Personality Traits, States, and Social Cognition – in life and everyday life

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To Ulla and Rolf Winter,
to follow in your footsteps.

No Man is an Island
No man is an island entire of itself; every man
is a piece of the continent, a part of the main;
if a clod be washed away by the sea, Europe
is the less, as well as if a promontory were, as
well as any manner of thy friends or of thine
own were; any man's death diminishes me,
because I am involved in mankind.
And therefore never send to know for whom
the bell tolls; it tolls for thee.

– John Donne, 1624

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Gratitude is a virtue and a humbling feeling of connectedness. It is all the more important that we remind ourselves of the people who supported us on our paths. In my case, it was the path to the doctorate which can at times feel very isolating. The support I received took many forms–economical, intellectual, and emotional: among others a sympathetic ear, wise counsel, lots of patience, kindness, and open doors. I am grateful for my friends, my family, my colleagues, as well as the institutions that made this endeavor possible.

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Thank you.

Eigenständigkeitserklärung

Hiermit erkläre ich, die Dissertation selbstständig und nur unter Verwendung der angegebenen Hilfen und Hilfsmittel angefertigt zu haben.

Ich habe mich anderwärts nicht um einen Doktorgrad beworben und besitze keinen entsprechenden Doktorgrad.

Ich erkläre, dass ich die Dissertation oder Teile davon nicht bereits bei einer anderen wissenschaftlichen Einrichtung eingereicht habe und dass sie dort weder angenommen noch abgelehnt wurde.

Ich erkläre die Kenntnisnahme der dem Verfahren zugrunde liegenden Promotionsordnung der Lebenswissenschaftlichen Fakultät der Humboldt-Universität zu Berlin vom 5. März 2015.

Weiterhin erkläre ich, dass keine Zusammenarbeit mit gewerblichen Promotions-bearbeiter*innen stattgefunden hat und dass die Grundsätze der Humboldt Universität zu Berlin zur Sicherung guter wissenschaftlicher Praxis eingehalten wurden.

Berlin, 24.03.2023
Richard Wundrack

Liste der Publikationen

Die vorliegende Arbeit wird in kumulativer Form vorgelegt und stützt sich auf die folgenden vier Veröffentlichungen, die im Appendix auch im Originalformat wiedergegeben sind.

Danvers, A. F., Wundrack, R., & Mehl, M. (2020). Equilibria in personality states: A conceptual primer for dynamics in personality states. *European Journal of Personality*, *34*(6), 999–1016. Copyright © 2020 SAGE Publications. https://doi.org/10.1002/per.2239

Wundrack, R., Asselmann, E., & Specht, J. (2021). Personality development in disruptive times: The impact of personal versus collective life events. *Social and Personality Psychology Compass*, *15*(9), e12635. CC BY. https://doi.org/10.1111/spc3.12635

Wundrack, R., Prager, J., Asselmann, E., O'Connell, G., & Specht, J. (2018). Does intraindividual variability of personality states improve perspective taking? An ecological approach integrating personality and social cognition. *Journal of Intelligence*, *6*(4), 50. CC BY. https://doi.org/10.3390/jintelligence6040050

Wundrack, R., & Specht, J. (2023). Mindful self-focus–an interaction affecting Theory of Mind? *PLOS ONE*, *18*(2), e0279544. CC BY. https://doi.org/10.1371/journal.pone.0279544

Abstract

Does our own variability affect how we think about others? Do personality states changes involve more than ourselves? How do others affect our personality development?
How does focusing on oneself affect thinking about others? This dissertation explores the many relationships between an individual's personality and ther relation to and interaction with other people across multiple areas of personality psychological research. Before summarizing four publications of this cumulative project, I explain my theory-driven approach and introduce the field of personality dynamics and processes. In particular, I focus on the concepts of personality traits, within-person variability, personality development, self-focus, egocentrism, egocentric bias–often in light of their relevant for Theory of Mind. The first publication proposes a two-tier framework of how within-person variability can facilitate Theory of Mind by broadening and relativizing a person's egocentrism. The second publication introduces the terminology and statistical tools of dynamic systems theory to the investigation of personality state levels and presents possible use cases. The third publication introduces a classification system to differentiate between personal and collective live events in a systematic way that is sensitive to the different mechanisms by which both kinds of life events can affect personality development. The fourth publication presents evidence for a small but robust positive relationship between mindful self-focus and Theory of Mind. Finally, I reflect on the publications' contributions to the field and suggest three lines of research stemming from risk management, personality psychology, and neuroscience that could inform research on within-person variability and personality development as well as on egocentrism and Theory of Mind further in the future.

Keywords: Personality dynamics, within-person variability, Theory of Mind, egocentrism, egocentric bias, dynamic systems theory, personality development, major life events

Zusammenfassung

Beeinflusst unsere eigene Variabilität, wie wir über andere denken? Betrifft die Veränderung unserer Persönlichkeitszustände mehr als uns selbst? Wie beeinflussen andere unsere Persönlichkeitsentwicklung? Wie wirkt sich der Fokus auf uns selbst auf das Denken über andere aus? In dieser Dissertation werden die vielfältigen Beziehungen zwischen der Persönlichkeit eines Menschen und seiner Beziehung zu und Interaktion mit anderen Menschen in verschiedenen Bereichen der persönlichkeitspsychologischen Forschung untersucht. Bevor ich die vier Veröffentlichungen dieses kumulativen Projekts zusammenfasse, erläutere ich meinen theoriegeleiteten Ansatz und führe in das Feld der Persönlichkeitsdynamik und -prozesse ein. Insbesondere konzentriere ich mich auf die Konzepte der Persönlichkeitsmerkmale, der innerpersonellen Variabilität, der Persönlichkeitsentwicklung, des Selbstfokus, des Egozentrismus und der egozentrischen Verzerrung–oft im Rahmen ihrer Bedeutung für die Theory of Mind. In der ersten Publikation wird ein zweistufiges Model dafür vorgeschlagen, wie die innerpersonelle Variabilität die Theory of Mind durch Erweiterung und Relativierung des Egozentrismus einer Person erleichtern kann. In der zweiten Publikation werden die Terminologie und die statistischen Werkzeuge der dynamischen Systemtheorie für die Untersuchung von Persönlichkeitszuständen eingeführt und mögliche Anwendungsfälle vorgestellt. Die dritte Publikation stellt ein Klassifizierungssystem vor, mit dem zwischen persönlichen und kollektiven Lebensereignissen auf systematische Weise unterschieden werden kann, wobei die unterschiedlichen Mechanismen berücksichtigt werden, durch die beide Arten von Lebensereignissen die Persönlichkeitsentwicklung beeinflussen können. Die vierte Publikation präsentiert Belege für eine kleine, aber robuste positive Beziehung zwischen achtsamer Selbstfokussierung und Theory of Mind. Abschließend reflektiere ich die Beiträge der Publikationen zum Fachgebiet und diskutiere drei Forschungsansätze aus dem Risikomanagement, der Persönlichkeitspsychologie und den Neurowissenschaften, die die Forschung zu innerpersönlicher Variabilität und Persönlichkeitsentwicklung sowie zu Egozentrismus und Theory of Mind in der Zukunft weiter voranbringen könnten.

Schlüsselwörter: Persönlichkeitsdynamik, innerpersönliche Variabilität, Theory of Mind, Egozentrismus, egozentrische Verzerrung, dynamische Systemtheorie, Persönlichkeitsentwicklung, wichtige Lebensereignisse

Table of contents

Part I: Introduction

1.   Topics & themes, a motivational overview

The urban phrase '*alone together*'–meaning "doing your own thing, but around each other" (*Urban Dictionary*, 2018)–sums up the tension of living in a modern Western society very well: striving for both individualism and relatedness at the same time. As a discipline, personality psychology similarly attempts this balancing act by focusing on the individual, knowing that they[1] must be understood in light of others. At its core, my research interest is exactly about this relation between the seemingly stand-alone individual and their ubiquitous entanglement with the external world in general and other people in particular:

> ➢ Does our own variability affect how we think about others (Wundrack et al., 2018)?
> ➢ Do personality state changes involve more than ourselves (Danvers et al., 2020)?
> ➢ How do others affect our personality development (Wundrack et al., 2021)?
> ➢ How does self-focusing affect thinking about others (Wundrack & Specht, 2023)?

Personality psychology is primarily concerned with the *ABCD of personality*, an individual's Affec, Behavior, Cognition, and Desires that (A) allow one to meaningfully distinguish people from one another, (B) explain the processes underlying all human activity, (C) predict what people do in everyday life and how well they manage their life, and (D) how they change and develop throughout life. A subdiscipline that has been rapidly growing in popularity over the last decade or two concerns personality dynamics and processes (Jayawickreme, Fleeson, et al., 2021; Kuper et al., 2021; Rauthmann, 2021b). A hallmark of this research is the explicit distinction between how personality can be *described* and how personality can be *explained* (Fleeson & Jayawickreme, 2015; Mischel & Shoda, 1995). In this sense, the field–and so am I–is concerned with (i) personality traits, the relatively stable patterns in our thoughts, feelings, and behaviors, (ii) personality state levels, the actual moment-to-moment thoughts, feelings, and behaviors, (iii) the relationship between traits and state levels, (iv) how both are affected by the environment, by everyday life situations, and major life events, and (v) how they relate to our cognitive skills.

Regarding the latter (v), my particular interest lies in perspective taking–or more precisely Theory of Mind–, the ability to reason and infer other people's thoughts, feelings, and behaviors (Preckel et al., 2018). Note how the content of personality state levels and Theory of Mind is basically the same. In other words, I am interested in both, first, how we as scientists think about personality state levels, and second, how laymen think every day about the personality state levels of other people when they take their perspective.

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[1] I use 'they', 'their', 'them', and 'themself' [!] to refer to unspecified individuals in a gender-neutral way.

To me, the fascinating thing about personality psychology is that many of the ideas researchers unpack today are almost as old as psychology itself, yet we are only equipped to answer them now in the wake of the digital age. Not the oldest but one of the most prominent historical ideas concerning the expression of personality in real life is Kurt Lewin's field theory (Lewin, 1951). Simply speaking, Lewin suggested that an individual's behavior is a function of the person and their environment, which is primarily defined by other people.[2] The question of how much in this equation depends on the person and how much on their immediate environment started a debate that lasted over three decades, the infamous person–situation debate (Funder, 2006; Mischel, 1969). It was hardly the case that there was real doubt that our personality influences our behavior. Instead, the conflict concerned the fact that personality psychology had been bent on the concept of personality traits which by design capture rather stable attributes that allow distinguishing people *without* the need to refer to specific situations or the circumstances of their lives. Bringing the situation back into the equation, required a different approach to personality, for example in terms of momentary personality state levels.

If there were doubts that our personality is consequential in our lives, modern personality psychology has cleared them away (Beck & Jackson, 2022; Soto, 2019, 2020). More importantly, however, researchers have come up with new ways of thinking about the interplay of personality and everyday life situations (Back, 2021; Beck & Jackson, 2021; Blum et al., 2018; Geukes et al., 2017; Quirin et al., 2020; Rauthmann et al., 2019; Rauthmann & Sherman, 2016; Sosnowska et al., 2019; Ziegler et al., 2019) as well as major life events (Baumert et al., 2017, 2019; Geukes et al., 2018; Jackson & Beck, 2021; Luhmann et al., 2014, 2020; Specht, 2017). They have also refined how personality processes are investigated using among others ambulatory assessments, mobile sensing, and social media footprints (Mehl & Wrzus, 2021; Stachl et al., 2020, 2021; Wright & Zimmermann, 2019).

I have mostly done empirically informed theoretical work. In light of the replication crisis and the good scientific practice movement in psychology (Anvari & Lakens, 2018; Morawski, 2019; Vazire, 2018; Wiggins & Christopherson, 2019), one of the major concerns of my work was being very explicit about how psychological concepts are defined, how these definitions are operationalized, and how well certain measures fit the operationalizations. This is necessary because it is, what links theory and data, and makes our hypotheses testable.

One simple yet persistent obstacle slowing scientific progress in psychology to this day is the long-known *jingle-jangle fallacy* (Block, 1995). It consists of the *jingle fallacy* (Thorndike, 1904), the assumption of real equality where there are mere homonyms, that is multiple things with the same name, and the *jangle fallacy* (Kelly, 1927), the assumption of real differences where there is merely a polyonym, one thing with multiple names. Arguably, recent examples of jingle-jangle concern the assessment of emotion state levels with items from trait affect scales (Weidman et al., 2017) and research on grit instead of conscientiousness (Schmidt et al., 2020). Ambiguity is commonplace in psychological science (Lilienfeld et al., 2015) and jingle-jangle often occurs due to mislabeled, incorrectly used, unreliable, or unvalidated tests and scales. Inconsistently used terminology across studies and a mismatch of the terms and measures within studies results in researchers talking past each other and drawing false conclusions.

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[2] Interestingly, it has recently been suggested that in many cases the situations a person encounters could simply be modeled in terms of the personality traits of the interaction partners (Asendropf, 2017).

This does not mean that there is no room for vagueness and ambiguity in psychological research–as long as it is made explicit as in the case of anger (Russell & Fehr, 1994). Especially, because the desired clarity can only be achieved by doing the research and having the scientific discourse, for example, regarding the 'questionable dimensional trait-state distinction' (Kandler, 2017, p. 549). In an attempt for more precision, technical terms changed throughout my research as well. For example, in my first publication, I used the phrase '*perspective taking*', while I opted for the more precise phrase '*Theory of Mind performance*' in my final publication (Wundrack et al., 2018; Wundrack & Specht, 2023). The latter phrase made it more clear that I was talking about the ability to infer another person's mental state and not the ability to take someone else's visuospatial perspective. This is important because unfortunately many Theory of Mind tasks are primarily about whether a participant is aware of what another person can or cannot see (Quesque & Rossetti, 2020; Rubio-Fernández, 2017; Zaitchik, 1991).

Taken together this resonates with what has been concluded with regard to research on personality dynamics and processes in general: "[F]uture research needs to put a stronger emphasis on conceptual clarity, terminological accuracy and consistency, and operationalization to move towards formalizable theories. For example, some authors lump different phenomena under the term 'process' (jingle fallacy), while others use different labels for 'process' (jangle fallacy)." (Kuper et al., 2021, p. 35).

2. Topics & themes, a scientific selection

2.1. Personality dynamics and processes

The group around John F. Rauthman, editor of the first 'Handbook of Personality Dynamics and Processes' (Rauthmann, 2021b), said the field is experiencing a 'renaissance' (Kuper et al., 2021, p. 34) since the settlement of the person–situation debate mentioned above. Research on personality dynamics and processes shows that psychology has come a long way. Take, for example, the key formula of field theory (Lewin, 1951):

$$B = f(P, E)$$

It introduces the idea that our behavior B is a function of the person P and their environment E. Then look at the illustration (cf. Figure 1) of the Person-Environment Relations Model published 70 years later (Rauthmann, 2021a) which lays out only some of the relations at play–though herein the behavior of a person is just one of the possible outcomes considered. The interplay between a person and their environment over time while taking into account navigation mechanisms like selection and modulation as well as the outcome including the behavior of the person and the affordances of the situations is extremely complex. Here it merely serves as an illustration of the matter at hand: personality dynamics and processes.

'*Dynamics*' simply means 'change over time' which is captured by the figure's inclusion of the time points T1 and T2 (top to bottom). With respect to personality, this 'change' can be transitory as in the case of personality state changes or lasting as in the case of personality

development, and the 'over time' part can reference time periods that last mere moments or a lifetime, and anything in between. Thus, research on personality dynamics covers a wide area, however, it is largely descriptive in nature showing that personality changes and what the trajectory of such change is.
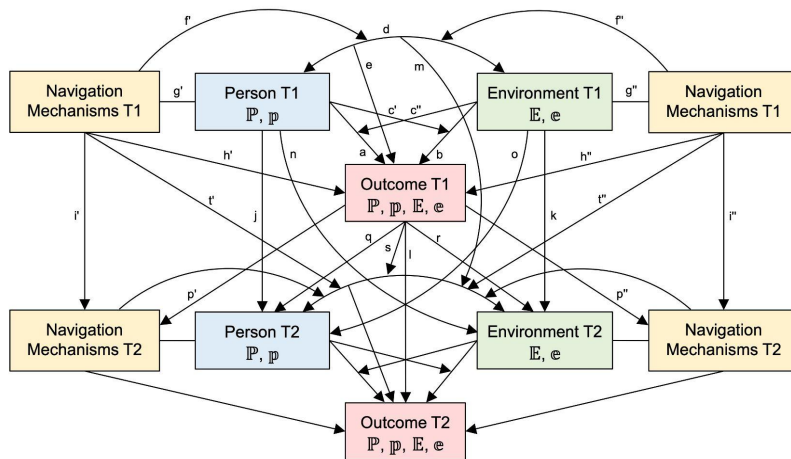

Figure 1. A basic Person-Environment Relations Model. Note: The elements and effect paths are not explained in the text. The figure was originally published in (Rauthmann, 2021a) available under CC BY 4.0.

Research on personality '*processes*', on the other hand, is mostly about detailing and explaining the change and why the interplay unfolds as it does. In Figure 1, this is represented by differentiating between the person, environment, outcome, and navigation mechanisms as well as the arrows going left and right between them. Recent examples from the literature include WTT, the Whole Trait Theory (Fleeson, 2001; Fleeson & Jayawickreme, 2015; Jayawickreme et al., 2018) and KAPA, the Knowledge and Appraisal Personality Architecture (Cervone, 2004, 2021), both of which evolved from CAPS, the Cognitive-Affective Personality System (Dingess & Wilt, 2020; Mischel & Shoda, 1995)). The models share the idea that we can explain personality state levels and traits by social-cognitive mechanisms or processes.

In a nutshell, the two key purposes of this line of research are the description of personality dynamics and their explanation by (social-cognitive) processes.

2.2.   Personality traits

Previously, I have stated that personality is about our thoughts, feelings, and behaviors–or alternatively, about affect, behavior, cognition, and desires (Wilt & Revelle, 2015). A similarly broad understanding of personality was suggested in a landmark paper targeted at integrating all the different aspects of research on personality dynamics and processes (Baumert et al., 2017)–though they chose the wider concept of motivations instead of desires.

Personality traits are the relatively stable patterns or tendencies of certain dimensions. For example, the Big Five (also called OCEAN) include the dimension Open-mindedness (previously Openness to experience), Conscientiousness, Extraversion, Agreeableness, and Negative emotionality (previously Neruoticism) (Soto & John, 2017). Importantly, there is a

small but important difference in meaning hidden between 'patterns' and 'tendencies'. A researcher speaking of characteristic patterns subscribes to the (in principle) directly observable. From this point of view, a personality trait should simply reflect the (statistical) aggregate of the respective personality state levels (Rauthmann et al., 2018). According to Whole Trait Theory, for example, personality traits can be operationalized as the mean of the density distribution of personality state levels (Fleeson, 2001; Fleeson & Jayawickreme, 2015; Jayawickreme et al., 2018). To get an exact estimate of the personality trait is then merely a question of collecting enough data points on an individual's personality state levels (Horstmann & Rauthmann, 2022).

Speaking of characteristic 'tendencies', however, touches on the potential and readiness to think, feel, and behave a certain way given a certain situation, even if the situation never realizes. 'Tendency' implies a what-if nature that is well illustrated by the opening sentences of an article on the NIPS model, the Nonlinear interaction of Person and Situation (Blum et al., 2018, p. 286): "Have you ever been chased by a T-Rex? Even if not, it is relatively easy to predict what you would do. You would flee." The central idea of the model is that individual differences can only be expressed as far as a situation offers the opportunity to do so.

Both interpretations of traits allow for predictions. The theoretical difference, however, is that patterns are purely descriptive. A prediction of how a person will think, feel, or behave in the future is based on the mere continuation of the pattern. Tendencies can–with reference to counterfactual thinking–additionally be read as causal (Holland, 1986; Pearl, 2009; Robins & Greenland, 2000). In light of the previous section's point about the descriptive nature of personality dynamics, it is important to note that this causal reading should not be applied to personality itself as this would be circular–extraversion does not explain assertive behavior and *vice versa*–but personality traits can explain other outcomes like income (Denissen et al., 2018).

2.3.   Within-person variability

Personality state levels are the temporary personality trait expressions that include the concrete thoughts, feelings, and behavior of a person in a specific situation. While the content of the state levels can clearly be attributed to the person, why a person may think, feel, or behave one way or the other depends on the person as well as their situation. This complicates one aspect of personality dynamics in particular: the concept of 'within-person variability'–or more precisely 'intraindividual personality state level variability'. The reason is that variability can be seen from multiple perspectives. Among others (Beck & Jackson, 2021), variability differs across different timescales and frequencies of measurement (Danvers et al., 2020), variability differs within- and across contexts (Geukes et al., 2017), and variability has to be evaluated in light of the variety of daily life (Lindner et al., 2023), that is to answer whether a person is variable in the face of a uniform or versatile lifestyle.

As multifaceted as the conceptualization of within-person variability is, are the methodological issues that have been raised against the construct. There are justified concerns regarding the reactivity to repeated self-report measures (Baird & Lucas, 2011), statistical confounds due to extreme response styles and conflation with the mean (Baird et al., 2017),

and the lack of validated personality state measures (Baird et al., 2006). While statistical corrections can solve some of these problems (Deng et al., 2018; Mestdagh et al., 2018), up until recently there were no validated self-report measures for personality state levels available (Horstmann & Ziegler, 2020; Ringwald et al., 2022). However, the question is also whether such a scale is validated to evaluate within-person variability (Lang et al., 2019).

From a dynamic systems perspective, which considers state level changes explicitly over time (Danvers et al., 2020), variability is not merely about the range of personality state levels a person takes on in general but about the range covered within a certain time. That means, if researchers wanted to think about variability in terms of standard deviation (SD) of personality state levels, they better consider, for example, '*daily* SD' (or 'mean SD per day'). Moreover, the assessment frequency should also be specified because different personality processes can take place over different periods of time that may lie between assessments. The statistical aggregate would then be something like the '*daily* SD *for an hourly assessment*'. While this would make researching within-person variability even more demanding, it would also allow for better cross-study comparisons.

In conclusion, we may just not yet have the appropriate (and agreed upon) methods and a large enough amount of data to say whether within-person variability is an individual difference that is relatively stable and predictive. That said, research on within-person variability–especially at the workplace–is on the rise (Abrahams et al., 2023; Alaybek & Dalal, 2021; Beckmann et al., 2021; Sosnowska et al., 2021; Vossen & Hofmans, 2021).

2.4. Personality development and major life events

Major life events demarcate important changes in certain areas of our lives. For example, moving in with a partner, marriage, separation, and divorce are common events in the domain of love (Asselmann & Specht, 2020) as they are "time-discrete transitions that mark the beginning or the end of a specific status" (Luhmann et al., 2012, p. 594). The fact that such life events can be pinpointed to a specific date and person allows looking at personality developmental effects that occur before and after such an event by comparing individuals who have experienced the life event against those who have not.

Personality development falls into the realm of personality dynamics and associating major life events with specific changes in personality traits is primarily a descriptive task. By themselves, life events are not an explanation. They merely showcase the malleability of personality traits across the lifespan (Specht et al., 2014). Explained is personality development (Wundrack & Specht, 2023) by personality processes that occur or change around a life event. Life events indicate changing social roles, expectations, affordances, and environments (Roberts & Nickel, 2017). For example, TESSERA, the Triggering situations, Expectancy, States/State expressions framework (Quintus et al., 2021; Wrzus, 2021; Wrzus & Roberts, 2017) links long-term personality changes to short-term processes of facing new situational and social constellations.

However, reducing major life events to mere indicators does not do them justice because of the information they carry regarding the socioenvironmental changes that they

entail. The debate on how to best conceptualize them is long and ongoing (Luhmann et al., 2020; Reese & Smyer, 1983; Wundrack et al., 2021). Similar to the question around the person–situation debate (Funder, 2006; Mischel, 1969) whether more behavioral variance is explained by the person or the situation factors, the debate is in many regards around the question of whether more personality developmental variance is explained by the individual or societal perception/construction of the life event. In the latter case, life events could, for example, simply be classified into generally positively and negatively perceived events (Specht, 2017). In the former case, the question is rather whether an event is positively or negatively perceived by the individual (Luhmann et al., 2020; Rakhshani et al., 2022). Even more, the latter approach also implies that the individual in question could over time change their perception of the event (Haehner et al., 2022).

Eventually, the question for one or the other approach to major life events should not be answered *a priori* but it should be answered by the data. Thus, much of the debate arguably seems to be about practical matters. Assessing the multidimensional individual experiences of a life event requires much more resources than an approach that simply asks whether or not someone has experienced an event or not. Our own contribution (Wundrack et al., 2021) can be understood as the search for a compromise that at the same time adds another layer of complexity by asking what the social circumstances of the event experience were.

2.5. Self-focus, egocentrism, and egocentric bias

All in all, I am aware of little recent research that has been done to connect self-focus, egocentrism, or egocentric bias with research on personality dynamics and processes in recent times (Tajmirriyahi et al., 2020). Much of it is rather concerned with other concepts related to self-focus like self-awareness, -concept, -esteem, -knowledge, -monitoring, -reflection, -rumination, and -talk (Morin & Racy, 2021).

Self-focus is simply about the attention directed towards oneself. As such, self-focus is part of normal psychological functioning though it has primarily been investigated in light of psychological problems in which self-focus seem to increase (Ingram, 1990; Mor & Winquist, 2002). Egocentrism, in turn, is about the leverage self-focus has on our cognition in general and an on Theory of Mind in particular (Preckel et al., 2018). The idea is that humans are by default egocentric (Epley et al., 2004; Ford, 1979) as egocentrism is an efficient way to organize knowledge about the world (Greenwald, 1980): the things more immediate to the individual become more relevant, prioritized, or salient than what is more distant. Egocentric bias, in turn, is often used synonymously with egocentrism but can also be understood as the measure of egocentrism: how often or how much an individual is mistaken about another person given what they know about the other person but discard or ignore due to their privileged knowledge and perspective.

Research concerning self-focus, egocentrism, and egocentric bias is ridden with jingle-jangle as the concepts are closely related and many slightly different definitions out there leave room for interpretation. For example, particularly egocentric individuals have been said (a) to tend to rely too heavily on their own perspective, (b) to project their own perspective

onto other people, (c) to have a limited ability to differentiate between themself and others, or (d) to be unable to accurately assume or understand any perspective other than their own (Elkind, 1967; Preckel et al., 2018; L. Ross et al., 1977; M. Ross & Sicoly, 1979). Furthermore, regarding self-focus and egocentrism researchers are not even sure whether to consider them personality traits–so much so that even a recently developed scale for egocentrism only refers to it as "trait-like" (Tajmirriyahi et al., 2020).

Part II: My research

3.   The scientific and lived relationship between the publications[3]

In my motivational overview, I have stated that my research interest is largely theoretical and focused on personality and how we relate to other people in real life. To this end, my colleagues and I have published four articles. The first publication proposes a model for how within-person variability might positively affect Theory of Mind (Wundrack et al., 2018). The second publication introduces the terminology and statistical tools of dynamic systems theory to research personality state level changes (Danvers et al., 2020). The third publication provides a framework for the dimensional distinction between personal and collective life events and their respective potential to affect personality development (Wundrack et al., 2021). The fourth publication evaluates under which circumstances focusing on oneself can help Theory of Mind (Wundrack & Specht, 2023). Figure 2 illustrates where the four articles are located within the concept space of my research interests. Although the research content is the red thread connecting the publications, it must be acknowledged that the thread has been spun by practical matters of resources and opportunities as well.
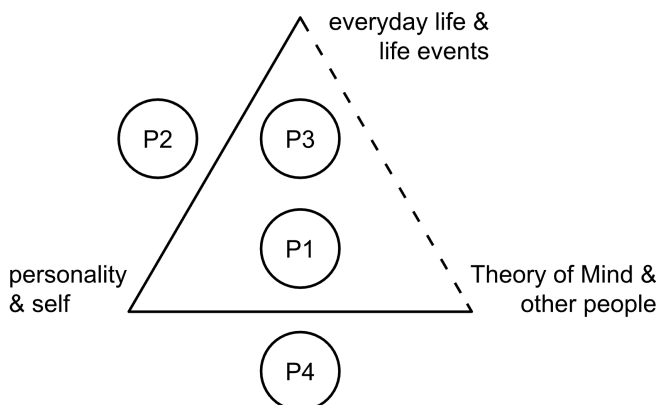
Figure 2. Core research contents and the placement of my publications (P1-4) within the concept space. Publications within the triangle touch upon all three topics, publications on the outside only on the two topics between which they are positioned. The dashed line indicates research not centered around the individual goes beyond the field of psychology.

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[3] I begin Part II with the section sketching out the relationship between the research articles because I wanted to provide the greater context first. I am aware that this requires you, the reader, to see connections before knowing all the details. You are welcome to change the reading order. I did my best to make it comprehensible either way.

3.1.   Publication 1 "Relating personality and Theory of Mind"

My doctoral project began with the proposal of a model on how within-person variability–that is how different a person is across everyday life–might positively affect their Theory of Mind performance (Wundrack et al., 2018). The article spurred some discussion (Jauk et al., 2019) which highlighted the importance to distinguish between 'healthy variability' and 'clinical volatility' of personality states and raised the possibility that taking someone else's perspective might also affect personality state variability.

More important for the further course of my doctorate, however, were the critical comments of the reviewers, which were concerned with the feasibility of assessing and analyzing personality state variability. The problems with within-person variability mentioned were largely the ones I laid out earlier in the scientific selection. Irrespective of the possibility of statistical corrections for some of these issues (Deng et al., 2018; Mestdagh et al., 2018), the fact remained that at the time, there were no appropriate and validated personality state self-report measures available (Horstmann & Ziegler, 2020). The development of such a scale was beyond my expertise and the scope of my dissertation. Together, this was enough to first rethink the conceptualization of variability in Publication 2.

The proposed positive relation between within-person variability and Theory of Mind was twofold. We argued that personality variability relativizes the egocentric perspective from which perspective taking starts and broadens what is "central" to the egocentric perspective. First, being aware of the fact that one's thoughts, feelings, and behaviors keep changing might make a person more willing to deviate from their current perspective when taking another person's perspective. Second, experiencing being in different personality state levels provides a wealth of experiences to draw from, when reasoning about what another person might think and feel in a certain situation. This puts the quality of a person's egocentrism at the heart of Theory of Mind, a topic that was continued in Publication 4.

3.2.   Publication 2 "Personality as a dynamic system"

During a research semester at the Naturalistic Observation of Social Interaction Laboratory of Mathias Mehl, I had the opportunity to be part of a research project that looked at personality state levels through the lens of dynamic systems theory. In contrast to the conceptualization in Publication 1, system thinking as laid out in the second publication required to think about within-person variability in terms of change over time (Danvers et al., 2020).

Within the dynamic system's framework, a person and the situations they encounter have to be understood as a single system. Such a system can be described by a certain topography of the expected trajectory of state level changes. While we primarily introduced systems thinking for the short-term personality dynamics, we also discussed that it is similarly applicable to the long-term. One important difference therein is the assumption that the topography itself can change as well. Topographical changes concern personality development and can come about when structural changes in the person–situation/environment system

occur. System changes in terms of social role and social environment changes that affect personality development are the topic of Publication 3.

Unfortunately, research in this fruitful personnel composition and with access to our primary source of data (Vazire et al., 2015) was discontinued when one team member decided to leave academia.

