noted persons' capacities to shape their environments (e.g., niche-picking, niche-building: Scarr & McCartney, 1983; niche construction: Laland & Brown, 2006; genotype-specific habitat selection: Hedrick, 1990; experience-producing drives: Bouchard, Lykken, Tellegen, & McGue, 1996). Still, niche construction seems to have been a neglected process in evolutionary biology (Laland & Sterelny, 2006; Odling-Smee, Laland, & Feld, 2013). However, recent efforts have been made to develop a niche construction theory (for reviews, see Laland, Matthews, and Feldman, 2016 and Scott-Phillips et al., 2014), focused on "the process whereby organisms, through their metabolism, their activities, and their choices, modify their own and/or each other's niches" (Odling-Smee et al. 2003, p. 419). Indeed, niche construction seems to be – besides natural selection – a key driver of evolution as "[t]he properties of environments cause (some of) the properties of organisms through the action of natural selection, but equally the properties of organisms cause (some of) the properties of selective environments through niche construction" (Laland, 2004, p. 316). Taken together, in the long haul, person→environment NMs may thus stand in the service of (active) developmental regulation (Baltes, 1997; Caspi et al., 2005; Haase et al., 2013; Roberts & Caspi, 2003), ontogenetic gene-environment correlations (Plomin et al., 1977, 2008), and even cultural and evolutionary processes (Arslan & Penke, 2015; Day, Laland, & Odling-Smee, 2003; Kendal, Tehrani, & Odling-Smee, 2011; Laland, 2004; Laland, Odling-Smee, & Feldman, 1996, 1999; Nettle & Penke, 2010; Penke, 2010; Penke, Denissen, & Miller, 2007a,b; Penke & Jokela, 2016). For example, concepts from evolutionary psychology such as frequency-, density-, and competition-dependent selection imply that different genes, behavioral syndromes, and

environmental resources are distributed differently and can have profound adjustment, fitness, and phylogenetic effects (Penke, 2010).¹⁵

5.2.1.1 A Systematic Account. Table 9 summarizes general person→environment NM types from different literatures (see Rauthmann & Sherman, 2016 and Rauthmann, 2018c who referred to these as “situation management strategies”). The person→environment NMs in Table 9 may differ with respect to different properties (e.g., intentionality, effort, control, extent of actual change induced, etc.), but these remain to be empirically tested (see later also 6.5 *Conceptualizing, Measuring, and Studying Calibrations and Navigation Mechanisms* for more open questions). The different person→environment NM types can also be brought into a meaningful system, as depicted in Figure 9. Notably, the person→environment NMs may operate and unfold at both actualgenetic and ontogenetic timescales, depending also on the timescales of the person and environment variables involved in the calibration. Further, they should not be viewed as mutually exclusive, but some can be combined, mixed, or used simultaneously. Lastly, each person→environment NM type may have its advantages and disadvantages, and so their relative (dys-)functionalities may vary across and within persons and environments.

– Table 9 –

– Figure 9 –

At a very basic level from an agency perspective of a person, a person may have the opportunity to influence something about her-/himself (autoplastic mechanisms), the current

¹⁵ The PERM currently concerns only more actualgenetic and ontogenetic processes explicitly. While phylogenetic processes (e.g., transformation of gene pools, environments, cultures, etc.) may also be included into it to some degree, the PERM has not yet been devised to address such issues clearly (see, e.g., Laland, Odling-Smee, & Feldman, 1996, 1999). This chapter is thus at this point not so much concerned with evolutionary mechanisms (e.g., migration, selection, drift, etc.) although it will be important to consider evolutionary, cultural, and behavioral ecological theorization, methods, and findings in the future. Moving forward, these topics (see, e.g., Kendal et al., 2011) should be addressed an eco-evo-devo perspective adopted (e.g., Gilbert, Bosch, & Ledón-Rettig, 2015).

environment (alloplastic mechanisms), or both at once or in rapid succession. The person→environment NMs in Figure 9 concern alloplastic mechanisms where something happens to the environment as a function of the person. As can be seen in Figure 9, the evaluation of an environment may result in either of two broad person→environment NMs: “maintaining” versus “terminating.” Specifically, Rauthmann (2016) hypothesized that perceiving the environment as more pleasant than unpleasant should result more likely in maintaining, while perceiving it as more unpleasant than pleasant more likely in terminating.¹⁶ However, maintaining may also happen if the person cannot influence her/his environment and thus is rather passive. The maintenance person→environment NMs can fall into (1) remaining and just letting things happen (*passive maintenance*), (2) trying to preserve the environment as is (*active maintenance*), or (3) trying to get the most out of the environment (*active maximizing*). The latter may entail mild-intensity modifications and thus could also be grouped under the modification person→environment NMs instead of maintenance.

If the maintenance person→environment NMs are not desired, sensible, or possible, then termination person→environment NMs will (have to) be used. These can be either behavioral or mental. If they are mental, then a person changes something about the perceived environment. Technically (and as per Rauthmann et al., 2015a), this means persons change something about themselves, namely, their own perception of the environment (*re-construal*). However, the object of such re-construal still concerns the environment, meaning that the perceived but not actual environment is calibrated to oneself. As such, the re-construal mechanism is grouped here under person→environment NMs instead of being an autoplasic regulation mechanism (where the

¹⁶ This process is in actuality more complex as these environment perceptions will also be compared to how well one can handle the environment and thus also depend on persons’ self-perceptions (e.g., of abilities, coping, etc.). Further, environments can have both pleasant and unpleasant (perceived) characteristics at once, and thus both need to be considered in conjunction with (or in relation to) each other simultaneously.

object is the self, not the environment). Some persons will engage in re-construal even if there is no necessity to do so; however, in most cases, re-construal is likely more of a secondary option when behavioral person→environment NMs – which focus on the actual (and not just perceived) environment – are not desirable, sensible, or possible. Those behavioral person→environment NMs can be termed “shaping” because a person somehow shapes the environment into a different version. Such shaping may be achieved by (1) willfully or inadvertently eliciting certain reactions (*evocation*), (2) leaving the current environment and entering a new one (*selection*), or (3) staying in the current environment and doing something with it (*modification*). Depending on the extent of purposeful changes made to the environment (mild-intensity: *modulation*; strong-intensity: *creation*), the pre-existing one may have slightly or moderately changed (*modulation*) or may have become an entirely new one (*creation*). In both selection and creation person→environment NMs, a new situation is the result, but by different means: Selection means exiting one environment and going into another one that is already there, while creation entails actively shaping an existing environment to become a new one. Of course, in daily life and across the lifespan, multiple person→environment NMs may be used or combined, even at the same time and perhaps even in the service of each other (i.e., there can also be correlations, interactions, fits, and transactions among and between navigation mechanisms).

5.2.1.2 Empirical Evidence. The different person→environment NMs in Table 9 and Figure 9 have not been systematically studied in unison, that is, how all of them operate on actual genetic and ontogenetic timescales. Indeed, a grave limitation of most studies examining person-environment transactions is their inference, rather than actual measurement, of the past or current operation of person→environment NMs. For example, researchers could (and have) interpreted monodirectional person → environment transaction patterns (see 9-12 in Figure 8) as

evidence for selection effects: some prior traits (p) may predict later niche characteristics (e) (e.g., personality traits at age 18 predict work characteristics at age 26: Roberts, Caspi, & Moffitt, 2003). Such a conclusion can be warranted if one knows that the niches have changed (e.g., persons changed jobs), but then selection may still be entangled with evocation, modulation, or creation because persons also shape and craft their niches in addition to picking them (e.g., vocations, jobs: Holland, 1959, 1987; Wrzesniewski, 2001). Similarly, different environment → person transaction patterns (see 13-16 in Figure 8) have been interpreted as socialization effects (e.g., Denissen et al., 2014).¹⁷ However, in all of these instances possible explanatory mechanisms have been reduced to only one category (e.g., selection) and inferred from a pattern of findings (e.g., that prior person variables predict later environment variables). Both of these aspects are problematic.

The operation of alternative mechanisms cannot be ruled out that easily. For example, what may often seem like selection could easily also be evocation, modulation, or creation. After all, often certain trait levels may predict certain characteristics levels (see “contact” in Rauthmann et al., 2015c), but such observations do not allow firm conclusions regarding explanatory mechanisms. However, there are ways to tease apart some of the person→environment NMs even without measuring them explicitly. For example, under the condition that persons remain in the same niches (i.e., no ontogenetic selection effects; e.g., staying in the same job at the same organization), then showing that person characteristics levels (e.g., Big Five traits) predict *changes* in environment characteristics levels (e.g., in a job) across time can signify transformative person→environment NMs, such as re-construal, evocation, modulation, or creation. There is research that suggests such transformative power of traits

¹⁷ These do not concern person→environment NMs, but navigation mechanisms for environment→person calibrations.

shaping niches (e.g., Sutin & Costa, 2010; Wille, Beyers, & de Fruyt, 2012) and of persons crafting their jobs and work according to their goals, values, and abilities (e.g., Wrzesniewski, 2001). However, most studies have used self-reports for assessing both person and environment variables. Thus, it is not clear whether the underlying person→environment NMs have targeted the perceived environment via mental mechanisms (re-construal), the actual environment via behavioral mechanisms (evocation, modulation, creation), or both. A remedy is to use different data sources for measuring person and environment variables (see Denissen et al., 2014 for an example). When perceptions of environments can be differentiated from the exposure to actual environments, then it seems so far that persons' unique or idiosyncratic construals of daily situations (E) are more strongly tied to personality traits (P) than the exposure to or contact with certain situations (Abrahams, Rauthmann, & De Fruyt, in prep.; Bolger & Schilling, 1991; Hong, Chan, & Lim, 2020; Rauthmann et al., 2015c).

Different person→environment NMs also cannot be disentangled easily because they are rarely if ever measured at all. The operation of a person→environment NM is usually post hoc inferred solely from a certain pattern of findings (e.g., see discussion of “selection effects” above). Because there can be multiple explanations, such inferences are often too weak to warrant the firm conclusion that one certain person→environment NM can explain the person-environment transaction pattern. Worsening matters is that the environment variables have often also not been assessed in a proper way (see Rauthmann et al., 2015a for a through discussion), that is, they often reflect actually person variables either conceptually (e.g., job satisfaction is a person variable although it pertains to a job) or by research design (e.g., the perception of an environment characteristic by one person is just a perception, not a “true” environment variable; for details, see Rauthmann et al., 2015a). Thus, any person-environment transaction with such

problematic measurement of the environment actually just represents a person-person transaction and can also inflate the associations found via common-method variance. Luckily, the measurement of situation information has progressed (e.g., Rauthmann, Horstmann, & Sherman, 2020) so that this aspect of the problem will hopefully cease to exist soon (see also *6.1 Taking Environment Assessment Seriously*). A direct remedy to the “missing mechanisms problem” is obviously to actually measure the person→environment NMs (or any other type of navigation strategy; see Table 8 for all calibrations) and model their impacts (mediational or moderational, depending on the theory used) on the person-environment transaction patterns found. Unfortunately, there do not seem to be any validated and widely used measurement systems of person→environment NMs available so far (see also *6.5 Conceptualizing, Measuring, and Studying Calibrations and Navigation Mechanisms* later).

One of the first attempts to directly measure person→environment NMs was conducted in the “Narrative Dataset” by Ryne Sherman (see Brown, Blake, & Sherman, 2017; Rauthmann & Sherman, 2016). Two hundred and ninety-eight participants wore narrative clips (life-logging devices) that took pictures of persons’ everyday lives every few seconds (. In a later laboratory session, participants segmented their entire photo stream into different situations. Among other things, they then also indicated in a forced-choice format why a situation had changed, using five person→environment NM options. Of all situations reported ($k = 5,280$), the following percentage changed because of a certain person→environment NM (in descending order, with items in parentheses): 46.6% for selection (*I left the situation for another situation*), 23.9% for manipulation (*I did something to intentionally change the situation*), 13.8% for construal (*My perceptions or goals in the situation changed*), 11.0% for evocation (*The situation change was beyond my control*), and 4.7% for Other (a leftover category if neither of the other four categories

applied). Thus, apparently persons report considerable agency over their daily situations and their changes, suggesting that person → environment calibrations especially with the navigation mechanisms of selection and manipulation (a mixture of modulation and creation) may be pervasive: together, they explain changes for 70.5% of situations.

