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Taxonomic models of individual differences: a guide to transdisciplinary approaches

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Models and constructs of individual differences are numerous and diverse. But detecting commonalities, differences and interrelations is hindered by the common abstract terms (e.g. 'personality', 'temperament', 'traits') that do not reveal the particular phenomena denoted. This article applies a transdisciplinary paradigm for research on individuals that builds on complexity theory and epistemological complementarity. Its philosophical, metatheoretical and methodological frameworks provide concepts to differentiate various kinds of phenomena (e.g. physiology, behaviour, psyche, language). They are used to scrutinize the field's basic concepts and to elaborate methodological foundations for taxonomizing individual variations in humans and other species. This guide to developing comprehensive and representative models explores the decisions taxonomists must make about which individual variations to include, which to retain and how to model them. Selection and reduction approaches from various disciplines are classified by their underlying rationales, pinpointing possibilities and limitations. Analyses highlight that individuals' complexity cannot be captured by one universal model. Instead, multiple models phenotypically taxonomizing different kinds of variability in different kinds of phenomena are needed to explore their causal and functional interrelations and ontogenetic development that are then modelled in integrative and explanatory taxonomies. This research agenda requires the expertise of many disciplines and is inherently transdisciplinary.

This article is part of the theme issue 'Diverse perspectives on diversity: multi-disciplinary approaches to taxonomies of individual differences'.

1. Taxonomic models of individual differences: importance and challenges

Individual differences in a species' psycho-bio-socio-ecological systems reveal important insights into these systems' functions, causes, development and evolution. Taxonomizing this diversity is a fundamental task; it provides reference models for many fields of research and applied settings. But it is challenging. Where to begin? What to focus on? Countless models were developed, each focusing on particular phenomena, categorizations and interpretations. This heterogeneity hinders exchange and integration to advance our understanding of individuals.

Diversity among models also reflect differences in basic terms and concepts. More than 50 'personality' definitions exist [1]. Controversies revolve around distinguishing personality as socio-cultural concept from 'temperament' as biologically based concept [2]. Trait concepts are particularly diverse. A 'trait' may denote an abstract concept describing stable individual differences or a single measurement datum; a population's dimension of individual differences or an individual's score on such a dimension; a summary description of observable individual differences or an internal psychobiological entity influencing individuals' thoughts, feelings and behaviours [3,4]. Different conceptual

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understanding entails different approaches to develop taxonomies that may therefore reflect different phenomena, rendering models incomparable and hindering integration.

This article explores these issues from a philosophy-of-science perspective by applying a transdisciplinary paradigm for research on individuals that provides frameworks for conceptual integration across disciplines. These frameworks and relevant concepts are first briefly introduced and used to scrutinize central terms and concepts of individual differences research (§2). Then, they are applied to explore the methodological foundations of taxonomy development, illustrated with examples from various fields (§3). The article concludes with implications for future research (§4).

2. Transdisciplinary philosophy-of-science paradigm for research on individuals (TPS-Paradigm)

The TPS-Paradigm comprises interrelated philosophical, metatheoretical and methodological frameworks that coherently build upon each other (therefore called paradigm). In these frameworks, basic assumptions, concepts, approaches and methods from various disciplines are systematically integrated, further developed and complemented by novel ones, thereby creating unitary frameworks that transcend disciplinary boundaries. Its philosophy-of-science focus reflects the aim of making explicit basic assumptions, metatheories and methodologies underlying given scientific systems to help scientists scrutinize and further develop their established theories, models and practices [5–11].

(a) Complexity theories and epistemological complementarity

The philosophical framework specifies presuppositions made about the nature and properties of individuals and the fundamental notions by which knowledge about them can be gained.

First, the TPS-Paradigm builds on complexity theories to consider that individuals are living organisms that can be conceived as nested systems at different levels of organization, from cells over single individuals up to societies. At each level, living organisms function as integrated wholes in which dynamic non-linear processes occur from which new properties emerge that could not have been predicted from knowledge simply of their constituents and that can feed back to the constituents from which they emerge. Dynamic multilevel transactions create complex patterns of upward and downward causation, which are incompatible with deterministic and reductionistic assumptions [12–14].