3.3.   Publication 3 "Personal vs. collective life events"

And then COVID-19 happened. The pandemic affected the entire world including how research could be done. In reaction, doctoral candidates were invited to contribute research that related this exceptional situation to their niche of research. My niche was 'personality dynamics in everyday life' and the pandemic turned mundane everyday life into a major life event, the field of expertise of my supervisor (Specht, 2017; Specht et al., 2014).

What the pandemic made apparent and what became the impetus for the fourth publication (Wundrack et al., 2021), was that the typical way of going about major life events in personality developmental research was not entirely suitable for collective life events. We addressed this and other challenges regarding major life events by adapting a framework from geographical information sciences (Dunkel et al., 2019) that allowed us to discern gradual rather than discrete differences between personal and collective life events. This relates this publication to Publication 2: it pays tribute to the fuzziness and vagueness of the boundaries between individuals and the world around them. The transition between personal and collective life events as well as between everyday life and major life events is fluid. Personality processes and lasting personality changes in particular do not usually happen from one day to the next but occur incrementally through repeated exposure to some (new) kinds of situations, environments, social roles, expectations, and affordances over a longer period of time (Bleidorn et al., 2020; Roberts, 2018; Roberts & Nickel, 2017; Wrzus & Roberts, 2017). In other words, the person–situation/environment system changes as discussed in Publication 2.

Additionally, longer periods of such changes are potentially accompanied by heightened personality state variability as a person must adapt to new social roles and daily routines. Going back and forth between old and new patterns they may be temporarily more variable and arguably better at putting themself in the shoes of others (cf. Publication 1). Especially those most similar to their old and those most similar to their new self.

3.4.   Publication 4 "Mindful self-focus and Theory of Mind"

While Theory of Mind is by definition about reasoning and thinking about the thought, feelings, and intentions of another person (Preckel et al., 2018), it seems to start from one's own egocentric perspective (Tamir & Mitchell, 2013). In Publication 1, we looked at egocentric bias as something that has–arguably in dependence on within-person variability–a certain scope and a certain pull on someone's Theory of Mind performance. Meaning, it matters what

is "central" to someone's perspective and how willing they are to deviate from it. In contrast, in the fourth publication (Wundrack & Specht, 2023), we looked at self-focus as a fundamental part of egocentrism and how the quality–here mindful vs. absentminded–of self-focus changes the role egocentrism can play for Theory of Mind performance: either as a source of information or as a source of error according to the common understanding of egocentric bias.

4.   Summary of the publications

4.1.   Publication 1 "Relating personality and Theory of Mind"

In "Does Intraindividual Variability of Personality States Improve Perspective Taking? An Ecological Approach Integrating Personality and Social Cognition" (Wundrack et al., 2018), we proposed a two-tier model of how going through a variety of personality state levels in everyday life might benefit Theory of Mind. This theoretical work was motivated by the observation that little research addresses how the relationship between personality and cognitive abilities might actually come about (Ackerman, 2018).

First, introduced the concept of within-person variability and grounded it in Whole Trait Theory (Fleeson, 2001; Fleeson & Jayawickreme, 2015). Therein, personality is primarily operationalized in terms of a person's density distribution of personality state levels, that is the relative frequency of their actual moment-to-moment state levels. How variable a person is in everyday life can then be captured by the standard deviation of the density distribution. We addressed that the practicality of within-person variability for psychological research was strongly debated. Methodological issues like (a) the reactivity to repeated self-report measures and statistical confounds including (b) floor- and ceiling effects for extreme response styles in self-reports, and (c) conflations with the mean were raised (Baird et al., 2006, 2017; Baird & Lucas, 2011; Geukes et al., 2017; Jones et al., 2017). Given these concerns, we discussed available solutions (Deng et al., 2018; Mestdagh et al., 2018) and the option of complementing self-report measures of personality state levels with behavioral measures. However, we also pointed out that behavioral measures might be inapt to fully replace self-reports because they merely provide indirect insight into the subjective experience which is more important for the proposed role of within-person variability for Theory of Mind.

Second, we turned to Theory of Mind as a socio-cognitive process of reasoning about someone else's mental state and distinguished it from empathy as a socio-affective process of sharing someone else's emotional state (Preckel et al., 2018). We discussed the complexity involved in taking someone else's perspective and contrasted it with the simplicity of most Theory of Mind tasks. In real life, a person has to draw on multiple sources of knowledge about the other person, their situation, and the social norms in which both the person and situation are embedded (Westra, 2017). In contrast, most Theory of Mind tasks merely require inferring from visual cues what a stranger can and cannot know in a certain situation. We argued for using a more ecologically valid Theory of Mind task like the Movie for Assessment

of Social Cognition which requires participants to reason about the intentions, thoughts, and feelings of four characters interacting with each other at a social event (Dziobek et al., 2006).

Third, for Theory of Mind to benefit from within-person variability, there must be a mechanism of how a person reasons about another person's perspective that is susceptible to their variability. This is the case for simulation theory which states that people approximate other people's mental state contents based on their own mental states (Tamir & Mitchell, 2013). The simulation postulates an anchoring and adjustment process. This is commonly understood as starting the simulation from one's egocentric perspective (anchoring) and sequentially correcting this perspective for what one knows to be different about the other person (adjusting). Alternatively, we argued that anchoring is better understood as a person's readiness to deviate from their own perspective. Accordingly, anchoring does determine the perspective from which to start the simulation but also influences the endpoint by affecting how much a person is willing to adjust their perspective. This brought the concept of anchoring much closer to its roots in egocentric bias. We argued that egocentric bias can be thought of as a generic overestimation of the subjectively immediate over the distant. By failing to acknowledge self–other differences a person stops the adjustment process too soon.

Finally, with the above conceptualizations of within-person variability, Theory of Mind, and egocentric bias, we were able to suggest two complementary pathways by which variability might positively affect Theory of Mind performance. The first pathway, *ego-dispersion*, suggests that increased variability weakens anchoring effects. In other words, it increases the readiness to deviate from one's perspective because the greater variability implies that any single perspective is less consolidated in relation to all occupied personality states levels (cf. Figure 3 (1)). The second pathway, *perspective-pooling*, hypothesizes that increased variability improves adjustment because over time the person accumulates a greater wealth of experiences from which to draw when adjusting for another person's perspective (cf. Figure 3 (2)). A similar mechanism has been shown to be at work for the positive relationship between trait openness to experience and fluid intelligence (Ziegler et al., 2012): open individuals experience a greater variety of novel and stimulating situations which positively affects their fluid intelligence.
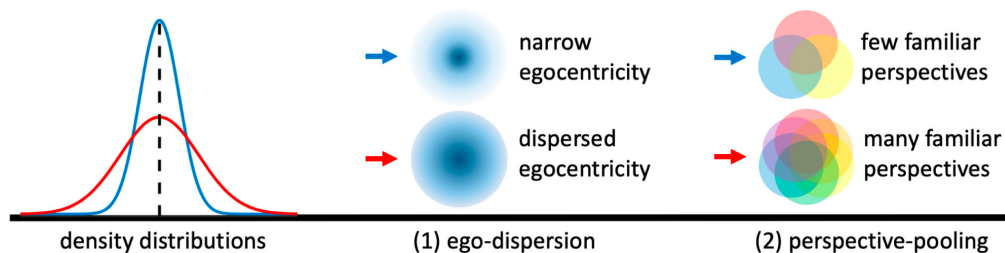
Figure 3. The two links, ego-dispersion and perspective-pooling. With increased within-person variability (Red > Blue) (1) egocentric bias (here 'egocentricity') decreases (the gradient from the center to the border of the circle is weaker in the bottom than the top circle) and (2) the number of self-experienced perspectives available for adjustment increases (more colored circles from top to bottom). The figure was originally published in (Wundrack et al., 2018) available under CC BY 4.0.

Based on our detailed discussion of the constructs and their operationalization, we formulated six hypotheses regarding the relations between the constructs and made suggestions on how to

appropriately test for them. The publication illustrates the difficulty of establishing the mechanisms that relate personality and cognition, how difficult they can be to test, and how many alternative explanations have to be considered.

4.2.   Publication 2 "Personality as a dynamic system"

In "Equilibria in Personality States: A Conceptual Primer for Dynamics in Personality States" (Danvers et al., 2020), we provide an introduction to the mathematical and conceptual fundamentals of dynamic systems modeling applied to personality state research. Our goal was to explain the modeling of personality state level changes over time in a simple and practical fashion. To do so, we drew on the Change as Outcome model (Butner et al., 2014) which allows explaining the core concepts of dynamic systems relying on simple linear regression models. Furthermore, we applied the model to actual data ($N = 434$) from wave 1 of the Personality and Interpersonal Roles study (Vazire et al., 2015) to illustrate our points.

Dynamic personality systems require consideration of the temporal order in which personality state levels occur. To highlight the importance of the temporal dimension, we contrasted our approach with the popular Whole Trait Theory (Fleeson, 2001; Fleeson & Jayawickreme, 2015; Jayawickreme et al., 2018) which operationalizes personality in terms of an atemporal density distribution of personality state levels (cf. Figure 4). By ignoring the temporal order in which personality state levels follow one another in favor of their mere relative frequency, the Whole Trait Theory is blind to the process that created the specific distribution of personality state levels.

With the Change as Outcome model, the temporal dependency between the state levels moves into focus. To this end, person-centered systems are considered in terms of their idiosyncratic topographies that describe the expected trajectory of state level changes (cf. Figure 5). The trajectory is defined by one or more equilibrium points–that is points where the system should be at rest–and the push and pull these points exert on the system when it is not at rest (Butner et al., 2014). Because such a system is constantly perturbed–for example, by the changing goals of the person and the situational requirements–in reality, it is never at rest.

In its simplest form, the topography can be illustrated by a regression model that optimizes the relationship between some personality state levels at some timepoint x with the change in state level to timepoint x+1. Then the slope of the regression line can be understood as the expected change in state level (cf. Figure 5). Where the regression line is at an expected change of 0 is an equilibrium point of the system.[4] Embedded in a negative slope, the equilibrium point is an attractor point, embedded in a positive slope it is a repeller. When the system is not at this exact state level of no expected change the system is assumed to move towards the attractor and away from the repeller with the strength of the slope of the line.

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[4] The most simple mathematical representation of the Change as Outcome model is $\Delta_x = m * x + b$, a linear model where Δ_x is the estimated personality state level change given the personality state level x times the regression coefficient m plus the intercept b. The equilibrium point is found by solving for $\Delta_x = 0$ with $-b/m = x$.

B: Density Distribution with Mean and Standard Deviation Overlaid

Density Distribution of State Extraversion for P10448

B: Change as Outcome Model Plotted for One Participant
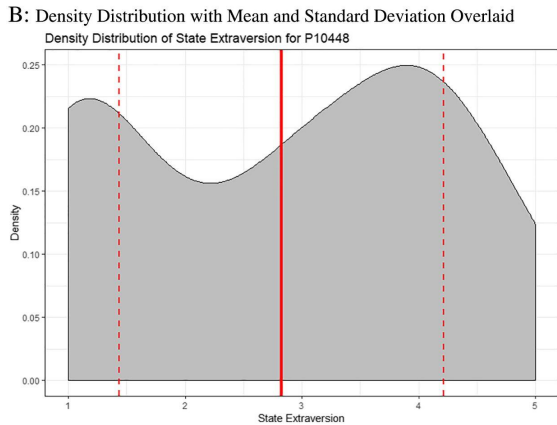
EXT Change as Outcome Plot P10448

Figure 4. Converting personality state measurements to a density distribution. Density distribution (grey area) with the mean (solid red line) and standard deviation (dashed red lines) potted for extraversion for one participant.

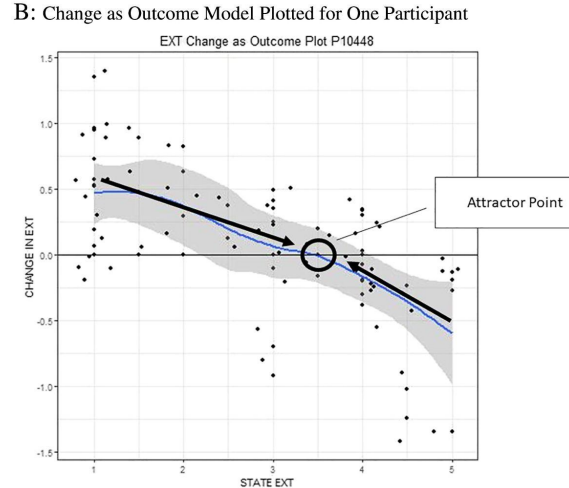Both figures were originally published in (Danvers et al., 2020) available under CC BY 4.0.

Figure 5. Identification of an attractor point in a Change as Outcome model. The Change as Outcome model is plotted for the same participant and trait as in Figure 4. The solid horizontal line is where no change in state level is expected. The blue solid line of the LOESS function with confidence intervals (grey area) describes the expected state level change. On either side of the horizontal line state level changes towards the intersection (black circle) are expected (black arrows).

More complex models are possible. Dynamic systems describing individuals can have both repellers and attractors or even a multitude of both. However, more complex dynamics can only be evaluated if personality states are assessed at a high enough rate and if the order of the function used to describe the system is high enough. Indeed, although sometimes more complex models are appropriate, in our data analysis we found that given assessments 3h apart for the majority (97.6% for agreeableness) of participants a linear model was appropriate.

Importantly, the system comprises the person in and across all considered moments and situations (specifically those included in data collection). Thus, an attractor point should not be thought of as the person's ideal or desired personality state but simply as the descriptive 'gravitational center' of a system bigger than the person. For such a system, clear attribution of how much variance can be explained by person factors and how much by situation factors is not possible because the dynamic perspective acknowledges their interdependence, and reciprocal relationships. Instead, these systems primarily distinguish between aspects that are part of their characteristic pattern of trajectories and those aspects that don't fit the pattern, the unmodeled portions of observation or perturbations.

Finally, besides discussing various aspects and limitations of the Change as Outcome model for different contexts and alternatives models like the Personality Dynamics model (Sosnowska et al., 2019), we discussed its usefulness regarding the analysis of personality developmental processes in the face of major life events or concerning the evaluation of the success of psychological interventions. Given the basic assumption that person-centered systems are malleable, the Change as Outcome model offers new ways of thinking about and–more importantly–formalizing personality processes and target outcomes. First, life events

and interventions could change the location of the attractor point. Second, they could also change the attractor strength, that is how much quicker or slower a person moves from one personality state to the next. Third, they could change the number of equilibrium points and thus the complexity of the overall topography of the system.

4.3.   Publication 3 "Personal vs. collective life events"

In "Personality development in disruptive times: The impact of personal versus collective life events" (Wundrack et al., 2021), we used a four-dimensional framework to flesh out the differences between personal and collective life events that we deemed relevant to personality development research. The framework is based on a classification system proposed for the study of reactions to referent events in geographical information science (Dunkel et al., 2019) that distinguishes between the thematic, social, spatial, and temporal aspects of an event. The project was motivated by the pandemic highlighting that previous event classification systems have insufficiently regarded the thematic, social, and spatial scope of life events.

First, we reviewed the mixed literature on the malleability of personality traits across the lifespan (Specht et al., 2014). The neo-socioanalytic perspective (Roberts & Nickel, 2017) was presented as one explanation for why personality change is related to major life events in the first place – the main reason being that such events indicate changes in social roles and environments that have the potential to have lasting and temporary effects (Roberts, 2018). This explanation fits a common definition of life events as "time-discrete transitions that mark the beginning or the end of a specific status" (Luhmann et al., 2012, p. 594).

Second, we introduced the two most debated approaches to major life event research for personality development that we called the 'event approach' and the 'experience approach' (Luhmann et al. 2020; Reese & Smyer, 1983). The event approach usually groups life events according to different aspects of life like family, love, health, or work, and tries to directly describe and predict general developmental trends given some life event (Denissen et al., 2019). The experience approach suggests that any such trends are mediated by the specific subjective experience like the emotional significance the event carries for the person (Luhmann et al., 2020). We concluded that these approaches point complementarily at different qualities – normative and subjective qualities, respectively – that might affect personality development.

Third, turning to the systematic distinctions between personal and collective life events, we first looked at thematic differences. We found personal life events to be tied to an individual as happening specifically to them. In contrast, collective life events like natural and human-made disasters or social, economic, or political power struggle usually happen without any one particular individual needing to be involved. Moreover, they might cause or occur in the form of different and multiple personal life events for different people. Finally, collective life events also have the power to change social practices and meanings around social roles (Hofstede, 1984) thus, allowing them to induce personality change without a person actually having to experience a status change regarding a social role (Centola et al., 2018).

Furthermore, we argued for crucial differences in their social and spatial qualities. On the one hand, individual life events exclusively affect individuals directly, while collective life

events can also affect individuals indirectly through group-based experience (Mackie & Smith, 2018). A person is indirectly affected by a collective life event when they identify with a group directly affected by the event. On the other hand, spatial concerns of where an event occurs in relation to the person are usually of little interest for personal life events. However, for collective life events, the location and spatial distribution of the event and the questions of a person's absolute physical and their relative psychological distance to the event are of great concern because they determine a person's exposure to the event.

The temporal relation between personality development and life events can generally be quite complex (Luhmann et al., 2014). We argued that the effects are likely to exist similarly for both personal and collective life events but that the underlying mechanisms might differ. We summarized the differences and similarities of personal and collective life events across the four dimensions in Table 1. The distinctions should not be understood as mutually exclusive categorizations but as their usual allocation on a spectrum, especially because collective life events can dramatically differ in size and the number of people involved.

Table 1. Comparison of typical differences between personal and collective life events. The table was originally published in (Wundrack et al., 2021) available under CC BY 4.0.

Referent event facet	Personal life event	Collective life event
Thematic facet: Thematic attributes characterizing the event	Events are typically from the domains of family, love, work, and health of a single individual or household; usually marked by individual status changes	Events are typically from the domains of (natural or human-made) disaster and (socioeconomic or political) powers struggle; usually covered by the media
Social facet: People affected by the event	Events typically affect a single individual, dyad, or household directly and independently from other people	Events typically affect a large group of individuals or households directly or indirectly, though each one possibly in different ways and to different degrees
Temporal facet: Instance or interval the event happens	Can typically be identified with an exact date (of status change) but their actual duration and effectiveness can extend long into the past and future	Can typically be identified with an exact date or period but their actual duration and effectiveness can extend long into the past and future
Spacial facet: Spatial location associated with the event.	Typically, the event location is tied to the location of the individual involved	Typically, the event location is distributed across the location of all the people directly involved and distance from the event location can play different roles

We concluded that the distinction between personal and collective life events shows that it is psychologically meaningful whether something is happening to an individual or a group of people. Given the outlined differences regarding their thematic, social, spatial, and temporal facets and our proposal of how to operationalize them, we argued that the framework can help build and test hypotheses more soundly on why and how a life event should affect an individual or not. Finally, we showed how the proposed classification system might add to the existing event and experience approaches by offering a perspective of different degrees of event exposure. On the one hand, it allows for a more fine-grained evaluation than the typical event approach because it looks beyond a mere status change–a person experienced or not experienced an event–or a change in social roles–like changing from employment to

unemployment. On the other hand, it adds important dimensions of socio-spatial context to the subjectivity of the experience approach (Luhmann et al., 2020). Eventually, the question for one or the other approach to major life events should not be answered *a priori* but it should be answered by the data.

4.4.   Publication 4 "Mindful self-focus and Theory of Mind"

In "Mindful self-focus–an interaction affecting Theory of Mind?" (Wundrack & Specht, 2023), we reported on finding a small but robust interaction effect of mindfulness and self-focus on Theory of Mind based on cross-sectional data of German and English speaking participants ($N = 543$). Investigating this relationship was motivated by the sparse and mixed evidence for three different rationals why self-focus (a) might improve (Duval & Wicklung, 1972) or (b) worsen (Fenigstein & Abrams, 1993) taking another person's perspective or (c) why it might do either depending on the circumstances (Ingram, 1990).

We understood Theory of Mind as the ability to infer the thoughts, feelings, and intentions of other people (Preckel et al., 2018). This ability is based on drawing information from many different sources of general and person-specific knowledge (Achim et al., 2013) to which we added the person's own perspective as a double-edged sword, a bias with the potential to inform and make robust inferences or to misinform and make egocentric inferences (Gigerenzer & Brighton, 2009; Gigerenzer & Gaissmaier, 2010).

Self-focus is the state- or trait-like tendency to attend to one's own thoughts, feelings, and intentions. Although it is part of normal psychological functioning it has most often been regarded in the context of psychopathology or even as an indicator of psychopathological problems (Ingram, 1990; Mor & Winquist, 2002). We found that concerning Theory of Mind research, it is particularly sparse and inconclusive. One reason for the latter is that self-focus is often merely operationalized in terms of egocentric behavior which should not be equated with accuracy in Theory of Mind performance. Nevertheless, we kept our first cautious hypothesis in line with the most prominent theory on self-focus and Theory of Mind, objective self-awareness theory (Duval & Wicklung, 1972):

(H1) If there is a main effect on self-focus on Theory of Mind at all, it is probably positive.

Mindfulness is the awareness of what is going on within oneself and in one's surroundings in the present moment. Most research suggests that mindfulness positively affects social cognitive abilities (Campos et al., 2019) but does not agree on the specific mechanism behind it which is why we suspected:

(H2) There is a positive main effect of mindfulness on Theory of Mind.

Moreover, we deemed mindfulness as a likely moderator of the relationship between self-focus and Theory of Mind because (a) it has been argued that it is the quality of self-focus that makes the difference (Ingram, 1990) and (b) mindfulness can easily be understood as a qualifier of self-focus. Accordingly, we hypothesized:

(H3) Mindfulness positively moderates the relation of self-focus and Theory of Mind

To address these hypotheses, we used the Self-Focus Sentence Completion task (Exner, 1973) for self-focus, the Mindfulness, Attention, and Awareness Scale (Brown & Ryan, 2003) for mindfulness, and the Double Movie for Assessment of Social Cognition–Multiple Choice (Dziobek et al., 2006) for Theory of Mind performance. We analyzed the postulated interaction using ordinary and robust multiple regression analysis comparing (a) a model of the covariates with (b) a model of the main effects of self-focus and mindfulness and their interaction, (c) and a joined model comprising both predictor, moderator, and the covariates.

Not supporting H1 and H2, neither ordinary nor robust interaction models with nor without covariates found a main effect for self-focus or mindfulness. However, all four models supported H3 with a weak yet highly significant effect (β-range = [0.113; 0.128]; p-range = [0.004; 0.01]). Speaking for the reliability of the data, crucial covariates had main effects in the expected directions: Younger age, more years of education, more task attention, and language nativity (vs. non-nativity) were all positively related to the outcome.
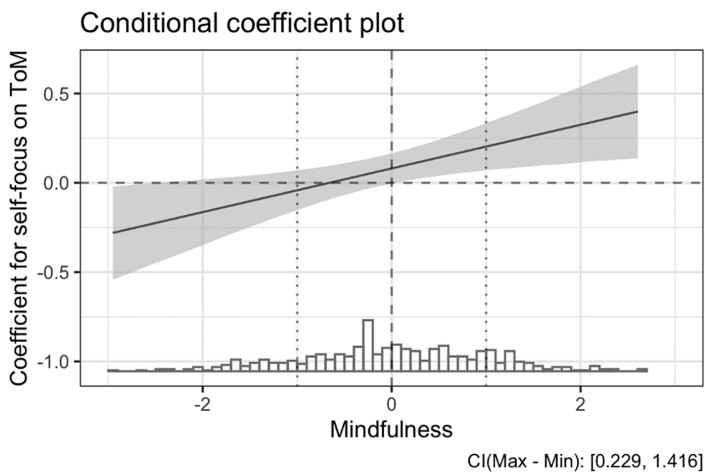

Figure 6. Conditional coefficient plot. Based on the OLS interaction effect model without control variables. Dotted vertical lines indicate -/+ 1 SD for mindfulness, and the dashed vertical line indicates the mean. The plot shows how the relationship between self-focus and Theory of Mind performance, the coefficient, changes from negative to positive as the mindfulness level continuously increases. The figure was originally published in (Wundrack & Specht, 2023) available under CC BY 4.0)

Visual model inspection disclosed that self-focus had a positive effect on Theory of Mind performance once the mean level of mindfulness was exceeded (cf. Figure 6). Taken together with the lack of main effects of self-focus and mindfulness, this suggests in line with Ingram's suggestion (Ingram, 1990) that it does matter what quality a person's self-focus has (here mindful self-focus). Critically reflecting on our findings, we discussed whether the effect was too weak to care about. Nevertheless, we deemed the finding informative given that self-focus and Theory of Mind performance measures have never been combined this way before and in a sample this large. Thus, we took the main message from our research to be that "even if self-focus affects egocentric bias as suggested by previous findings, this may not directly translate into better or worse Theory of Mind." (Wundrack & Specht, 2023, p. 10). Instead, it depends on the quality of one's self-focus.

Part III: Discussion

5.   Reflections

First, I want to take a moment to reflect on what I think about the publications today, what they contributed to the field, and what I would do differently if I had to do it all over again.

5.1.   Publication 1 "Relating personality and Theory of Mind"

The first publication carries with it all the merits and shortcomings of a first contribution. I still believe that it introduces an intriguing, albeit niche idea about how our own experience in everyday life shapes the way we reason about other people (Wundrack et al., 2018). However, the idea is too simple and too complex at the same time. It is too simple in that it is very likely not enough to consider "internal" within-person variability (Beck & Jackson, 2021) but that it is also necessary to measure "external" everyday life variety (Lindner et al., 2023), that is to consider the person and their environment as one dynamic system (Danvers et al., 2020).

It is too complex in two ways. First, to answer the postulated relationships, great efforts must be made including multi-method longitudinal data collection to gain what can be expected to be of relatively small explanatory value compared to other cognitive factors that play a role in Theory of Mind (Bukowski, 2014; Bukowski & Samson, 2017). Second, to establish the psychological mechanism between within-person variability and Theory of Mind performance, we had to rely on other theories like Simulation theory and concepts like egocentrism which are themselves still in much need of further research and discussion (Bukowski, 2014; Bukowski & Samson, 2017; Newen & Schlicht, 2009). Thus, I will not overvalue the contribution of our proposal for the illumination of the many relationships between personality and cognitive abilities (Ackerman, 2018).

5.2.   Publication 2 "Personality as a dynamic system"

So far, the second publication (Danvers et al., 2020) was the most influential given the number of citations and authors who cited it (among others Hecht et al., 2022; Kandler & Rauthmann, 2022; Mõttus et al., 2020; Wilt & Revelle, 2022). Thematically and argumentatively, it fits well in line with the currently dominant narrative in the field of personality dynamics and processes. Dynamic systems thinking offers a variety of new ways for idiographic analyses of time series data for personality psychologists. At the same time, it should be treated with care like any

fairly new method and be evaluated in light of the information and predictive power gained as well as its validity and reliability–all of which can only be estimated in the long run.

Given that the publication was meant as an introduction to system thinking for personality dynamics, I would have liked to be even more clear about how the Change as Outcome model relates to Whole Thrait Theory. This could have been achieved, for example, by including a figure like Figure 7 where the density distribution is a marginal plot of the central plot of a Change as Outcome model. Additionally, this illustration allows considering another possible trait-like individual difference based on the right-hand marginal density plot: within-person change variability.
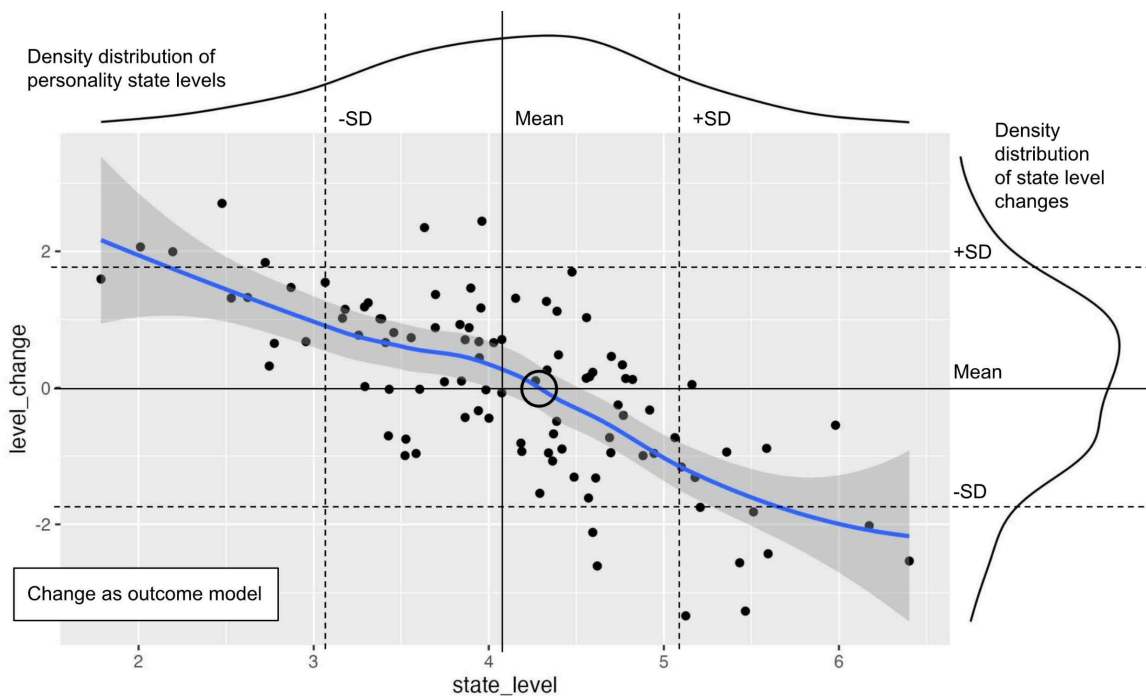

Figure 7. Change as Outcome model with marginal density plots. At the center is the Change as Outcome model based on simulated data on a fictional scale. The blue LOESS function describes the system's expected state level change. Where it crosses 0 on the y-axis (black circle) is the system's equilibrium point. The black solid lines show the means for the marginal density plot and the dashed lines the standard deviation. The top marginal plot shows the density distribution of personality states which describes the basis of Whole Trait Theory. The right marginal plot shows the density distribution of state level changes. If the former's standard deviation is the common *atemporal* operationalization of 'within-person *state level* variability', or the typical range of states levels they are in, the latter's standard deviation is the *state level ignorant* operationalization of another type of within-person variability: 'within-person *change* variability', a person's typical range of rates at which they go through state level changes. Note that this requires being explicit about the assessment frequency as discussed in the section on Within-person variability.

5.3. Publication 3 "Personal vs. collective life events"

The third publication (Wundrack et al., 2021) has so far received only marginal attention from the scientific community concerning the impact of the pandemic on development (de Vries et al., 2022; Sutin et al., 2022). However humanly tragic, the invasion of Ukraine ("Russian Invasion of Ukraine (2022–Present)," 2023), the earthquake at the Turkish-Syrian border ("2023 Turkey–Syria earthquake," 2023), and the mass layoffs in the tech industry (Turner, 2023) offer new scientifically promising opportunities to put the framework to the test. The war has brought about different groups of people who are differently affected fighting, fleeing, parting from, and losing their loved ones, homes, and livelihoods. Countrymen living abroad are indirectly affected as well. This is similar for those affected by the earthquake which is so close to the Turkish-Syrian border and affects among others a Kurdish minority and rebel fractions allowing for the comparison of the relevance of physical and psychological distance to the event. The mass layoffs in the tech industry, on the other hand, can have very local as well as very globally spread-out effects on an entire group of the workforce and their identification with the sector. Contrasting the classic event approach with the more recent experience approach (Luhmann et al., 2020), and with our more granular group approach would allow the methods to be weighed against each other and see how much variance can be explained by the individual experience, the group membership, and the social normativity of the events.