While this is (as far as I know) the first study to actually measure and quantify person→environment NMs and thus provide first direct empirical evidence for their operations, there are also glaring limitations. First, a relatively undifferentiated person→environment NM measure was used that was created in an ad hoc fashion (after all, there was nothing else to use). It did not include all person→environment NMs (e.g., it focused only on terminating but not on maintaining because the task was to study situation change), it meshed different ones (e.g., modulation and creation are blended into one), and it only allowed a forced-choice among the person→environment NMs. Regarding the latter issue, it stands to reason that different person→environment NMs do not have to be mutually exclusive but could actually be used simultaneously or at least in rapid succession (e.g., modulation and re-construal in conjunction). Thus, there need to be more systematic efforts to conceptualize and measure person→environment NMs.

Second, all data are self-reports only from the persons in the situations. While there is intuitive appeal to this approach (after all, those persons in their own situations could be viewed as “experts”), the sole reliance on what persons report about their situations changing is problematic. For example, they may suffer from different self-serving, memory, or other biases that could explain the strong observed levels of person agency over situations: persons could erroneously conclude that a situation has changed because they *think* (or wished) they used selection or manipulation, but they may be (for different reasons) blind to other reasons (e.g.,

evocation). Thus, it is important to measure person→environment NMs not just via self-reports but ideally also observationally or behaviorally (i.e., what persons actually do to/with their environments). This has been difficult so far, but novel smartphone and machine sensor technology may alleviate this problem and make such measurements possible in a continuous, fine-grained, and unobtrusive manner (e.g., Blake et al., in press; Harari et al., 2017, in press; Harari et al., Chapter 29; Miller, 2012; Pérez-Edgar, MacNeill, & Fu, 2020), of course keeping legal and ethical issues in mind.

5.2.2 Navigation Mechanisms for Environment → Person Calibrations. Table 8 also lists six macroscopic “mechanisms” of how environments may calibrate persons. This list is neither exhaustive nor systematic, and in reality, there is likely a myriad of different mechanisms. However, the list offered here reflects a first attempt at tying together different streams of research under the umbrella of belonging to navigation mechanisms for environment → person calibrations (i.e., environment→person NMs). Additionally, most of the environment→person NMs listed are not just “inverted” forms of person→environment NMs. Indeed, it would be possible to conceptualize environments as “affording” maintenance, re-construal, evocation, selection, modulation, or creation and thus making persons do these things. While straightforward, this somewhat diminishes persons’ agencies and also is a conceptual cop-out: There is no reason to believe that environment-based mechanisms *have to* follow the same molds as person-based mechanisms, even if that would be easier to process and be more elegant. Thus, I explicitly tried to compile environment→person NMs that would be largely unique to environments’ agency over persons, launching persons into certain presses that would impact their mental and behavioral functioning. It is beyond the scope of this chapter to also detail each of the environment→person NMs, but I hope that this non-exhaustive list could serve as a viable starting point to think about how environments draw, repel, and shape persons.

6. Recommendations and Future Directions

The preceding sections attempted to organize and review the scattered literatures on person-environment relations. But where to go from here? Below, I compile ten suggestions and recommendations on how to proceed.

6.1 Taking Environment Assessment Seriously

To examine the phenomena and paths in the PERM, psychometrically optimized assessments of person and environment variables are vital. While trait variables have received a tremendous amount of attention and spurred multiple well-validated and widely used assessment instruments, the assessment of person states (e.g., Horstmann & Ziegler, 2020) and of any environment variables still lags behind (Rauthmann et al., 2015a). Recently, there have been some efforts to remedy this in the study of psychological situations (Rauthmann & Sherman, 2020), with newer research aiming to measure perceived or psychologically active characteristics of situations by judgments of persons (for an overview of taxonomic systems and measures, see Rauthmann et al., 2020).

However, the assessment of environment variables has further issues that need to be resolved. First, there are exciting developments for multi-trait multi-method multi-occasion data modeling (e.g., Geiser et al., 2015, Chapter 35; Hintz et al., 2019) that present powerful data-analytical strategies to model many of the PERM's variables and effects on a latent basis. Nonetheless, latent occasion variables often remain truly latent, simply inferred from the measurement of variables at different occasions (e.g., personality states) without the actual measurement of environment variables. This is akin to much of twin-study research that has decomposed phenotypical variance into genetic and environment contributions but failed to account for the actual environment variables (which, unfortunately, are usually not directly measured) that may explain the shared or non-shared environment variance. These kinds of

models had to historically cope with the fact that almost no measures of environment variables were available, so they have proceeded without incorporating any manifest environment indicators. To fully understand person-environment relations, however, both person and environment variables need to be assessed with great care. Thus, manifest environment variables need to be directly sampled in future research (see Zapko-Willmes, Riemann, & Kandler, 2018, for an example of a twin family study approach with multiple assessments of the person variable “authoritarianism” and the environment variable “differential parenting”).

Second, if psychological characteristics of environments (especially E) – as manifest variables – are to be assessed (see Rauthmann et al., 2015a,b for a rationale for this approach), then it is important to not just use one person’s perception of a situation. Indeed, such a perception is actually merely a person variable (namely, P) and not an environment variable. To obtain actual environment variables from ratings, it is necessary to form composite scores from several raters – ideally even of different perspectives (*in situ*: from within a given situation; *juxta situm*: from bystanders who are not directly affected; *ex situ*: from written texts, audio, or video footage). Such a multi-source composite will better approximate an actual environment variable instead of capitalizing on a person variable (i.e., one person’s perception). Specifically, such a variable will likely represent the shared variance or consensus among different raters (Rauthmann & Sherman, 2019; Zapko-Willmes et al., 2018).

6.2 Employing Appropriate Research Designs

To capture the effect paths outlined in the PERM and provide robust estimates of them, real-life multi-method multi-situation multi-time multi-group (RL-MM-MS-MT-MG) designs should be used (see Rauthmann et al., 2015a) that enable testing multiple constraints on generality (Simons, Shoda, & Lindsay, 2017) and thus the robustness of findings. First, those designs should approximate *real life* (RL) as well as possible. This means that both field and

laboratory data can be sampled (Wrzus & Mehl, 2015), but in each instance there should be ecologically valid settings involved which may require the use of novel technologies to truly do so (e.g., using virtual and augmented reality in the laboratory and wearables in the field; Blake et al., in press; Harari et al., Chapter 29; Riva et al., 2016). The underlying idea is that findings should generalize to persons' everyday lives and be applicable there. This is especially important for experimental designs (often conducted in a laboratory) because they usually eradicate preexisting person-environment correlations. The person-environment relations found, then, are different ones than those in the field where there are natural person-environment correlations.

Second, designs should involve *multi-method data* (MM) from different sources (e.g., see the BIOPSIES mentioned earlier for trait and state assessments; Rauthmann, 2017). This is especially important when sampling environment variables (see *6.1 Taking Environment Assessment Seriously*), but should also be taken into account when sampling person variables. The shared variance among the different data sources or methods may better approximate the latent variables to be measured, and differences between methods (or their uniquenesses) may be of interest (Geiser et al., 2015; Hintz et al., 2019). The underlying idea is that findings should generalize across different methods used.

Third, designs should sample person and environment variables in *multiple situations* (MS) per person and not just in one or a few. If the situations (measurement occasions) have been sampled representatively for each person in their daily life, then this will be especially beneficial to sampled momentary person (P) and environment variables (E). Further, having several measurement occasions allows estimating density distributions of the measured variables and thus quantifying intra- and inter-individual variabilities (Fleeson, 2001). The underlying idea is that such designs can quantify the short-term fluctuations in effects and also examine to what extent effects reside at the within- or between-person levels (as measurement occasions will be nested within persons).

Fourth, designs should use *multiple time-points* (MT) to sample person and environment variables. The time-points would ideally be far apart (e.g., months or years as intervals), and at each time-point multiple measurement occasions can be sampled (measurement burst design: Sliwinski, 2008). Such designs allow quantifying the levels of stability vs. change in all variables and effects uncovered and may be used to answer developmental or lifespan questions (e.g., Freund & Baltes, 2000; Haase et al., 2013). The underlying idea is thus that the temporal robustness of findings can be examined (i.e., the extent to which they generalize across time).

Lastly, designs should make use of *multiple groups* of persons and/or environments (MG). Groups of interest may vary with research hypotheses and by discipline, but person groups could be distinguished, for example, by sex/gender, education, (un-)employment, mental health (healthy vs. disordered), zygosity (monozygotic vs. dizygotic), postal zip code, or even country. Environment groups (classes) could be distinguished, for example, by categories such as “everyday vs. extreme”, “hazardous vs. non-hazardous”, “leisure vs. work”, etc. The underlying idea is that findings may or may not generalize across (perhaps qualitatively) different sets of persons and environments, and commonalities and differences can be examined closely.

Taken together, a full RL-MM-MS-MT-MG design sampling person and environment variables in ecologically valid settings with multiple methods at multiple measurement occasions for multiple time-points in multiple groups of persons and/or environments would be a most powerful design. Such a design would permit estimating several forms of robustness, replicability, or generalizability at once. However, even “lesser” designs (e.g., RL-MM-MS: Rauthmann et al., 2015c) can also permit relatively strong conclusions about person-environment relations. Nonetheless, as a general recommendation, more than one and ideally as many of the five design requirements as possible (RL, MM, MS, MT, MG) should be combined in one design.

6.3 Zooming into Processes, Sequences, and Cycles

This chapter is only concerned with relatively abstract classes of processes, such as ontogenesis and actualgenesis or manifestation and accretion. However, *how exactly* and which different processes unfold and to what extent, when, and how they concatenate to sequences or even cycles has been omitted. Nonetheless, to study personality dynamics, processes, and functioning, it will be important to zoom in on these neglected topics (cf. Baumert et al., 2017; Blum et al., Chapter 2; Fleeson, 2017; Wrzus & Roberts, 2017). This will hopefully lead to a richer understanding of person-environment relations. Indeed, it will likely be necessary to adjust the generic PERM in Figure 2 in certain ways to suit dynamic personality research even better. An example of this is given in Figure 6 as well as in Box 5 and Figure 10. Specifically, in Figure 6, a process model of person-environment fit and its consequences is shown – effectively acting as a magnifying glass on the macroscopic effects captured in the PERM. In Box 5 and Figure 10, a corresponsive pattern of personality development is exemplarily traced within a modified PERM. The PERM should be seen as a flexible framework that can, and should, be modified according to different research aims, substantive research questions, and specific hypotheses. One particularly fruitful avenue will be to use the PERM for a more dynamic understanding of personality and its development.

– Box 5 –

– Figure 10 –

6.4 Explanation vs. Prediction and Causality

Person-environment correlations, interactions, fits, and even transaction patterns may be used to *explain* or *predict* certain outcomes, such as diversity in personality expressions (in different populations of persons and environments), continuity and change in personality

development, success at work, longevity, or intra- and interpersonal adjustment. Notably, it is important to distinguish explanation from prediction and appreciate the tension between them. For example, according to Yarkoni and Westfall (2017), there is a trade-off between explanatory models that are supposed to be simple, theoretically elegant, and contain abstract principles versus predictive models that are more complex, not theoretically grounded, and pragmatically optimize the prediction of an outcome by any means. Especially with the advent of machine learning and “Big Data” approaches (Bleidorn & Hopwood, 2019), prediction has moved nearer into the grasp of personality science. Nonetheless, explanation is still the predominant concern in psychology. This has led to a wide-spread acceptance of experiments (i.e., manipulating an independent variable to gauge its causal effects on a dependent variable, while controlling, standardizing, or randomizing many other variables that could have influences) to establish causality (Shadish, Cook, & Campbell, 2002). In this view, explanation (“If X *explains* Y, then X *causes* Y”) is in fact different from prediction because predictions are still possible even without predictors causing the criterion variables. Causality has been traditionally a thorny issue in psychology, but research on personality (Costantini & Perugini, 2018; Lee, 2012; Möttus & Kandler, 2018) and person-environment relations (Asendorpf & Motti-Stefanidi, 2018) is of course also interested in making causal claims. Experimental studies are likely to remove naturally occurring person-environment correlations and thus may lead to artificial effects. On the other hand, non-experimental studies may contain too much “noise”, spurious effects, or wash out otherwise interesting effects.

In keeping with the requirements of RL-MM-MS-MT-MG designs that include time-sensitive information, cross-lagged analyses can be performed to establish temporo-sequential chains that could approach causality (Gollob & Reichardt, 1987). However, they only establish a certain direction of effects which represent Granger causality (Granger, 1969). In the absence of

coupling such designs with experimental manipulation, many would argue that only quasi-causality can be established. However, more sophisticated frameworks for establishing causality exist (e.g., Pearl, 2009; Rubin, 1974; Spirtes, Glymour, & Scheines, 2001), and these can and should also be applied to PERM effects. For example, several parts of the PERM may be translated into directed acyclic graphs (for an accessible discussion and demonstration, see Lee, 2012). Further, conceptual rigor and proper operationalizations as well as theories and sound hypotheses are needed in the first place. For example, Lee (2012) alerts us that “[a] developmental process may predetermine Y well before X, even if X is measured first” and “[t]hus, the soundness of any causal conclusion depends on both conforming data and the correctness of the requisite assumptions” (p. 373). Taken together, for person-environment relation research to move forward in both explanation and prediction as well as establishing causalities, it will be important to prudently use and firmly interlock theory, research designs, and sophisticated data-analytical strategies.

6.5 Conceptualizing, Measuring, and Studying Calibrations and Navigation Mechanisms

The NMs in Figure 9 have been identified partially in and scattered throughout different literatures (see Table 9). Although different kinds of NMs should be distinguished (Table 8), arguably among the more interesting ones for personality researchers will be the mechanisms for person → environment calibrations. This chapter only provided a very general roadmap towards structuring and potentially distinguishing those NMs (see 5.2.1.1 *A Systematic Account*). More conceptual clarity and theorizing are needed. Additionally, there are to date no validated measurement tools for assessing (inter-individual differences in the use of) NMs available (cf. Brown et al., 2017 for an ad hoc, forced-choice, and self-report measure). Thus, future research should develop methodologies for assessing the NMs from different data sources (e.g., self-ratings, peer-ratings, behavioral observation, actual behavioral measurement) in a valid and

reliable manner. Such measurement can then help address several substantive research questions that remain unanswered so far. For example, future empirical research – based on better conceptualizations and psychometrically validated measures – could investigate for the NMs: (1) the extent of inter-individual differences in their habitual or preferential use; (2) to what extent they are consciously and deliberately used; (3) which role underlying needs and motivations play; (4) how time, energy, and resources are allocated to perform them and which decision rules persons use (e.g., when to remain vs. terminate a situation); (5) which opportunities and obstacles govern their usage; (6) their proximal and distal functional values and adaptive purposes (*why*, *when*, and *for what* are they used?); (7) their styles of utilization (*how* or *in what manner* are they used?); (8) their nomological networks (causes/antecedents, concomitants, and consequences in actualgenetic and ontogenetic contexts); (9) if, how, and when they contribute to accentuating, changing, stabilizing, or destabilizing inter-individual differences; (10) levels of genetic variance at different ages; (11) stability vs. change and trajectories across the lifespan (as well as inter-individual differences in these); and (12) if, when, and how their repeated actualgenetic use may coalesce into niche picking, crafting, and fitting on an ontogenetic scale.

6.6 Distinguishing Different Types of Person-Environment Fit

Because profile-oriented and variable-oriented person-environment fit analyses capture distinct phenomena (in each case “fit” is quantified differently and captures different aspects), researchers need to specify *exactly* which kind of “fit” they are examining, why they refer to “fit” in the first place, and which data-analytical strategies they have exactly used. In any case, person-environment fit will not be a monolithic or static phenomenon in people’s lives. As this chapter hopefully made clear, there can be multiple forms of fit, depending on the types and content of variables used as well as the levels of abstraction. For example, one could conceptually envision a hierarchical model of person-environment fit with a global and undifferentiated fit factor f_g at

the apex and then several more domain-specific fits f_s at lower levels (e.g., fit to culture, work team, company, sports, education environment, friends, romantic partner, a specific restaurant, etc.). Additionally, each of these types of fit may be accompanied by other dynamics and processes (De Cooman et al., 2019; for a suggested general starting point, see Figure 6). Taken together, it is of crucial importance to clearly specify what kind of person-environment fit is studied and what its scope shall be as the nomological networks (with causes/antecedents, concomitants, and consequences) of one fit may not necessarily generalize to others fits.

6.7 A Transactional Perspective on Traits and Personality

Attentive readers may have noticed that neither the exact relations between person traits ($\mathbb{P}$) and states ($\mathbb{P}$) nor their respective exact definitions have been made clear in this chapter (save for Figure 10 that served only for illustration purposes; see Box 5 for details). This was done in a deliberate attempt to avoid several thorny issues in the definitions of traits and states and thus to focus more on the person-environment relations. However, moving forward, traits and states do require being specified better. For example, a systems-theoretical approach (e.g., Rauthmann, 2015a; Sosnowska et al., 2019) might model the concurrent and temporal structures and dynamics of circumscribed PERM systems. To the extent that some structures and dynamics show a non-chance patterning and are recurrent, these may together represent a “trait.” Thus, a trait would be an *emergent* phenomenon arising from networks or systems of functionally related variables (for similar views, see Cramer et al., 2012) rather than a separate entity in the system.

Such a transactional perspective has several implications for how we understand personality as a whole as well as traits and person dynamics in particular. First, here traits “exist” *between* persons and environments as well as *within* their structural and dynamic relations. This view is not new, however, and has already been espoused by early interpersonal theorists. For example, for Sullivan (1953) “personality is the relatively enduring pattern of interpersonal

situations that characterize a life” (pp. 110-111). New treatises of normal and abnormal personality functioning also subscribe to such a view (Hopwood, 2018). Indeed, there is also some empirical evidence that traits manifest in the ways in which persons engage with their environments (e.g., Srivastava, Angelo, & Vallereux, 2008), and traits could also be conceptualized as tendencies towards establishing certain situations.

Second, by knowing in which kinds of situations or environments a person habitually is and how she/he navigates those situations, it should be possible to know the person better and derive accurate personality judgments. For example, it has been argued that “one’s choices of the settings in which to live one’s life ... may reflect features of one’s conceptions of self, one’s characteristic dispositions, one’s attitudes and values, and other attributes of personality” (Snyder & Ickes, 1985, p. 915). Further, early theorizing has posited that the self is manifest in “symbolic” environments, such as one’s house or places (e.g., Cooper, 1974; Proshansky, Fabian, & Kaminoff, 1983). An empirical example is Gosling et al.’s (2002) study that examined to what extent judges’ trait ratings correlated with targets’ self- and peer-ratings based solely on viewing the targets’ bedrooms or offices. It rests on the idea that persons’ behaviors manifest in imprints in their offline and online environments and leave behavioral residues that can be judged by persons (e.g., Gosling, Gifford, & McCunn, 2013; Gosling et al., 2008; Graham, Sandy, & Gosling, 2011; Kosinski, Stillwell, & Graepel, 2013; Mehl, Gosling, Pennebaker, 2006; Vazire & Gosling, 2004). Thus, environmental niche variables $\mathfrak{e}$ that are an effect of single or repeated person states $\mathbb{P}s$, which in turn are instances of person traits $\mathbb{P}s$, can be used to infer $\mathbb{P}s$.

Lastly, a transactional perspective resolves the apparent dichotomy between persons and situations (Fleeson & Nofhle, 2008a,b; Hogan, 2009) because both always need to be considered in unison. This perspective further underscores how silly the person-situation debate actually was (though it was productive in terms of pushing researchers to confront thorny issues and

concretize their thoughts; see Kenrick & Funder, 1988). Indeed, to explain complex phenomena such as that “[p]eople create, seek out, or otherwise gravitate to environments that are compatible with their traits” (Hampson, 2012, p. 318) or that persons show considerable amounts of within-person variability of behavior (Beck & Jackson, Chapter 4), it is important to consider persons and environments *jointly*. To give an example where such joint consideration is especially useful, consider Ickes, Snyder, and Garcia’s (1997, p. 166) assertion that “[persons’] preferred environments provide opportunities for personal dispositions to be manifested and reinforced” and that “[o]nce individuals are in their chosen situations, their words and actions are genuine reflections of their personalities.” Several hypotheses can be derived here, such as that (1) persons should have cognitive-affective preferences towards some environments but not others; (2) persons may be motivated to gravitate towards preferred, and shun non-preferred environments; (3) selected environments should entail higher congruence between traits and manifested state enactments (i.e., associations between persons’ traits and states are moderated by their environment selection); (4) those environments should additionally serve to reinforce, or stabilize, the state enactments, thus leading to higher state-to-state consistency; and (5) persons may perhaps pick up on their “genuine” trait-state congruence in those environments and thus feel authentic (but see for counterevidence Cooper et al., 2018). These hypotheses can only be tested if we subscribe to a more transactional perspective as well as sample and model both person and environment variables at the same time.

6.8 Formalization

To avoid even more complexity and provide a more accessible treatise of person-environment relations, this chapter did not engage in full mathematical formalization of all functions or elements and relations depicted in Figure 2. However, there is already recent theorization that moves towards more formalization. For example, Todd and Gigerenzer (2020)

2004 propose in their ecological rationality approach that person variables represent an adaptive
 2005 toolbox (AT) of heuristics that can be used to make decisions and take action (B) with respect to
 2006 certain environmental settings (E), thus yielding: $B = f(AT, E)$. They exemplify their approach
 2007 with trust in doctors, parental investment in middle-born children, and burglars choosing a
 2008 property to break in. The ecological rationality approach has the aim to concretize the often
 2009 abstract “function” relating person variables (adaptive decision heuristics) and environment
 2010 variables. Further, Wood, Spain, and Harms (2020) have presented a functional approach to
 2011 representing the interplay of persons, situations, and behaviors in a formalized way using
 2012 functional fields (see also Wood, Chapter 24; Wood et al., 2019), integrating ideas from Lewin’s
 2013 (1943) field theory and modern causal modeling (Pearl, 2009). Functional units may exert causal
 2014 forces, and these can be represented in vector spaces. Indeed, such thinking has already been
 2015 espoused quite early, as in Lewin (1943) but also in Raymond Cattell’s impressive body of work
 2016 (see Boyle, 2019 for an overview). Further, dynamic systems theory also provides a rich and
 2017 mathematically formalizable framework to understand person-environment systems (Allen,
 2018 Sylaska, & Mayer, Chapter 26; Rauthmann, 2015a; Richardson, Dale, & Marsh, 2014;
 2019 Scheinerman, 1996; Sosnowska et al., 2019; Micheals, Vallacher, & Nowak, Chapter 38). Lastly,
 2020 stronger formalization is a requirement for computational modeling and proof-of-principle
 2021 hypothesis testing (Fraley & Roberts, 2005; Möttus, Allerhand, & Johnson, 2020; Read et al.,
 2022 2010) where person and environment variables as well as their relations need to be carefully
 2023 operationalized and according parameters and models formulated. For example, Fraley and
 2024 Roberts (2005) concluded based on simulated dynamic models that reactive, evocative, and pro-
 2025 active “transactional processes serve to amplify the degree of stability in individual differences”
 2026 and “also allow persons, constants, and environments to function as a coherent system of
 2027 elements that mutually sustain and reinforce one another” (p. 68). Recently, Möttus, et al. (2020)

have also provided simulated examples of person-environment relations where accumulated situational experiences impacted the variance in personality characteristics across time and gave rise to structural personality factors.

Formalization is conditional upon conceptual clarity and rigor. Currently hampering stronger formalization, however, are terminological inconsistencies and conceptual blurriness that are pervasive throughout the literature.¹⁸ Moreover, some phenomena do not even have clear labels (yet). For example, person variables could be examined as states or traits. The entirety of all traits may represent, or at least approximate, personality. On the other hand, we have no clear label for the entirety of a person's momentary states. Can we speak of "stat(e)ality"? Moreover, environment variables can be defined for the shorter-term (situations) and longer-term (niches). However, how are their respective variables to be labeled (e.g., Blum & Schmitt, 2015)? Should situations have states, and niches traits? Or could both a situation or a niche have either a state (when only one person judges their characteristics) or a trait (when there is cross-person consistency, or consensus, in judging their characteristics), respectively?¹⁹ And how is the entirety of state or trait characteristics of environments (situations or niches) referred to? Can we speak of "situationality", "nichality", or "environmentality" in some or either one of these? These are issues that would need to be resolved in the future to move towards a more unified, consensual language that will help set the basis of a formalized and precisely communicable perspective on person-environment relations.

6.9 Theory, Multidisciplinary Integration, Replication, and Collaboration

Identifying meaningful and robust effects is a core aim of any scientific endeavor. For person-environment relations, previous empirical research has shown that distinguishing between

¹⁸ And unfortunately likely also even within this very chapter!