5.4. Publication 4 "Mindful self-focus and Theory of Mind"

The fourth publication is too recent to have had a visible impact on its field of research. Nevertheless, I believe the sample size and the novelty of how we conceptualized and related self-focus, mindfulness, and Theory of Mind make this study relevant to future research. Since we originally collected the data to relate Big Five personality traits and Theory of Mind performance and data collection fell into the first months of the pandemic, I believe the study would gain from a partial replication with preregistered hypotheses and analysis script but different or additional assessment methods as well as a more homogeneous group of participants and a more controlled assessment environment.

For self-focus, the Self-Focused Attention Scale (Kiropoulos & Klimidis, 2006) could be an interesting addition to consider different facets of self-focus. Similarly, for mindfulness, the Comprehensive Inventory of Mindfulness Experience (Bergomi et al., 2014) offers the possibility to analyze the contribution of different aspects of mindfulness. The measure of Theory of Mind performance was appropriate, however, the lack of control over the participants' attention to the task in a distraction-free environment could not be ensured in an online study. In addition, we interpreted our results regarding egocentric bias. Therefore, this construct should be assessed as well to allow for a clearer distinction between the closely

related constructs of self-focus and mindfulness. One possibility may be the recently developed Egocentrism Scale (Tajmirriyahi et al., 2020). Finally, latent factor analysis may be preferable to get a better understanding of the joint variations between self-focus, mindfulness, and egocentrism items.

6. Thoughts on current and future research, a selection

Science is an ongoing discourse that is continuously fed new evidence and theories regarding its talking points. Thus, I want to close by discussing the constructs which got me into the doctorate in the first place–that is personality dynamics, egocentrism, Theory of Mind, and personality development. The way scientists think about these constructs has already changed to some extent since the time I started this project.

6.1. On within-person variability and personality development

Research on personality dynamics and processes still faces a lot of general challenges and open questions. Among others, there is (1) the question of how far self-reported personality state or trait changes may just be changes in explicit self-concepts, (2) the lack of validated state measures, (3) the challenge of adequate sampling, (4) the open question which within-person dynamics constitute individual differences that are stable and consequential, (5) the challenge of distinguishing and relating short-, middle-, and long-term dynamics, and (6) there is the dire need of conceptual clarity, terminological accuracy, and consistency, as well as operationalizations that allow for formalizable theories (Kuper et al., 2021). As I have pointed out throughout this dissertation within-person variability is particularly affected by these challenges because it is a comparatively new concept for which we do not have designated measurement tools and best research practices yet. This puts the interpretation and evaluation of current findings in jeopardy yet tremendous efforts are made to get a hold of the concept, its operationalization, and its analysis (Alaybek & Dalal, 2021; Beck & Jackson, 2021).

As stated earlier, from a dynamic systems perspective, personality development is the long-term counterpart of short-term within-person variability that comes about when the systems topography changes and TESSERA is one framework that can explain the underlying mechanisms of such topographical changes (Quintus et al., 2021; Wrzus, 2021; Wrzus & Roberts, 2017). Within the field of personality development, research on resilience and post-traumatic growth in the face of adverse or negative life events has received a lot of attention in recent years (Asselmann & Specht, 2022; Gomez et al., 2009; Mangelsdorf et al., 2019). Admittedly, not all of it was good with researchers pointing out conceptual and methodological difficulties (Infurna & Jayawickreme, 2019; Jayawickreme, Infurna, et al., 2021; Jayawickreme & Infurna, 2020; Kandler & Specht, 2014; Kashdan et al., 2021).

Here, I want to highlight recent research in psychology (Kaveladze et al., 2022; Markey-Towler, 2018) that has picked up the concept of 'antifragility' (Taleb, 2012; Taleb &

Douady, 2013). This research makes very clear distinctions between fragile, robust, resilient, and antifragile systems and may be informative to both within-person variability and personality development–especially resilience, and posttraumatic growth. Antifragility research states that a system is fragile when it requires a stable environment and any shock to the system can have great negative effects. A robust system is unaffected by shocks. A resilient system is affected by shocks in the short term but will recover in the long run. Finally, an antifragile system thrives under shocks meaning shocks can have greatly positive effects on the system.

This has a couple of important implications for personality developmental psychology as well as more short-term personality dynamics. First, what is usually referred to as posttraumatic growth is antifragility. This emphasizes that 'resilience' and 'growth' should not be used interchangeably as is so often the case but has been criticized before (Infurna & Jayawickreme, 2019; Troy et al., 2023). Second, from this perspective, the valence of an event is secondary to the extent of change in the environment in which the system is embedded. Then, being resilient in the face of adversity and being trapped in the hedonic treadmill are just two sides of the same coin which can be described by set-point theory (Asselmann & Specht, 2023; Lucas, 2007; Luhmann et al., 2012). Moreover, it suggests that a system prone to growth does not require suffering, but only a new and sufficiently large challenge (Mangelsdorf et al., 2019).

The point to consider for within-person variability are the following: It is most likely that a person is not one way or the other across all aspects of their life but that they are fragile, robust, resilient, and antifragile to different extends under different circumstances and for different aspects of their life. Accordingly, within-person variability should not be interpreted independent of the context as either good or bad, advantageous or detrimental, adaptive or maladaptive. Instead, a 'healthy' person's 'normal' level of within-person variability in everyday life could be considered their comfort zone of disturbance or perturbation. As long as a person's within-person variability remains in this range the potential fragility of their being is not threatened to break but also their antifragility is not stimulated to induce growth. Alternatively, their usual level of within-person variability could be taken as a measure of how robust a person is in the face of the variety of daily life (Lindner et al., 2023) and extraordinary life events. Seen the other way around, any deviation from a person's usual level of within-person variability could be taken as an indicator of make or break, of the person leaving their comfort zone and being in a situation that tests their (anti-)fragility one way or the other.

In conclusion, I believe there is still much room for development for how future research will approach and interpret personality dynamics in general and within-person variability and personality development in particular. That both fields at large still provide very mixed results from one study to the next may simply be an indicator that we have not yet found the most appropriate way to look at the data.

6.2. On egocentrism & Theory of Mind

To summarise, self-focus is part of normal psychological functioning (Ingram, 1990; Mor & Winquist, 2002) and the advantage of self-referential processing of information in perception, memory, and cognition have been repeatedly shown for over forty years (Dinulescu et al., 2020;

Rogers et al., 1977). Thus it seems, egocentrism is an efficient way to organize and use information (Greenwald, 1980). It seems we are egocentric by default–temporally (Critchfield & Kollins, 2001; O'Connell et al., 2018), spatially (Colombo et al., 2017), socially (Bradford et al., 2015; Thornton et al., 2019), and psychologically speaking (Liberman et al., 2007; Liberman & Trope, 2014; Soderberg et al., 2015)–so that what is more immediate to us is more accessible, and more important to us than what is more distant.

   Turning to Theory of Mind, however, relying on one's own perspective as the basis for someone else's perspective is generally speaking a double-edged sword. On the one hand, the mere fact that a person has a perspective on a particular situation makes that perspective a viable heuristic as to what perspective any person might have on that matter (Gigerenzer & Brighton, 2009; Gigerenzer & Gaissmaier, 2010). In addition, the egocentric bias inherent to a person's perspective can protect them against grounding their reasoning in spurious situational or momentary information about the other person's thoughts, feelings, or intentions.

   On the other hand, a person's own perspective is very likely inaccurate with regard to the perspective any other person might have on some matter just because they are not the same person. Thus, a person's own perspective can always only be a starting point that needs to be corrected according to what they know about the other person. A series of studies suggests that the failure to do so is either because a person prioritizes their own perspective over the other person's perspective or because they fail to appropriately handle the conflict in the two perspectives, that is self–other distinction (Bukowski, 2014; Bukowski & Samson, 2017).

   Now, two separate lines of research–one from personality psychology, the other one from neuroscience–can add to this picture of egocentrism and Theory of Mind in two ways. In personality psychology, the Realistic Accuracy Model (Funder, 1995, 2012) suggests four moderators of accurate personality judgment: (1) the target person, (2) the target property, (3) the quality and quantity of information available, and (4) the judge. This model could be adapted for Theory of Mind as well–especially when considering the findings in neuroscience presented in the next paragraph. When a person reasons about another person's thoughts, feelings, and intentions regarding a specific situation this is not only a question of (4) them as a judge, their egocentric bias, and their readiness to counter it. It is also the case that (1) different people are difficult to assess in different ways because they are more or less transparent in their actions and the judge may be more or less observant a receptive to different external cues. Moreover, (2) different thoughts, feelings, and intentions may also be difficult to assess in different ways as they can be more or less complex and demanding. Finally, it is also a question of (3) how much and what kinds of information a person has about the person and their situation (Achim et al., 2013; Westra, 2017). I am aware of little to no Theory of Mind task that includes and allows for the analysis of varying degrees of uncertainty regarding another person, the target mental state, and the level of familiarity with the person and their situation.

   In neuroscience, three comprehensive studies done by Mark A. Thornton and colleagues connect Theory of Mind, and egocentrism to personality states in the following way: First, their research suggests that we represent other people according to the mental states we perceive them to habitually experience (Thornton et al., 2018); second, that people represent mental states along the three dimension of (1) whether a state is rational or emotional, (2) more or less socially impactful, and (3) has positive or negative valence (Thornton & Tamir, 2020); and third, that people represent their own mental states with greater detail than the ones of

other people. In other words, the first finding suggests that people represent other people not in terms of their personality traits but along the lines of Whole Trait Theory (Fleeson & Jayawickreme, 2015) in terms of distributions of personality state levels. Together with the second finding, this gives empirical support to our argument from the first publication (Wundrack et al., 2018) that our own personality state levels are likely to inform or affect our Theory of Mind because the contents of personality state levels and Theory of Mind are more or less the same kinds of mental representations. Last but not least, the third finding is in line with our first publication's other suggestion that egocentrism is about the overvaluation of the immediate over the distant.

Taken together, I see a convergence in how personality psychologists and social neuroscientists think about personality/mental states, and a convergence of how scientists think about personality/mental states and people actually represent these states in everyday life. It would be interesting to see if a scale developed to assess (self- and other-rated) personality state levels or a Theory of Mind task based on the three dimensions of how humans represent personality/mental states, would be particularly productive.

7. Conclusion

During my doctoral studies, I have been able to explore various questions in the broader field of personality dynamics and processes. In doing so, my colleagues and I have challenged existing ways of thinking about the core constructs of my field of research: within-person variability, egocentrism, Theory of Mind, and personality development concerning major life events. Since this is theoretical work, its value lies in the extent to which it could help to see existing problems more clearly and to open up a new interpretative framework of how these problems could be solved. Often, this was achieved by drawing ideas from other disciplines of the sciences and humanities. Thus, this body of work tried to contribute to the advancement of personality psychology by exploring and exploiting an inter- and multidisciplinary approach to the problems at hand. By itself, this approach would not be enough. It can only be of real value when it is taken to complement more expert and niche research answering more detailed research questions about underlying structures, processes, and mechanisms based on empirical evidence. Luckily, science is a product of collective efforts that I was happy to be a part of.

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Appendix

A.   Publication 1 "Relating personality and Theory of Mind"

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Does Intraindividual Variability of Personality States Improve Perspective Taking? An Ecological Approach Integrating Personality and Social Cognition

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Abstract: Research integrating cognitive abilities and personality has focused on the role of personality traits. We propose a theory on the role of intraindividual variability of personality states (hereafter state variability) on perspective taking, in particular, the ability to infer other peoples' mental states. First, we review the relevant research on personality psychology and social cognition. Second, we propose two complementary routes by which state variability relates to anchoring and adjustment in perspective taking. The first route, termed ego-dispersion, suggests that an increased state variability decreases egocentric bias, which reduces anchoring. The second route, termed perspective-pooling, suggests that an increased state variability facilitates efficient adjustment. We also discuss how our theory can be investigated empirically. The theory is rooted in an ecological interpretation of personality and social cognition, and flags new ways for integrating these fields of research.

Keywords: big five personality traits; personality states; intraindividual variability; whole trait theory; perspective taking; theory of mind; egocentric bias; simulation; anchoring; adjustment

1. Introduction

Are you ever struck by how diverse you can be in everyday life? Consider solely your extraversion within the scope of your daily work as a researcher; you may be talkative in your lectures, quiet during team meetings, outgoing with participants, yet coy at scientific conferences. Experiencing such diverse manifestations of your personality may have a positive side effect when putting yourself in someone else's shoes. On the one hand, experiencing the fleeting nature of your own perspective might help you to distance yourself from your own current perspective when considering another one. On the other hand, experiencing the diversity of your own personality manifestations might help you to skillfully construct another person's perspective.

Here, we propose a theory suggesting that such a diversity in personality manifestations, captured by the within-person variability of personality states (hereafter state variability), is positively associated with perspective taking, the ability to infer other people's mental states. The theory posits two routes for this effect. One is an effect of state variability on perspective taking through changes in egocentric bias—the tendency to overestimate the relevance of your own current perspective. This route we have termed ego-dispersion. According to ego-dispersion, individuals higher in state variability have a lower egocentric bias, which allows them to consider other people's perspectives while being less restrained by their own perspective. The other route is an effect on the skill to construct the mental states of others. This route, we term perspective-pooling. According to perspective-pooling,

individuals higher in state variability have a wider repertoire of self-experienced perspectives that they can apply when reconstructing someone else's perspective.

Ackerman argues in this issue that there are "relatively few hypotheses that address the *how* question" (italics in original, [1]) concerning the relation between personality and intellectual abilities. With our theory, we propose an answer to such a question, "how does state variability influence perspective taking abilities beyond the influence of personality traits?". Before presenting the theory in more detail, we outline the research forming the basis for our theory and guiding its future, empirical investigation.

2. Literature Review

2.1. Personality Psychology

2.1.1. Personality Traits and States

Personality traits describe the individual differences in people's general patterns of thoughts, feelings, and behaviors that stay relatively stable over time. A large proportion of these differences can be described by the Big Five personality traits, namely: openness to experience, conscientiousness, extraversion, agreeableness, and emotional stability [2]. The Big Five have been shown to reliably predict a variety of life outcomes, including academic performance and subjective well-being, among others [3–7]. While the Big Five have shown to be reliable over time, it needs to be noted that these traits are specifically conceptualized to capture temporally stable between-person differences in personality, and that they are insensitive to the moment to moment within-person variability of thoughts, feelings, and behaviors [8,9]. The everyday life fluctuations in personality manifestations are described by personality states.

Whole trait theory is a prominent model that integrates the trait and state approach to personality [10]. Here, personality states are simply defined "as having the same affective, behavioral, and cognitive content as a corresponding trait but as applying for a shorter duration" (p. 84, [10]). Fleeson and colleagues' research [9–12] suggests that everyone will eventually express the entire range of possible personality state levels, but that there are individual differences in the frequency with which the different state levels occur in everyday life. This is expressed by the density distribution of personality, which you get if you plot the state occurrence frequency as a function of the state level (cf. Figure 1) (note that in real-life, density distributions are not necessarily normally distributed). It can also be read as an individual's trait-specific disposition to be in one personality state as compared to another. The mean point of such a density distribution is taken to describe the state-corresponding trait level, while the variance around the mean (e.g., standard deviation) describes the state variability.

Imagine that the two curves in Figure 1 describe the state density distributions of extraversion for two people, Red and Blue. Their density distributions have the same mean (dashed line), therefore Red and Blue have the same level of trait extraversion. However, Blue's state level extraversion is more narrowly distributed than Red's (i.e., Blue's state variability is lower). That means that Blue experiences fewer instances of more extreme manifestations of extraversion—in this case, in both directions. We argue that this would put Red at an advantage over Blue when considering other people's perspectives, because Red is more experienced with a wider range of perspectives, as they accompany the more diverse manifestations of Red's extraversion.
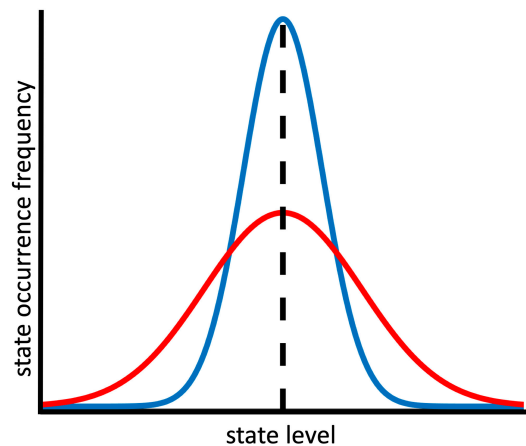
Figure 1. Personality state density distributions. The red and blue line describe the state density distributions corresponding to a personality trait of two individuals (cf. state extraversion of Red and Blue in the example given in the text). The dashed line specifies the mean shared by both distributions.

2.1.2. State Variability and Self-Reports on Personality States

State variability is captured by the variance of an individual's trait-correspondent density distribution. It has been argued that state variability may be a global trait in itself [13], that is, if a person is variable in one trait, they are likely to be variable in other traits as well. However, there is an ongoing debate regarding the confounds of intraindividual variability measures that question that state variability is a global trait. As this issue is currently unresolved, here, we consider state variability as a stable feature of the separate traits.

As illustrated by the example of Red and Blue (cf. Figure 1), the personality trait level and state variability should be two independent aspects of a density distribution. However, practical concerns were raised with respect to the repeated self-report measures of personality states on which most research on intraindividual variability is based [13–16]. For example, if a person scores extremely low or high on a given personality trait, floor- or ceiling-effects must occur because of the limits of the utilized scale, restricting the ability to measure changes in state variability at these extreme endpoints. Therefore, a mean-corrected variance parameter should be used as an indicator of state variability.

Fortunately, Mestdagh and colleagues recently introduced a widely applicable correction, the relative variability index, which is defined as "the ratio of the variability divided by the maximum possible variability given the mean" (p. 5, [16]).[1] Unfortunately, correcting for the confound with the mean led Baird, Le, and Lucas [13] to conclude that the previously established relationships of state variability with psychological maladjustment and lower subjective well-being [17–21] vanished. Thus, they argue that state variability may be of no predictive value beyond trait levels. Mestdagh and colleagues raised similar concerns regarding the variability of emotional instability, questioning its utility as a diagnostic feature of borderline personality disorder [16].

In a follow-up paper, Baird, Lucas, and Donnellan [22][2] highlight yet another confound of state variability based on repeated self-report measures, as follows: the measured variance might largely be a reflection of an individual's response style, that is, their tendency towards mild or extreme responses on questionnaire scales. With supporting evidence beyond the Big Five, they argue that the concept of intraindividual variability in general, as it is currently assessed and operationalized, is a confounded construct whose usefulness has yet to be shown.

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[1]   The relative variability index can be calculated using free sofware packages for R and MATLAB available online here: https://ppw.kuleuven.be/okp/software/relative_variability/.
[2]   We are indebted to an anonymous reviewer for making us aware of this article and the issue it raises.

In response, Deng and colleagues [23] developed a correction for extreme response styles by extending Bock's [24] nominal response model, and Zettler and colleagues [25] recently proposed yet another approach that corrects not only for extreme but also indifferent and directional response styles. After correction for both mean and response style, Deng and colleagues were able to show the improved predictive power of intraindividual affect variability concerning smoking cessation [23]. Thus, their work suggests that intraindividual variability can be meaningfully related to other psychologically interesting constructs if the necessary care is taken.

2.1.3. Complementing Self-Reports with Behavioral Measures on Personality States

Taken together, the above concerns give reason for researchers interested in state variability to complement self-reports of personality traits in a multi-method approach with measures of well-defined behaviors, which are not prone to the mentioned confounds[3]. Behavioral measures provide objective information that is not distorted by an individual's explicit self-concept. For example, given an ecological momentary assessment of personality states [26–29], audio snippets from people's daily lives—recorded with the electronically activated recorder (EAR) application [30,31], transcribed, and analyzed with the linguistic inquiry and word count (LIWC) software [32]—could be used to match an individual's recorded talkativeness proximate in time to their self-reports on extraversion, and their positive word use proximate in time to their self-reports on agreeableness. This would allow for comparing the self-experienced and objective levels of state extraversion and agreeableness. Of course, similar matches have to be found for each personality trait that one is interested in, for example, all of the Big Five personality traits.

Importantly, it is not enough to gather only behavioral data. Behavioral measures capture a diversity of experience that does not equal the diversity of perspectives with respect to these experiences. Consider state variability—the continuous change in temporary thoughts, feelings, and behaviors—a product of the diversity of experience and the diversity of perspectives as they are relevant to personality. The diversity of experience as it is understood here is the diversity of objective experience—who does what, when, where, how, and with whom. This can be assessed with naturalistic behavioral measures and life-logging [33]. Diversity of perspective, on the other hand, describes the diversity of subjective experience of how someone actually thinks and feels, while being engaged in those objective experiences. Currently, the most ecological assessment method in that regard is from repeated self-reports given by the participants as they go about their lives [26–29].

While it is certainly the case that the diversity of experience is positively associated with the diversity of perspectives, it can only be a coarse approximation. The behavioral measures that capture the objective experience cannot capture the accompanying variability in thoughts and feelings as captured by repeated self-report measures of personality states. A good example comes from an approach to state variability that makes a further distinction between within- and cross-context variability [15]. On the one hand, state variability can occur across contexts, for example, Red is extraverted with friends but introverted with colleagues. On the other hand, variability can occur within contexts, for example, Blue is sometimes extraverted and sometimes introverted when surrounded by friends. Theoretically, both kinds of variability can add to the state variability we are interested in; thus, at this point, we do not make any strong claims about which relation to context is more relevant to our theory. However, it highlights how an exclusive reliance on a behavioral measure might fall short in capturing the diversity of perspectives with respect to within-context variability. For example, imagine estimating Red and Blue's extraversion based on the number of their interaction partners. What you might miss, however, is that Blue might feel increasingly uneasy as the group size increases, while Red enjoys interacting with some groups but not with others.

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[3]   We thank the editorial team for their suggestion to raise the issue of behavioral measures and context-effects.

Thus, to counterbalance the respective shortcomings of behavioral measures and self-reports, and to capture trait-specific state variability, we suggest a multi-method approach to state variability, combining repeated self-report and behavioral measures into a single state variability estimate, for example, by confirmatory factor analysis. Furthermore, with respect to the last example, we also recommend expanding the ambulatory assessment of personality states by measures like the ultra-brief measure for the situational eight DIAMONDS domains [34,35], in order to differentiate between contexts or situations.

2.2. Social Cognition

2.2.1. Empathy and Perspective Taking

The success of social interactions depends on our mutual understanding. However, this is not a unitary ability. Prominently, it involves the ability to share others' feelings (i.e., empathy) and the ability to infer others' mental states (i.e., perspective taking (also theory of mind or mentalizing), among others). Historically, the distinction has not always been straightforward [36]. We follow the modern distinction of Preckel, Kanske, and Singer, who define empathy as a socio-affective "process of sharing feelings, that is, resonating with someone else's feelings, regardless of valence (positive/negative), but with the explicit knowledge that the other person is the origin of this emotion" [37]. In contrast, perspective taking is a socio-cognitive process of inference and reasoning about someone else's beliefs, thoughts, or emotions, that results in propositional knowledge about their mental state [37]. This conceptual distinction mirrors brain imaging research, suggesting distinct neural networks underlying both processes [38–40].

Understanding other people's mental state in real-life is a complex task and may require considerations of their circumstances, beliefs, knowledge, feelings, intentions, and their personality [41]. In doing so, motor empathy [42], the automatic mimicking of and synchronization with another person's motor output—their posture, movements, facial expression, and vocalizations—aids both the sharing of their feelings and the understanding of their mental states [43–45]. However, most of the standard perspective taking tasks [46–50] do not require such holistic reasoning efforts but focus solely on what the other can know and what they are going to do. Moreover, they are not designed to allow for motor empathy to improve performance, because only pictographic and static scenes [46–50] or short clips are presented to the participants [51].

Take, for example, the classic perspective taking task, the false-belief task developed for autistic children [52]. In this task, two dolls, Anne and Sally, are presented to a child. Sally puts a marble in a basket and leaves the scene. Anne takes the marble out of the basket and puts it into a box without Sally's knowledge. When Sally comes back looking for her marble, the child is asked where Sally is going to look for her marble, in the basket or in the box. In this task, the possible feelings and personalities of the dolls are irrelevant, nor can the child make use of motor empathy to understand Sally or Anne's behavior.

Of course, more sophisticated perspective taking tasks have subsequently been developed for adults [37–42], but they usually share similar limitations. Consider Figure 2 from left to right. During the director's task [46], the participant has to account for a director's limited knowledge because of the director's limited field of vision while following the instructions to move certain objects. Similar to the false-belief task, the belief–desire continuity test [26] requires participants to make informed guesses regarding where someone else will look for a desired object. Another paradigm [47] requires participants to determine the intention communicated in a voice message.

Another, more naturalistic assessment of perspective taking that is not depicted here is movie for assessment of social cognition (MASC) [51], in which social inferences have to be made about characters engaged in a discussion, which is shown in a short movie clip. Assessments based on video clips and standardized interactions in virtual reality—although the latter has so far mostly been used to train and not to test social cognition in autism [53,54]—are currently the most ecologically

valid approaches to investigating perspective taking more holistically. To investigate our theory, we suggest implementing a perspective taking task that requires participants to make social inferences of personality trait-relevant content (i.e., thoughts, feelings, and behaviors that are connected to different personality traits). Further key features of the required task will be specified in the following section.
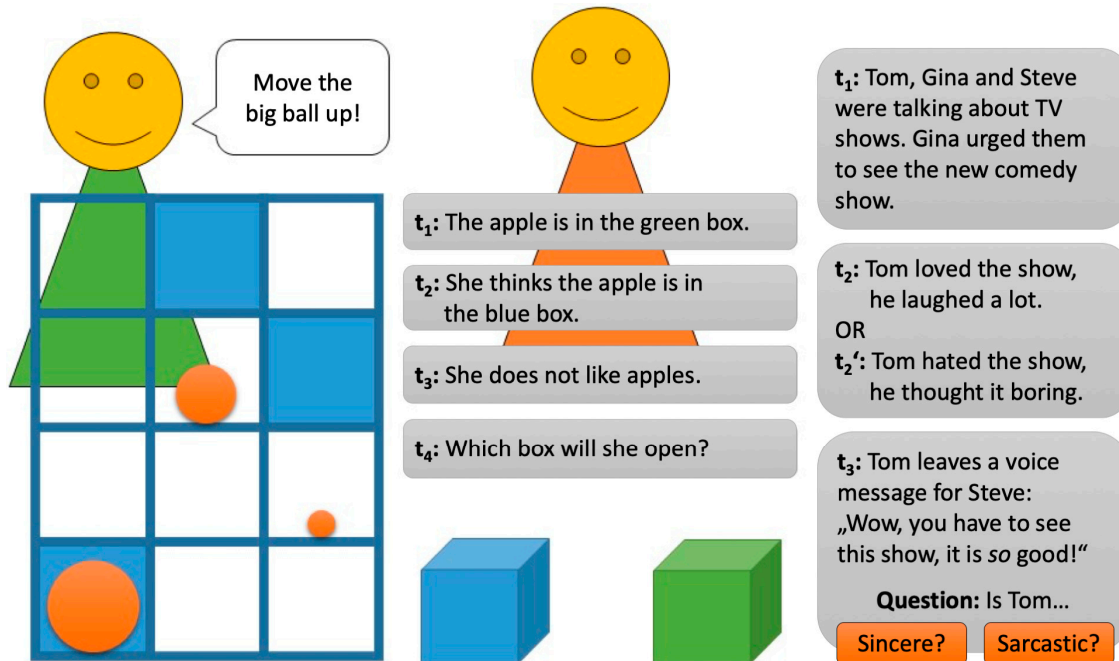

Figure 2. Standard perspective taking tasks. From left to right: the director's task, belief–desire continuity test, and adapted anchor and adjustment paradigm.

2.2.2. Perspective Taking as Simulation

According to simulation theory, for most real-life cases of perspective taking, we can apply self-knowledge to make the right social inferences [55]. Simulation theories suggest that we can imitate, copy, or reproduce other's perspectives based on our own mental experiences [56]. Goldman [57], for example, holds that before attributing a perspective to others, we generate and introspect a model perspective. Simulation theory further suggest that perspective taking involves the two processes of anchoring and adjustment, which are crucial to our theory.

Anchoring is often only considered in terms of establishing an initial anchoring perspective from which a simulation starts off—the anchor is often a person's own current perspective. However, we consider it much more useful to think of anchoring as a person's readiness to deviate from their initial perspective when simulating someone else's perspective. Adjustments are made serially to the initial perspective until an acceptable approximation of the other person's perspective is reached. How fast and accurate we can make these adjustments depends on, among others, on how much we can rely on our self-knowledge (i.e., memories and familiar thoughts, feelings, and beliefs we associate with the circumstances we deem the other person to be in). However, at which point the adjustment process is terminated—which eventually determines how accurate we will be—depends on how much our anchor holds us back from deviating from our own perspective. Thus, anchoring and adjustment are interlocked; the larger the initial self–other discrepancy in perspectives, the more one has to adjust. But how accurately one adjusts depends first on the information a person can draw on, and second, at which stage of the simulation they stop to adjust.

For our purposes, the perspective taking task has to be able to differentiate between the anchoring and adjustment effects. We suggest a speed–accuracy task similar to Tamir and Mitchell's design [55], where subjects report their own perspectives before they infer those of others, to allow for parameterizing the initial and final perspective and the self–other discrepancy in the perspectives. The

anchoring effect can be operationalized as the relative difference in the initial and final perspectives (i.e., the actualized readiness to deviate (adjust away) from one's own perspective). To the extent that an individual is less anchored in their own perspective, they should in comparison account for more self–other discrepancy. To the extent that participants simulate more efficiently, they should be able to adjust faster for a given self–other discrepancy in perspectives. Finally, only if both the anchoring and adjustment are improved, perspective taking should be more accurate (i.e., the final self–other discrepancy in perspectives should be minimal).

2.2.3. Egocentric Bias

The ability to differentiate between one's own mental states and those of another person is crucial for perspective taking. A failure to do so can stem from egocentric bias; the tendency "to project one's own emotional or mental states on someone else" (p. 3, [37]). For example, you might mistakenly assume that because you cherish a tidy workspace, your colleagues do too.

Another way to think of egocentric bias is the (overly) self-referential structuring of information [58]. From this perspective, overcoming egocentric bias means to account for this dynamic by actively distancing yourself from your own perspective, and by disregarding your immediate feelings, knowledge, beliefs, and intentions (note, that merely overcoming egocentric bias does not necessarily mean that you are better at perspective taking [59]; importantly, you have to do so in favor of what you know about the other person). In fact, one may think of egocentric bias as a generic overestimation of the immediate over the distant—temporally, spatially, and socially. For example, it has recently been argued that overcoming the egocentric bias involves the same processes when considering others and considering a future or past version of oneself [60–63]. Notably, O'Connell and colleagues [60,61] suggest that overcoming egocentric bias when thinking about one's future self and about the perspective of others is regulated by the same neural network. This supports the idea that egocentric bias is a general feature of our cognition, to overstate the immediate over the distant. This begs the question of whether people who score higher in state variability are better at perspective taking, because they experience more diverse thoughts, feelings, and behaviors more regularly themselves (i.e., these thoughts, feelings, and behaviors are more immediate or less distant to them).