¹⁹ I thank Gabriela Blum for bringing up this idea in a personal email communication (May, 2019).

conceptually more and less plausible relations makes a difference: effects for conceptually plausible pairs of person and environment variables appear to be stronger and more robust vis-à-vis implausible ones (Horstmann et al., 2020; Rauthmann et al., 2016). This underscores that a priori hypothesis generation and theory will be important. However, there are barely any strong theories explicitly for person-environment relations. For example, this chapter did not present a theory, but rather a formal meta-model or framework within which to systematically couch different phenomena and effects. This may not be too problematic as, in fact, the argument could be made that person-environment relations research still needs to be somewhat atheoretical at this point: Exploratory and descriptive work with large datasets and broad questions should, over time, lead to more refined hypotheses and theory-building. However, we still do not have enough of such work. Indeed, the PERM alerts us to several blind-spots that still need to be filled.

Once more systematic work with robust findings has been conducted, a major aim will be to integrate the insights gleaned and craft actual theories. Such synthesis will also entail utilizing synergies from multidisciplinary projects. The cross-talk between different disciplines (e.g., genetics, behavioral ecology) that are also concerned with person-environment relations, but from different perspectives, will be immensely important going forward. For example, an eco-evo-devo framework (Gilbert et al., 2015) – which is also relevant to PERM phenomena – already demonstrates the utility and value of cross-fertilization between different disciplines to address complex questions. The resulting hopefully inter- or even transdisciplinary theories will then be generative in the sense that they make lacunas obvious, channel research efforts, and produce hypotheses for confirmatory testing. This, however, also requires different theories, approaches, and methods *within* psychology to be integrated. For example, this chapter has hopefully demonstrated that person-environment relations have been examined in several psychological disciplines (especially personality, social, developmental, evolutionary, genetic, applied,

environmental/ecological) – usually in a separate and insular manner. Particularly environmental and ecological psychology has seemed to embrace “transactionalism” where persons and environments are interdependent, the person-environment relation is the unit of analysis, and persons and environments can transform each other across time (e.g., Altman & Rogoff, 1987; Gifford, 2007; Saegert & Winkel, 1990; Stokols, 1995; Stokols, Clitheroe, & Zmuidzinas, 2000; Stokols & Shumaker, 1981; Walsh et al., 2000; Wapner, 1982). However, much of that work is barely integrated into common personality, social, and developmental psychological literatures. Additionally, there seems to be some rift between more basic and applied disciplines as they tend to also form distinct literatures (e.g., applications to occupational performance: Law et al., 1996; Strong et al., 1999; social work practice: German, 1981; leadership: Gammel, Chapter 43; psychopathology and psychotherapy: Ringwald et al., Chapter 11). Further, there are also several personality-psychological models concerned with dynamics and processes (e.g., PERSOC model: Back et al., 2011; KAPA: Cervone, Chapter 22; Cybernetic Big Five Theory: DeYoung, 2015; Whole Trait Theory: Fleeson, Chapter 21; Fleeson & Jayawickreme, 2015; Jayawickreme et al., 2019; Five-Factor Theory: McCrae, 2019; McCrae & Costa, 2008; socioanalytic and neo-socioanalytic model of personality: Hogan & Roberts, 2000; Roberts & Damian, 2017; Roberts & Nickel, 2017; Roberts & Wood, 2006; Cognitive-affective processing system: Mischel & Shoda, 1995, 1999, 2008; socio-genomic model of personality: Roberts, 2018; TESSERA model of personality development: Wrzus, Chapter 5; Wrzus & Roberts, 2017) that would also need to be integrated with each other (cf. Quirin et al., in revision) and merged with a person-environment relations perspective. Altogether, it would be desirable to create one larger and strong “river” from the various parallel “streams” of literatures to study person-environment relations more holistically and in a unified manner.

Any theories developed will have to integrate methodology, and any methodology (e.g., new technological advances, RL-MM-MS-MT-MG designs) needs to incorporate theory – in other words, both need to be balanced to yield synergies because each of them alone will not be sufficient to grasp the complex nature of person-environment relations. While methodologies – including research methods and data-analytical strategies – are rapidly evolving, theory may currently not be keeping the pace enough. A solid exploratory phase is important for now, but researchers should already try to craft proto-theories or at least have bigger pictures in mind.

Theories will have to rely on a good data basis as science is a cumulative process. Thus, insights need to be robust or we at least need to understand their constraints on generality (Simons et al., 2017). Towards this end, it will be important to employ RL-MM-MS-MT-MG designs and explicitly attend to the robustness, replicability, or generalizability of findings. This includes identifying contextual and moderator conditions that render established effects weaker or stronger. Moreover, many of the empirical findings surveyed in this chapter still await corroboration and replication. In other words, for most effects in the PERM, we simply do not have well-grounded knowledge yet. However, a strong cumulative knowledge base of replicable effects and a deeper understanding will, in turn, be essential in crafting good theories.

Lastly, science is not only a cumulative, but also a cooperative endeavor. Studying person-environment relations may be time-consuming and require many resources. Thus, it is vital to start working towards multidisciplinary consortia that tackle large and complex questions with coordinated multi-site designs and sophisticated data-analytical strategies (for inspiration, see the entire *Section III: Methods and Statistics* of this handbook). This will be more economical and efficient than single and arguably more limited research projects. This recommendation is not to discourage well-crafted single research projects; rather, it should be understood as a call for *more cooperation and cross-talk* because that will also spur the cross-fertilization of ideas across

multiple psychological disciplines and beyond. A multidisciplinary consortium could further conceptually hone the crude concepts presented in this chapter and conduct cutting-edge research that might lead to a truly inter- and even transdisciplinary approach to person-environment relations.

6.10 Working Towards Principles of Person-Environment Relations

This chapter deliberately did not introduce any “principles” of person-environment relations just yet. While there are some findings that seem robust and may begin to materialize as principles (e.g., that construal may be tied more strongly to personality traits than other navigation mechanisms, that selection effects often seem to be ontogenetically stronger than socialization effects), I think it is still too early and thus premature to declare any principles. When Roberts and colleagues first formulated principles of personality development (e.g., Roberts & Wood, 2006), they could already look back at impressive amounts of work in a circumscribed domain of research. This is not yet the case with person-environment relations research that is scattered across different literatures. More importantly, however, there appears to be no overarching framework or theory guiding research on person-environment relations, and so it is difficult to integrate findings and distill a set of principles from robust and recurring patterns of insights (see 6.9). While the principles of personality development now effectively serve to integrate different findings on the continuity and change of personality and are thus regularly updated (e.g., Roberts & Nickel, in press), no such thing exists for person-environment relations yet. My hope is that this chapter can represent a *first step* towards thinking more systematically about person-environment relations and locating different phenomena – with their studies and findings – within a common proto-framework that is still in flux and will likely change once more empirical findings arrive. In other words, hopefully this chapter and many other efforts can set the stage so that principles of person-environment relations can be chiseled out in the future.

7. Conclusion

Personality dynamics, processes, and functioning can take place at different timescales, and they will always involve person-environment relations. This chapter attempted to coherently structure the plethora of topics revolving around person-environment relations within the generic PERM and review relevant but as of yet barely integrated literatures dealing with such relations. Specifically, most phenomena can be subsumed under person-environment *interactions*, *correlations*, and *transactions*, with different conceptualizations and operationalizations of *fit* being a special case of the former two. It is my hope that this chapter can be used as a starting point to think more systematically and deeply about person-environment relations as well as their causes, concomitants, and consequences in daily life and across the entire lifespan.

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Box 1

Polynomial Regression and Response Surface Analysis

The full second-degree polynomial regression in Equation 6 yields five regression weights (b_1 : person variable; b_2 : environment variable; b_3 : square of the person variable; b_4 : person variable $\times$ environment variable interaction; b_5 : square of the environment variable) which can be used to compute the response surface parameters a_{1-4} . The latter define a three-dimensional response surface that is created when predicting an outcome variable on the z -axis by the full crossing of two predictor variables (e.g., a person and an environment variable), where one variable defines the x -axis and the other the y -axis. This is exemplified in Figure 4d where the person, environment, and outcome variables are all measured on a standardized scale, ranging from -3 to +3.

As can be seen, the response surface has a “Line of Congruence” (LOC; thick solid line) from -3/-3 to +3/+3 where values of the person and the environment variable, respectively, show exact numerical correspondence. The surface also has a “Line of Incongruence” (LOIC; thick dotted line) from -3/+3 to +3/-3 where the values of the person and the environment variable, respectively, show exact numerical non-correspondence. Notably, neither the LOC nor the LOIC per se are the “fit” of the person and environment variable; “fit” is defined as an entire pattern of effects and thus more complex (Humberg et al., 2019; see 4.1.5 *Outcome-based, Variable-oriented Person-Environment Fit*). Both the LOC and LOIC have a linear slope (a_1 and a_3 , respectively) and a curvilinear slope (a_2 and a_4 , respectively). Applied to a scenario where an outcome variable is predicted from person and environment variables, the response surface parameters can be interpreted the following ways (for an accessible general summary, see Barranti, Carlson, & Côté, 2017):

- The parameter a_1 ($= b_1 + b_2$) concerns to what extent matches at higher values of the person and environment variable entail higher (or lower) values on an outcome variable than matches at lower values of the person and environment variable. The parameter will be strong when one or both of main effects of the person and/or the environment variable are present, potentially signaling additive effects.

- The parameter $a_2 (= b_3 + b_4 + b_5)$ concerns to what extent matches at more extreme values of the person and environment variable entail higher (or lower) values on an outcome variable than matches at less extreme values of the person and environment variable. The parameter will be strong when an interaction of the person with the environment variable and/or any non-linear effects of the person and the environment variables, respectively, are present.
- The parameter $a_3 (= b_1 - b_2)$ concerns to what extent one direction of mismatches in values (e.g., person variable values > environment variable values) entails higher (or lower) values on an outcome variable than the other direction of mismatches (e.g., environment variable values > person variable values). The parameter will be strong when either one of the main effects of the person and the environment variable, respectively, is (much) stronger than the other.
- The parameter $a_4 (= b_3 - b_4 + b_5)$ concerns to what extent matches in values of person and environment variables entail higher (or lower) values on an outcome than mismatches.

Each response surface parameter allows a different insight into the data and together provide a more detailed picture on the effect pattern. It is also possible to construct confidence intervals around each parameter estimate and apply usual tests of statistical significance (if desired). While more parsimonious models with less predictors should be favored (and thus models with less predictors tested against models with more predictors), polynomial regressions may explain more variance and do consider quadratic effects which could be more common than expected (Edwards & Parry, 1993). As can be seen in Figures 4a-c, response surfaces can be crafted to understand the relations between predictors and an outcome better even if not all predictors significantly or sizably predict the outcome. As such, they allow a more nuanced view on the data. Further, polynomial regressions are preferable to using difference scores (e.g., subtracting an environment score from a person score) as predictors of outcome variables because the latter possess several shortcomings despite having been used as indices of “fit” (Edwards, 2001, 2002).

Box 2*Analysis of Variable-oriented Person-Environment Correlations and Fits*

Estimating variable-oriented person-environment correlations or fits is straightforward: If there is one measurement occasion, then two concurrent person and environment variables are correlated, yielding a sample estimate of the correlation. This is usually all, but researchers may be interested in more. For example, additional questions could be: How strong are inter-individual differences in those correlations? Are those inter-individual differences stable across time (or age)? How do they develop or change? With which nomological variables (e.g., causes/antecedents, concomitants, consequences) are those inter-individual differences associated with? How strongly, when (moderations), and how (mediations) are they associated with those nomological variables? These and other questions can usually not be addressed when subscribing to a variable-oriented view, though they become readily answerable when using profile approaches (see 4.2.2 *Person-oriented Profile Correlations*).