2.3. Linking Personality and Cognition

2.3.1. Personality Traits and Perspective Taking

Aside from a recent study suggesting social cognitive advantages for individuals with flexible personalities styles [64], previous research has often focused on relating personality and empathy in the context of medical practice and patient satisfaction [65–69]. For example, Song and Shi [69] analyzed the answers of 530 Chinese medical students on a Big Five Inventory and the Interpersonal Reactivity Index, an empathy questionnaire with four dimensions, one of which is perspective taking [70]. They found that perspective taking was moderately associated with agreeableness, while it was modestly associated with neuroticism, openness, and conscientiousness, accounting for 19.4% of the variance.

In fact, all of the Big Five personality traits have at some point been shown to have some meaningful relationship to perspective taking [65–69], and there are intuitions for all of them. Open people might encounter more diverse situations, which makes them knowledgeable about more perspectives and situations (cf. Section 2.3.2). Conscientious people might be more intent upon taking all of the necessary steps. Extraverted people might be engaged in more social interactions, exposing them more to the viewpoints of others. Agreeable people may be more motivated to understand the other person, because they strive for a harmonious relationship. Finally, emotionally stable people might be less anxious and thus less egocentrically biased when taking someone else's perspective [50]. Given (a) the widespread association of personality traits and perspective taking, and (b) the possible confounds of trait levels and state variability discussed above [13,16], investigators are well-advised to

be particularly sensitive to the impact of personality trait levels on perspective taking, independent of state variability. Furthermore, the widespread associations suggest that it is worthwhile investigating the state variability of all of the traits with respect to perspective taking and thus our theory. Moreover, possible relations to empathy could be considered as well.

2.3.2. State Variability, Openness, and Intelligence

Research on the relationship between openness to experience and intelligence (e.g., the openness-fluid-crystallized-intelligence (OFCI) model [71]), has inspired this paper's central claim, that personality can influence cognitive abilities. As in the OFCI model, we understand fluid intelligence as "to use deliberate and controlled mental operations to solve novel problems that cannot be performed automatically" (p. 5, [72]). Ziegler and colleagues' [71] investigation explored the mutual influence of openness and fluid intelligence. On the one hand, they investigated the environmental enrichment hypothesis, wherein people who score high in openness may be exposed to more novel, intellectually stimulating situations, which positively influence their fluid intelligence [73]. On the other hand, they investigated the environmental success hypothesis, wherein having a higher fluid intelligence enables people mastering novel situations, which might make it more likely for them to be more open and seek more novel, mentally challenging situations [74,75].

In brief, the author's findings support the former but not the latter hypothesis [71], that is, they find support that a personality trait can affect cognitive abilities by enriching the stimulation of the mind via the environment. This is in line with our notion of the diversity of experiences. The current proposal expands this notion, by arguing that the personality states themselves are stimulating multipliers of experiences (i.e., subjective experiences). Therefore, we suggest that the assessment of state variability has to comprise the diversity of perspectives. Open people may explore more novel situations (i.e., increased diversity of experience), but individuals high in state variability will experience a more diverse set of perspectives across situations (i.e., diversity of perspectives).

The OFCI model is relevant in at least two more ways. First, assuming that goals and motivations (seeking more intellectually stimulating situations) can be a production mechanism for personality traits (openness to experience) [76], one might also want to consider that contemplating the perspective of others might affect state variability. This is not predicted by our theory but could be tested by evaluating whether training in perspective taking increases state variability. Second, their two hypotheses may apply similarly to our case, making openness and fluid intelligence competing influencers of perspective taking independent of state variability. In line with the environmental enrichment hypothesis, open people may be better at taking other people's perspective, because of their extensive experience with different situations. In line with the environmental success hypothesis, intelligent people may be more successful in making social inferences, motivating them to make even more social inferences, which improves their overall perspective taking abilities.

Moreover, there is evidence that intelligence is positively associated with perspective taking [77,78]. Fluid intelligence may be particularly relevant to adjustment, which, in contrast to anchoring, is a more readily controlled mental operation. Thus, not only do we recommend to control for the influence of personality trait levels, but for that of fluid intelligence on perspective taking as well, (e.g., by including an intelligence test like the I-S-T 2000 R [79]). In contrast, crystalline intelligence, understood as acculturated knowledge [72], appears to be less relevant to perspective taking—at least when cultural differences do not play a major role for successfully taking someone else's perspective.

2.4. Intermediate Conclusion

In reviewing the literature on personality and social cognitive psychology, we set the stage to ask and answer the question of whether and how state variability may influence perspective taking. With respect to personality psychology, we argued that whole trait theory offers an intriguing approach, in which state variability is a feature of traits that await more thorough investigation. However, we

also highlighted the methodological issues of operationalizing state variability. With respect to social cognition, we differentiated the roles that egocentric bias, anchoring, and adjustment play for the efficient perspective taking. Research joining both fields is rather limited and awaits more extensive investigations (e.g., in the light of our theory presented below). Furthermore, research on openness and fluid intelligence gives reason to believe that state variability can affect perspective taking by diversifying our perspectives. Thus, based on the reviewed constructs and ideas, we propose two routes by which state variability may influence perspective taking.

3. Two Routes: Ego-Dispersion and Perspective-Pooling

Up to this point, we have assumed a certain interchangeability of the contents of personality states and perspectives by operationalizing the diversity of perspectives as the state variability of repeated self-reports. The argument in favor of such an approach is that the content of self-reports in personality state assessments overlap with those during naturalistic perspective taking. In both cases, we are interested in a person's thoughts, feelings, and (intended) behaviors. Thus, we argue that self-reports on personality states capture essential parts of a person's perspective, the subjective experience of their inner life, its outer expression, and their relation to the world. If self-reports on personality states approximate people's perspectives, their state variability may also hold information relating to the diversity of their perspectives. Notably, there is no reason to believe that this is limited to social traits. One's perspectives will be diversified by the extent to which one engages with the world at different state levels of extraversion, as well as different state levels of conscientiousness.

In addition, we argue that a person's own perspective can inform their reasoning regarding another's perspective. Therefore, we propose that increased state variability improves perspective taking. Imagine, doll Sally from the classic false-belief task was to report on her personality state just before she goes back into the room with Anne and her marble. Sally may report that she is distrustful, which explains why she looks for the marble she had just put away. There are two ways in which having high personality state variability might help us to accurately infer Sally's suspiciousness from her behavior. As we experience a wider range of trust-distrust beliefs and feelings in our own lives, two things occur. Firstly, our trust state variability will be rather distributed, indicating that our disposition to be trustful is biased away from a specific interpretation of the situation. Thus, we are freer to choose an interpretation based on other factors such as contextual cues, for example the hasty return of Sally to the room. In contrast, if you are by nature an extremely trusting person, you may miss this cue. Moreover, if you were extremely distrusting, your advantage in this specific set-up would be coincidental. We term the diminished egocentric bias that weakens anchoring because of the experience of a wider range of possible dimensions of a given state ego-dispersion.

Secondly, familiarity with the situation might facilitate fast and accurate perspective taking via another route. If we happened to have been in a comparable situation (i.e., storing something of value while someone else is watching us suspiciously), it is more likely that we will correctly predict Sally's mistrust. Even if we were currently very trusting, having previously experienced a similar situation would facilitate the adjustment of our perspective. In contrast, if we were trusting by nature and had never been in a situation wherein we felt spied on, we might fail to make the proper inference. Experiencing—if not knowing—how thoughts, feelings, behaviors, and circumstances fit together in our own lives, helps us make sense of other people. We term this accumulation of a repertoire of plausible, self-experienced perspectives that facilitates adjustment perspective-pooling.

Taken together, living through a multitude of personality states positively influences perspective taking, because it implies the experience of a multitude of perspectives, enabling us to distance ourselves from our own perspectives, and to relate to how other people experience the world. Thus, state variability is the starting point of ego-dispersion and perspective-pooling, two functionally independent routes, which jointly benefit the efficiency of simulating someone else's perspective (cf. Figure 3). In the next two sections we describe these routes in more detail.
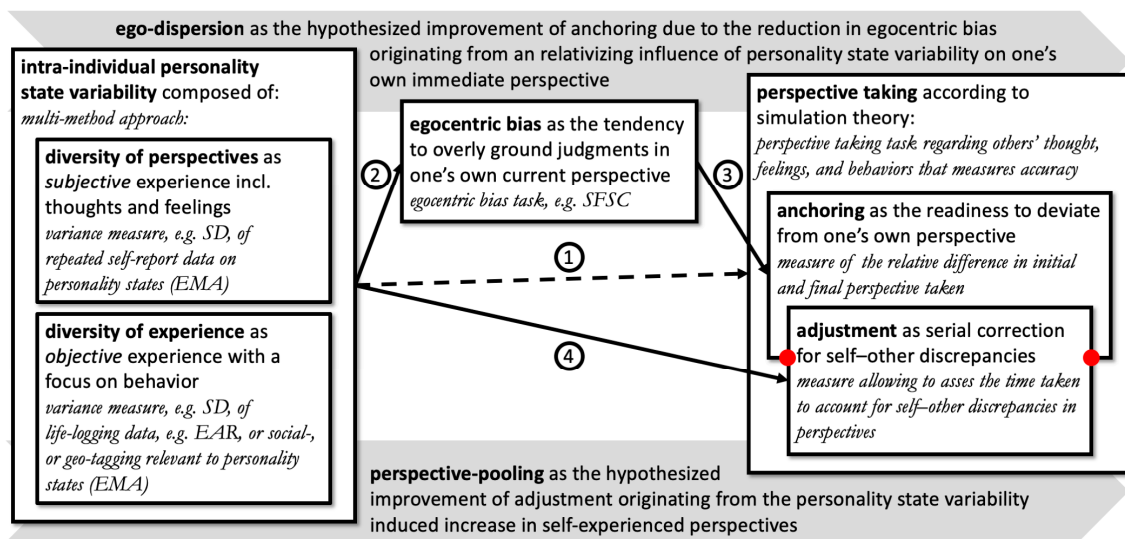
Figure 3. Proposed relation of state variability and perspective taking. *Format*: constructs are in bold, construct specifying notes in roman, and construct operationalizations in italic. *Abbreviations*: EAR—electronically activated recorder; EMA—ecological momentary assessment; SD—standard deviation; SFSC—self-focus sentence completion task. *Numbers*: Compare Section 3.3, summarizing hypotheses (1) to (4). We propose a two-fold positive relation between state variability and perspective taking. Ego-dispersion describes the effect of state variability on anchoring mediated by egocentric bias ((2) and (3)). Perspective-pooling describes a direct effect of state variability on the adjustment process (4). Taken together, this should explain how state variability allows for more accurate perspective taking (1). The solid arrows specify the two routes hypothesized by our model, while the dashed arrow specifies the overall effect if the relation of state variability on perspective taking is considered without the details of our model. Furthermore, the dashed arrow may specify the direct effects of state variability on perspective taking not considered by our model.

3.1. Ego-Dispersion Route

With ego-dispersion (cf. Figure 3), we propose that the reoccurring shifts in your own perspective that you experience as your personality states change reduces your egocentric bias. Being aware that your current perspective is transient and only one of many possible perspectives undermines the significance of your own point of view as an anchor when considering another person's perspective. Therefore, you may be more able or willing to deviate from your own perspective when attributing a perspective to someone else and may make more adjustments before you terminate the simulation.

Consider the spectrum of individual differences in state variability in healthy adults. At one extreme are people with exceptionally high scores in state variability, and on the other are people whose personality states hardly fluctuate. Take the (exaggerated) example of the cliché stoic, an ever-calm philosopher unmoved by what is happening to her. If you were to assess her personality states, she would always report to be cheerful. The stoic perspective centers around the sole state of cheerfulness, for which the price is experiencing only one pleasant perspective despite the ups and downs of life. In contrast, you most likely move regularly through a variety of personality states and experience various perspectives of which cheerfulness is just one which you can easily relate to. Ego-dispersion suggests that state variability counteracts egocentric bias, thus you are less anchored in one particular perspective, because more perspectives are similarly immediate rather than distant to you. To the stoic, only cheerfulness is immediate. To you, there is joy and pain, calm and disquiet (i.e., a wide spectrum of personality states you have experienced more or less recently).

There are two ways to put it, people high in state variability are either (a) equally as egocentric as people low in state variability, but they experience more perspectives as "central" (i.e., more immediate to them), or (b) they are less egocentric because state variability interferes with the allocation of what

is "central" to them (cf. the blurred center of the circles in (1) in Figure 4). Thus, ego-dispersion is the hypothesized route by which state variability reduces or relativizes the egocentric bias. This weakens anchoring and allows for a greater sensitivity to other cues and information than one's own perspective when taking someone else's perspective. Note that ego-dispersion leads to improved accuracy only indirectly, as a weaker egocentric bias implies a reduced anchoring effect on the adjustment process. Because we believe this process to be fairly content-independent, we assume that the effect is domain-general. It matters less how variable you are with respect to which specific aspect of your personality, instead, it is the general awareness of the transiency of your own perspective that is decisive at this stage.
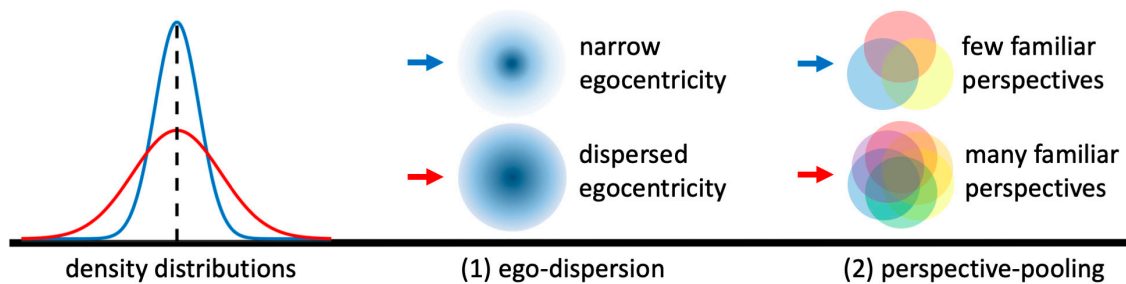

Figure 4. The two links, ego-dispersion and perspective-pooling. With increased state variability (Red > Blue) (1) egocentricity decreases (more blurring of the center of the circle from top to bottom) and (2) the number of self-experienced perspectives availabel for simulation increases (more coloured circles from top to bottom).

3.2. Perspective-Pooling Route

Over time, people high in state variability become familiar with and knowledgeable of a wider range of perspectives. With perspective-pooling (cf. Figure 3), we suggest that this self-knowledge provides valuable inputs that facilitate the efficient simulation of another person's perspective. Specifically, it allows for relatively faster and more accurate adjustments that reduce existing self–other discrepancies in perspectives. In contrast to ego-dispersion, we believe that this effect is domain-specific (e.g., if you are variable in extraversion but not in conscientiousness, adjustment advantages may apply only insofar as the perspective taking efforts relate to someone else's social engagement but not to where it concerns their diligence). The difference in domain-specificity may be used as a further means to differentiate perspective-pooling and ego-dispersion.

Consider Figure 4: Red has greater state variability than Blue regarding some trait. Conceptually, Red cannot exploit more fragments of self-knowledge than Blue to simulate someone else's perspective, because, according to Fleeson's conceptualization [9], both may have experienced the entire range of state levels. However, a larger range of them seems to be more immediately available to Red (cf. colored circles in (2) in Figure 4). Therefore, Red can—all else being equal—simulate more efficiently than Blue under most circumstances. Eventually, Red is either (a) as equally accurate as Blue but faster, or (b) Red is more accurate than Blue given the same amount of time if Red's anchor is not preventing the additional accuracy-increasing adjustments. To give another example, imagine you rarely ever experienced feelings of mistrust and you never cared about materialistic things like a marble, simulating how Sally is feeling about her situation with Anne will put you at a disadvantage when compared to someone who has previously suffered materialistic loss and mistrust.

Importantly, perspective-pooling has less to do with egocentric bias than with the richness of experience over time. In other words, perspective-pooling builds on the increased growth in diverse self-knowledge for people high in state variability. Thus, perspective taking should improve with age. However, research indicates that aging has a negative effect on perspective taking. The suggested mechanisms include a loss of motivation and cognitive decline, among others [80,81]. Therefore, as a side note, for people who score high in state variability, we would expect a sharper increase and a flattened decrease of the inverted-U shaped curve for the progression of perspective taking abilities

over the life span, because of perspective-pooling. In contrast, we do not expect a similar dynamic with respect to egocentric bias because of ego-dispersion.

3.3. Examining the Link between State Variability and Perspective Taking

Assume that all of the relevant variables can be assessed sufficiently. Based on the intuition that the more variable your own daily thoughts, feelings, and behaviors are, the better you might be at inferring the thoughts, feelings, and behaviors of others, our theory suggests the following: (1) Individuals with a higher (vs. lower) state variability should perform better at perspective taking. For testing this, we suggest correlating state variability as the standard deviation of the trait density distributions, and accuracy as self–other discrepancy in perspectives in trait-matched perspective taking tasks. To exclude that the direction of the relation is actually contrary to our prediction, we predict that training individuals in perspective taking should not subsequently increase individuals' state variability in their everyday live. Note that state variability requires ambulant data collection, but all of the other variables key to the theory can be assessed in a laboratory setting.

With respect to ego-dispersion, (2) individuals with a higher (vs. lower) state variability should be less egocentric, which could be tested by relating state variability to the outcome in (e.g., the self-focus sentence completion task (SFSC) [82]). As in the case of perspective taking, reducing individuals' egocentric bias though training should not increase their personality state variability. (3) We expect less (vs. more) egocentric individuals to adjust their perspective, not more or less accurate but comparatively more (i.e., we predict a relatively larger difference between initial and final perspectives taken for less egocentric individuals). (4) With respect to perspective-pooling, individuals with a higher (vs. lower) state variability are expected to make more efficient adjustments during perspective taking (i.e., they should account faster for any given self–other discrepancy in perspectives). However, they should only be more accurate in dependence to reduced anchoring. Moreover, (5) we expect ego-dispersion but not perspective-pooling to be effective in a domain-general fashion. Thus, participants' accuracy but not their relative deviation from their initial perspective may vary in dependence to the trait-specific contents of the task at hand.

Taken together (cf. (1)), if state variability is related to an individual's perspective taking abilities through both ego-dispersion and perspective-pooling, perspective taking should be more efficient for individuals higher (vs. lower) in state variability. Specifically, they should be comparatively faster and more accurate with respect to tasks whose content relates to traits in which participants are more variable. Alternatively, (6) if perspective-pooling is the only link, perspective taking should be faster but similarly accurate with respect to tasks whose content relates to traits in which participants are more variable. In contrast, if ego-dispersion is the only link, participants higher in state variability should deviate more from their initial perspective but be equally inaccurate independent of trait-related contents of the task. If neither of these predictions applies, support for a positive association of state variability and perspective taking according to our theory is lacking.

4. Discussion

In the current paper, we propose a model that builds on state variability as a dynamic aspect of personality that affects our social cognitive abilities. Whereas personality traits describe general affective, behavioral, and cognitive tendencies, state variability captures how often and strongly people diverge from their general dispositions. The more often and strongly they diverge, the more the range of the subjective experiences they have on a more or less regular basis in everyday life expands. With ego-dispersion and perspective-pooling, we argued for two complementary routes, in which the diversity of self-experienced perspectives may increase the likelihood of being able to efficiently infer the perspective of other people. Despite its arguably intuitive appeal, the theory and its empirical investigation face certain limitations and alternative explanations that have to be taken into account, the most important of which are considered in the following sections.

Eventually, in asking whether who we are impacts what we are able to do, we are striving for a more fine-grained integration of personality and ability. We follow a trend in the mind and brain sciences, in order to give a more holistic picture of the human faculty, which considers individuals within the context of their (social) environment. Given how alienating living in a globalized world may be, where people of unfamiliar cultures, ethnicities, and socioeconomic backgrounds are neighbors, it is important to explore how the diversity in our own personalities may propagate mutual understanding through experiences of overlapping or shared perspectives.

4.1. Limitations

First, we assume that our predictions apply to any personality trait. However, it is of course possible that state variability is more important in some traits, possibly those relevant to social interaction, than in others or that global cross-trait variability is decisive after all. Moreover, we do not make any claims of whether within- or cross-context state variability [15] is more relevant. Nevertheless, differences are possible. Thus, research is needed to examine whether the relevance of state variability differs across individual traits or contexts.

Second, we argue for a multi-method approach to trait-specific state variability to counterbalance the weaknesses of self-reports and behavioral measures. The current state of the art of operationalizing personality states and state variability, however, may still require more basic research before state variability can be utilized in the proposed manner. Furthermore, using the multi-method approach prevents evaluating the assumption that the diversity of perspectives is indeed relevant over and above the diversity of experiences.

Third, we outline key features of the speed–accuracy perspective taking task, including the assessment of the initially and finally taken perspective, and social inferences with personality trait relevant content including thoughts, feelings, and behaviors. All this may be necessary to differentiate between ego-dispersion and perspective-pooling. Nevertheless, differentiating the two routes empirically with respect to anchoring and adjustment may be difficult, because anchoring and adjustment are closely related and describe foremost a conceptual segmentation of simulation.

Forth, beyond the related psychological factors, like empathy and intelligence, discussed here, there may be other mediators or moderators influencing the relation between state variability and perspective taking that are not part of our theory and that have not been mentioned.

Fifth, the assumed processes may vary across the sub-samples of the population. For example, individuals with specific mental disorders, such as bipolar or borderline personality disorder, may be extremely high in state variability, but in these cases, their experience might not result in beneficial perspective-pooling, because their self-knowledge might not transfer to others. In summary, we tried to balance a comprehensive presentation of the psychological concepts involved and practical recommendations regarding their investigation and the evaluation of our theory.

4.2. Alternative Explanations

A potential approach with even greater ecological validity than the method proposed in this paper would further consider the potential variability in perspective, taking performance over time, or following personality state changes.[4] It is likely that cognitive performance levels are subject to similar fluctuations as personality states levels [83–85]. Therefore, it would be interesting to assess the personality state level in which participants undergo perspective taking tasks, and to repeat the task while participants are occupying different state levels. Of course, training effects would have to be considered as well. However, the intraindividual variability of perspective taking abilities is not central to our theory, which focuses on the impact of intraindividual variability of personality states and not the individual, momentary personality state per se.

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[4]   We thank the anonymous Reviewer 3 for raising this point.

Future investigations into our theory might, however, consider the influence of self-monitoring on personality states and their variability.[5] Individuals who score high in self-monitoring voluntarily adapt their self-expression so as to gain appraisal or to protect themselves from the disapproval from others [86,87]. One question might be whether there is a difference between the personality states they "truly" occupy, and the one suggested by their expressive behavior (including self-reports). Moreover, do the continuous social inferences needed for increased self-monitoring lead to improved perspective taking?

Potentially the most interesting alternative explanation may concern the origin of improved perspective taking regarding state variability.[6] Consider once again Red and Blue's difference in extraversion; perhaps it is not the overall variability in extraversion that gives Red an advantage over Blue, but simply the relative time spent in more extraverted states than Blue. It may be that Red's increased social involvement in these situations makes Red more experienced in perspective taking. Thus, it is not the general state variability, including states extremely low and high in extraversion, but only the sub-set of highly extraverted states that affects perspective taking. However, this alternative explanation could only be true when the relevant trait is also assumed to relate directly to perspective taking. Whereas our theory is more trait-agnostic, the alternative explanation is more likely for social traits than for non-social traits and suggests that state variability would only be of relevance where the trait level is as well. Therefore, specific relationships between certain traits and perspective taking abilities add a layer of complexity to the way in which variability across a trait will affect perspective taking. Employing our suggested empirical approach should allow for comparing the outlined alternative explanation and our theory.

5. Conclusions

The goal of this paper is to advance ability–personality integration research by means of considering state variability as an additional feature of personality traits. We reviewed recent developments in personality and social cognition research that suggest that we often rely on our own perspectives when inferring other people's minds. On the one hand, we have suggested that state variability may influence egocentric bias and thus how anchored people are (i.e., the ego-dispersion route). On the other hand, we have proposed that state variability enriches the repertoire of self-experienced perspectives that allow for efficient adjustments (i.e., the perspective-pooling route). Additionally, we discussed other influencing psychological constructs as well as confounds that might distort the proposed relationship. Furthermore, we have suggested hands-on ways to tackle the central hypotheses of our theory experimentally. Thus, we provide the narrative and theoretical background for future investigations to test our theory. Hopefully, we also inspired the reader to think differently about the possible relations and interactions between personality and cognitive abilities, considering not only interindividual but intraindividual differences as well.

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[5] We thank the anonymous Reviewer 2 for raising this point.
[6] We thank the anonymous Reviewer 1 for raising this point.

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Equilibria in Personality States: A Conceptual Primer for Dynamics in Personality States⌂

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Abstract: We provide a basic, step-by-step introduction to the core concepts and mathematical fundamentals of dynamic systems modelling through applying the Change as Outcome model, a simple dynamical systems model, to personality state data. This model characterizes changes in personality states with respect to equilibrium points, estimating attractors and their strength in time series data. Using data from the Personality and Interpersonal Roles study, we find that mean state is highly correlated with attractor position but weakly correlated with attractor strength, suggesting strength provides added information not captured by summaries of the distribution. We then discuss how taking a dynamic systems approach to personality states also entails a theoretical shift. Instead of emphasizing partitioning trait and state variance, dynamic systems analyses of personality states emphasize characterizing patterns generated by mutual, ongoing interactions. Change as Outcome modelling also allows for estimating nuanced effects of personality development after significant life changes, separating effects on characteristic states after the significant change and how strongly she or he is drawn towards those states (an aspect of resiliency). Estimating this model demonstrates core dynamics principles and provides quantitative grounding for measures of 'repulsive' personality states and 'ambivert' personality structures. © 2020 European Association of Personality Psychology

Key words: dynamic systems; personality states; equilibrium; Personality Dynamics; development of personality

INTRODUCTION

Personality psychology has done important and lasting work in understanding the origin and structure of traits. Nevertheless, researchers have repeatedly stressed the need for a deeper understanding of the processes that generate these traits (Baumert *et al*., 2017, Fleeson & Jayawickreme, 2015; John & Srivastava, 1999; Fleeson, 2001, 2004; Benet-Martinez *et al*., 2015; Mischel & Shoda, 1995). Processes inherently unfold over time, and so studying personality processes requires theorizing about and modelling changes over time (Vazire & Sherman, 2017). Understanding the characteristic patterns of change that emerge from different components interacting over time is the core goal of dynamic systems theorizing and methods, and researchers have repeatedly suggested that dynamic systems can give insight into personality processes (e.g. Mischel & Shoda, 1995; Read & Miller, 2002; Read, Droutman, & Miller, 2017; Sosnowska, Kuppens, De Fruyt, & Hofmans, 2019; Mayer, 2015;

Endler & Magnusson, 1976). We believe that the field of personality psychology can enhance both its explanatory and predictive potential through the systematic integration of ideas from dynamic systems research.

Like the Personality Dynamics (PersDyn) approach of Sosnowska *et al*. (2019; this issue), our approach includes core explanatory concepts from dynamic systems, including equilibria, attractor states, repeller states, phase space, and perturbations. Our goals are complimentary to those of Sosnowska *et al*.: we would like to see people consider personality through the lens of dynamic systems, an approach that has been extraordinarily fruitful in allied disciplines (Beer, 2000; De Bot, Lowie, & Verspoor, 2007; Otto & Day, 2011; McElreath & Boyd, 2008; Rabinovich, Varona, Selverston, & Abarbanel, 2006; Van Geert, 1991). Researchers have invoked the high-level theoretical concepts from dynamics to explain personality for decades (e.g. Endler & Magnusson, 1976; Magnusson & Torestad, 2008; Lerner, 1996; Lucas, 2007), but a frequent difficulty we encounter when trying to discuss these ideas with researchers less familiar with dynamic systems modelling is vagueness and trepidation about understanding what core dynamics constructs mean at the concrete level of modelled data. We address this lack of clarity by introducing readers to the Change as Outcome model (Butner, Gagnon, Geuss, Lessard, & Story, 2014), a simple dynamic systems model that can be estimated using regression. We explain core dynamic systems constructs in detail by considering the specifics of this model, breaking down each component of the

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equations used to estimate it, and providing visualizations to guide intuition.

The ideal audience for this manuscript is a psychologist with limited training in dynamic systems but who would like to gain some intuition about the 'nuts and bolts' of applying dynamic systems to personality psychology means. Our approach is not intended to be at odds with or superior to other personality dynamics approaches; rather, we believe it 'pairs well' with them, particularly the article on PersDyn in this special issue (Sosnowska *et al.*, 2019; this issue) in that it intends to provide a strong theoretical fundament and step-by-step primer of how to 'become a dynamic systems thinker' in the domain of personality—and then lays out what implications this can have for the field of personality and personality development.

There are many statistical models used to estimate change over time in psychological data, including latent change scores (McArdle, 2009; McArdle & Grimm, 2010), dynamic structural equation modelling (Asparouhov, Hamaker, & Muthén, 2018), differential equation models (Deboeck & Bergeman, 2013), Bayesian hierarchical process modelling (Oravecz, Tuerlinckx, & Vandekerckhove, 2016), among others. Some models of personality dynamics are even instantiated as neural networks (e.g. the cue–tendency–action model; Brown, 2017; Revelle & Condon, 2015). We chose to present the Change as Outcome model, a relatively simple model that can be estimated in a linear regression framework, specifically because it is easier to illustrate and understand the dynamics using this model. We do not attempt a direct quantitative comparison of these modelling strategies nor do we claim that this is the most sophisticated contemporary approach for modelling personality dynamics—although, because of the close 'proximity' of the two articles within the special issue, we do provide a direct comparison with the parameterization of PersDyn in an appendix. Our goal is decidedly to illustrate, in the clearest and immediately applicable way, the mathematical and conceptual core of a dynamic systems approach, rather than to evaluate which of the employable statistical dynamic systems technique fits data best.

CORE CONCEPTS IN DYNAMIC SYSTEMS

Core concepts from the dynamic systems literature—such as equilibria, attractors, repellers, topologies, and perturbations—allow personality researchers to think in a nuanced way about patterns of change over time. We believe these concepts are necessary for more fully understanding personality processes and that dynamic systems theory is particularly well-suited to understanding the reciprocal way person factors and situation factors interact and feed off each other to generate specific patterns of behaviour.

Our approach in this manuscript is inherently exploratory. Some researchers have developed formal models of personality and underlying processes, which translate 'top–down' theoretical intuitions into quantitative simulations (e.g. Read & Miller, 2002; Smaldino, Lukaszewski, Von Rueden, & Gurven, 2019). To complement these top–down approaches, we estimate here parameters from observed data,

hoping that this 'bottom–up' approach will spur further theorizing about dynamic processes underlying personality.

Our approach is also inherently person-centred, or idiographic, in that different models are estimated for each participant in a study. The importance of person-centred analysis has been stressed in personality research for decades, and we will not reiterate these arguments in detail (Molenaar, 2004; Molenaar & Campbell, 2009; Pelham, 1993; Barlow & Nock, 2009; Fisher, Medaglia, & Jeronimus, 2018). Briefly, the approach stresses that processes may differ between people and therefore the interrelationships between variables might also differ between people. For example, for some people, socializing in a group might elicit positive emotions (like excitement) while for others it might elicit negative emotions (like anxiety). The association between the variables 'being around others' and 'emotional valence' would therefore differ substantially across people. Trying to summarize a whole group of people by saying 'being around others leads to positive emotion' would ignore the underlying differences in processes across individuals. Even worse, a variable-centred analysis might average out these opposing effects and lead researchers to conclude that socializing has no influence on emotions—although that conclusion might not hold for any single individual in the sample. Person-centred approaches therefore begin by analysing the relationships between variables within a single person and only then try to form aggregates or clusters that capture regularities in differences in processes.

In this manuscript, we begin by describing the Change as Outcome model, drawing primarily on the description provided by Butner, Gagnon, *et al.* (2014). We identify its key features and how to interpret them in the context of personality state variables. We then describe ways in which this model should influence personality theory and reorient our thinking. Next we describe how to implement the model in a linear regression framework, providing accompanying R code in the supporting information (https://osf.io/dps4w/). We then provide summaries of a series of Change as Outcome models run on a large sample of participants, demonstrating how parameters estimated from these models differ from those estimated from more traditional approaches. Finally, we discuss implications for this approach moving forward.

STATE PERSONALITY

Researchers employing the Whole Trait approach to personality construe trait levels as features of the distribution of experienced personality states (Fleeson, 2004; Fleeson & Jayawickreme, 2015). Over the course of a week, for example, one person might be very extraverted at times—perhaps on a Friday night—and less extraverted at other times—perhaps on a Monday morning. From the perspective of Whole Trait Theory, personality is the overall density distribution of these states, which can be represented quantitatively using different moments of the distribution such as mean, standard deviation, skewness, and kurtosis. An example of a time series of state extraversion measures and the resulting density

A: Time Series with Mean and Standard Deviation Overlaid

A: Theoretical Change as Outcome Model

B: Density Distribution with Mean and Standard Deviation Overlaid

Note: The solid line overlaid on both plots represents the mean of the distribution. Dotted lines represent the mean plus and minus one standard diviation.
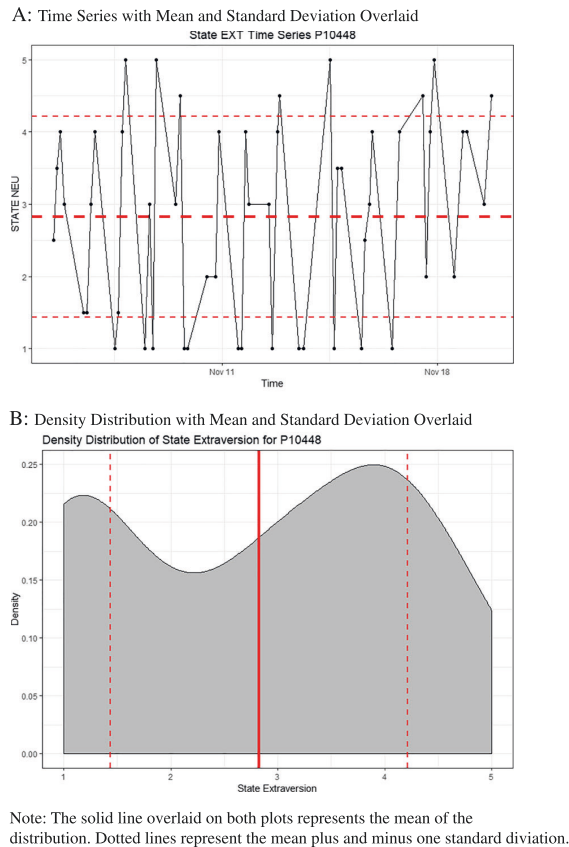
Figure 1.   Converting personality state measurements to a density distribution. (a) Time series with mean and standard deviation overlaid. (b) Density distribution with mean and standard deviation overlaid. *Note.* The solid line overlaid on both plots represents the mean of the distribution. Dotted lines represent the mean plus and minus one standard deviation. [Colour figure can be viewed at wileyonlinelibrary.com]

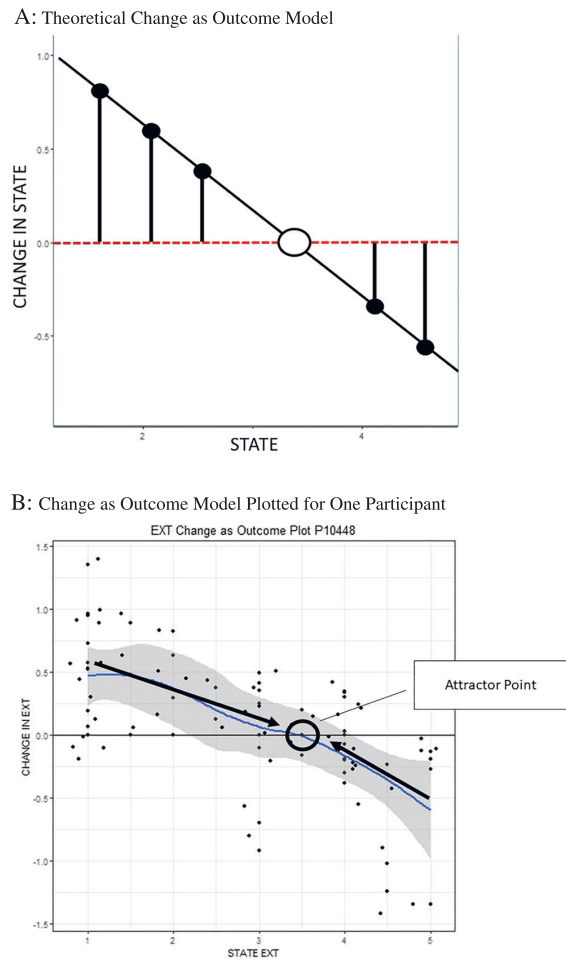B: Change as Outcome Model Plotted for One Participant

Figure 2.   Identification of an attractor point in a Change as Outcome model. (a) Theoretical Change as Outcome model. (b) Change as Outcome model plotted for one participant. [Colour figure can be viewed at wileyonlinelibrary.com]

distribution are given in Figure 1(a) and 1(b). Data are taken from the Personality and Interpersonal Roles Study, where participants completed a series of three items related to extraversion four times per day, approximately 4 h apart (further details of data are given as follows).

However, characterizing a series of measurements taken over a period of days, weeks, or months merely by a state density distribution completely ignores the temporal ordering of the data. All information about which state came before or after any other is lost in conversion. From a dynamic systems perspective, this information about how the states change is vital for understanding the process that generated the data.

We can introduce changes to our representation of personality states by plotting the value of the personality state along the *x*-axis, as previously shown, against the *change in personality state* along the *y*-axis. Butner, Gagnon, *et al.* (2014) describe this as the 'hidden dimension' of change over time. This scatterplot allows us to see the typical level of change associated with a particular state. This is a visualization of a Change as Outcome model (cf. Figure 2).

Values above 0 on the *y*-axis correspond to increases in personality state. So if a point is in the upper left quadrant of the plot, this indicates that when the state is low (to the left on the *x*-axis), the expected change in the next time point will be positive (up on the *y*-axis). Points in this quadrant indicate that low states tend to move back towards a higher equilibrium over time. Points in the lower right quadrant of the plot indicate that when a state is high (to the right on the *x*-axis), the expected change will be negative (down on the *y*-axis). The tendency is for high values to move back towards a lower equilibrium. An example of this kind of plot using real data is given in Figure 2(a).

One way to visually explore the tendency of an individual to increase or decrease at a particular state is to add a loess regression line to the plot. Loess is a form of local regression that tracks the shape of the data without making any assumptions about the underlying relationship between plotted variables (e.g. linear relationship, quadratic, etc.). The loess line displays the trend to increase or decrease across

all possible state values. An example of plotting the Change as Outcome model based on real data with a loess line is given in Figure 2(b).

The line $y = 0$ takes on a special significance in this plot. When the expected change in a state is 0, this indicates an equilibrium point. Because the expected change is 0 (i.e. we neither expect an increase or decrease from the current to the consecutive state), the person is expected to stay in this state unless some unexpected force moves her away from it. Of course, many forces throughout someone's day—both in the form of external features of a situation and internal changes in cognitions and emotions—may jostle the person from this theoretical resting point, but an equilibrium is important because it can indicate the location of an *attractor* within the *structure* (*topography*) of the system.

An attractor is a technical term used in the dynamic systems literature and is one of two kinds of equilibria that can occur in a one-dimensional system (a system that is tracking just one state at a time). An attractor is a point that a system is drawn towards. We would interpret it in this case by saying that whenever something pushes this system (the person in their environment) away from the attractor point, the natural tendency is to return to it.

The representation of this individual's measurements using a Change as Outcome model gives different measures from a density distribution. Instead of a mean, we obtain an equilibrium point. This is the state towards which the system naturally moves over time, and it has a different theoretical interpretation, and may differ empirically, from the mean of the distribution. Instead of a standard deviation, we can estimate the strength of the attractor. This is the speed with which the system returns to the attractor. A system (person in their environment) with a stronger attractor will return to that point more quickly. These features enrich our picture of personality states, complimenting quantities already incorporated in Whole Trait Theory.

We identify the kind of equilibrium point by estimating the local behaviour around it. Examining the local slope— the slope around an equilibrium point in the Change as Outcome model—gives us insight into both the strength and type of the equilibrium point. If the local slope around the equilibrium is negative, as in Figure 2(b), this indicates an attractor. Starting at the equilibrium point, as the state increases a small amount, the subsequent predicted change is to decrease— meaning the system will move back towards the equilibrium. As the state decreases a small amount, the subsequent predicted change is to increase—again moving the state back to its equilibrium.

If the local slope around the equilibrium point is positive, this indicates the equilibrium point is a repeller. A repeller is a point that the system tends to move away from. As the state increases a small amount, the subsequent predicted change is to increase further—meaning it moves further away from the equilibrium point. As the state decreases a small amount, the subsequent predicted change is to decrease further—again moving away from the equilibrium. In the dynamic systems literature, this is sometimes referred to as an unstable equilibrium because while no change is expected when the system is in *exactly* at that

state, any perturbation will push the system away from that equilibrium. This makes it unlikely that the system will land in the unstable equilibrium in the first place. A useful metaphor is balancing a pencil on its point; while it is theoretically possible to do so, any tiny movement will tend to push it away from this balanced equilibrium state.

Next consider the angle of the slope. If the slope is very steep—either in the positive or the negative direction—this means that the attractor or repeller is very strong. Strength is defined here in terms of rate of change: stronger means that the state changes more quickly. This can again be understood visually on the Change as Outcome figure. Consider an attractor with a steep versus shallow slope, as in Figure 3. If the slope is steep, this indicates that when the state increases a small amount, the subsequent predicted decrease is larger.

A: Strong Attractor, as Indicated by Steep Local Slope Around the Equilibrium Point
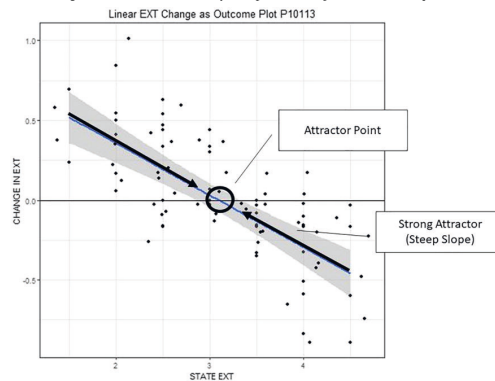
B: Weak Attractor, as Indicated by Shallow Local Slope Around the Equilibrium Point
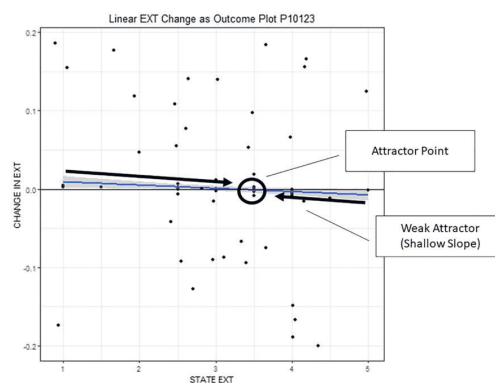
Note: Change is in per hour metric. The y-axes are scaled based on the data, so the top plot indicates a large amount of expected change (~ 0.5 change for a one-point increase or decrease) while the bottom plot indicates a small amount of expected change (~0.001 change for a one-point increase or decrease). In both cases, a linear model (as opposed to a loess smooth) was plotted, because a linear model was found to fit the data well.

Figure 3. Visualizing attractor strength. (a) Strong attractor, as indicated by steep local slope around the equilibrium point. (b) Weak attractor, as indicated by shallow local slope around the equilibrium point. *Note.* Change is in per hour metric. The y-axes are scaled based on the data, so the top plot indicates a large amount of expected change (~0.5 change for a 1-point increase or decrease) while the bottom plot indicates a small amount of expected change (~0.001 change for a 1-point increase or decrease). In both cases, a linear model (as opposed to a loess smooth) was plotted because a linear model was found to fit the data well. [Colour figure can be viewed at wileyonlinelibrary.com]

The person returns to the equilibrium value more quickly. If the slope is shallow, a small increase in state leads to only a small decrease in the next time point. The person returns to the equilibrium value more slowly. A special case occurs when the absolute value of the slope is greater than 1: the person increases so much that she overshoots her equilibrium point. For such cases, a specialized model such as a damped oscillator might be appropriate (e.g. Chow, Ram, Boker, Fujita, & Clore, 2005). This case has not been observed in any of the hundreds of personality state time series we have analysed.) Note that other dynamic models have slightly different interpretations of equilibria; in Revelle and Condon's (2015) model, they represent the balancing of opposing forces, and in Sosnowska *et al.*'s (2019; this issue) model, equilibria can only be attractors, and they represent a person's baseline state.

THEORETICAL IMPORTANCE OF A SINGLE ATTRACTOR MODEL

It is tempting to think of this attractor as an ideal or desired personality state, but this agentic language is not quite accurate. In our interpretation, the person is just one part of the system; the environment and responses elicited by the person are also part of the system. Saying that the system is 'drawn towards' an attractor does not necessarily mean that the individual is considering their ideal state and taking steps to adjust their behaviour to reach the situation. This is different from the conceptualization of personality states in Whole Trait Theory, which suggests these states vary due to people pursuing different goals (McCabe & Fleeson, 2012; Prentice, Jayawickreme, & Fleeson 2019). Goals are typically conceived of as internal and conscious, while system dynamics do not necessarily need to be either.

For example, an individual might resist going out to meet friends—and indeed might tell themselves or others that their goal is to have a 'quiet night'—but nonetheless end up finding themselves out with friends and in a high extraversion state. In the dynamic systems perspective, this is because of the continuous feedback between person and situation. The social situation might slowly edge the person towards higher extraversion—and internal factors, such as liking conversations with friends might edge the person towards being pulled into these social situations. The extraversion therefore emerges naturally through system dynamics without a plan to satisfy a need for connection; indeed it can emerge in opposition to a conscious plan to stay in.

This explanation also does not mean that the situation controls a person's state in the sense of a 'strong situation' (Cooper & Withey, 2009). The situation does not 'want' a person to act in any particular way, although it does have an influence on personality state. There is continuous feedback between person and situation and so some people who are naturally 'energized' by social interaction might end up having a synergistic reaction that leads to high extraversion. Other people might be naturally stressed by social interaction and so be pushed towards a low extraversion state. The attractor is therefore distinct from either goal pursuit or strong

situational influences; it is a description of the expected behaviour of the *person in the situation*—with the situation, in this case, representing the typical places and events that a person encounters in their daily life. This is the set of situations (or niche) the person has created for themselves in their day-to-day life.

This shift to thinking in terms of person versus situation to the *person in situations* is one of the most important points to understand about this perspective. Theoretically, the attractor is generated by the continuous, ongoing interactions between both changes in the person and in the situations she encounters in her everyday life. Disentangling these to describe a behaviour as *X*% caused by the situation and *Y*% caused by the person cannot capture the true complexity of the idiosyncratic origin of the behaviour. In fact, the analytic paradigm is shifted from trying to divide causes of behaviour into person, situation, and person x situation interaction to something new: trying to understand the behaviour of the person in the situation as a single coherent entity (the system). That is, we want to characterize the consistent patterns of the person/situation system, the idiosyncratic changes, and potential modifiers of this system-level pattern.

Imagine a person laughs at a friend's joke. In the moment, both the situation—the joke—and the person—her sense of humour—influence the behaviour. But the dynamic system approach invites us to consider the causal history of this event. The friend's decision to tell the joke was in part caused by knowledge of the person's (good) sense of humour—so the situation was elicited by previous personality states. The person's sense of humour was also influenced by her exposure to her friend's jokes—so personality was caused by previous situations. The history of the previous interactions between the components of the system influence the current behaviour of the system.

Given that earlier interactions between system components influencing the current state, the state can take radically diverging paths. A person who has joked with a friend a lot in the past can end up laughing a lot more at a given joke because of their shared history of interactions, while that same joke would barely warrant a smile with a different friend. One hallmark of complex systems (a subset of the broader field of dynamic systems) is dependency on initial conditions so that the ultimate trajectory of a state can diverge broadly based on small differences, i.e. the butterfly effect (Lorenz, 2000). Disentangling the proportion of variance explained for these mutually influencing, continually interacting components is impractical and in some cases impossible. Instead, dynamic systems researchers focus on characterizing the behaviour of the system as a whole; in this case, the typical trajectory of interactions of the person with her funny friend.

Identifying an attractor in personality states is an example of identifying a system-level characteristic. The attractor is a pattern that is created by the continuous interactions between person and situation. Changes to either have the potential to alter the underlying dynamics, as do changes in the way they interact, thus, they might change location and strength of the attractor. For example, a person who becomes more responsive to her situation (e.g. becoming sensitized to others noticing her) might change her extraversion dynamics without

fundamentally changing her extraversion levels; similarly, a social situation that is suddenly more responsive to the person's extraversion (e.g. she ends up at the centre of attention in a group) could change the dynamics, even if the characteristic ways that people respond to extraversion (e.g. talking more to people in extraverted states) have not changed. Fundamentally, then, the dynamic systems approach to personality states is about shifting the focus of a model from *decomposing* person–situation influences to *characterizing* how person and situation work together to determine a person's state. Distinct from the largely static, multiplicative way person by situation interactions have been modelled previously, it emphasizes that the components of the system are continuously interacting and so any particular summary snapshot of person and situation will not give a definitive answer to the question of what caused a particular behaviour.

VARIABILITY AND ERROR IN THE CHANGE AS OUTCOME MODEL

Variability and error in the Change as Outcome model—as in many dynamic systems—is characterized in terms of natural *perturbations*. The system that governs change in personality state over time—the personality state system—is taken to have a characteristic internal dynamic that guides its evolution over time. Left unperturbed, the system would change in a purely deterministic fashion, moving towards an attractor and then remaining at that point (ignoring the more complex idea seen in multidimensional systems that cycles of change can themselves be attractors). However, systems in the real world are constantly being influenced by idiosyncratic internal and external events that have not been modelled. Personality states influence themselves such that they will tend to move in a characteristic way towards an attractor, but the many internal and external idiosyncrasies occurring in a person's life 'perturb' the system, pushing it away from its dominant pattern.

Perturbations can be thought of as idiosyncratic events and reactions, which are modelled as essentially random deviations from the dominant trajectory that reveal its topology. Consider a person whose attractor state for extraversion is 3.3 and whose current state is at this attractor. The person gets called unexpectedly into a meeting, which pushes her extraversion state up to 4 as she responds to the situation. If she has no further external perturbations—no more pokes from new, unexpected situations—she will eventually go back to her normal job tasks and return to her attractor state of 3.3. This will be more or less rapid based on the strength of the attractor.

Given how frequently situations change and influence us, perturbations to the system are likely to occur frequently. So the personality state system is continually trying to move towards its attractor point, but unexpected forces are continually pushing it in unexpected directions. Measurements of personality state capture the system responding to its own dynamics and to idiosyncratic pushes. Error in the Change as Outcome model can be thought of as these perturbations.

Perturbations can be thought of as representing concrete entities; a specific perturbation might be running into an old friend or becoming engrossed in a book and ignoring social opportunities. These are specific events, but researchers can understand that no model can account for every possible event without becoming unworkably complex. The Change as Outcome model—as any dynamic model of a real-world process—divides our representation of the world into events that are part of a characteristic, repeating pattern and those events that are deviations from the pattern. Perturbations are error terms in a model, while characteristic changes are meaningful terms (e.g. regression coefficients—see as follows for details of specifying models).

Because the person–situation distinction is such a persistent conceptual frame in psychology, it is worth emphasizing that perturbations are not the 'situation part' of a Change as Outcome model. Perturbations are the part of the observations that cannot be explained with reference to the characteristic pattern captured in the model. The characteristic pattern includes both person and situation influences, so the 'situation part' is split into characteristic recurring parts and unexpected, non-recurring parts. Perturbations can also come internally from within the person. For example, feeling tired, appraising a situation as threatening, or an internal change in hormone or neurotransmitter levels can all be conceived of as perturbations if they are not part of the person's characteristic pattern of state changes. While it is easy to think of perturbations in terms of external events, it is more accurate to think of them as unmodelled portions of an observation.

MORE EXOTIC TOPOLOGIES

While the simplest case—and the case encountered in the vast majority of personality state time series we have analysed—is a topology where there is a single attractor point, more complex topologies are possible. Consider the Change as Outcome plot in of the participant in Figure 4.
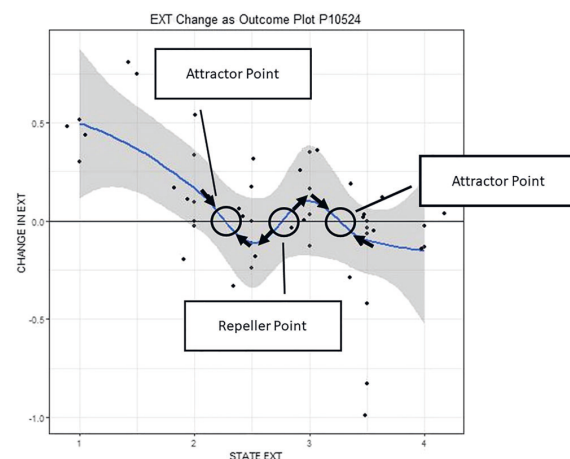

Figure 4. An example of a three-equilibrium topology. [Colour figure can be viewed at wileyonlinelibrary.com]

The loess regression crosses the $y = 0$ line in three places. Because each time the regression crosses this line indicates an equilibrium point, the data suggest that this participant has three different equilibria.

As described previously, the local slope of the line around an equilibrium point determines the type of equilibrium: an attractor or a repeller. In Figure 4, two equilibrium points—one around $x = 2.4$ and one around $x = 3.3$—have negative local slopes. These are attractor states. When this individual's state extraversion is close to 2.4, it will be drawn to this value; when the individual's state extraversion is close to 3.3, it will be drawn to this higher attractor value. The prior state of the system therefore dictates where the system will naturally be drawn: to a low or high attractor state.

The slope around the equilibrium point at approximately $x = 2.8$ is positive, indicating that this is a repeller. If an individual has a personality state variable of exactly 2.8, then the modelled dynamics of the situation suggest that they will remain at exactly that state. However, as soon as there is any perturbation—they move a little bit above or below 2.8—then they will continue to move away from the repeller point. If they are pushed from 2.8 to 2.9, then they will increase in state extraversion until they reach the attractor at 3.3. If they are pushed from 2.8 to 2.7, then they will continue to decrease in state extraversion until they reach the attractor at 2.4.

Overall, the dynamics of this system suggest that the individual has two characteristic levels of extraversion and will move from one to the other whenever his state extraversion crosses a dividing threshold around 2.8. In our exploration of personality state time series, multiple equilibria in a single topology like this was rare. However, this form of modelling allows for the identification of unusual, person-centred topologies that can potentially be theoretically and practically informative. For example, in popular culture, the term 'ambivert' is sometimes used to describe a person who can be characterized by introverted and extroverted tendencies at different times. The Change as Outcome model suggests that ambiverts can be characterized in a formal way by examining the number of attractor points in personality state topology; the dynamics illustrated in Figure 4 define the individual as an ambivert. This form of modelling may prove useful in characterizing the personality state dynamics of specific kinds of people, for example, people building new habits; or people in specific kinds of situations, for example, people with very different social roles at home versus at work. Furthermore, the existence of ambiverts emphasizes that the equilibrium approach has the potential to expand current theoretical possibilities.

IDENTIFYING EQUILIBRIA IN PERSONALITY STATE DATA

Dynamic systems are specified by an equation or a system of equations that describe how a state variable changes over time. To analyse the system, researchers use the equations to identify the points at which no change is expected. These are the equilibrium points. The equations are also used to determine the behaviour of the system around these equilibrium points. The visual exploration of dynamics described previously relates the current state of the system (plotted along the x-axis) to change in the next state (plotted along the y-axis). A simple mathematical representation of this relationship takes a form familiar to researchers who have used regression analysis.

$$_x = m * x + b$$

In this equation, the change in x is represented by the symbol. This is analogous to the outcome or criterion variable in a regression. Change is being predicted by x, the state variable, times a regression coefficient—here written as m—and an intercept, written as b. This equation indicates that the current state has a linear relationship with change.

Specifying a linear relationship is significant. In our visual exploration, we examined places where the loess line crossed the line $y = 0$, which here correspond to $\Delta = 0$ (no change). A straight line can only cross the line $\Delta = 0$ once, so a linear regression model *assumes* that there is only one equilibrium point. To model a system with more than one equilibrium point, a different mathematical description must be used. For example, Butner, Gagnon, *et al.* (2014) discuss how a cubic regression equation—with x^2 and x^3 terms—allows for the possibility of three equilibrium points. However, we will focus on the simple linear case in this manuscript, as our analyses suggest that it is appropriate to capture changes in personality states in the majority of participants we have analysed.

In our linear regression model, the value of m in this equation indicates the strength of the relationship between x and Δ. If m has a large value (either positive or negative), this indicates that the current state has a strong influence on change. This corresponds to *strength* of an attractor or repeller. For example, if m is very small, this would indicate that the current state does not have a very strong influence on the next state. Although there may be an attractor, the person is not moving very quickly towards that point.

The sign of m indicates the behaviour expected around the equilibrium point. If m is negative, it indicates that when the value of x increases, there tends to be a negative change—at the next time point, x will decrease. This suggests that there is a value towards which x will return. The equilibrium point will therefore be an attractor. On the other hand, if m is positive, then increases in x are associated with further increases in the next time point. This suggests that there is increasing movement away from a point. The equilibrium point will therefore be a repeller.

In a system with only a single equilibrium point, it is rare for that point to be a repeller. Having just a single repeller suggests that there is just one characteristic pattern: the system is driven as far as possible from a specific value. Conceptually, this is a poor match for the analysis of personality states. It would suggest that, absent perturbations, the individual would continually be pushed towards the extreme ends of the scale. We would suggest that if a researcher fits a linear Change as Outcome model to personality state data

and finds a positive value of *m*, it should give pause. It may be that this is not an appropriate characterization of the data, and other functional forms (such as a cubic polynomial expansion) should be explored.

The specific location of the equilibrium point can be identified through an algebraic manipulation of the linear regression that was specified previously. An equilibrium point is defined as the point at which the expected change is 0. We therefore want to find the value of *x* that leads change to be equal to 0. We do this by setting $\Delta = 0$ and solving for *x*. The steps of the algebraic manipulation are given as follows:

$$0 = m*x + b$$

$$-b = m*x$$

$$\frac{-b}{m} = x$$

Through this algebra, we can see that the value of *x* at which there is no expected change is given by $-b/m$. This is the location of the equilibrium point. When *m* is negative, we can see that the value of the equilibrium point will ultimately be positive. It will therefore typically be a value in the range of the response scale used by the participants. When *m* is positive, the value of the equilibrium point will be negative, which is outside the range of the response scale. This is another reason why finding that *m* is positive in a linear Change as- Outcome model suggests a problem with the model. If the model is going to characterize the data well, its major topological features should be in the range of allowable responses. We present a summary of dynamic systems terms introduced in this manuscript in Table 1.

UNEVEN SAMPLING

Researchers using experience sampling methods *only* to characterize the mean and standard deviation of a state need to be concerned with collecting an adequate sample of points to accurately represent a person's typical experiences. In this traditional analysis, the rate of sampling is of secondary interest because the relation between consecutive time points is not being modelled. Dynamic systems analyses, on the other hand, account for the temporal sequence of measurements. Researchers interested in using these analyses should be more concerned with sampling rate.

First, sampling rate dictates what kind of patterns can be observed. If an individual's conscientiousness rises and falls every 30 min and this person only reports on their conscientiousness level every 4 h, then it will be impossible to capture the true process. Important points at which the state changes simply are not measured. The resulting problem is referred to as *aliasing* in time series literature, and it occurs when a continuous time signal is sampled less frequently than twice the rate of the highest frequency component of interest (Hinich & Wolinsky, 1988). Formal tests can be performed to determine if aliasing has occurred in a data set (Hinich, 1982).

Determining the proper sampling rate for a particular process might be addressed empirically by sampling a person's personality states at incredibly high rates—for example, every 5 min—and then determining from these measures how frequently the state needs to be assessed to capture the patterns of change. Methods developed for use in historical data can help determine if higher frequency sampling is needed (Nason, Powell, Elliott, & Smith, 2017). However, in the case of personality states, this would create a prohibitively high burden on the participant. The participant would be so busy filling out surveys she would not be able to experience life naturally (however, analyses using passive mobile sensing for imputation of 'in-between' states may be able to help address these concerns; e.g. Ghahramani *et al*., 2018).

We therefore suggest that determining the proper sampling rate is primarily a theoretical issue. The researcher should consider beforehand what the likely time scale of their process of interest is. If we were interested in the way a person's conscientiousness changes in a fast-paced, highly variable environment, we would choose to assess this state more often. Our hypothesis would have an inherent time scale; we would be interested in the way rapid shifts in work tasks influence conscientiousness. On the other hand, if we were interested in the way the development of a habit—occurring over the course of months—changes conscientiousness, we would sample less frequently. Our hypothesis about the role of a habit (such as daily mediation) on conscientiousness has a longer time scale.

The second major concern with sampling rate is related to the ability to make fair comparisons between change scores. An individual increasing in conscientiousness by 1 point

Table 1. Core dynamic systems concepts in Change as Outcome model

Concept	Definition
Equilibrium	States at which a system is not expected to change. In a one-dimensional system, equilibria can be an attractor or repeller
Attractor	State towards which a system is drawn over time. Can be one of multiple equilibria so that the system is only drawn to this state locally, but in other parts of the state space, the system is drawn towards other states
Attractor strength	Speed with which a system is drawn towards a particular attractor. A stronger attractor is one the state is drawn to more quickly
Repeller	State a system is pushed away from over time. Can be one of multiple equilibria, so that the system is only pushed away from this state locally
Repeller strength	Speed with which a system is pushed away from a particular repeller. A stronger repeller is one the state is pushed away from more quickly
Topology	Representation of the characteristic patterns of change estimated in a model, with indications of the expected direction of change at each location

after 2 h is different from that same individual increasing by 1 point after 6 h. When plotting raw change scores, both these changes will appear identical. Yet if we assume that the change from 1 point to the next is linear—and it is difficult to do otherwise when no points are sampled in between—then the first change is relatively rapid while the second is relatively slow. We therefore suggest converting the change scores to a common metric, such as change per hour. In our example, the first change score would be transformed from 1 point to 0.5 point per hour, while the second change score would be transformed from 1 point to 0.17 point per hour. This allows for a fairer comparison in change points and is useful when conducting secondary data analysis. However, this conversion is not a substitute for higher quality data with a consistent sampling rate and good participant compliance. Addressing these issues at the point of planning and data collection as opposed to in modelling afterwards will lead to more accurate results.