However, there is a little-known work-around that allows estimating individual differences from a sample-level correlation. Asendorpf (1990) described such a procedure for obtaining individual consistency estimates (I) when correlating two scores across measurement occasions, but his procedure can be extended to any pair of correlated variables and thus also to variable-oriented person-environment correlations or fits. Specifically, for each individual in the sample, their individual correlation between any kind of commensurate person (PER) and environment variable (ENV), can be derived with following equation:

$$I_{\text{PER,ENV}} = 1 - \frac{(z_{\text{PER}} - z_{\text{ENV}})^2}{2} \quad \text{Equation 7}$$

where $I_{\text{PER,ENV}}$ = individual person-environment correlation score, z_{PER} = z -score of an individual's score on the person variable PER, and z_{ENV} = z -score of an individual's score on the environment variable ENV. The resulting $I_{\text{PER,ENV}}$ scores will be heavily skewed. To use them for further analyses, a transformation (similar to Fisher's r -to- z transformation) has to be applied to them first (see Asendorpf, 1990, p. 9 for exact details). It can be shown that the mean of all $I_{\text{PER,ENV}}$ scores represents the sample-level

person-environment correlation. Deriving such $I_{\text{PER,ENV}}$ scores has so far not been done for person-environment relations research, but they can help expand the scope of variable-oriented analyses to examine the stability and nomological networks of inter-individual differences in variable-oriented person-environment correlations or fits.

Another approach to estimating variable-oriented person-environment correlations or fits is available when there are several measurement occasions per person in the sample (e.g., as in experience sampling or longitudinal data). Then, hierarchical linear modeling or multi-level modeling (MLM) can be used to analyze such nested data (usually measurement occasions at level 1 nested within persons at level 2). In such models, one has to distinguish between a predictor (e.g., E: perceived level of Sociality in a given situation) and a criterion variable (e.g., P: perceived level of sociable behavior in a given situation). Although the designation as either predictor or criterion may seem arbitrary in non-lagged data where all associations are concurrent²⁰, great care should be taken here and extracted slopes cautiously interpreted (as reversing predictors and outcomes could yield other conclusions). The level 1 associations between person and environment variables – here interpreted conceptually as person-environment correlations (although statistically in MLM they represent slopes) – have also been termed if-then patterns (Mischel & Shoda, 1995, 1999, 2008), situation-behavior patterns (Smith et al., 2009), contingencies (Fleeson, 2007; Sherman et al., 2015), and signatures (Fournier et al., 2008, 2009). The advantage of using MLM is that the level 1 slopes can vary between individuals. If there are sizable inter-individual differences, these slopes may be associated, for example, across time with each other to examine their stability or with external correlates (such as personality traits, goals, well-being, etc.) to examine their nomological networks. In case of the latter, a level 2 predictor (e.g., a personality trait) is introduced that predicts the person-environment associations on level 1. Notably, such cross-level analyses then test interactions (see Sherman et al., 2015).

²⁰ If lagged data were used (for example, as in Rauthmann et al., 2016), then temporally clear predictor-outcome relations can be established. In such cases, person-environment transactions are examined. In cross-sectional and non-lagged data, only concurrent associations can be modeled, and these are termed here *conceptually* person-environment correlations – even if *statistically* not a correlation coefficient, but slopes are estimated.

Box 3*Analysis of Profile-oriented Person-Environment Correlations and Fits*

In a profile approach, each person has a set of conceptually commensurate person and environment variables (Caplan, 1987) that are correlated. The profile correlation has been interpreted as person-environment fit, where the “gestalt,” configuration, or pattern of the person and environment variables match up *holistically* with each other: one rank-ordered set of variables is correlated with the other rank-ordered set of variables within one person.²¹ The correlation (also termed in the literature as: association, agreement, concordance, correspondence, congruence, fit, matching, similarity) between two profiles can be quantified by *q*-correlations (Stephenson, 1952), which are mathematically regular Pearson product-moment correlations ranging from -1 (perfect negative correlation) to 0 (no systematic correlation) to +1 (perfect positive correlation).²² Notably, these correlations capture to what extent the rank-order among the person variables match the rank-order among the concordant environment variables. For example, if a person is generally more talkative than anxious (p), then this person’s niche should generally also be more social than negative (e). *Q*-correlations quantify how similar the shape of two profiles are (as the constituting profiles are standardized each to an elevation of $M = 0$ and scatter of $SD = 1$; Biesanz & West, 2000; Furr, 2010). Although there are also other ways of quantifying the similarity between two profiles that take into account the elevation, scatter, and shape of the profiles to different degrees (e.g., D^2 , D'^2 , and D''^2 ; Cronbach & Gleser, 1953), *q*-correlations have been often favored because they (1)

²¹ There are several methodological/statistical and conceptual complexities to this that cannot be elaborated on in detail here. Methodologically, different properties of the variables in the profiles (e.g., their number, positively and negatively keyed directions, variances, reliabilities etc.) as well as the mathematical estimation of the profile association index need to be considered. Conceptually, the point at which a profile association is termed “fit” also needs to be answered. For some, it is sufficient that the associated profiles are contentwise commensurate; any association is then a fit. However, one could also argue that “fit” only starts at a certain level of association (i.e., below that level we do not have conclusive evidence of “strong enough” fit and thus refrain from referring to fit there). Another approach would be to focus more on the conceptual content of the profiles. For example, the person and the environment profiles could “fit” together in a supplementary or a complementary way (see 4.3.1 *Important Distinctions*).

²² Observed *q*-correlations can be tested in randomization procedures (e.g., Sherman & Funder, 2009) against *q*-correlations obtained from random variable pairs (with the expectation that the latter are weaker than the former).

produce findings consistent with other indices (e.g., De Fruyt et al., 2006), (2) are widely employed and thus can be compared to different literatures (e.g., Furr, 2008; Sherman, Nave, & Funder, 2012; Wood & Furr, 2016), and (3) perform favorably compared to other indices (McCrae, 2008; Rounds et al., 1987).

A profile-approach to person-environment fit is person-oriented because each person idiographically obtains a q -correlation score. When several persons are sampled, this also makes it possible to nomothetically quantify inter-individual differences in person-environment fit and position them in nomological networks (i.e., examining their causes/antecedents, concomitants, and consequences). As can be seen in the PERM (Figure 2; Table 4), the person-environment correlation or fit may be predicted from prior navigation mechanisms (paths t' , t''), outcome variables (path s), and itself (path m) over time, while also predicting later variables (path e). If profile fits are computed for a number of measurement occasions for each individual, then intra-individual density distributions in person-environment fit can be obtained. An example of such a within-person distribution of q -correlations is given in the left panel in Figure 5. For each person, different density distribution parameters (e.g., mean, median, standard deviation, minimum, maximum, skewness, kurtosis) are available to be explored. This also means that in a sample of several persons, single persons or groups of persons can be compared in their density distribution parameters (see middle panel in Figure 5), revealing inter-individual or group-level differences. Further, obtaining q -correlations in cross-sectional data for persons from different ages (e.g., 15-80 years) can yield a lifespan perspective on mean levels of person-environment fit (see right panel in Figure 5). Obtaining q -correlations from longitudinal data (i.e., at least two measurement points) for persons from different ages can yield a lifespan perspective on how inter-individual differences in person-environment fit among the sampled persons are conserved across time. Such data allow the examination of the levels of (1) rank-order stability in general, (2) rank-order stability in relation to age, and (3) inter-individual differences in intra-individual change of person-environment fit (which could then also potentially be explained or predicted by other variables). To my knowledge, no study has examined these questions yet.

Regularly computed “overall” q -correlations between “raw” profiles contain a certain amount of normativity (Cronbach, 1955; Cronbach & Gleser, 1953; Furr, 2008)

which can artificially inflate their size and also create misleadingly positive correlations with external variables (Wood & Furr, 2016). For example, an overall profile correlation may be high because persons in the sample are like normative persons with a typical variable profile who encounter normative environments with a typical variable profile. Wood and Furr (2016) thus recommend a two-pronged data-analytical strategy of reporting overall profile correlations containing normativity and distinctive profile correlations controlling for normativity. An index of overall fit is simply the regular q -correlation, which will be high to some degree simply because the to-be-correlated profiles are each similar to normative profiles (e.g., where each element of the profile is a mean across many and ideally representative persons or environments). Normativity captures what is typical (or deemed socially acceptable or desirable) in a given socio-culture. However, persons and environments may deviate from existing norms, and such deviations may be psychologically meaningful. A distinctive profile correlation is obtained when one first controls in both to-be-correlated profiles for their respective normative profiles and then correlates the resulting two residual profiles. Overall profile correlations confound both normative *and* distinctive aspects; by additionally quantifying distinctive profile correlations, the contribution of normativity can be made apparent. Thus, there are actually three kinds of profile-based person-environment fit: overall, normative, and distinctive fit. Importantly, these cannot be ordinarily disentangled with a variable-oriented approach but only within a profile-oriented one.²³

²³ The procedure of obtaining overall and distinctive profile correlations is somewhat inelegant because it requires several piecemeal steps (especially when predictors, correlates, or outcomes are introduced) and does not provide any direct quantification of normative person-environment fit. A more powerful modeling procedure based on Biesanz' (2010) Social Accuracy Model and relying on random-coefficients modeling of profiles (level 1) nested within individuals (level 2) can be devised, though it has to date not been used in any empirical research yet (for details, see Rauthmann, Horstmann, and Sherman, in prep.), rests on several assumptions that may not be easily met, and is more difficult to understand.

Box 4*Analysis of Cross-lagged Person-Environment Transactions*

The PERM in Figure 2 contains a cross-lagged model where a predictor at T1 predicts a criterion at T2 while controlling for the criterion at T1. Reversing the roles of predictors and criterion can help establish a lead-lag relationship (Finkel, 1995). These sorts of analyses can be conducted with multiple linear regressions or structural equation modeling (path analysis). However, there are several improvements to the basic idea of cross-lagged analyses available. For example, there are cross-lagged longitudinal mediation models (Cole & Maxwell, 2003) and advancements of and alternatives to cross-lagged models (Mund & Nestler, 2019). Further, high-intensity longitudinal measurements across time (Horstmann, Chapter 30) allow for more dynamic or even continuous modeling of the data (e.g., Costantini, Chapter 39; Geiser et al., Chapter 37; Driver & Völkle, Chapter 34; Michaels et al., Chapter 38; Sadikaj et al., Chapter 33; Völkle et al., 2019; Wagner, Lüdtke, & Völkle, 2019). Additionally, it is important to distinguish between within- and between-person effects (Asendorpf, Chapter 31; Hamaker, Kuiper, & Grasman, 2015). Further, different instantiations of longitudinal models to study reciprocal relations exist, and these can all be couched within a single unified framework (see Usami, Murayama, & Hamaker, 2019).

Box 5

Example of Corresponsive Personality Change via Person-Environment Relations

The PERM in Figure 2 is a macroscopic model that can be further concretized for different research purposes. For example, it can be reassembled to capture downstream effects of person-environment fit (Figure 6). However, the PERM can also be rearranged by dropping the outcome variables and distinguishing different hierarchically nested person and environment variables (short-term, momentary: P, E; middle-term, aggregated: $\bar{P}$, $\bar{E}$; long-term, enduring: p, e; constraints, often individually immutable: genome g, culture c) and additionally combining Figures 7 and 8 into it. Such a reworking yields Figure 10 which is better equipped to track processes, sequences, and cycles more easily. Figure 10 is already filled with an illustrative example for a corresponsive pattern of personality change (see discussion in *4.4.1.1 Ontogenetic Processes*).

There are some particularities of the model in Figure 10 that need to be noted before describing an exemplary corresponsive pattern. First, the hierarchical system is multi-determined, multi-final, and multi-functional. The depiction is, however, already simplified. Second, some effects (e.g., from g to P) have to “trickle down” via multiple intermediate levels (e.g., gene expression, cell structures, neuroanatomy, biochemical processes, etc.). Indeed, there are only few direct effects in the model. Most effects will be indirect or mediated by several variables, thus creating temporal and/or causal sequences or chains. Conversely, across time effects may accumulate and “trickle up” (e.g., repeated P sequences, or $\bar{P}$, coalescing into p). It will be rare though not entirely impossible that a short-term variable has a direct and immediate effect on a long-term one (with exceptions such as brain damage after a car crash, intense bouts of violence inducing psychological trauma, etc.). However, these direct, timescale-asymmetrical effects are not depicted in Figure 10 because they are either not the norm or hard to track. Repeated enactments of ABCDs (affects, behaviors, cognitions, desires; Wilt & Revelle, 2015) or exposure to situations will, in most cases, have effects on more enduring

variables or even constitute these.²⁴ Third, the model contains effects occurring within or across different timescales, capturing ontogenetic, manifestive, actualgenetic, and accretive processes. These processes may interlock to bring forth different patterns of interest (e.g., a corresponsive pattern of personality change). Thus, patterns can be traced within this model and associated processes specified more easily.

The red highlighted paths in Figure 10 represent an *exemplary* tracing of a corresponsive personality change effect unfolding across time. Consider the red highlighted paths from the left (Points 0' and 0'') to the right (Point 11). First, a trait p is to some degree a function of, and bound by, a genome and genetic activity g (Point 0'). The trait p is related to habitual ABCDs $\bar{P}$ in daily life (Point 1) which are actualgenetically manifested in several specific ABCD states P at each moment (Point 2). These states P show some consistency and stability, and they are also actualgenetically related to momentary situation characteristics E (Point 3). Specifically, there are bidirectional transactions between P and E variables as well as (later) also correlations among them (Point 3). The E variables, in turn, are related to habitual environment characteristics $\bar{E}$ (Point 4) which are themselves related to even more enduring environment characteristics e (Point 5). The latter, in turn, are embedded into a cultural and historical context c (Point 0'') – analogous to how experiences and behavior are embedded into the genetic, neurological, and biophysiological functioning of persons (Point 0'). The enduring environment characteristics e show some stability across time (Point 6), and the later ones are related to later instances of $\bar{E}$ (Point 7). Those $\bar{E}$ variables, in turn, are related to actualgenetic E instantiations (Point 8) which show some consistency and stability and also begin to exert direct effects on later P states (Point 9). Those P states, then, also show some consistency and stability and are related again to a habitual $\bar{P}$ (Point 10). That habitual $\bar{P}$ is part of the now changed trait p (Point 11). Tracing the red highlights thus granted the opportunity to pinpoint *how* a trait changed sequentially in a corresponsive way via 11 consecutive steps. Of course, this served just

²⁴ For example, each P could be seen as caused by an underlying p (reflective model), forming the p (formative model), or being functionally related within a complex network where temporally stable structures and dynamics constitute p as an emergent phenomenon (network model). Thus, there are different perspectives that can be invoked (Fried, 2017), and each of them come with different measurement and data modeling assumptions. Figure 10 thus only contains arrows if the causal direction is clear(er) and/or temporally warranted (i.e., prior variables predict later ones).

as an illustrative example, and there are also several other ways how corresponsive patterns could emerge.

Taken together, as can be seen in Figure 10, something as simple as a corresponsive effect (i.e., traits craft niches which then change traits) is a function of several concatenated effects. One can zoom into the variables, effects, and sequences contained in Figure 10 even more. For example, each P variable actually represents different ABCDs that stand in certain relations to each other (e.g., in a network: Cramer et al., 2012). Further, each path or effect (e.g., the arrows) can reflect different mechanisms going on (e.g., calibration types with associated navigation mechanisms). Lastly, each process may itself be constituted of a myriad of microscopic sub-processes (e.g., Baumert et al., 2017; Wrzus & Roberts, 2017). Though there can never be a gapless tracing of everything involved, these further complexities should still be taken into account. Only then can we move towards more causal understandings of person-environment relations (see 6.4 *Explanation vs. Prediction and Causality*).

Table 1
Overview and Summary of PERM Concepts

Concepts	Amount	Items	Table	Figure
Basic elements	4	<ul style="list-style-type: none"> • Person variables: $\mathbb{P}$, $\mathbb{p}$ • Environment variables: $\mathbb{E}$, $\mathbb{e}$ 	2	2
Measurement flections	2	<ul style="list-style-type: none"> • Once (single-moment) vs. repeated • Variable- vs. profile-oriented 	2	-
Predictive combinations	60	Variations from $\mathbb{O} = f(\mathbb{P}, \mathbb{p}, \mathbb{E}, \mathbb{e})$	3	-
Effect paths	20	Paths a-t	4	2
Person-environment relations	4	<ul style="list-style-type: none"> • Interactions • Correlations • Fit • Transactions 	4	2
Approaches to person-environment interactions	3 (+2)	<ul style="list-style-type: none"> • Variance decomposition • Linear • Non-linear • (Effect patterns) • (Outcome-based person-environment fit) 	5	3, 4
Approaches to person-environment correlations	2	<ul style="list-style-type: none"> • Variable-oriented • Person-/Profile-oriented 	6	5, 6
Approaches to person-environment fit	2	<ul style="list-style-type: none"> • Outcome-based, variable-oriented (simple correlations; polynomial regression and response surface analysis) • Person-/Profile-oriented (profile correlations: overall, normative, distinctive) 	-	4d, 5, 6
Timescales of transaction processes	4	<ul style="list-style-type: none"> • Ontogenetic (long $\rightarrow$ long) • Manifestive/expressive (long $\rightarrow$ short) • Actualgenetic (short $\rightarrow$ short) • Accretive/accumulative (short $\rightarrow$ long) 	-	7
Effect patterns of person-environment transactions	16	<ul style="list-style-type: none"> • Non-transaction patterns (4x) • Bidirectional transaction patterns (4x) • Monodirectional transaction patterns (8x) 	7	8
Calibration types	4	<ul style="list-style-type: none"> • Person $\rightarrow$ Person • Person $\rightarrow$ Environment • Environment $\rightarrow$ Person • Environment $\rightarrow$ Environment 	8	-
Person $\rightarrow$ Environment navigation mechanisms	6	<ul style="list-style-type: none"> • Maintenance • Construal • Evocation • Selection • Modulation • Creation 	8, 9	9
Recommendation and suggestions	10	<ol style="list-style-type: none"> 1. Taking the assessment of environment variables seriously 2. Employing appropriate research designs 	-	-

3. Zooming into processes, sequences, and cycles
4. Attending to explanation vs. prediction and causality
5. Conceptualizing, measuring, and studying calibration and navigation mechanisms
6. Distinguishing different types of person-environment fit clearly
7. Devising a transactional perspective on traits
8. Providing (mathematical) formalizations
9. Increasing efforts for theory, integration, replication, and collaboration
10. Working towards principles of person-environment relations

Table 2
Basic Elements and their Flections

Element	Description	Attributes			
		Variable Group	Time-scale	Measurement Occasions	Measurement Orientation
P	Placeholder for <i>any</i> kind of short-term person variables (one or several)	Person	Short-term	Any	Any
pp	Placeholder for <i>any</i> kind of long-term person variables (one or several)	Person	Long-term	Any	Any
E	Placeholder for <i>any</i> kind of short-term environment variables (one or several)	Environment	Short-term	Any	Any
e	Placeholder for <i>any</i> kind of long-term environment variables (one or several)	Environment	Long-term	Any	Any
P	Single short-term person variable measured once in time	Person	Short-term	Single-time	Variable (Single)
p	Single long-term person variable measured once in time	Person	Long-term	Single-time	Variable (Single)
E	Single short-term environment variable measured once in time	Environment	Short-term	Single-time	Variable (Single)
e	Single long-term environment variable measured once in time	Environment	Long-term	Single-time	Variable (Single)
P̄	Density distribution parameter or latent score of a repeatedly measured single short-term person variable	Person	Short-term	Repeatedly	Variable (Single)
p̄	Density distribution parameter or latent score of a repeatedly measured single long-term person variable	Person	Long-term	Repeatedly	Variable (Single)
Ē	Density distribution parameter or latent score of a repeatedly measured single short-term environment variable	Environment	Short-term	Repeatedly	Variable (Single)
ē	Density distribution parameter or latent score of a repeatedly measured single long-term environment variable	Environment	Long-term	Repeatedly	Variable (Single)
⋮P	Profile of several different short-term person variables, each measured once in time	Person	Short-term	Single-time	Person (Profile)
⋮p	Profile of several different long-term person variables, each measured once in time	Person	Long-term	Single-time	Person (Profile)
⋮E	Profile of several different short-term environment variables, each measured once in time	Environment	Short-term	Single-time	Person (Profile)
⋮e	Profile of several different long-term environment variables, each measured once in time	Environment	Long-term	Single-time	Person (Profile)
⋮P̄	Profile of density distribution parameters or latent scores of several different short-term person variables, each measured repeatedly	Person	Short-term	Repeatedly	Person (Profile)
⋮p̄	Profile of density distribution parameters or latent scores of several different long-term person variables, each measured repeatedly	Person	Long-term	Repeatedly	Person (Profile)
⋮Ē	Profile of density distribution parameters or latent scores of several different short-term environment variables, each measured repeatedly	Environment	Short-term	Repeatedly	Person (Profile)
⋮ē	Profile of density distribution parameters or latent scores of several different long-term environment variables, each measured repeatedly	Environment	Long-term	Repeatedly	Person (Profile)

Note. Outcome variables ① may be defined as any P, pp, E, or e variables.

Table 3
Basic Predictive Combinations

Formula	Predictor Variables ^a	Prediction Type ^b	Element Balance ^c	Time Symmetry ^d
$\mathbb{O} = f(\mathbb{P})$	Person-only	One-way	-	-
$\mathbb{O} = f(\mathbb{P})$	Person-only	One-way	-	-
$\mathbb{O} = f(\mathbb{P}, \mathbb{P})$	Person-only	Two-way	-	No
$\mathbb{O} = f(\mathbb{E})$	Environment-only	One-way	-	-
$\mathbb{O} = f(\mathbb{E})$	Environment-only	One-way	-	-
$\mathbb{O} = f(\mathbb{E}, \mathbb{E})$	Environment-only	Two-way	-	No
$\mathbb{O} = f(\mathbb{P}, \mathbb{E})$	Mixed	Two-way	Yes	Yes
$\mathbb{O} = f(\mathbb{P}, \mathbb{E})$	Mixed	Two-way	Yes	No
$\mathbb{O} = f(\mathbb{P}, \mathbb{E})$	Mixed	Two-way	Yes	No
$\mathbb{O} = f(\mathbb{P}, \mathbb{E})$	Mixed	Two-way	Yes	Yes
$\mathbb{O} = f(\mathbb{P}, \mathbb{E}, \mathbb{E})$	Mixed	Three-way	No	No
$\mathbb{O} = f(\mathbb{P}, \mathbb{E}, \mathbb{E})$	Mixed	Three-way	No	No
$\mathbb{O} = f(\mathbb{P}, \mathbb{P}, \mathbb{E})$	Mixed	Three-way	No	No
$\mathbb{O} = f(\mathbb{P}, \mathbb{P}, \mathbb{E})$	Mixed	Three-way	No	No
$\mathbb{O} = f(\mathbb{P}, \mathbb{P}, \mathbb{E}, \mathbb{E})$	Mixed	Four-way	Yes	Yes

Note. The letters with double lines ($\mathbb{O}$, $\mathbb{P}$, $\mathbb{P}$, $\mathbb{E}$, $\mathbb{E}$) denote *sets* of variables that are undifferentiated placeholders that could be any form of a specific variable. For example, $\mathbb{P}$ refers to any kind of momentary person variable (and could denote $\mathbb{P}$, $\bar{\mathbb{P}}$, $\ddot{\mathbb{P}}$, or $\ddot{\mathbb{P}}$; see Table 2), while a $\mathbb{P}$ refers to a specific momentary person variable measured once in time at one given measurement occasion.

Outcome variables $\mathbb{O}$ may be defined as any $\mathbb{P}$, $\mathbb{P}$, $\mathbb{E}$, or $\mathbb{E}$ variables. Taking this into account, there are actually $4 \times 15 = 60$ different predictive combinations possible. Note further that any of the predictors ($\mathbb{P}$, $\mathbb{P}$, $\mathbb{E}$, or $\mathbb{E}$) represent sets and thus could stand for only one predictor or multiple predictors of the same element (e.g., $\mathbb{P}_1, \mathbb{P}_1, \dots, \mathbb{P}_n$) in each equation.

To obtain a palpable example of how the formula could look in each instance, following sample variables may be plugged in: $\mathbb{O}$ = making new friends, $\mathbb{P}$ = pleasant mood, $\mathbb{P}$ = trait extraversion, $\mathbb{E}$ = party, $\mathbb{E}$ = social network.

^a Predictor variables: Are person and/or environment variables, respectively, used as predictors?

^b Prediction type: How many distinct *sets* of person and/or environment variables, respectively, are used as predictors?

^c Element balance: Are person and environment variables (the elements) represented to equal amounts?

^d Time symmetry: Are the person and environment variables (or sets of variables), respectively, either defined both as short-term or both as long-term variables, respectively? In other words: Do the timescales of the predictor variables match up?