EMPIRICAL EXAMPLE

To demonstrate this approach, we used data from wave 1 of the Personality and Interpersonal Roles study (Vazire *et al.*, 2015). This study includes a time-based experience sampling design and has been published on extensively (Beck & Jackson, 2018; Colman, Vineyard, & Letzring, 2017; Edwards & Holtzman, 2017; Finnigan & Vazire, 2017; Solomon & Vazire, 2014; Sun, Schwartz, Son, Kern, & Vazire, 2019; Sun & Vazire, 2018; Wilson, Harris, & Vazire, 2015; Wilson, Thompson, & Vazire, 2017). Detailed documentation of the study is available on the Open Science Framework (https://osf.io/dps4w).

Participants

Participants were 434 undergraduate students from Washington University in St. Louis, and of these, only participants who completed at least 25 measures of a given construct were included in these analyses.

Procedure

The data analysed were from an experience sampling method survey emailed to participants at 12 PM, 3 PM, 6 PM, and 9 PM for 15 days. Participants were asked to respond to Big Five Inventory (John & Srivastava, 1999) questions describing their state in the last hour. Items corresponding to extraversion, agreeableness, neuroticism, and conscientiousness (but not openness) were used. Data on openness were not available in this data set. Two items for each trait—except neuroticism, which had three—were used, rated on a 5-point Likert scale. Moreover, agreeableness items were only assessed when participants were in social situation leading on average to less measurement point for agreeableness than for extraversion, neuroticism, and conscientiousness. Change as Outcome models for each trait were estimated separately.

Analysis strategy

We used a two-step approach to estimating equilibria. First, we conducted an exploratory analysis, estimating a loess regression line connecting state to change per hour. We then identified the number of equilibria by identifying the number of times the loess regression crossed the line $y = 0$ (computationally this can be done by comparing each successively estimated point in the loess to determine if they have opposite signs). We then grouped the participants according to the number of equilibria points. We estimated models using polynomial expansions to capture the number of equilibria seen in the loess regression. For example, if one equilibrium was found, a first-order equation was used; and if three equilibria were found, a third-order equation was used. The values of the equilibria points and the strengths of attractors and repellers were estimated for all individuals.

Results

The distribution of equilibria points observed varied in expected patterns across the four personality states assessed. Of the total 422 time series estimated, one-attractor topologies were found for 412 agreeableness time series, 403 conscientiousness time series, 406 extraversion time series, and 368 neuroticism time series. We found 14 extraversion ambiverts (people with two extraversion set points), 8 agreeableness ambiverts (people with two agreeableness set points), 17 conscientiousness ambiverts (people with two extraversion set points), and 46 neuroticism ambiverts (people with two neuroticism set points). There were a few cases with two set points, where using one extreme end of the rating scale was a repeller. In the neuroticism data, there was one case with three attractors and two repellers—a 'trivert'—and one case with two attractors and two repellers. This suggests that topologies with multiple features are uncommon but likely to be present in a large sample of participants. They occur most commonly for neuroticism, perhaps indicating that many college students have periods of high anxiety and low anxiety in response to shifting demands of classes and internal self-evaluations.

Only topologies with a single attractor were considered in the following analyses, as these are quantitatively comparable with each other. Equilibria tended to be highest for agreeableness, a desirable personality state; and lowest for neuroticism, an undesirable personality state. The locations of the equilibria were highly correlated with the means of the distributions [$r = .95$, $t(783) = 83.36$, $p < .001$] but were only weakly related to the standard deviations of the distributions [$r = -.30$, $t(783) = -8.82$, $p < .001$]. Also of note is the relatively small variability in equilibria for agreeableness compared with other traits. Many participants had equilibrium points around agreeable states from 4 to 5, while extraversion equilibria were more evenly distributed between 2 and 4, and neuroticism equilibria were distributed between 1.5 and 3.5. This may be due to a self-perception gap, where individuals see themselves as more agreeable than others do (Sun & Vazire, 2018).

The strength of the attractors formed distinctive clusters for all traits: one large group of people had very weak attractors, while another group had stronger attractors. Attractor strength was weakly related to the mean [$r = -.10$, $t(783) = -2.75$, $p = .006$] and standard deviation [$r = .05$, $t(783) = 1.37$, $p = .170$] of response distributions. Attractor location and strength were also weakly related [$r = -.11$, $t(783) = -3.21$, $p = .001$]. People with weak attractors are those who are not very strongly drawn to their equilibria or strongly and continuously pushed away from their equilibria, suggesting that perturbations have longer lasting effects on the personality system. These people might be flexible, less reactive to the situation, or face more open-ended situations. Another large group of people do tend to consistently return to their equilibria, suggesting a more active person–situation regulatory processes or a more structured everyday life. Figure 5 displays the distributions of attractor points and equilibria for participants with just one attractor in their topology.

The correlations among estimated topological features are provided in Table 2. Note that the position and strength of the attractors for each trait are only very weakly correlated. On the other hand, the strength of the attractors was
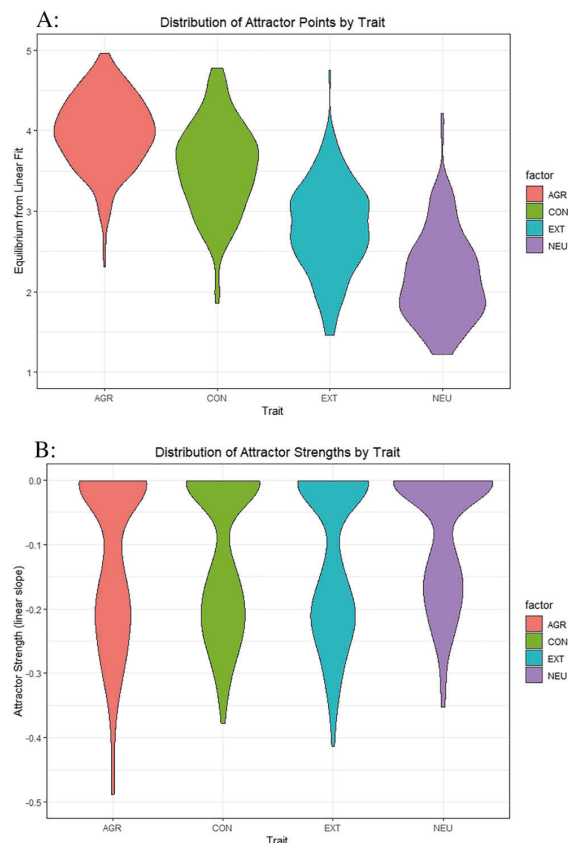
relatively highly correlated. This suggests that the tendency to return to a baseline state quickly may be a generalized tendency among individuals.

ALTERNATE REGRESSION MODELS FOR CAPTURING TOPOLOGIES

We have discussed in detail the use of a simple linear regression to characterize personality state topology. However, as discussed, linear regression assumes that (i) there is only a single attractor and (ii) the strength of the attractor is the same for all states. Using polynomial expansions of the state variable as further predictor terms is one approach that loosens the first restriction and allows for multiple attractors. The typical approach to determining the necessity of higher order terms in a model is to conduct hierarchical regression, where a significance test determines if including the additional term increases the fit of the model (Aiken, West, & Reno, 1991). This approach has been proposed to determine if a model allowing for more equilibria is warranted (Butner et al., 2014). In the context of one participant's measurements on a 5-point or 7-point Likert scale, we have seen few cases when the addition of a higher order term was supported by such a significance test. Further, significance tests of higher order regression coefficients are likely to be underpowered given typical time series for a single individual (assuming regression coefficients of the size seen in our data set; see Jayasuriya, 1996). We therefore advocate for a qualitative assessment of model fit as a first step in analysis. Further development of this method may yield greater insight into optimal solutions for identifying the number of equilibria to include in a model.

The second assumption of the linear model that the attractor has the same strength when an individual is at any state can be loosened using regression splines. Regression splines are a series of two or more regression lines that have been joined. These splines allow for the slope of a regression to change in different regions of a predictor variable. For example, the slope of the line relating conscientiousness to change might be very steep when state conscientiousness is low; when state conscientiousness is high, however, the slope might be less steep. Similarly, we might model attractor strength differently when the state is above or below the attractor point.

A comparable approach was taken by Gottman et al. when modelling the affective states of husbands and wives during interactions (Cook et al., 1995; Gottman, Swanson, & Murray, 1999; Gottman, Swanson, & Swanson, 2002). Each husband and each wife was assumed to have a typical pattern of change for positive affect (when the valence score was above 0) and a different pattern of change for negative affect (when valence was below 0). While a regression spline approach does not appear common when analysing unidimensional systems, it would be possible to specify different slopes above and below a particular knot point—or to allow a machine learning algorithm like multivariate adaptive

A:

Distribution of Attractor Points by Trait

B:

Distribution of Attractor Strengths by Trait

Note: All attractors and attractor strengths strengths are calculated based on the change-per-hour metric.

Figure 5. Distributions of attractor points and strengths for participants with one-attractor topologies. *Note*. All attractors and attractor strengths are calculated based on the change-per-hour metric. [Colour figure can be viewed at wileyonlinelibrary.com]

Table 2. Associations among topological features. Means, standard deviations, and correlations with confidence intervals

Var.	M	SD	1	2	3	4	5	6	7
1. Ext: Pos.	2.81	0.58							
2. Ext: Str.	−0.13	0.12	−.05 [−.19, .08]						
3. Agr: Pos.	4.00	0.47	.20** [.07, .33]	−.02 [−.16, .12]					
4. Agr: Str.	−0.13	0.13	−.07 [−.21, .06]	.83** [.78, .87]	−.01 [−.14, .12]				
5. Neu: Pos.	2.17	0.59	−.19* [−.33, −.04]	−.03 [−.19, .12]	−.21** [−.35, −.07]	−.10 [−.25, .05]			
6. Neu: Str.	−0.09	0.10	−.07 [−.22, .08]	.89** [.85, .92]	.04 [−.11, .19]	.81** [.75, .86]	.06 [−.09, .20]		
7. Con: Pos.	2.89	7.81	−.05 [−.18, .09]	−.10 [−.23, .04]	.17* [.03, .30]	−.09 [−.22, .05]	−.15 [−.30, .00]	−.08 [−.23, .07]	
8. Con: Str.	−0.12	0.11	−.04 [−.18, .10]	.89** [.86, .91]	−.07 [−.20, .07]	.83** [.78, .87]	−.05 [−.20, .10]	.86** [.81, .89]	−.10 [−.23, .03]

Note: M and SD are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. Agr, agreeableness; Ext, extraversion; Neu, neuroticism; Con, conscientiousness; Pos, position; Str, strength. *Indicates $p < .05$. **Indicates $p < .01$.

regression splines to use pre-specified criteria for identifying an optimal knot point.

We recommend a two-step process for estimating models. We first suggest an exploratory approach, where a localized regression is fit to the data, and the adequacy of a one-equilibrium model with a relatively constant slope is assessed qualitatively. We then suggest estimating this model in all time series for which it is relevant. If this model appears inadequate, we suggest exploring other functional forms, including a higher order polynomial or a spline regression.

MEASUREMENT ERROR

While our emphasis in this manuscript is on developing a non-technical introduction to what a Change as Outcome model provides theoretically, a similar framework has developed in the structural equation modelling literature under the name latent change scores (McArdle, 2009; Ferrer & McArdle, 2010; McArdle & Nesselroade, 2014). This approach estimates a latent variable that represents change in a state over time and can be implemented in a multivariate framework with latent change in two or more variables estimated simultaneously. However, this approach has also been geared primarily towards researchers estimating longitudinal models using a few time points and is less commonly applied to data collected in intense bursts (such as experience sampling method data). For example, Grimm, Zhang, Hamagami, and Mazzocco (2013) estimated a latent change score and latent acceleration factor as a method for modelling non-linear development in math scores, measured annually at eight grade levels. Additionally, latent change score models are typically variable-centred, as opposed to person-centred. One advantage of the modelling technique advanced in the PersDyn article in this issue is that their dynamic model accounts for measurement error. A version of the Change as Outcome model in a structural equation modelling framework, possibly using latent change scores, is an area for future research.

SUMMARY AND FUTURE DIRECTIONS

The number, location, and strength of attractors and repellers are quantitative properties estimated by the Change as Outcome model that characterize system dynamics. These are core concepts from the literature on dynamic systems originating outside of psychology, and we believe they can provide new insight into personality states. These concepts, and the dynamic systems perspective more broadly, requires some re-orientation on ways of conceptualizing data. We summarize some key principles of dynamic systems as follows, but we would encourage researchers interested in these ideas to read more general treatments of dynamic systems in psychology (e.g. Vallacher, Read, & Nowak, 2017; Richardson, Dale, & Marsh, 2014).

WHAT IS IMPORTANT ABOUT PERSONALITY STATES?

The Change as Outcome model characterizes personality states in terms of equilibria and their strengths, adding the concepts of prior state and system topology to our explanatory toolbox. The Change as Outcome approach explicitly links current state to the next state by modelling change. Each new state is determined in part by the previous state. The system topology is a way of characterizing characteristic person–situation patterns, which suggests that there are meaningful person–situation patterns to be picked up on in the data. Each new state is determined partly by these recurring person–situation patterns in daily life and in part by unique natural perturbations.

IMPLICATIONS FOR PERSONALITY DEVELOPMENT

The Change as Outcome model can be used to describe several different ways personality dynamics can change in response to external events. These changes can represent taking on a new role, such as becoming a parent or a manager in a company; undergoing a major life event, such as moving to a new city or dealing with the death of a loved one; or even the results of personality change through therapy (Roberts *et al.*, 2017; Roberts & Mroczek, 2008; Hudson & Fraley, 2015). Traditional analyses would suggest that these significant changes could be modelled as changes in the mean or standard deviation of the distribution of personality states; for example, a large meta-analysis recently found that therapy appears to make people less neurotic (Roberts *et al.*, 2017). In the dynamic systems framework we present here, however, significant changes can be thought of as shifting the person's underlying personality state topology. If repeated measurement burst designs were used, development in these dynamic traits of personality states could be tracked across the lifespan (Ram & Gerstorf, 2009).

In the Change as Outcome model, significant life events, which influence personality development (e.g. Specht, Egloff, & Schmukle, 2011), can have several different effects. They can change the *location of an attractor state*. For example, a person's characteristic neuroticism score might be lowered from 3.5 to 2. This can be seen in Figure 6(a). They might also change the *strength of an attractor*. For example, a person might be drawn more quickly back towards a neuroticism state of 2.8. This could be treated as a form of resiliency, or the ability to bounce back to a healthy pattern after a perturbation. This can be seen in Figure 6(b). Finally, the intervention could fundamentally change the *features in the topology*. A person could shift from having attractors at states 4.5 and 1.8 to just having an attractor at state 2.8. This can be seen in Figure 6(c). Change as Outcome modelling therefore gives a richer conceptual vocabulary and mathematical tools that can be used to describe how significant events change people's personalities. For example, while grieving an individual might not increase in neuroticism (e.g. mean-level change) but might return to their baseline level of neuroticism more slowly than before they experienced the death of a friend (e.g. a heightened vigilance). Therapy or recommendations to deal with this situation might therefore focus on strategies for returning to baseline—as opposed to strategies for shifting the baseline.

TOWARDS A MULTIVARIATE APPROACH

Current research in personality dynamics often centres around discussions of network models, which typically represent correlations among many variables as a series of edges connecting variables to each other (conceptualized as nodes). These models emphasize the 'system' aspect of dynamic systems, with development centring around capturing the specifics of the interrelationships between every measured
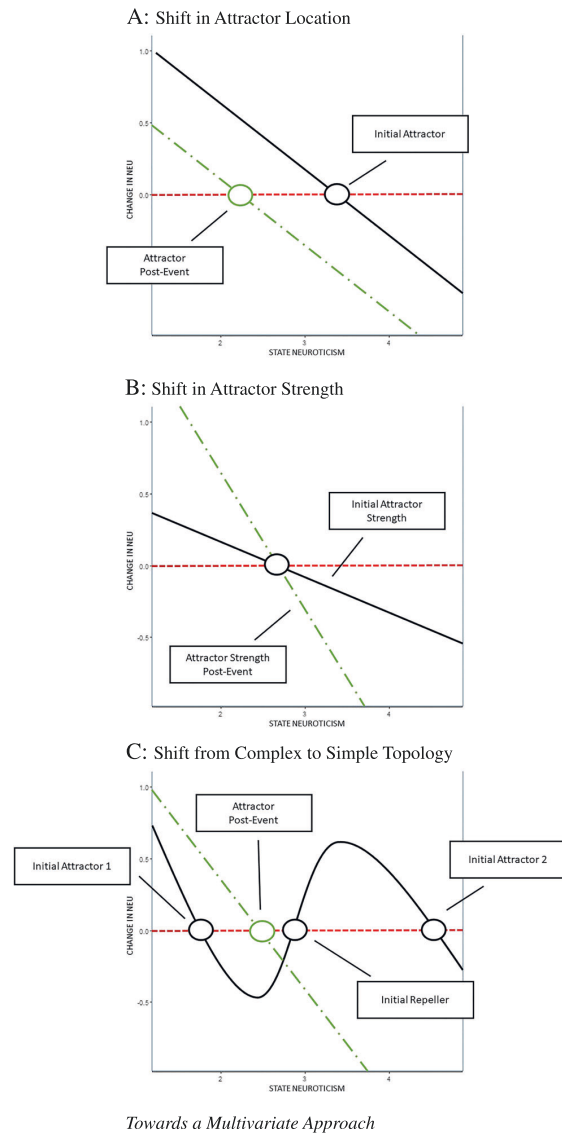

Figure 6. Hypothetical personality development effects of significant life events. [Colour figure can be viewed at wileyonlinelibrary.com]

variable (Epskamp, Borsboom, & Fried, 2018). However, network models are not inherently 'dynamic'—in the sense that they can be estimated on data that were all collected at the same time (e.g. cross-sectional networks; Costantini *et al.*, 2015). This is because network models were developed as an alternative to latent variable models, so the problem they were introduced to solve is not one of how best to think about change over time but how best to think about the interrelationships between many variables (Schmittmann *et al.*, 2013). However, many psychologists may be surprised that dynamic systems researchers in other fields often consider capturing the patterns of change to be of primary interest, and often limit their investigation to just one or two variables changing over time (Otto & Day, 2011; McElreath

& Boyd, 2008; Nowak, 2006). Psychologists using typical analysis of variance and regression models can estimate three-way, four-way, five-way, or even higher order interactions but are often discouraged from trying to estimate these complicated effects because of difficulty of interpretation and instability of estimates; similarly, students learning dynamic modelling are often encouraged to consider change in only a handful of state variables at a time.

When systems are more complex, researchers are encouraged to consider modelling 'combined' variables (e.g. a ratio between two quantities of interest) or to consider certain variables to be fixed for the purposes of analysis (e.g. the carrying capacity or overall population size of an environment in population biology models). Even one-dimensional dynamic models can have interesting dynamics that yield scientific insight (May, 2004). In psychology, for example, the Haken–Kelso–Bunz model of motor coordination has a single state variable, the relative phase angle of two people performing a rhythmic action together (Haken, Kelso, & Bunz, 1985). This single-dimensional model combines information about two people acting together in a single quantity—the relation between two oscillating movements, such as fingers or hammers being swung back and forth—and yet has been the basis for decades of motor dynamics research.

Our modelling approach begins by capturing change in just one personality factor at a time, primarily for didactic purposes. Understanding system dynamics one at a time provides an opportunity to illustrate the core constructs in a relatively straightforward way. However, a two-dimensional extension of the Change as Outcome model has been used in prior research (Butner, Berg, Baucom, & Wiebe, 2014), and we think it is plausible that personality states may interact with each other over time. However, there are many other kinds of dynamics possible when two states interact—including limit cycles, saddle points, spiral attractors and repellers, and torus (or donut-shaped) relationships. Future manuscripts will discuss a two-dimensional extension of this approach, providing space and detail for describing these more complex relationships.

LIMITATIONS AND AREAS FOR FUTURE RESEARCH

There are many open areas in dynamic systems theory and modelling being addressed by thoughtful and innovative researchers; we cannot feasibly address all these open areas in this manuscript. Work in measurement and psychometrics of experience sampling data is sorely needed, but our modelling strategy is largely orthogonal to this concern. If a new personality state scale with better psychometric properties was developed this year, all of our discussion would still apply—we would just encourage researchers to use this better scale (e.g. Zimmerman *et al*., 2018).

Another issue raised by early reviews of our work is the question of whether personality states themselves can be thought of as continuous—i.e. that they exist at all times and can be measured at any given moment—or whether another conceptualization is needed. For example, perhaps only certain relevant states exist in a given moment (e.g. state

extraversion only 'exists' in situations relevant to socializing). Continuity of states is a fundamental assumption shared by almost all contemporary approaches to personality dynamics. While we would be interested in theoretical reconceptualizations of personality states, and in how to interpret self-reported personality states under the assumption that personality was not continuous, defending this core assumption of the personality dynamics literature is beyond the scope of this manuscript. We take it as given that an individual does have an underlying personality state incorporates content like thoughts, emotions, and situational awareness that change continuously over time and that researchers can assess its current status at any given moment (with few exceptions, e.g. while sleeping and while performing another task like driving that requires full concentration). The modelling strategy we present may need to be modified or dropped for researchers making alternate assumptions.

Another criticism is that changes in personality states are non-linear and highly reactive to situations. For example, state extraversion might jump quickly after a person goes to a party and stays high—instead of increasing continuously while at the party. Only measuring state extraversion an hour before the party and then 3 h later towards the end of the party would miss the shape of this change; the consistent high extraversion at the party just would not be measured. This is a common issue faced by all modelling strategies using time series data: was the data sampled at a rate that can provide an adequate picture of the process the researcher is interested in? (see the earlier section on sampling rate). This is an open question in personality state research because extremely high frequency personality state data (e.g. every 5 or 10 min) are not typically available. If the appropriate data for addressing these rapid fluctuations in personality became available, we would still advocate for a dynamic systems approach, as the feedback loops common to dynamic systems modelling are well-suited to represent non-linear changes. However, more sophisticated models might be indicated to capture that pattern.

We have also prepared a thorough comparison of our model with the PersDyn model presented in this issue in an appendix. Briefly, the Change as Outcome model allows equilibria to be either attractors or repellers, allows for multiple equilibria to be present in a person's personality system, and uses a 'purely idiographic' approach by not allowing data from other participants to influence the estimation of parameters for a specific participant. PersDyn models personality variability separately from attractors includes a measurement model and is estimated in continuous time. Our approach is therefore better suited to introduce dynamic systems ideas, but the PersDyn model is more sophisticated in several ways.

IMPLICATIONS FOR THE PERSON–SITUATION DEBATE

Researchers in the allied disciplines of personality and social psychology generally agree at a broad level that both the person and the situation are responsible for determining any given behaviour. The systems level view presents a way of

doing this without emphasizing person versus situation. It suggests instead that we need to characterize the patterns emerging from the continuous, ongoing interactions of person and situation—the coherent entity that we describe as the system. The interactions described in a dynamic systems approach are different from those in a typical analysis of variance or regression analysis because the assumption underlying these traditional analyses is that an outcome—for example, a behaviour being predicted—is a linear combination of main effects and interactions that are clearly separable. Interactions in a dynamic system, however, are assumed to involve ongoing non-linear feedback loops. Situations change personality states, which in turn change situations, so that there is no clear break point at which we can separate out their influences into person + situation + person x situation interaction. The estimated effects of each factor would change from moment to moment as the ongoing feedback alters the relationship between parts of the system. The dynamic person–situation system is the underlying fundamental unit of analysis.

To adequately characterize these interactions, we need to consider the role of time in understanding behaviour. The history of a dynamic system helps to constrain and determine its current behaviour; people's current behaviour is similarly guided by their own 'history' of lived experiences as well as their expected and imagined future. For example, a person that has been in a satisfying relationship for the last years and who can expect to return to their partner at the end of the day might act very differently in a romantic setting than a single person would. The focus of dynamic systems analysis is on understanding how small, repeated interactions can lead to broad patterns that can be characterized by a model. People are constantly interacting with their physical and social environments such that most medium-scale behaviours psychologists are interested in understanding—from conversations to attitudes to identity—will necessarily be the result of some combination of person and situation. A useful dynamic systems model of personality state change will capture the important patterns in these medium-scale behaviours and provide insights for how the system as a whole can move towards adaptive or maladaptive outcomes.

We believe the Change as Outcome model will be particularly useful when applied to analyse time series of personality state data. Yet we hope that it also contributes to the broader conversation about how best to develop an integrated understanding of the ways in which person variables and situation variables jointly influence behaviour. Taking a dynamic systems approach has the promise of yielding a deeper philosophical and quantitative unification of person and situation.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Open Science Disclosure Form

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APPENDIX A.: DETAILED COMPARISON OF CHANGE AS OUTCOME AND PERSONALITY DYNAMICS MODELS

In this issue, Sosnowska *et al*. (2019) present Bayesian hierarchical Ornstein–Uhlenbeck modelling (BHOUM) as a parameterization of their Personality Dynamics (PersDyn) model. The PersDyn model and our model both draw on core concepts from dynamic systems, such as attractors, that have been discussed for decades by several research groups in personality psychology (e.g. TESSERA, Wrzus & Roberts, 2017; CAPS, Mischel & Shoda, 1995; Magnusson & Torestad, 1993). The manuscript by Sosnowska *et al*. presents a high-level overview of the current status of an active research programme aimed at integrating dynamic systems thinking into personality psychology, with a prior theoretical manuscript laying out the conceptual foundations of this approach (Sosnowska *et al*., 2019). Integrating dynamic systems thinking into personality psychology is also our goal, and we believe their manuscript is a significant contribution in this area. That said, there are several differences in the details of our approaches worth noting.

First, we describe the attractor location in the context of the broader category of equilibria. Equilibria in a one-dimensional system can include either attractors—points a system is drawn towards—and repellers—points a system is drawn away from. The BHOUM model used for PersDyn takes the following form:

$$d\Theta(t) = B(\mu - \Theta(t))dt + \sum dW(t)$$

The term $B(\mu - \Theta(t))$ indicates that change is proportional to deviation from the mean, so the model always assumes people are drawn back to their average personality state. That is, the model assumes people have a single attractor state and precludes the possibility of repeller states or multiple equilibria. Our analyses suggest that this simplifying assumption is warranted with personality state data; we rarely encountered time series in which an individual's dynamics could not be adequately captured using just a single attractor. However, we believe that providing examples of repellers and systems with multiple equilibria is helpful when considering what insights the dynamic systems perspective can provide. Further, we believe there may be subpopulations where topologies with multiple equilibria are common, such as individuals with certain personality

disorders or whose lifestyle involves intense differences across tasks—such as emergency responders.

Additionally, we opt for a 'pure idiographic' approach to personality dynamics in this manuscript, meaning that we estimate models separately for each individual. Hierarchical modelling, which is used in PersDyn, takes into account data from the broader population when estimating parameters for the individual. This can be thought of as a kind of regularization; the parameters estimated for each individual —such as attractor strength and location—are biased towards the mean of the group. Further, in a hierarchical model, all participants need to have the same parameters; there cannot be individual differences in the number of equilibria points. By estimating separate models for each individual, we allow for the possibility that some people will differ in the *structure* of their change over time. We also allow each person to be independent from all others, without assuming that people's attractor and attractor strength parameters are drawn from common underlying distributions. It may be that only certain groups of people come from a common distribution, while other groups come from different distributions. While a hierarchical model with a common structure appears empirically adequate in the data we have examined so far, it is worth examining this assumption in future research using the conceptual tools provided in this manuscript.

This manuscript also presents details on how major life changes might shift personality dynamics. Although the PersDyn model has not yet addressed the role of major life changes on personality dynamics, we believe that this description is largely consistent with the way that PersDyn models personality dynamics. The exception, as previously mentioned, is that PersDyn currently only allows for topologies with a single attractor. This means that the BHOUM model could not capture life changes that add or subtract equilibria to personality topology. We suspect that this will only be important in special cases, perhaps in response to

stress or trauma, but believe these kinds of changes are worthy of future empirical attention.

The PersDyn model also includes several important distinctions not present in our work. First, BHOUM is a continuous time model, meaning it is technically modelling the derivative of the outcome variable with respect to time. This allows the BHOUM to deal with the unequal spacing of experience sampling method data by incorporating a time-varying term associated with both the change and the error process. Continuous time models can lead to less biased estimates of continuously varying processes than discrete time models, like vector autoregression (de Haan-Rietdijk *et al.*, 2017). Our own approach to dealing with uneven spacing by creating a change score is more similar to latent change score modelling, an alternative statistical model (McArdle, 2009). We find the Change as Outcome model more intuitively accessible for introducing constructs, but a review of the statistical fit of the most advanced modelling techniques might ultimately suggest a continuous time model is necessary to reduce bias in parameter estimation.

PersDyn involves a third core construct beyond attractor location and attractor strength: level of variability. This natural level of fluctuation has had an important role in prior theorizing, particularly in Whole Trait Theory (Fleeson & Jayawickreme, 2015). Currently, our model treats variability not accounted for by attractor location and strength as part of the model residuals—which we describe as perturbations. We are still determining if there is an important role for variability in personality states in a future iteration the Change as Outcome model.

The PersDyn model is also currently able to handle two-dimensional systems using the BHOUM parameterization, and the manuscript points to further modelling techniques for including more dimensions. Our modelling technique focuses on the one-dimensional case, although there are clear extensions that could allow us to model higher dimensional

Table A1. Comparison of Change as Outcome model and Personality Dynamics model

Construct	PersDyn	Change as Outcome
Modelling of time	Continuous	Change per hour
Interpretation of parameters	Internal, as features of the individual	System level, as features of consistent person–situation interactions
Equilibria	Discusses only attractors, one kind of equilibria	Includes attractors, repellers, and the possibility of multiple equilibria in a single model
Attractors	Included	Included
Repellers	Not included	Included
Multiple equilibria	Not included	Included
Effects of interventions/life changes on dynamics	Not included	Included
Estimation technique	Bayesian	Frequentist (could be implemented in Bayesian framework in future iterations)
Level of analysis	Combined between and within (multilevel)	Purely idiographic, within person, allowing for unique person-level dynamics
State variability	Included	Part of perturbation term and not clearly distinguished
Including more than one state	Modelling approach discussed; not demonstrated	Modelling approach discussed; not demonstrated
Measurement model	Included	Not included

PersDyn, Personality Dynamics.

cases. In this regard, the PersDyn model has already given more thought to this more complex case, and we look forward to seeing the details of a two- (or more) dimensional model being implemented.

Further, the PersDyn model includes a measurement model in its estimation. In the interests of keeping our explanation and modelling simple and easy to follow, we have not included a measurement model in our current estimation. However, this is clearly an area in which Change as Outcome modelling will need to progress in the future, and an area that has been given more thought by the researchers using the PersDyn approach. The incorporation of personality variability as a core construct and use of a measurement model capture an underlying difference in our goals in our manuscripts: Sosnowska *et al.* (2019) are presenting the most up-to-date thinking on a new theoretical model, while we are attempting primarily to illustrate several core concepts from dynamic systems to an audience looking for an entrance point to dynamic system thinking.

There is also an important theoretical distinction between the way that we conceptualize dynamic systems models. Sosnowska *et al.* (2019) interpret attractor strength as representing an aspect of an individual's regulatory strength, suggesting it is an internal property of the individual. We would interpret it as consistency of patterning in the person–situation system. That is, the demands of a person's daily life (e.g. a demanding work schedule) can pull them back towards a particular state as quickly as their internal need to be in that state (e.g. a strong achievement motivation).