Table 4
Summary of PERM Effect Paths

Effect Path	Variables	Description ^a	Type	Timeframe	Person-Environment Relation
a	$\text{Person}_n \rightarrow \text{Outcome}_n$	A person variable is concurrently associated with (predicts) an outcome variable.	Prediction	Concurrent	Interaction (Fit)
b	$\text{Environment}_n \rightarrow \text{Outcome}_n$	An environment variable is concurrently associated with (predicts) an outcome variable.	Prediction	Concurrent	
c'	$\text{Environment}_n \rightarrow (\text{Person}_n \rightarrow \text{Outcome}_n)$	An environment variable moderates the effect of a person variable on an outcome variable.	Moderation	Concurrent	
c''	$\text{Person}_n \rightarrow (\text{Environment}_n \rightarrow \text{Outcome}_n)$	A person variable moderates the effect of an environment variable on an outcome variable.	Moderation	Concurrent	
d	$\text{Person}_n \leftrightarrow \text{Environment}_n$	A person variable is correlated with an environment variable.	Correlation	Concurrent	Correlation (Fit)
e	$(\text{Person}_n \leftrightarrow \text{Environment}_n) \rightarrow \text{Outcome}_n$	A person-environment correlation is associated with (predicts) an outcome variable.	Prediction	Concurrent	-
f', f''	$\text{Mechanism}_n \rightarrow (\text{Person}_n \leftrightarrow \text{Environment}_n)$	A mechanism variable is concurrently associated with (predicts) a person-environment correlation.	Prediction	Concurrent	-
g'	$\text{Mechanism}_n - \text{Person}_n$	A mechanism variable originates from or is tied to a person.	Origination ^b	Concurrent	-
g''	$\text{Mechanism}_n - \text{Environment}_n$	A mechanism variable originates from or is tied to an environment.	Origination ^b	Concurrent	-
h	$\text{Mechanism}_n \rightarrow \text{Outcome}_n$	A mechanism variable is concurrently associated with (predicts) an outcome variable.	Prediction	Time-lagged	-
i', i''	$\text{Mechanism}_n \rightarrow \text{Mechanism}_{n+1}$	A prior mechanism variable predicts itself at a later time-point.	Stability/Change	Time-lagged	-
j	$\text{Person}_n \rightarrow \text{Person}_{n+1}$	A prior person variable predicts itself at a later time-point.	Stability/Change	Time-lagged	-
k	$\text{Environment}_n \rightarrow \text{Environment}_{n+1}$	A prior environment variable predicts itself at a later time-point.	Stability/Change	Time-lagged	-

l	$\text{Outcome}_n \rightarrow \text{Outcome}_{n+1}$	A prior outcome variable predicts itself at a later time-point.	Stability/Change	Time-lagged	-
m	$(\text{Person}_n \leftrightarrow \text{Environment}_n) \rightarrow (\text{Person}_{n+1} \leftrightarrow \text{Environment}_{n+1})$	A prior person-environment correlation predicts itself at a later time-point.	Stability/Change	Time-lagged	-
n	$\text{Person}_n \rightarrow \text{Environment}_{n+1}$	A prior person variable predicts a later environment variable.	Prediction	Time-lagged	Transaction
o	$\text{Environment}_n \rightarrow \text{Person}_{n+1}$	A prior environment variable predicts a later person variable.	Prediction	Time-lagged	
p', p''	$\text{Outcome}_n \rightarrow \text{Mechanism}_{n+1}$	A prior outcome variable predicts a later mechanism variable.	Prediction	Time-lagged	-
q	$\text{Outcome}_n \rightarrow \text{Person}_{n+1}$	A prior outcome variable predicts a later person variable.	Prediction	Time-lagged	-
r	$\text{Outcome}_n \rightarrow \text{Environment}_{n+1}$	A prior outcome variable predicts a later environment variable.	Prediction	Time-lagged	-
s	$\text{Outcome}_n \rightarrow (\text{Person}_{n+1} \leftrightarrow \text{Environment}_{n+1})$	A prior outcome variable predicts a later person-environment correlation.	Prediction	Time-lagged	-
t', t''	$\text{Mechanism}_n \rightarrow (\text{Person}_{n+1} \leftrightarrow \text{Environment}_{n+1})$	A prior mechanism variable predicts a later person-environment correlation	Prediction	Time-lagged	-

Note. PERM = Person-Environment Relations Model. For an integrated graphical depiction of the PERM effects, see Figure 2.

^a The descriptions are all framed in a variable-oriented manner, but for some effects (especially person-environment correlations and fits) person- or profile-oriented views are also possible and sensible.

^b Navigation mechanisms can originate from persons (signified by ' in relevant paths) if they are geared towards a person $\rightarrow$ environment calibration. In the same manner, navigation mechanisms can also originate from environments (signified by " in relevant paths) if they are geared towards an environment $\rightarrow$ person calibration. All paths involving navigation mechanisms can thus exist at the person (left in Figure 2, with ') and at the environment side (right in Figure 2, with ").

Table 5
Overview of Selected Person-Environment-Outcome Effect Patterns

Patterns		Presence of PERS and ENV Predictor Effects				
Label	Krueger (2009)	PERS	ENV	PERS $\times$ ENV	PERS ²	ENV ²
<i>Linear Patterns</i>						
Zero (Intercept-only)	Wash-out					
Person-only	Disposition only	•				
Environment-only	Situation only		•			
Additive	Non-hydraulic	•	•			
<i>Interactionist Patterns</i>						
Interaction-only	Interaction only			•		
Person plus Interaction	Classic trait	•		•		
Environment plus Interaction	Classic social		•	•		
Additive plus Interaction	Complexity	•	•	•		
<i>Non-linear Patterns</i>						
Person Strength	-				•	
Environment Strength	-					•
Non-linear Additive	-				•	•
Non-linear Additive plus Interaction (Strict Fit Pattern) ^a	-			•	•	•
<i>Full Complexity Pattern</i>	-	•	•	•	•	•

Note. PERS = any person variable (either $\mathbb{P}$ or $\mathbb{p}$), ENV = any environment variable (either $\mathbb{E}$ or $\mathbb{e}$).

• = statistically significant, sizable, or otherwise meaningful effect of a predictor.

The full polynomial regression (see Equation 6) is given by $\text{Outcome} = b_1 \cdot \text{PERS} + b_2 \cdot \text{ENV} + b_3 \cdot \text{PERS}^2 + b_4 \cdot \text{PERS} \times \text{ENV} + b_5 \cdot \text{ENV}^2$.

Response surface parameters: $a_1 = b_1 + b_2$; $a_2 = b_3 + b_4 + b_5$; $a_3 = b_1 - b_2$; $a_4 = b_3 - b_4 + b_5$.

Samples of all patterns are depicted in Figures 4a-d.

^a See the first panel of Figure 4d under “Strict Fit Pattern”.

Table 6
Possible Types of Person-Environment Correlations

Correlation Between		Symmetry ^a	Type ^b	Correlation ^c
Person	Environment			
<i>Variable-oriented</i>				
P	E	Yes	State	<i>R</i>
P	$\bar{E}$	No	Mixed	<i>R</i>
P	e	No	Mixed	<i>R</i>
P	$\bar{e}$	No	Mixed	<i>R</i>
$\bar{P}$	E	No	Mixed	<i>R</i>
$\bar{P}$	$\bar{E}$	Yes	State-Aggregate	<i>R</i>
$\bar{P}$	e	No	Mixed	<i>R</i>
$\bar{P}$	$\bar{e}$	Semi	Mixed	<i>R</i>
p	E	No	Mixed	<i>R</i>
p	$\bar{E}$	Semi	Mixed	<i>R</i>
p	e	Yes	Trait	<i>R</i>
p	$\bar{e}$	Semi	Mixed	<i>R</i>
$\bar{p}$	E	No	Mixed	<i>R</i>
$\bar{p}$	$\bar{E}$	Semi	Mixed	<i>R</i>
$\bar{p}$	e	No	Mixed	<i>R</i>
$\bar{p}$	$\bar{e}$	Yes	Trait-Aggregate	<i>R</i>
<i>Profile-oriented</i>				
$\ddot{P}$	$\ddot{E}$	Yes	State	<i>Q</i>
$\ddot{P}$	$\ddot{\bar{E}}$	No	Mixed	<i>Q</i>
$\ddot{P}$	$\ddot{e}$	No	Mixed	<i>Q</i>
$\ddot{P}$	$\ddot{\bar{e}}$	No	Mixed	<i>Q</i>
$\ddot{\bar{P}}$	$\ddot{E}$	No	Mixed	<i>Q</i>
$\ddot{\bar{P}}$	$\ddot{\bar{E}}$	Yes	State-Aggregate	<i>Q</i>
$\ddot{\bar{P}}$	$\ddot{e}$	No	Mixed	<i>Q</i>
$\ddot{\bar{P}}$	$\ddot{\bar{e}}$	Semi	Mixed	<i>Q</i>
$\ddot{p}$	$\ddot{E}$	No	Mixed	<i>Q</i>
$\ddot{p}$	$\ddot{\bar{E}}$	Semi	Mixed	<i>Q</i>
$\ddot{p}$	$\ddot{e}$	Yes	Trait	<i>Q</i>
$\ddot{p}$	$\ddot{\bar{e}}$	Semi	Mixed	<i>Q</i>
$\ddot{\bar{p}}$	$\ddot{E}$	No	Mixed	<i>Q</i>
$\ddot{\bar{p}}$	$\ddot{\bar{E}}$	Semi	Mixed	<i>Q</i>
$\ddot{\bar{p}}$	$\ddot{e}$	No	Mixed	<i>Q</i>
$\ddot{\bar{p}}$	$\ddot{\bar{e}}$	Yes	Trait-Aggregate	<i>Q</i>

Note. This table only contains correlations between person and environment variables (disregarding person-person and environment-environment correlations which are, of course, also possible).

When the person and environment variables are contentwise commensurate or correspond in some meaningful way functionally to each other, then the correlations may denote fit.

^a Yes = both variables are exactly on the same timescale; No = both variables are at different timescales; Semi = both variables are at approximately the same timescale (but not exactly the same).

^b Different types of variables may fit among or between each other (states, state-aggregates, traits).

^c *R*-correlations are computed between two variables across a sample of persons (or environments). *Q*-correlations are computed between two profiles of variables within one person (or environment).

Table 7
Overview of Different Types of Person-Environment Transaction Patterns

Transaction Pattern	Stability Paths ^a		Cross-lagged Paths ^a		Depiction in Figure 8
	$PERS_n \rightarrow PERS_{n+1}$	$ENV_n \rightarrow ENV_{n+1}$	$PERS_n \rightarrow ENV_{n+1}$	$ENV_n \rightarrow PERS_{n+1}$	
<i>Non-Transactions</i>					
Zero Transaction					1
Person Stability	•				2
Environment Stability		•			3
Bi-Stability	•	•			4
<i>Bidirectional Transactions</i>					
Full Bidirectional Transaction	•	•	•	•	5
Reset Bidirectional Transaction			•	•	6
Person-tilted Bidirectional Transaction	•		•	•	7
Environment-tilted Bidirectional Transaction		•	•	•	8
<i>Monodirectional Transactions</i>					
<i>from Persons to Environments</i>					
Person-tilted Monodirectional Transaction	•	•	•		9
Full Person Transaction	•		•		10
Partial Person Transaction		•	•		11
Weak Person Transaction			•		12
<i>Monodirectional Transactions</i>					
<i>from Environments to Persons</i>					
Environment-tilted Monodirectional Transaction	•	•		•	13
Full Environment Transaction		•		•	14
Partial Environment Transaction	•			•	15
Weak Environment Transaction				•	16

Note. Indirect effects, curvilinear effects, and effects of variables from time $n+2$ etc. are not considered here. This means that even further, and more complex, patterns can be expected besides the 16 basic ones compiled in this table. Further, it is assumed that the effects do not vary across time.

The 16 transaction patterns are visualized in Figure 8.

^a The stability paths (person variables: path j; environment variables: path k) and cross-lagged paths (person to environment variables: path n; environment to person variables: path o) can be found in Figure 2.

Table 8
Overview of Calibration Types and Associated Navigation Mechanisms

Calibration Type	Selected Potential Navigation Mechanisms
Person → Person	Selection, Optimization, Compensation (SOC) Strategies Intentional personality change Self-regulation
Person → Environment	Maintenance Construal Evocation Selection Modulation Creation
Environment → Person	Transitioning Strength Nudging Attraction (drawing via rewards) vs. Attrition (repelling via punishments) Socialization Trauma
Environment → Environment	Chance Autopoiesis

Note. For details on navigation mechanisms for person → environment calibrations, see Table 9 and Figure 9.