More broadly, we believe that dynamic systems models —and the Change as Outcome model in particular—call for a reconceptualization of the person–situation dichotomy in psychology. Dynamic systems approaches emphasize that there is continuous feedback between aspects of a system, such as person and situation. Experience sampling data measuring personality states are always made when an individual is in (or just was in) a particular situation, so from a dynamic systems perspective, we believe these measurements should be conceptualized as the joint product of both person and situation. That is, if my state extraversion at one time point is 3.8, this measurement was influenced both by the situation I was just in (e.g. I may have been talking to colleagues) and by my own internal processes (e.g. I become more extraverted when around colleagues).

Given this theoretical commitment, we understand dynamic models to be capturing the consistent patterns in the way one person's personality state changes over time. For example, the attractor locations and strengths estimated in the Change as Outcome model should be thought of as a quantitative summary of the consistent, dominant pattern of person–situation influences on personality states. These patterns are like a temporal version of Mischel and Shoda's situation–behaviour profiles (Mischel, Shoda, & Mendoza-Denton, 2002). Instead of situating personality in the consistent part of a situation–behaviour graph, the Change as Outcome model situates dominant personality dynamics in the consistent feedback between person and situation in the individual's daily life.

Like all statistical models of human behaviour, there is necessarily a residual error term in the Change as Outcome model. This residual error is the part of the observation that is not modelled by the other estimated terms. Given that the estimated terms are capturing the broad, consistent pattern of personality state fluctuations, the residual error must therefore contain information about the 'random' or surprising and idiosyncratic thoughts and events that influence personality states. That is, error is not just imprecise measurement—we assume that it represents the substantive concept of natural perturbations. These perturbations are also influenced by both person and situation. They can represent idiosyncratic reactions to normal events, normal reactions to surprising events, or some mix of these.

Estimating dynamic models therefore suggests an important distinction not commonly discussed in personality: that between consistent patterns and idiosyncrasies. Person and situation are assumed to influence both patterns and idiosyncrasies through continual coupling and feedback. In dynamic systems modelling, the complex interplay of person and situation in determining behaviour can effectively be bracketed and treated (perhaps just temporarily) as 'irreducibly complex'. Instead, dynamic modelling suggests that we can gain traction by addressing a different distinction: consistent patterns versus idiosyncrasies. We suggest that this conceptual metaphor will be a more fruitful way to think about patterns of behaviour than the traditional distinction of 'some is caused by the person, other parts are caused by the situation'. This theoretical commitment is not shared by many prior conceptualizations of personality dynamics. Table A1 presents key differences between our model and the PersDyn model, including theoretical interpretations.

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RESEARCH ARTICLE

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Personality development in disruptive times: The impact of personal versus collective life events

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Abstract

Personality development is related to life events that change social roles and environments. Here, we provide an overview of the differences between personal and collective life events relevant to personality development. Following some basic assumptions about the malleability of personality traits due to life events, we discuss the differences in the thematic, social, spatial, and temporal characteristics of personal and collective life events. Personal life events often cover the domains of health, work, family, and love in individual people's lives, while collective life events refer to disasters and power struggles that affect many people. Collective life events are different because they can (a) trigger different personal life events for different people, (b) indirectly affect many more individuals who identify with a directly affected group, and (c) change social role demands through cultural changes. We discuss how these, and other differences affect the way researchers should investigate collective life events.

1 | INTRODUCTION

Imagine Ada, Bea, and Cem: Ada quit her job for personal reasons, the plant where Bea was working was shut down, and Cem was laid off during an economic crisis. In short, at some point, all three transitioned into unemployment. In contrast to Ada's case, Bea and Cem's personal setbacks were the result of collective changes affecting hundreds and millions of people, respectively.

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Researchers interested in the impact of life events for personality development often focus on *personal life events* like unemployment (Binder & Coad, 2015; Boyce et al., 2015; Gnambs & Stiglbauer, 2019; Hald Andersen, 2009; Vellekoop, 2016; Winkelmann, 2009) that primarily affect a single individual or household. However, numerous *collective life events* like plant closures or economic crises (Anger et al., 2017; Obschonka et al., 2016) involve larger groups of people, set the contexts for personal life events, and can themselves influence personality development. Our goal is to highlight these and other typical differences between personal and collective life events because they may (a) affect personality development differently, and (b) require to be treated differently in research on personality development.

2 | PERSONALITY AND ITS DEVELOPMENT

Personality captures relatively stable individual differences in thoughts, feelings, and behaviors. Shaped by biological and environmental factors, previous research suggests that personality remains malleable across the entire life span (Bleidorn et al., 2014; Caspi & Roberts, 2009; Graham et al., 2020; Kandler et al., 2012; Specht et al., 2014; Wagner et al., 2020) and changes particularly during young and old age (Roberts et al., 2006; Specht et al., 2011; Wagner et al., 2016). Core personality traits like the Big Five or HEXACO—that is, openness to experience, conscientiousness, extraversion, agreeableness, neuroticism or emotional stability, and honesty-humility—and other individual differences such as life satisfaction and self-esteem have been found to predict various life outcomes (Luhmann et al., 2012; Orth et al., 2012; Roberts et al., 2007; Soto, 2019, 2021) including the occurrence of life events (Beck & Jackson, preprint; Denissen et al., 2019; Niehoff et al., 2017; Richter et al., 2020). At the same time, life events have been shown to play a crucial role in personality development. However, previous findings have often been heterogeneous and the strengths, durations, and directions of the associations between life events and personality trait changes varied greatly across different samples and studies (Allemand et al., 2010; Asselmann & Specht, 2020, 2021; Bleidorn et al., 2018; Bleidorn et al., 2013; Lucas, 2007; Luhmann & Eid, 2009; Luhmann et al., 2014; Orth & Luciano, 2015; Specht, 2017; van Scheppingen et al., 2016). Some of these inconsistencies might be explained by different event properties and the fact that different individuals can experience the same kind of event differently (Luhmann et al., 2020; Reese & Smyer, 1983). Here, we are interested in both typical differences in event properties and in the subjective experiences that set collective life events apart from personal ones and might help to explain why previous findings were often mixed.

2.1 | The neo-socioanalytic perspective

One framework that fits well with this general account of personality is the *neo-socioanalytic theory* (Roberts & Nickel, 2017; Roberts & Wood, 2006). It considers a broad range of individual differences including traits, abilities, narratives, motives, and values that are crucial for peoples' identities and their reputations. The theory suggests a functional interpretation of personality relating to the social roles and environments a person inhabits. Importantly, this implies that changes in social roles and environments—often demarcated by life events—are seen as the primary drivers of personality development besides biological factors.

Most relevant to within-person development, the theory's *sociogenomic model* specifies two epigenetic systems of personality malleability (Roberts, 2018; Roberts & Jackson, 2008). One system explains *lasting* personality trait changes through relevant environmental factors occurring during a specific developmental stage. The other system explains *temporary* personality trait changes in response to other environmental factors occurring at other times. However, the question of which aspects of personality can change lastingly and which temporarily for which reasons is ongoing (Henry & Mõttus, 2020; Kandler et al., 2014).

Additionally, the neo-socioanalytic theory provides eight principles of personality development—four on personality change (1–4) and four on personality consistency and continuity (5–8). The most general principle of change is (1) the *plasticity principle* which states that personality traits are malleable at any age. More specifically, (2) the *maturity*

principle posits that agreeableness, conscientiousness, and social dominance (a facet of extraversion) increase and neuroticism decreases with age, while (3) the *social investment principle* suggests that personality traits of young adults change because they commit to adult social roles. Moreover, (4) the *correspondive principle* posits that the personality traits that make it more likely that a person experiences a certain life event are also the ones that change in response to that event. In contrast, (5) the *niche-picking principle* states that people create social environments that help maintain their existing personality trait levels. In line with that (6) the *role continuity principle* states consistent social roles, rather than consistent physical environments are the cause of personality continuity. Additionally, (7) the *identity continuity principle* posits that developing, committing to, and maintaining an identity facilitates personality consistency. Finally, (8) the *cumulative continuity principle* states that personality traits increase in rank-order consistency until the fifties and then decrease again.

Although the degree of empirical support varies for different principles (Roberts & Nickel, 2017), the neo-socio-analytic theory provides a rich explanatory toolbox of why and how life events can affect personality development across the lifespan. For example, the social investment principle suggests that young adulthood is an important developmental stage during which personality matures when young adults commit to adult social roles. One piece of evidence comes from the varying onsets of personality maturation across cultures depending on the age at which young adults commonly experience life events like "starting a job," "getting married," and "childbirth" in these cultures (Bleidorn et al., 2013; Roberts et al., 2005).

2.2 | Two approaches to life events

In psychology, life events are defined as "time-discrete transitions that mark the beginning or the end of a specific status" (Luhmann et al., 2012, p. 594). This definition allows for a pragmatic operationalization by categorical variables like "employed/unemployed." Moreover, it suits the neo-socioanalytic perspective in that status changes typically indicate changes in social roles and environments—for example, whether working hours are spent with colleagues at the office providing financial security for one's family or spent home alone looking for new employment and worrying about bills that must be paid.

How to best examine the role of life events for personality development has been debated for decades (Luhmann et al., 2020; Reese & Smyer, 1983). Two general approaches can be discerned: (a) an *event approach* that asks how a specific type of life event tends to affect personality development and (b) an *experience approach* that asks how specific subjective experiences regarding some life event affect personality development. One difference is that the event approach attempts to describe and predict developmental trends in the general population or specific groups of people regarding some type of life event (e.g., unemployment). In contrast, the experience approach attempts to identify the psychological processes that underlie personality development due to specific event-related experiences (e.g., experiencing a lack of control) across different types of life events. Thus, the two approaches are complementary as they answer different research questions. Eventually, one could construe different life events in terms of different likelihoods to make certain subjective experiences. For example, job loss may be more likely to be experienced as a loss of social status, while a promotion may be more likely to be experienced as a gain in social status.

So far, most studies have used the event approach and grouped life events into the domains of family, love, work, and health. Typical examples of family or love life events are the beginning and end of romantic relationships, marriage, divorce, childbirth, and widowhood; typical examples of life events in the domain of work are graduation, first job, volunteering, unemployment, promotion, and retirement; typical examples of health life events are diseases, mental illnesses, and personal accidents (Asselmann & Specht, 2020, 2021; Bleidorn et al., 2018; Denissen et al., 2019; Magee et al., 2013). Notably, all these events are personal life events that primarily concern a single individual or household.

Recently, however, the experience approach has gained increased attention. Luhmann and colleagues (2020), for example, proposed nine subjective dimensions—valence, impact, predictability, challenge, emotional significance, change in worldviews, social status changes, external control, and extraordinariness—along which individual experi-

ences of life events differ. These dimensions might help to explain why the same type of life event can lead different individuals on different developmental paths (Rakhshani et al., preprint). How life events are subjectively experienced affects personality development because the individual experience may differ greatly from how an event is stereotypically painted by society. For example, a break-up stereotypically comes with emotional turmoil, but one person may feel lost and the other one liberated which could take the two on opposing developmental paths.

That said, the importance of subjective experience for the individual course of personality development does not cancel out the possible effects of more objective and normative changes in life circumstances, such as the time and resources required for raising a child. Accordingly, the impact of life events on personality development might stem partly from their subjective meaning for the individual and partly from more objective characteristics and the larger societal context.

3 | PERSONAL AND COLLECTIVE LIFE EVENTS

After having sketched out basic relations between life events and personality development, we now turn to the distinction between personal and collective life events. The main difference between personal and collective life events is of course the number of people affected. To examine their differences in more detail, we follow a framework for studying reactions to *referent events* (Dunkel et al., 2019). A referent event can be specified in terms of its thematic, social, temporal, and spatial characteristics: the thematic facet qualifies the event's contextual meaning; the social facet specifies who was involved in the event; the temporal and spatial facet describe time and place of the event, respectively. Table 1 summarizes typical descriptive differences between personal and collective life events. The framework similarly specifies *individual reactions* to an event, however, here these simply equate to the personality development of different individuals.

3.1 | The thematic facet

As mentioned above, personality developmental researchers often consider personal life events indicative of individual status changes in the domains of health, work, family, and love (Bleidorn et al., 2018; Denissen et al., 2019; Specht, 2017).

Personal life events depend on the individual. For example, losing a job affects one person at a time. Moreover, without that person, this particular job loss event could not have occurred. This is not the case for collective life events that involve many individuals whose involvement may be largely circumstantial: an earthquake, for example, can affect millions of people but its occurrence does not depend on any of them. Moreover, collective life events can trigger different personal life events for different people. The earthquake may leave everyone devastated but also costs one person their home, another one their family, yet another one remains unharmed. Accordingly, a generic status change from "unaffected" to "affected" does not sufficiently account for the complexity of many collective life events.

Additionally, we propose to classify collective life events along the thematic domains of natural or human-made *disasters*, and social, economic, or political *power struggle*s. Typically, disasters are negatively valenced and include events like earthquakes, hurricanes, and large-scale industrial accidents. Two recent disasters with the potential to affect personality development are the COVID-19 pandemic and the Beirut explosion. Typical power struggles are terrorist attacks, civil rights movements, military conflicts, genocide, refugeeism, nation secession, and unification. Notably, whether a power struggle is seen as positive or negative usually depends on which group is considered. Two recent power struggles are the George Floyd protests and Christchurch mosque shootings.

Considering just the last 10 years, there has been a steady flow of studies on personality development, personality growth, and psychopathology for disasters and power struggles like earthquakes (An et al., 2017; Milojev et al., 2014) hurricanes (Damian et al., 2021; Lowe, Manove, & Rhodes, 2013) the COVID-19 pandemic (Jeroni-

TABLE 1 Comparison of typical differences between personal and collective life events along their thematic, social, temporal, and spatial characteristics

Referent event facet	Personal life event	Collective life event
Thematic facet: Thematic attributes characterizing the event	Events are typically from the domains of family, love, work, and health of a single individual or household; usually marked by individual status changes	Events are typically from the domains of (natural or human-made) disaster and (socioeconomic or political) power struggle; usually covered by the media
Social facet: People affected by the event	Events typically affect a single individual, dyad, or household directly and independently from other people	Events typically affect a large group of individuals or households directly or indirectly, though each one possibly in different ways and to different degrees
Temporal facet: Instance or interval the event happens	Can typically be identified with an exact date (of status change) but their actual duration and effectiveness can extend long into the past and future	Can typically be identified with an exact date or period but their actual duration and effectiveness can extend long into the past and future
Spatial facet: Spatial location associated with the event occurrence	Typically, the event location is tied to the location of the individual involved	Typically, the event location is distributed across the location of all the people directly involved and distance from the event location can play different roles

mus, 2020; Peters et al., preprint; Sutin et al., 2020), terrorist attacks (Luhmann & Bleidorn, 2018), and military conflict (Cheung et al., 2020; Meyer et al., 2019; Stevanović et al., 2016). Moreover, several studies have focused on changes in mental health and resilience following disasters and power struggles (Brannen, 2020; Lai et al., 2017; Masten & Narayan, 2012; Munjiza et al., 2014; Neria et al., 2011).

Overall, these studies suggest that disasters and power struggles tend to negatively affect the subjective well-being and mental health of most people. In some people, such events might lead to severe psychopathology, while they are less likely to induce personality growth (Infurna & Jayawickreme, 2019; Jayawickreme & Blackie, 2014; Jayawickreme et al., 2021; Mangelsdorf et al., 2019). However, most previous studies on collective life events have examined whether and how certain personality traits predict and moderate changes in psychological functioning and other life outcomes. Comparatively, little research has examined how personality traits themselves change due to collective life events.

Three such exceptions provide little evidence for personality change due to disasters: The first study compared HEXACO trait changes in New Zealand residents affected and unaffected by the 2010/2011 Christchurch earthquakes (Milojev et al., 2014). The only difference they found was that affected residents became slightly less emotionally stable in the following years. Similarly, the second study found a slight decrease in emotional stability but no other Big Five traits during the acute phase of the first wave of the COVID-19 lockdown in a US sample (Sutin et al., 2020). The third study found no significant changes in the Big Five trait levels or their rates of change in Huston students a year after they were exposed to Hurricane Harvey in 2017 (Damian et al., 2021). Notably, none of these studies considered to what extend different individuals were personally affected by the respective disasters, which might explain the lack of notable changes.

A final point on the thematic characteristics of life events is that social roles implicitly reference a society's culture, that is, the social practices and meanings (Blau et al., 2013; Duffy et al., 2013; Hofstede, 1984). For example, the culture Ada, Bea, and Cem's are part of will influence their unemployment experience. The private and state social support systems in place and the value their society attributes to work and financial security affect their new social roles. For country-specific personal life event analysis, culture may be largely negligible. However, for collective life

events taking culture into account becomes crucial because they have the power to change the established social meanings and practices if a critical mass of people gets involved (Centola et al., 2018; Oliver et al., 1985). For example, before the spread of COVID-19 going to work despite not feeling well indicated conscientiousness. For now, the social meaning has reversed and is instead a sign of irresponsibility (Sutin et al., 2020). Moreover, the COVID-19 pandemic has changed the way employees can train in the job and make a career (Boeren et al., 2020; Guan et al., 2020). Thus, collective life events can change the opportunities and requirements of social roles that may affect personality development through cultural changes for which individual social role status changes are not indicative.

3.2 | The social facet

The role of others is most central for our proposal of a personal–collective distinction. Research on *group socialization theory* for young age (Harris, 1995), the *convoy model* for old age (Antonucci & Akiyama, 1987), and peer group relations across the lifespan (Reitz et al., 2014; Wrzus et al., 2013) illustrate how crucial the social environment is for personality development. Notably, the main issue is less about the absolute number of people involved but whether and how a person relates to other people. In this regard, collective life events are particularly potent to get individuals involved in the lives of others.

Research on individual emotion generation and regulation (Gross, 2015; Gross et al., 2007) suggests that "different emotion regulation strategies [...] should have different consequences for how a person feels, thinks, and acts, both immediately and over the longer term" (Gross, 2015, p. 7) making it likely they concern personality developmental as well. The research has been expanded to group-based emotion regulation (Goldenberg et al., 2016; Porat et al., 2020) through *intergroup emotion theory* (Mackie & Smith, 2018; E.R. Smith, 1993). This theory suggests that individuals self-categorize both as unique individuals and as members of different groups. Through the latter, they can experience group-based emotions to the degree they identify with a specific group, which in turn influences how they experience an event and how they act upon it (van Zomeren et al., 2008).

Group-based experience matters here because it allows for individuals to be indirectly affected—that is through their group identification—by life events that do not directly affect them otherwise. To illustrate the difference between direct and indirect involvement in a collective life event, first, reconsider Bea who was directly affected by two life events: the collective life event "plant closure" and the dependent personal life event "job loss." Second, consider Cem who might have become indirectly involved in hearing about the plant closure in the news without having lost his job due to the plant closure. Bea experiences her personal and the collective life event in two ways: once as an individual and once as a member of some group. In other words, here we use "personal" and "collective" to describe event types and "individual" and "group-based" to describe subjective experiences. Depending on the combination of event type and its subjective experience different developmental trajectories can be imagined (cf. cross-classification Table 2 quadrants):

A) Bea experiences job loss as an individual. Instead of working for her former employer, Bea now spends her days at home worrying about money and looking for new jobs. Without a job that structures her everyday life, Bea's conscientiousness might drop, and her neuroticism might rise. (In fact, research regarding the role of unemployment for basic personality trait development is yet inconclusive [Anger et al., 2017; Boyce et al., 2015; Gnambs & Stiglbauer, 2019; Vellekoop, 2016], while the negative effect on subjective well-being is well-established [Binder & Coad, 2015; Hald Andersen, 2009; Winkelmann, 2009].).

B) Bea experiences job loss as a member of her family. In this case, Bea's financial concerns extend to her family and Bea might take action for their sake as well. On the one hand, Bea's family might be an additional stressor, on the other hand, they might provide social support both of which might affect the trajectory of Bea's development.

TABLE 2 Cross-classification of personal and collective life events and their individual and group-based experience exemplified by Bea's unemployment due to plant closure

	Individual experience (concerns Bea personally)	Group-based experience (concerns Bea's people)
Personal life event (job loss)	**A**	**B**
	Cognitive–affective concern: "*I have to find a new job.*"	Cognitive–affective concern: "*How will my family get by?*"
	Behavior: *Bea looks for a new job.*	Behavior: *Bea asks her family to spend less.*
Collective life event (plant closure)	**C**	**D**
	Cognitive–affective concern: "*Working in plants has no future.*"	Cognitive–affective concern: "*We are victims of a broken system.*"
	Behavior: Bea changes industries.	Behavior: *Bea joins protests for social justice.*

C) Individually, Bea might experience the plant closure as an indicator that there is no future for her in this industry anymore which might make Bea even more worried about her future but also more open about alternative career paths.

D) Bea experiencing the plant closure as a member of the workforce. As such, she and her colleagues condemn the profit-driven decision to close the plant leaving the management with bonuses and the workforce jobless. Bea joins a protest for social justice leaving little time for the downward spiral of unemployment to take place. Instead, the newly found activism might facilitate Bea's sociability and assertiveness, two facets of extraversion.

In this example, Bea is directly affected by the collective life event "plant closure" because it involved the personal life event "job loss." Now consider Cem who was at this point still employed, did not work for the same company, and was not acquainted with Bea. There is no reason to assume Cem is—individually or as a member of some group (quadrant A and B)—affected by Bea's recent unemployment. However, Cem may be indirectly affected by the plant closure representing mass job loss after reading about it in the news. It might raise similar concerns regarding Cem's own future in the industry (quadrant C) but, more importantly, the plant closure may affect Cem as someone strongly identifying with the mistreated workforce (quadrant D). In the latter case, Cem might join the protests leading him on a similar developmental path as Bea.

The example of Bea and Cem illustrate that for the investigation of collective life events, we have to consider (a) who has been affected directly and indirectly through (b) which group membership, and (c) which personal life events have come for whom from the collective life event. The reality of indirect effects of collective life events on personality development is exemplified by findings of personality state changes in vicarious victims following the Paris terrorist attack (Luhmann & Bleidorn, 2018), well-being spillover effects of the Syrian conflict (Cheung et al., 2020), and changes in psychological functioning following low-intensity hurricane exposure (Mancini et al., 2021).

3.3 | The spatial facet

The field of geographical psychology investigates regional differences in personality trait levels and changes as they relate to the local topological, economic, or political conditions (Rentfrow, 2020; Rentfrow & Jokela, 2016). While such regional differences can play a role for both personal and collective life events, the particular role of the event location and an individual's distance from a life event tend to differ.

Here, distance can be understood in absolute terms of physical distance, how far a person is from an event, and in relative terms of psychological distance, how close a person feels to an event. Psychological distance subsumes

among others informational and social distance to a life event and one of the main routes by which information about a life event is provided and the social relevance is increased is its media coverage (Fiedler et al., 2012; Philippe & Houle, 2020; Trope & Liberman, 2003). Considering some life event's media coverage is particularly important to identify who is likely to be indirectly affected depending on where the event made the news and who was the target audience. Although the media is full of personal stories, they often serve to illustrate collective phenomena and the likelihood that the fate of a particular person is reported is very low.

Generally speaking, personal life events happen more or less spatially bound to the individual to whom they happen. People experience personal life events wherever they live and for many research questions, it does not matter where exactly, for example, someone got fired or hired. In contrast, location can play different roles for collective life events: Some collective life events can only occur in specific places, some are spatially distributed, and their severity can differ across regions. For example, hurricanes can only occur in the Atlantic, they are about 300 miles wide and across its different parts—outflow, feeder bands, eyewall, eye, and the storm surge—its destructive powers can vary dramatically. Thus, location can be important to determine who has been more or less exposed to some collective life event like a hurricane (Damian et al., 2021; Mancini et al., 2021). Moreover, topographical features like mountains can attract and foster individuals of a specific personality profile (Götz et al., 2020). Thus, there might even be selection and anticipation effects for experiencing different collective life events like avalanches and landslides. However, who anticipates disaster can also be distorted by socio-spatial constructs like state borders which have been shown to bias earthquake threat perception away from the actual physical distance to an epicenter (Mishra & Mishra, 2010). In yet other cases, physical location is no meaningful characteristic at all as in the case of #MeToo movement on social media.

3.4 | The temporal facet

For both kinds of life events, it is important to consider the timing and duration of the life event concerning the individual. At which age or developmental stage does an individual experience the event and for how long does it affect them? At the same time, it is crucial to consider the time course of personality development concerning the life event. Does personality change before, during, or after the life event happens, and does it do so gradually or rapidly? Comprehensive discussions of the role of time for the impact of life events on personality development (Luhmann et al., 2014) have motivated more fine-grained differentiation of multiple temporal effects, including selection, anticipation, immediate post-event year, and gradual socialization effects (Asselmann & Specht, 2020, 2021; Denissen et al., 2019).

The difference between personal and collective life events does not concern the types of temporal effects but how researchers can explain their occurrence. Most notably, individuals have much more control over personal life events, while collective life events are usually beyond individual people's control.

Selection effects describe whether individuals with different personality trait levels differ in the likelihood to experience a certain event and psychologists regularly use personality traits as predictors for various life outcomes (Beck & Jackson, preprint; Denissen et al., 2019; Luhmann et al., 2013; Orth et al., 2012; Roberts et al., 2007; Soto, 2019, 2021). For example, selection effects for having a sojourn experience due to different personality trait levels are well established (Niehoff et al., 2017; Richter et al., 2020). Having a sojourn experience tends to be the active choice of individuals of a certain cut. Concerning collective life events, a single individual rarely has the same amount of control over the event. Nevertheless, selection effects might occur because people with different personalities cluster in different regions thereby creating and exposing themselves to different risks and opportunities (Ebert et al., 2019; Götz et al., 2020). For example, regional differences in openness and extraversion have predicted the different spread of the COVID-19 pandemic across the United States and Germany (Peters et al., preprint) so that on average more open and extraverted people are more likely to experience more severe COVID-19 outbreaks.

Anticipatory effects describe changes in personality trait levels before the life event takes place. In many cases, the likelihood of anticipatory effects depends on how predictable life events are. However, anticipatory effects can occur either because an event can be expected or because the personality change itself leads to the event happening.

For example, Ada might have quit her job because she has grown to dislike it, or she changed voluntarily preparing for a different career (Allen et al., 2005; Thielmann & de Vries, 2021). Similarly, Cem foreseeing an economic hardship might have changed into a more frugal person or it was the growing greed in Cem and millions of other people that contributed to the economic crisis happening in the first place (Pettinicchi & Vellekoop, 2019; R. D. Smith, 2010).

Post-event year effects follow immediately after a life event but might wear off after a short period (Ormel et al., 2017). These effects might result from an immediate need to adapt to new circumstances and to transition into new social role demands. They should apply similarly to personal and collective life events with the exception that the effect onset can be delayed for individuals who become indirectly involved later in the process (Goldenberg et al., 2020).

Socialization effects occur gradually after an event as people settle into their new post-event living conditions including new social role demands and new social environments like the workplace (Alessandri et al., 2020; Einat & Suliman, 2021). We can expect socialization effects for both personal as well as collective life events. However, the potential of collective events to change social meanings and practices of social roles also allows them to potentially induce personality change without an obvious role status change of the individual. While personal life events usually indicate that a person adapts to a new social role, collective life events can also change the requirements of an established social role (cf. Section 3.1).

In conclusion, we can expect the same spectrum of developmental effects before and after personal and collective life events though the mechanisms may differ. Accordingly, researchers should be careful with their expectations and explanations why one or the other developmental effect might occur.

4 | DISCUSSION

Researchers slowly begin to untangle how life events affect personality development. The personal–collective distinction adds to the recent push for a more fine-grained and policy-relevant examination of personality, its development, and the role of life events (Baumert et al., 2019; Baumert et al., 2017; Bleidorn et al., 2019, 2020; Kuper et al., 2021; Luhmann et al., 2020; Wagner et al., 2020). We based our distinction on a model of referent events distinguishing thematic, social, spatial, and temporal event characteristics (Dunkel et al., 2019).

Personal life events typically refer to the health, work, family, and love life of the individual, whereas collective life events often relate to disasters and power struggles of many. Personal life events typically affect single individuals or households directly, whereas collective life events can affect many people directly but to different degrees and with different personal life events attached. Additionally, collective life events can affect many more people indirectly if people identify with the directly affected group. Especially in this latter case, a social role status change may not be a good indicator of whether or not an individual is affected by a collective life event. Instead, group identification and psychological distance are more decisive. Furthermore, personal life events usually imply the adaptation of a new social role, while collective life events can also change the requirements of existing social roles by changing the social practices and meaning around them. We have argued that the spatial characteristics of collective life events can vary and should be considered accordingly by the researcher. Finally, we argued that processes by which different developmental effects come about differ somewhat between personal and collective events with one reason being that the individual has less control over their occurrence.

4.1 | Implications for research on personality development

The distinction between personal and collective life events emphasizes that it is psychologically meaningful whether something happens to us alone, to us among others, or not directly to us but to the people, we relate to. Thus, researchers who aim to investigate collective life events should consider: (a) the characteristics of the particular collective

life event; (b) who may be directly, indirectly, or not affected; (c) which personal life events may have been triggered for whom; (d) how the respective life event may affect social roles, practices, and meanings, and (e) whether and how regional differences and media coverage should be considered.

When investigating collective life events, many of these questions can be answered by looking at the thematic, social, spatial, and temporal characteristics. In many cases, it will be useful to take an interdisciplinary approach including sociology, economics (geographical) information science, and psychology including its subdisciplines of personality, social, cultural, and geographical psychology as done here. So far, in psychology collective life events have been investigated largely for collective action and the resilience and (mental) health of individuals. Personality developmental psychologists who want to examine the role of collective life events for basic traits can draw on ample approaches from neighboring disciplines to do justice to the complexity of these life events. We recommend starting with (Centola et al., 2018; Dunkel et al., 2019; Fiedler et al., 2012; Goldenberg et al., 2020, 2016).

4.2 | Integrating the event and experience approach

We have argued for systematic and gradual differences between personal and collective life events. We have also argued that the same collective life event can be differently experienced by different people due to among others different levels of exposure or direct and indirect involvement. Indeed, at times our argumentation for different subjective experiences overlapped with Luhmann and colleagues (2020). However, where they provide a tool to assess experiential differences, we highlighted conceptual and practical differences between personal and collective life events to which researchers should be sensitive. For example, the "external control" dimension proposed by Luhmann and colleagues measures how much people feel in control of an event, while we have argued that people at large have very little control over collective life events and that this affects how we can or cannot explain related selection and anticipation effects.

Besides "external control," only one other dimension suggested by Luhmann and colleagues relates the subjective experience to other people, that is, the "extraordinariness" of a life event. Extraordinariness concerns how common individuals consider an event to be based on how likely it is to happen to other people as well. However, this does, for example, not say anything about whether and how many other people are involved in the same collective life event. Experiencing an earthquake can be extraordinary even if millions of other people are affected.

In this spirit, we suggest that there are two additional dimensions of subjective experience whose examination may be worthwhile: first, a "one-to-many" dimension to find out (a) whether personal and collective life events are accompanied by different feelings of being the only one affected or being one among many affected individuals and (b) whether this makes a difference for certain psychological and developmental outcomes; second, a "directness" dimension to find out how the feeling of being more or less directly or indirectly affected influences the impact some life event has on an individual.