Table 9
Navigation Mechanisms for Person → Environment Calibrations

Navigation Mechanism	Description	Other Literatures				
		Plomin et al. (1977) ^a	Scarr & McCartney (1983) ^b	Buss (1987) ^c	Caspi & Roberts (2001) ^d	Roberts (2006), Roberts & Nickel (in press) ^d
<i>Maintenance</i>	Remaining passively in or preserving an environment, thereby maintaining it	(Passive) (Active)	(Passive) (Active)	-	-	-
<i>Construal</i>	Uniquely re-construing a perceived environment differently than before	-	(Perception)	-	Reactive	-
<i>Evocation</i>	Willingly or unwillingly eliciting certain reactions from the environment	Reactive	Evocative	Evocation	Evocative	Evocation
<i>Selection</i>	Willingly avoiding one environment and approaching or entering another one	Active	Active	Selection	Pro-active	Selection Attrition Attraction
<i>Modulation</i>	Actively modulating a previous environment in a certain way so that it changes into a different one	(Active)	(Active)	Manipulation	-	Manipulation Transformation
<i>Creation</i>	Pro-actively creating an entirely new situation (from scratch)	(Active)	(Active)	Manipulation	-	Manipulation

Note. Modified from Tables 2 and 3 from Rauthmann & Sherman (2016). See Figure 9 for an ordering of the person→environment navigation mechanisms and their relations to each other in a coherent system.

Parentheses () mean that the respective term could potentially represent the navigation mechanism. A “-” means that there is likely no direct analog.

^a genotype-environment correlation

^b gene → environment effects

^c person-environment correspondence processes

^d person-environment transactions

Figure 1*Case Example for Unfolding Personality Dynamics*

Note. Situations 1-5 are different situational episodes (shaded areas) adjacent to each other in a temporal sequence of 34 measurement occasions in the stream of life of one person, Anna. The five situational episodes further correspond to three classes of situations (A: blue dots; B: green boxes; C: yellow triangles). Situational episodes 1 and 2 belong to Class A, episodes 2 and 4 to Class B, and episode 5 to Class C. At each measurement occasion, a personality state's intensity of expression is measured (e.g., by experience sampling, behavioral observation). White or blank spaces between the shaded situational episodes denote transitions from one situational episode to another. The measured personality states show markedly different intensities at different measurement occasions. This fictitious example shows variations within situational episodes (e.g., expression intensity changes in situational episode 1, becoming more and more) and across situations (e.g., expression intensity is higher in situational episode 4 compared to 5).

Taken from Rauthmann, J. F. (2020). *Person-Environment Relations (Figures)*. Retrieved from osf.io/ds6mw (CC-BY 4.0 license).

Figure 2

A Basic Person-Environment Relations Model (PERM)

Note. The elements (see Table 2) as well as all effect paths (a-t; see Table 4) are explained in the text.

Taken from Rauthmann, J. F. (2020). *Person-Environment Relations (Figures)*. Retrieved from osf.io/ds6mw (CC-BY 4.0 license).

Figure 3

Graphical Examples of Different Forms of Person $\times$ Environment Interactions

Note. The left two interaction forms are inspired by Figure 1 of Widaman et al. (2012). The right three interaction forms are hypothetical examples, where – depending on whether one wants to analyze one’s data from the perspective of persons or environments – X and Y could each represent either $\mathbb{P}$ or $\mathbb{E}$, respectively, and x and y could represent either $\mathbb{p}$ or $\mathbb{e}$, respectively.

Taken from Rauthmann, J. F. (2020). *Person-Environment Relations (Figures)*. Retrieved from osf.io/ds6mw (CC-BY 4.0 license).

Figure 4a

Sample Response Surfaces for Linear Person-Environment-Outcome Effect Patterns

Effect Pattern	Regression Coefficients	Surface Parameters	Response Surface Plot
Linear Patterns			
Zero	$b_1 = 0$ $b_2 = 0$ $b_3 = 0$ $b_4 = 0$ $b_5 = 0$	$a_1 = 0$ $a_2 = 0$ $a_3 = 0$ $a_4 = 0$
Person-only	$b_1 = 0.2$ $b_2 = 0$ $b_3 = 0$ $b_4 = 0$ $b_5 = 0$	$a_1 = 0.2$ $a_2 = 0$ $a_3 = 0.2$ $a_4 = 0$
Environment-only	$b_1 = 0$ $b_2 = 0.2$ $b_3 = 0$ $b_4 = 0$ $b_5 = 0$	$a_1 = 0.2$ $a_2 = 0$ $a_3 = -0.2$ $a_4 = 0$
Additive	$b_1 = 0.3$ $b_2 = 0.2$ $b_3 = 0$ $b_4 = 0$ $b_5 = 0$	$a_1 = 0.5$ $a_2 = 0$ $a_3 = 0.1$ $a_4 = 0$

Figure 4b

Sample Response Surfaces for Interactional Person-Environment-Outcome Effect Patterns

Effect Pattern	Regression Coefficients	Surface Parameters	Response Surface Plot
Interaction Patterns			
Interaction-only	$b_1 = 0$ $b_2 = 0$ $b_3 = 0$ $b_4 = 0.2$ $b_5 = 0$	$a_1 = 0$ $a_2 = 0.2$ $a_3 = 0$ $a_4 = -0.2$
Person plus Interaction	$b_1 = 0.2$ $b_2 = 0$ $b_3 = 0$ $b_4 = 0.2$ $b_5 = 0$	$a_1 = 0.2$ $a_2 = 0.2$ $a_3 = 0.2$ $a_4 = -0.2$
Environment plus Interaction	$b_1 = 0$ $b_2 = 0.2$ $b_3 = 0$ $b_4 = 0.2$ $b_5 = 0$	$a_1 = 0.2$ $a_2 = 0.2$ $a_3 = -0.2$ $a_4 = -0.2$
Additive plus Interaction	$b_1 = 0.3$ $b_2 = 0.2$ $b_3 = 0$ $b_4 = 0.2$ $b_5 = 0$	$a_1 = 0.5$ $a_2 = 0.2$ $a_3 = 0.1$ $a_4 = -0.2$

Figure 4c

Sample Response Surfaces for Non-linear Person-Environment-Outcome Effect Patterns

Effect Pattern	Regression Coefficients	Surface Parameters	Response Surface Plot
Non-linear Patterns			
Person Strength	$b_1 = 0$ $b_2 = 0$ $b_3 = 0.2$ $b_4 = 0$ $b_5 = 0$	$a_1 = 0$ $a_2 = 0.2$ $a_3 = 0$ $a_4 = 0.2$
Environment Strength	$b_1 = 0$ $b_2 = 0$ $b_3 = 0$ $b_4 = 0$ $b_5 = 0.2$	$a_1 = 0$ $a_2 = 0.2$ $a_3 = 0$ $a_4 = 0.2$
Non-linear Additive	$b_1 = 0$ $b_2 = 0$ $b_3 = 0.2$ $b_4 = 0$ $b_5 = 0.2$	$a_1 = 0$ $a_2 = 0.4$ $a_3 = 0$ $a_4 = 0.4$
Non-linear Additive plus Interaction (Strict Fit Pattern)	$b_1 = 0$ $b_2 = 0$ $b_3 = 0.2$ $b_4 = 0.2$ $b_5 = 0.2$	$a_1 = 0$ $a_2 = 0.6$ $a_3 = 0$ $a_4 = 0.2$

Figure 4d

Sample Response Surfaces for Person-Environment-Outcome Effect Patterns Denoting Fit

Effect Pattern	Regression Coefficients	Surface Parameters	Response Surface Plot
Fit Patterns			
Strict Fit Pattern	$b_1 = 0$ $b_2 = 0$ $b_3 = -0.05$ $b_4 = 0.1$ $b_5 = -0.05$	$a_1 = 0$ $a_2 = 0$ $a_3 = 0$ $a_4 = -0.2$	
Fit Pattern, with linear common main effects	$b_1 = 0.1$ $b_2 = 0.1$ $b_3 = -0.05$ $b_4 = 0.1$ $b_5 = -0.05$	$a_1 = 0.2$ $a_2 = 0$ $a_3 = 0$ $a_4 = -0.2$	
Fit Pattern, with curvilinear common main effects	$b_1 = 0.1$ $b_2 = 0.1$ $b_3 = -0.1$ $b_4 = 0.1$ $b_5 = -0.1$	$a_1 = 0.2$ $a_2 = -0.1$ $a_3 = 0$ $a_4 = -0.3$	

Notes for all Figures 4a-d. For all plots, the intercept (b_0) was set to 0.5.

Line of congruence (LOC) = solid blue line; line of incongruence (LOIC) = dashed blue line.

The three fit pattern examples in Figure 4d are slightly modified from Humberg et al. (2019, Table 3). All plots were generated by the plotRSA function from the RSA package in R (Schönbrodt, 2016a).

Darker green represents higher and darker orange to red lower values of an outcome in the plots.

b_0 = intercept; b_1 = slope of person variable, b_2 = slope of environment variable, b_3 = slope of squared person variable, b_4 = slope of interaction (product term) between the person $\times$ the environment variable, b_5 = slope of the squared environment variable. $a_1 = b_1 + b_2$; $a_2 = b_3 + b_4 + b_5$; $a_3 = b_1 - b_2$; $a_4 = b_3 - b_4 + b_5$. See Box 1 for details on polynomial regressions and response surface analysis.

Taken from Rauthmann, J. F. (2020). *Person-Environment Relations (Figures)*. Retrieved from osf.io/ds6mw (CC-BY 4.0 license).

Figure 5

Hypothetical Examples of Profile-oriented Person-Environment Fit

Note. The first panel “Within One Person” depicts an intra-individual distribution of q -correlations. Each q -correlation is derived by correlating a profile of person variables with a concordant profile of environment variables. Here, many such q -correlations could be computed for a person, and hence their frequency distribution with the person can be plotted. In this fictitious example, the person rarely has profile correlations below 0 and most above 0.

The second panel “Between Persons” depicts two density distributions of profile correlations from two different groups of persons (with some overlap, nonetheless). One group (dashed lines) has on average lower q -correlations, the other (solid lines) has on average higher q -correlations. Each distribution is obtained when examining different individuals’ q -correlations (which – if measured first repeatedly within each person – may have been mean-aggregated within each person first).

The third panel “Across Ages” depict profile correlations measured for different persons of different ages in cross-sectional data, or from the same persons measured intra-individually across their lifespans in longitudinal data. In both instances, profile correlations on the y-axis would have been converted to percent of maximum possible (POMP) scores for better interpretability with other scales from different literatures. The shown age trend or trajectory is hypothetical.

Details can be found in Box 3.

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Figure 6

A Process Model of Person-Environment Fit and its Consequences

Note. Taken from Rauthmann, J. F. (2020). *Person-Environment Relations (Figures)*. Retrieved from osf.io/ds6mw (CC-BY 4.0 license).

Figure 7
Transaction Timescales

Note. Longer and darker purple boxes (above) reflect more enduring, longer-term variables (person variables: $\mathbb{P}$; environment variables: $\mathbb{E}$); shorter and lighter purple boxes (below) reflect less enduring, shorter-term variables (person variables: $\mathbb{P}$; environment variables: $\mathbb{E}$); boxes around three shorter-term boxes reflect an aggregate across time (e.g., a mean from a density distribution).

Taken from Rauthmann, J. F. (2020). *Person-Environment Relations (Figures)*. Retrieved from osf.io/ds6mw (CC-BY 4.0 license).

Figure 8

Visualization of 16 Possible Person-Environment Transaction Patterns

 Note. Taken from Rauthmann, J. F. (2020). *Person-Environment Relations (Figures)*. Retrieved from osf.io/ds6mw (CC-BY 4.0 license).

Figure 9

A Systematic Dendrogram of Navigation Mechanisms for Person → Environment Calibrations

Note. Lighter yellow boxes reflect “end-product” person→environment navigation mechanisms that are not decomposed further here. Darker orange boxes reflect navigation mechanisms that can be decomposed further. Dotted light gray lines reflect secondary associations among navigation mechanisms (i.e., they may often co-occur, blend into each other, and/or be difficult to disentangle).

Taken from Rauthmann, J. F. (2020). *Person-Environment Relations (Figures)*. Retrieved from osf.io/ds6mw (CC-BY 4.0 license).

Figure 10

Example of Concretizing the PERM to Trace Correspondive Personality Change Effects

Note. PERM = Person-Environment Relations Model.

Back arrows highlighted in red reflect traceable paths in this example.

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