Finally, in many cases, assessing the subjective experience of each individual involved in some event may not be possible, not feasible, or not relevant Taking a more differentiated view towards the life event, however, may still be. For example, researchers may be able to relate different severity levels of a natural disaster to different zip codes. Or they can assess in a single multiple-choice item for whom the disaster also meant losing a spouse, a child, their home, or anything else to relate different developmental paths to different dependent personal life events. Again, this highlights that the event and experience approach are complementary.

5 | CONCLUSION

A growing body of research suggests that life events influence personality continuity and change in different ways. They occur not only in private settings but also in larger societal contexts. Based on the idea that personality changes especially due to changes in social role demands, we investigated the different impacts of personal and collective life events. We argued that social role demands can change due to individual status changes, due to cultural changes concerning these social roles, and for the sake of or on behalf of other people. One important mechanism for people being indirectly involved in collective life events is their group-based experience. This insight calls for interdisciplinary research and the consideration of group dynamics when investigating the role of collective life events on individual personality trait development.

CONFLICT OF INTEREST
The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS
The topic was developed jointly by Richard Wundrack, Eva Asselmann, and Jule Specht. The manuscript was written by Richard Wundrack and revised by Eva Asselmann and Jule Specht.

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Mindful self-focus–an interaction affecting Theory of Mind?

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Abstract

Is thinking about oneself helpful or harmful for understanding other people? The answer might depend on how a person thinks about themself. Mindfulness is one prominent construct that seems to affect the quality and content of a person's thoughts about themselves in the world. Thus, we hypothesize that the relationship between self-focus and Theory of Mind (ToM) is moderated by mindfulness. We evaluate our hypothesis with a large cross-sectional dataset ($N = 543$) of native and non-native German and English speakers using OLS and MM-estimated robust multiple regression analysis. We found a small but robust self-focus × mindfulness interaction effect on ToM so that there was a significant positive relation between self-focus and ToM for more mindful individuals and no significant relation for less mindful individuals. The findings support our hypothesis that mindfulness moderates the relationship between self-focus and ToM performance. We discuss the limitations and differences between the present study and previous findings.

Introduction

Is thinking about oneself helpful or harmful for understanding other people? *Self-focus* is the tendency to attend to one's own thoughts, feelings, and intentions [1,2], while *Theory of Mind* (ToM) is the ability to infer these in other people [3,4]. Intuitively, the tendency to think about oneself should bias inferences about other people in an egocentric manner [5]. *Objective self-awareness theory*, however, posits that self-focus actually reduces this bias because it suggests self-focus is taking a third-person perspective at oneself [6–8]. A third possibility is that self-focus can be helpful or harmful depending on *how* one thinks about oneself.

This third option is derived from the *meta-construct model* [2,9]. Self-focus is part of normal psychological functioning, yet historically it has often been considered regarding excessive self-focus associated with negative affect, anxiety, depression, and virtually every mental disorder [10–12]. Within this context, Ingram suggested that one should distinguish between the pervasive *process* of self-focus and its specific *content* or *quality* when evaluating its role.

Here, we explore this idea by investigating whether the relationship between *self-focus* and *ToM* performance is moderated by *mindfulness*. *Mindfulness* is the tendency to be conscious of what is going on in the present moment within oneself and in one's surroundings including other people [13,14]. Thus, mindfulness is an ideal candidate for a moderator affecting the

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content and quality of a person's attention, independent of whether it is focused on oneself, others, or something else. Indeed, previous research has shown that reflective or mindful self-focus has many benefits for psychological functioning making mindfulness a likely moderator for our hypothesis [15–20].

The outcome: Theory of Mind (ToM)

In real life, the ability to reason about other people's mental states requires the consideration of past, present, general, and occasion-specific information about people and social situations [21]. Additionally, one's own mental state regarding some context may provide valuable insight into other people's perspectives. Often, what is shared already explains quite a lot [22]. However, one can also be mistaken to project one's mental state onto other people or believe they are likeminded, that is *egocentric bias* and *false consensus belief*, respectively [4,23,24], the crux for successful ToM is appropriately differentiating between oneself and another person, that is *self–other distinction* [25].

Notably, bias and accuracy are not necessarily opposites; in the right circumstances, bias can facilitate accuracy because bias allows for robust predictions under uncertainty [26,27]. In other words, a person can be right for the "wrong" reason like when grounding inferences about other people's mental states in their own mental state rather than information about the other person. This is important because most ToM tasks measure either accuracy or bias but not both. Thus, they actually cannot answer whether in real life more egocentric participants will be less accurate or *vice versa*. Previous research on self-focus and ToM has mostly employed measures of egocentric bias, while here an accuracy measure was used.

The predictor: Self-focus

As mentioned, the tendency to focus on one's own mental states has often been considered from a psychopathological perspective. Much research differentiated between private and public, positive and negative, or reflective and ruminative self-focus [11] reinforcing the idea that the role of self-focus depends on its quality [2,9].

Nevertheless, most research focuses on the main effects of some kind of self-focus. For example, some studies have suggested a negative effect [5,28], and others have suggested a positive effect of self-focus on ToM [29,30]. With tasks like (a) writing an E on one's forehead, (b) judging how a third party would interpret a sentence the participant knows to be meant sarcastically, or (c) estimating how many peers share one's preferences, these studies examine the role of self-focus for egocentric bias but not for ToM accuracy.

We found only one study that employed a ToM accuracy measure, specifically *emotion recognition* [31]. Therein, accuracy was based on the comparison of participant ratings of the emotions conveyed in different video clips and the actors' self-ratings of their enacted emotions. However, the study investigated the role of *self-referential processing* which concerns the superior recall of information that has previously been related to oneself as compared to information that has not been related to oneself [32]. In contrast, self-focus is about the act and tendency to relate information to oneself in the first place. As such, self-focus is a prerequisite of self-referential processing. The study found that participants who better retrieved self-related information were also more accurate in judging other's emotions.

On grounds of research on objective self-awareness theory [6,7,33], self-focus seems to be positively related to ToM. Arguably, it facilitates taking a third-person perspective on one's own perspective. In other words, it should help with appropriate self–other distinction to account for otherwise misplaced egocentric bias. This leads to our first cautious hypothesis:

101

(H1) If there is a main effect of self-focus on ToM at all, it is probably positive.

The moderator: Mindfulness

Being aware of the present moment is relevant to both inward self-focus and outward ToM. Quite generally, research suggests a positive relation of mindfulness and most social cognitive abilities [34,35]. Disputed is mainly the underlying mechanism. Suggestions include among others that mindfulness improves ToM (a) by increasing self-knowledge or self-compassion [36–38], (b) by simply motivating a person to engage more in ToM [39], or (c) decreasing egocentric biases directly or indirectly through changes in affect [40–42]. Thus, we hypothesize:

(H2) There is a positive main effect of mindfulness on ToM.

We chose mindfulness as a likely moderator for self-focus because by definition mindfulness shapes how we relate to ourselves in the world and thus should determine the content or quality of our self-focus, for example, as being directed at one's present thoughts and feelings and being non-judgmental about them. A range of distinct adaptive properties have been discerned for reflective or mindful self-focus on mood and psychological functioning [15,17,18,20]. For example, it has recently been shown that paranoid thinking is maintained by ruminative self-focus but reduced by mindful self-focus [16].

Regarding ToM specifically, however, evidence is sparse. We found only one study that tested how the effect of self-focus on ToM was moderated but therein, the moderator was negative affect [43]. After inducing states of shameful, guilty, or neutral self-focus, the researchers asked participants to judge how sarcastic an uninformed third person would interpret a message praising a poor restaurant experience. Ashamed individuals expected a more sarcastic interpretation and guilt-ridden individuals expected a less sarcastic interpretation than individuals in the neutral condition. This illustrates that the direction of a person's egocentric bias can change depending on the (affective) quality of self-focus. Taken together with Ingram's suggestion [2], this motivates our central hypothesis:

(H3) Mindfulness positively moderates the relation of self-focus and ToM.

Control variables

Negative affect. The tendency or state of experiencing negatively valanced feelings [44,45] has come up multiple times. Negative affect is a broad construct comprising different feelings that in themselves serve widely different socio-psychological functions [46,47]. Different affective states can play different roles for both thinking style and thought content depending on the context and the object of affect attributions [48–51].

Thus, it should not be surprising that relation of negative affect to self-focus and ToM is not clear cut [2,11,12,15,17–20]. Case in point are the study on the role of shameful and guilt-ridden self-focus for egocentric bias [43] and a similar study suggesting that states of anxiety and surprise, but not anger or disgust drive individuals to rely more on their own perspective [52]. In contrast, the relation between negative affect and mindfulness clearly seems to be negative with an $r = -.39$ [53].

We consider negative affect an important control variable because it seems to be related to both self-focus and ToM–though at the domain level the direction remains unclear.

Other influential variables. There are several additional variables we consider: age, years of education, gender, participation language, language nativity, ToM task attention, and study participation duration. Although we do not expect either of them to drastically change the hypothesized relations, they are likely candidates to explain some of the variance and provide

102

some context for the interpretation of the effects of interest [54]: We expect ToM performance to be negatively related to age [55] but positively to years of education [56], and to be worse in male participants [57], in non-native speakers [58], and inattentive participants. Study participation duration may introduce noise to the data but should not significantly affect ToM performance in a particular direction or affect its relation to self-focus and mindfulness as both constructs are rather traits than states according to the understanding underlying the used measurements (compare *Materials*).

Materials and methods

Participants

The study was approved by our department's ethics committee (proposal number 2020–01). Between mid-February 2020 and mid-April 2020 $N = 584$ individuals were recruited by different means of on- and offline advertisement. Participant gave written informed consent. Native and non-native individuals above the age of 18 could take part in German or in English ($N = 291$ German natives, $N = 53$ German non-natives, $N = 75$ English natives, and $N = 162$ English non-natives). Compensation comprised personalized feedback, a 50 €-raffle per 100 participants, and study participation credit for local psychology undergraduates ($N = 44$). Participants were fairly international, being native to 61 different countries while residing in 37 different countries–though the majority were either German ($N = 298$) or residing in Germany at the time of the study ($N = 421$). Participants identified mostly as females ($N = 419$), were largely in their late twenties (median age = 29, range 18–88), and highly educated (highest degree achieved at a university ($N = 353$)). In summary, the sample was WEIRD [59,60].

Materials

Self-focus. Self-focus was measured with the self-focus sentence completion task (SFSC) [1] which requires subjects to finish 30 open-ended sentences prompting responses concerning themselves or others, e. g. "If only I could . . .". Each half-sentence response was coded by three raters according to the coding scheme suggested by Exner across his six categories: "egocentric" (self-focused, e.g. ". . . live my life freely."), "egocentric and negative" (e.g. ". . . end my life."), "allocentric" (other-focused, e.g. ". . . help my sister."), "allocentric and emotional" (e.g. ". . . stop hating my father for what he has done."), "both" (self- and other-focused, e.g. ". . . repair my relationship with my mother."), and "other" for answers that do not relate to a person or are too short (e.g. ". . . fly"). We followed modern research practice and evaluated the SFSC based on the count of "egocentric" and the "egocentric and negative" responses [12,61,62]. We divided their sum by the number of raters and the number of SFSC items to get a ratio of self-focus that is as unbiased as possible by the coding variability of an individual rater. The three raters were psychology students previously trained on a pilot sample ($N = 73$). Interrater reliability was *Fleiss' κ* = 0.695 (p < 0.001, 95% CI [0.692; 0.697]; [63]).

Mindfulness. Trait mindfulness was assessed using the Mindfulness, Attention, and Awareness Scale (MAAS) [14,64]. The MAAS is a popular 15-item frequency measure of dispositional mindfulness, including receptive awareness of, and attention to what takes place in the present moment (e. g. "I snack without being aware that I am eating."). All items are reverse-coded and rated on a 6-point Likert scale ranging from "almost always" (1) to "almost never" (6). Measurement reliability was α = .84 and λ_6 = .84 [65,66].

ToM. Here, we used the Double Movie for Assessment of Social Cognition–Multiple Choice (DMASC-MC) [67,68]. Throughout a 15-minute short movie, the DMASC-MC requires participants to answer 44 items on the thoughts, feelings, and intentions of four characters who spend an evening together (e. g. "Why did Michael say that?"). Each time,

participants selected one from four multiple choice options indicating what they think was true, which was coded as based on the DMASC-MC as "mentalized appropriately", "too much", "too little", or "not at all". We also included five attention checks inquiring which topics have been extensively discussed among the characters (e. g. what to cook for dinner). Our implementation of the DMASC-MC automatically jumped to the next video sequence as soon as participants selected an answer.

Negative affect.   Negative trait affect was measured alongside positive affect (not considered here) with the International Positive And Negative Affect Schedule Short Form (I-PANAS-SF) [69] which measures negative trait affect through subjects' self-rating with five items ('upset', 'hostile', 'ashamed', 'nervous', 'afraid') on a 5-point Likert scale ranging from "not at all" (1) to "extremely" (5). Measurement reliability was $\alpha = .79$ and $\lambda_6 = .77$.

Other covariates.   Among others, participation language (dichotomous: German/English), participation language nativity (dichotomous: native/non-native), gender (dichotomous: male/female), age (continuous), years of education (continuous), and ToM task attention (five multiple choice control items), and study duration (time-stamped) were assessed.

Procedure

Data collection was done in formr [70,71]. After being informed about the purpose of the study and agreeing to its terms and conditions, participants answered to the SFSC, the I-PANAS-SF, the MAAS, the BFI-2-S (not considered here) [72,73], another pilot questionnaire on the variability in Big Five trait expression (not considered here). Subsequently, participants completed the DMASC-MC and provided demographic information before finishing the study by choosing their means of compensation.

Except for the demographic and compensatory information, responses were mandatory. Due to the estimated length of the study (ca. 1h), participants were invited to take breaks between the tasks. In combination with the lack of a preset study expiration time, this led some individuals to spread their participation over a couple of hours or even days. The median study duration excluding study consent and compensation was 62 min with $N = 517$ subjects participating within 2h, $N = 56$ more participated within 24h, and $N = 11$ taking multiple days up to one week.

Data analysis

Data preparation.   We included all participants who got as far as fully completing the DMASC-MC ($N = 584$) and correctly answered at least 4 out of 5 attention check items during that task (out $N = 41$). We did not exclude participants for any other reason. Missing data for years of education ($N = 48$), gender ($N = 15$), age ($N = 10$), language nativity ($N = 3$), and study duration ($N = 1$) were imputed based on the variables included in the joined model (cf. section: Multiple Regression Analysis) using predictive mean matching for the continuous variables [74] and logistic regression for categorical variables [75]. We deemed a single imputation without variance estimation sufficient because it only concerned control variables.

Equivalence testing.   Descriptive statistics include equivalence testing following the *two one-sided test* procedure (TOST) [76,77]. This allowed us to judge whether small but according to *null hypothesis significance testing* (NHST) significant differences ($p < .05$) between the German and English subsamples were nevertheless statistically equivalent to zero based on the statistically necessitated threshold of the *smallest reliably detectable effect size* with a 90% confidence interval.

Multiple regression analysis.   ToM performance was predicted through multiple linear regression. We ran an interaction model with self-focus, mindfulness, and the self-

104

focus × mindfulness interaction, a covariates model including the following control variables: language (English vs German), language nativity (non-native vs native), gender (male vs female), correct attention control items (4/5 vs. 5/5), age, years of education, negative affect, and study duration. All continuous variables were z-standardized to better meet OLS assumptions, to prevent multicollinearity, and for better comparability across variables [78]. For all categorical variables, contrasts were set using weighted effect coding to account for their imbalanced distribution [79]. Finally, we ran the joined model including all predictors from the interaction and the covariates model.

For the central interaction effect model, we determined the smallest reliably detectable effect size through sensitivity power analysis (given 3 predictors, $\alpha = .05$, *power* = .95, $N = 543$) to be Cohen's $f^2 = .032$ for the whole model and a partial $f^2 = .024$ for one of three predictors [80]. Furthermore, we ran each model as an OLS and an MM-estimated robust regression model [81] to judge results independent of parametric assumptions.

Data and analysis access and software. With exception of the sensitivity power analysis done in G*Power version 3.1 [82], data analysis was entirely done in R version 4.0.2 [83] through R Studio version 1.4.1103 [83] using the following packages: broom [84], car [85], clickR [86], here [87], interactions [88,89,90], interplot [90], lmtest [91], MASS [92], mice [93], misty [94], performance [95], psych [96], sensemakr [97], sjmisc [98], tidyverse [99], TOSTER [76], and wec [79,100].

Results

The pseudonymized and scale-aggregated data and the analysis script are publicly available through the Open Science Framework: (https://osf.io/yneu7/). Descriptive statistics for all variables pooled and broken down by participation language are presented in Table 1. The

Table 1. Descriptive statistics.

		Total		German		English		Statistical Equivalence	
		$N = 543$		$N = 334$ (61.51%)		$N = 209$ (38.49%)			
Continuous variables		**M**	**SD**	**M**	**SD**	**M**	**SD**	**TOST**	**NHST**
ToM performance		34.29	4.04	34.56	4.08	33.87	3.94	*	ns
Age		32.19	11.57	32.80	12.87	31.22	9.05	*	ns
Years of education		15.31	4.70	15.67	4.43	14.75	5.07	*	*
Negative affect		2.03	0.76	1.85	0.68	2.32	0.78	ns	*
Study duration		145.75	550.89	165.95	672.77	113.46	253.90	*	ns
Mindfulness		3.94	0.71	3.99	0.70	3.88	0.72	*	ns
Self-focus		0.34	0.09	0.35	0.09	0.32	0.09	ns	*
Categorical variables		**N**	**%**	**N**	**%**	**N**	**%**	**TOST**	**NHST**
Nativity	- native	352	64.48	286	85.63	66	31.58	ns	*
	- non-native	191	35.17	48	14.37	143	68.48		
Gender	- female	402	74.03	254	76.05	148	70.81	*	ns
	- male	141	25.97	80	23.95	61	29.19		
ToM attention	- 5/5	411	75.69	275	82.34	136	66.51	ns	*
	- 4/5	132	24.31	59	17.66	73	33.49		

Listed are the pooled and language-group specific (a) means (M) and standard deviations (SD) of the continuous variables and (b) absolute and relative values for the categorical variables after imputation. Furthermore, the overview provides significant (*; at p < .05) and non-significant (ns) null hypothesis significant testing (NHST) and two one-sided test procedure (TOST) results comparing the statistical equivalence of the German and English subsample. A significant NHST result indicates the difference between the German and English subsample was statistically different from zero and more importantly a significant TOST result indicates the difference was statistically *equivalent* to zero.

105

Table 2. Correlation matrix.

			continuous							categorical		
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
continuous	1	ToM performance										
	2	Age	-.11									
	3	Years of education	.13	.13								
	4	Negative affect	-.08	-.11	-.03							
	5	Study duration	.01	.08	.03	-.03						
	6	Mindfulness	-.01	.18	.03	-.32	-.03					
	7	Self-focus	.06	-.16	.01	.10	.00	-.10				
categorical	8	Language	.11	.08	.12	-.39	.06	.10	.19			
	9	Nativity	.25	.11	.07	-.25	-.02	.03	.17	.55		
	10	Gender	-.13	.24	-.02	-.02	-.04	.09	-.05	.04	.00	
	11	ToM attention	.19	-.08	.07	.07	.05	.05	.08	.19	.12	.06

Continuous–continuous correlations (top left) have been computed as Pearson correlations; categorical–categorical correlations (bottom right) as bias-corrected Cramer's V; and continuous–categorical correlations (bottom left) as biserial correlations. Note that correlation coefficients cannot be directly compared across combinations of variable types due to different underlying assumptions.

German subsample was slightly more attentive during the ToM task, reported less negative affect, was slightly more self-focused, contained fewer non-native speakers than the English subsample, and took an average 40 min longer to complete the study. A correlation matrix is provided in Table 2. Table 3 details the results of the regression analyses. In particular, we provide the OLS and the respective MM-estimated robust counterpart of the covariates model (($F_{(8;534)} = 7.005$, $p < .001$, adj. $R^2 < 0.081$, Cohen's $f^2 = .104$); ($\sigma^{residual}(534) = 0.933$, Cohen's $f^2 = .103$)), the interaction model (($F_{(3;539)} = 3.124$, $p = .026$, adj. $R^2 = .012$, Cohen's $f^2 = .017$); ($\sigma^{residual}(539) = 0.988$, Cohen's $f^2 = .017$)), and the joined model (($F_{(11;531)} = 5.763$, $p < .001$, adj. $R^2 = .088$, Cohen's $f^2 = .119$); ($\sigma^{residual}(531) = 0.92$, Cohen's $f^2 = .117$)). Notably, the self-focus × mindfulness interaction was significant in the OLS and the robust interaction models and the covariates models. Furthermore, comparing models indicated that age, years of education, language nativity, and ToM task attention were significantly related to ToM performance but did not account for the variance explained by the self-focus × mindfulness interaction. Negative affect and participation language were only significant in the robust model. Lastly, regression diagnostics as well as the near-perfect correlation $r = .99$ between the residuals of the OLS models and their MM-estimated robust counterparts suggest any violations of OLS assumptions were negligible [101].

Discussion

We set out asking whether thinking about oneself is helpful or harmful for ToM performance. Reviewing the sparse and mixed literature, we found Ingram's theory [2] most compelling that the answer may depend on the specific *content* or *quality* a person's self-focus can take. We considered mindfulness a psychological construct that should affect the content or quality of self-focus because mindfulness specifies towards what and how a person focuses their attention. Thus, we explored the idea whether the relationship between *self-focus* and *ToM* performance is moderated by *mindfulness*. Overall, our results are in line with Ingram's idea findng different effects of self-focus on ToM performance depending on a person's level of mindfulness.

Most importantly, we found support for our central hypothesis (H3) that there is a moderation effect of mindfulness on the relation between self-focus and ToM. The moderation effect

106

Table 3. Regression models.

Models [AIC; BIC]		Covarates Model [1506; 1549]						Joined Model [1505; 1561]						Interaction Model [1541; 1562]					
Variable	Regres.	β	SE	95% CI		p	f^2	β	SE	95% CI		p	f^2	β	SE	95% CI		p	f^2
				LL	UL					LL	UL					LL	UL		
Intercept	OLS	.161	.055	.053	.269	.003	.016	.169	.055	.061	.277	.002	.018	.012	.043	-.072	.096	.778	.000
	robust	.204	.055	.092	.313	< .001		.214	.054	.106	.318	< .001		.076	.042	-.011	.16	.073	
Age	OLS	-.123	.043	-.207	-.039	.004	.015	-.109	.044	-.195	-.022	.014	.012						
	robust	-.111	.043	-.222	-.015	.011		-.088	.044	-.204	.004	.05							
Years of education	OLS	.136	.042	.054	.218	.001	.020	.138	.042	.056	.22	.001	.021						
	robust	.146	.041	.07	.233	< .001		.149	.041	.067	.233	< .001							
Negative affect	OLS	-.068	.043	-.153	.017	.118	.005	-.082	.046	-.173	.008	.074	.006						
	robust	-.079	.043	-.161	-.003	.066		-.102	.045	-.184	-.006	.026							
Study Duration	OLS	.016	.041	-.065	.098	.693	.000	.014	.041	-.067	.096	.728	.000						
	robust	.008	.04	-.043	.092	.841		.006	.039	-.034	.096	.875							
Gender [male]	OLS	-.134	.071	-.273	.005	.059	.007	-.122	.071	-.261	.017	.085	.006						
	robust	-.099	.071	-.26	.048	.161		-.092	.07	-.237	.053	.192							
Language [English]	OLS	.114	.065	-.014	.242	.081	.006	.125	.066	-.004	.255	.057	.007						
	robust	.122	.065	-.023	.262	.063		.143	.066	-.001	.299	.03							
Nativity [non-native]	OLS	-.459	.104	-.663	-.255	< .001	.037	-.449	.104	-.653	-.245	< .001	.035						
	robust	-.421	.104	-.679	-.207	< .001		-.421	.104	-.665	-.191	< .001							
ToM attention [4 out of 5]	OLS	-.185	.074	-.331	-.038	.013	.012	-.187	.074	-.333	-.041	.012	.012						
	robust	-.202	.075	-.361	-.036	.007		-.211	.074	-.384	-.046	.005							
Self-focus	OLS							.044	.044	-.041	.13	.31	.002	.081	.044	-.004	.167	.063	.006
	robust							.06	.043	-.031	.137	.166		.079	.043	0	.158	.066	
Mindfulness	OLS							-.008	.044	-.094	.079	.863	.000	.004	.043	-.08	.089	.921	.000
	robust							-.009	.044	-.117	.094	.838		.029	.043	-.073	.128	.505	
Self-focus × Mindfulness	OLS							.113	.044	.027	.199	.01	.012	.122	.045	.033	.211	.007	.014
	robust							.128	.044	.03	.222	.004		.117	.045	.025	.216	.009	

All continuous variables have been z-standardized and all categorical variables have been weighted effect coded. Note: Significant findings p > .05 are highlighted in bold.

was weak but significant in the OLS (β = .122, p = .007) and the robust (β = .117, p = .009) interaction model. The relation between self-focus and ToM performance became positive when the mean level of mindfulness was exceeded (Figs 1 and 2).

Notably, the moderation effect remained about the same strength even when controlling for covariates in the OLS (β = .113, p = .01) and the robust model (β = .128, p = .004). The interaction effect had about the same strength as age (β = -.109, p = .014) and years of education (β = .138, p = .001), while attention to the ToM task (β = -.187, p < .012) was almost twice as strong. Interestingly, language nativity (β = -.449, p < .001) was still four times as strongly related to ToM performance although participants clearly understood enough about the non-mental content of the conversations in the ToM task to pass the attention check.

A crucial question is whether we should care about the moderation [77,102,103,104] because its effect size was smaller (partial f^2 = .014) than the smallest reliably detectable effect size as determined by our sensitivity power analysis (partial f^2 = .024)–which was coincidentally close to Cohen's (1988) benchmark for small effects. It suggests that in the long run our finding may be associated with a Type I error rate exceeding the targeted 5% to some extent. By the same reasoning, however, here age and years of education were also unreliable
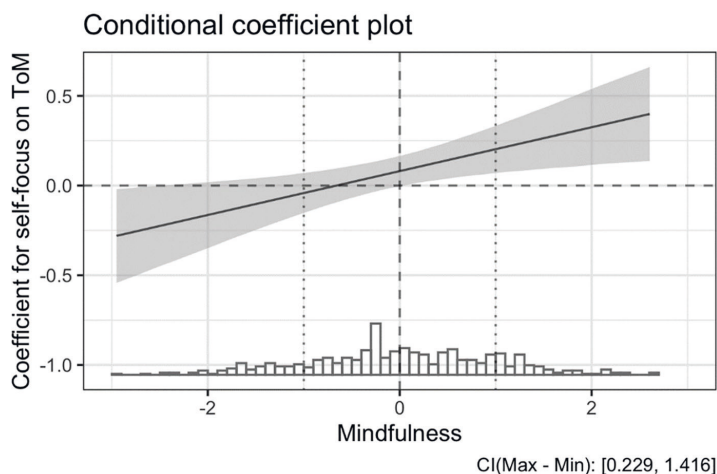
107

Fig 1. Conditional coefficient plot. Based on the OLS interaction effect model without control variables. Dotted vertical lines indicate -/+ 1 SD for mindfulness, the dashed vertical line indicates the mean. The plot shows how the relationship between self-focus and ToM performance, the coefficient, changes from negative to positive as the mindfulness level continuously increases.

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predictors of ToM although their significant relation with ToM has been repeatedly shown. Still, future studies should account for this by increasing their sample size.

Nevertheless, we believe that our results are informative given this study is the first of its kind relating self-focus and ToM accuracy instead of egocentric bias in a sample this large. First, our
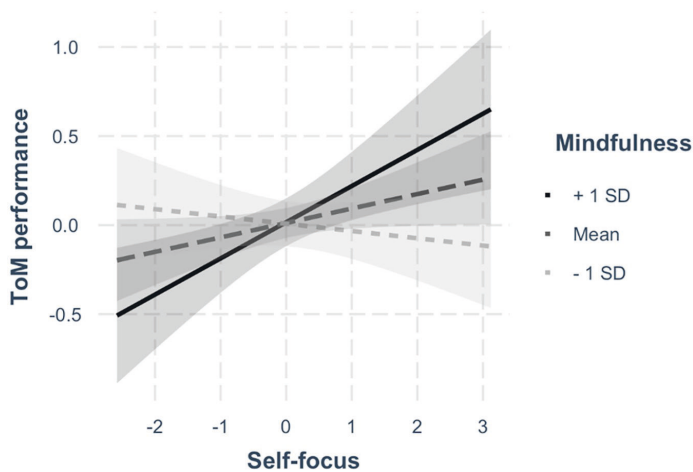
Fig 2. Interaction effect plot. Based on the OLS interaction effect model without control variables. The plot shows how the relationship between self-focus and ToM performance is different for high, average, and low levels of mindfulness, i.e., +1 SD, mean, and -1 SD, respectively. It is a discrete visualization of the continuous relationship depicted in Fig 1.

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108

finding suggests that even if self-focus affects egocentric bias as suggested by previous findings, this may not directly translate into better or worse ToM. A speculative reason may be a "tradeoff of egocentrism" between a person's own perspective being a source of bias and a source of information when reasoning about other people's mental states. As argued earlier, bias is usually considered detrimental to accuracy but can be advantageous given noisy information. It may be that mindfully self-focused individuals optimize this trade-off, while absentmindedly self-focused individuals fall short of recognizing their bias or the informativeness of their own perspective.

A second justification for the small but robust moderation effect might be that inferring other people's minds is a complex task involving a person's immediate mental state and other situational circumstances like the availability of more target-specific information. From this perspective, even the small interaction effect of two trait-like constructs (self-focus and mindfulness) may seem quite reasonable.

Our first and second hypotheses concerning the positive main effects of self-focus and mindfulness on ToM performance were not supported. However, together with the significant mediation effect, this may only strengthen our main claim that the role of self-focus for ToM is dependent on the quality or content of self-focus like whether self-focus is mindful or absentminded. The finding does not support objective self-awareness theory but it does not directly oppose it either because the SFSC arguably assesses a dispositional form of self-focus, whereas objective self-awareness theory is concerned with the role of state self-focus.

Limitations

Previous research on self-focus often relied on (quasi-)experimental designs in smaller samples often inducing different state levels of self-focus while measuring egocentric bias. We analyzed a large cross-sectional dataset including–depending on one's interpretation of what the SFSC measures–trait self-focus and a ToM accuracy measure.

The relationships between variables were generally weak with two key measures suffering methodological criticism: although in use for a long time, the SFSC's validity and reliability are questionable as there has been no formal validation against other measures of self-focus [1] and the MAAS items ask exclusively about absentminded behavior but the absence of absentmindedness might not equal mindfulness [104]. Moreover, our data might have been quite noisy: first, the study's overall procedure might have taken too long and been too demanding for an online study for which a distraction-free environment cannot be guaranteed; second, collapsing across German and English natives and non-natives might make the observations more heterogeneous without making the findings more generalizable.

Conclusion

We hypothesized that the role of self-focus on ToM performance depends on a person's level of mindfulness so that focusing on oneself, may hinder or facilitate accurate ToM or not. We found a small but robust and significant interaction effect of self-focus and mindfulness according to which there is a positive effect on ToM performance for mindfully self-focused individuals but not for absentminded individuals. Thus, our results provide initial evidence for the idea that ToM performance is differentially influenced by different qualities of self-focus. Future research is needed to investigate the exact mechanisms at work in this relationship.

Supporting information

S1 File.
(ZIP)

S2 File.
(ZIP)

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Formal analysis: Richard Wundrack.

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111

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113

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114