Second, the TPS-Paradigm builds on the principle of epistemological complementarity originally introduced to quantum physics as a resolution to the wave-particle dilemma in research on the nature of light [15]. It highlights that different methods can reveal information about properties of an object of research that are maximally incompatible with one another but both essential for an exhaustive understanding of it, and that may therefore be regarded as complementary to one another. This implies that studies should not be limited to just one method. Instead, methods should be adapted to the particular properties of the phenomena under study. The TPS-Paradigm applies this principle in several ways, such as to the body–mind problem [16], to elaborate criteria for appropriate phenomenon-methodology matching [5] and to resolve the idiographic-nomothetic controversy in research on individuals (§3).

Complexity theory and epistemological complementarity lay important conceptual foundations for taxonomizing individual variations in different kinds of phenomena studied in individuals.

(b) Differentiating various kinds of phenomena studied in individuals

A third presupposition of the TPS-Paradigm is that all science is done by humans, and thus limited by human perceptual and cognitive abilities. A *phenomenon* is therefore defined as anything that humans can perceive or can (technically) make perceptible or that humans can conceive[1]. A phenomenon's occurrence is called an *event* or *element*.

(i) Three metatheoretical properties

The paradigm's metatheoretical framework builds on three abstract properties that determine a phenomenon's perceptibility by humans and that are therefore scaled to human everyday experiences. These are a phenomenon's (1) *location in relation to the intact body of the individual studied* (e.g. internal, external), its (2) *temporal extension* (e.g. transient, long-lasting) and (3) *spatial extension* conceived complementarily as material and immaterial physical (spatially extended) versus 'non-physical' (without spatial properties). These properties, because they determine a phenomenon's perceptibility under everyday conditions, also determine the methods required to make it accessible under research conditions (elaborated in the methodological framework). Their particular constellation in any given phenomenon is used to metatheoretically differentiate and define various kinds of phenomena studied in individuals (e.g. behaviours, psyche). These differentiations are made only on the conceptual level; the phenomena themselves cannot be separated from another in any living individual (e.g. physiology and morphology). Moreover, the definitions denote the phenomena as such without also incorporating their explanation [5–7,10].

(ii) Basic kinds of phenomena

Four kinds of phenomena—morphology, physiology, behaviour and psyche—are considered as *basic* because they are inseparable in the individual.

Morphology denotes living organisms' bodily structures and their constituent parts; morphological phenomena are located internal and/or external, temporally extended and material physical (e.g. brain). *Physiology* denotes morphological phenomena's physical and chemical functioning. Physiological phenomena occur primarily internally (e.g. neurotransmitter activity), are immaterial physical (e.g. heat) and often momentary (e.g. heart beats), but some are temporally more extended (e.g. blood pH).

Behaviours are defined as 'external changes or activities of living organisms that are functionally mediated by other external phenomena in the present moment' [10]. Thus, behavioural phenomena are entirely external (publicly accessible), physical (mostly immaterial; e.g. movements, radiation) and momentary (transient). As their spatio-temporal extensions vary,

behaviours often fluctuate. An explicit differentiation is made between behaviour and the psyche.[2]

Psyche is defined as the 'entirety of the phenomena of the immediate experiential reality, both conscious and non-conscious, of living organisms' [5] (with immediate indicating absence of phenomena mediating their perception). Psychical[3] phenomena (e.g. cognitions, emotions, volitions) are conceived as occurring entirely internal. This differentiates them from their possible expression in behaviour and language (§2b*iii*) from which psychical phenomena can be inferred only indirectly. Psychical phenomena's immaterial properties show neither spatial properties in themselves nor systematic relations to the spatial properties of the physical phenomena to which they are bound (e.g. brain matter and physiology) and are therefore conceived as 'non-physical', reflecting complementary body–mind relations [16]. Psychical phenomena are perceptible only by each individual itself and only in the here-and-now, in individuals' *experiencings* (Erleben; e.g. thinking, feeling). But despite this transient access, some psychical phenomena are temporally more extended and therefore called *memorized psychical resultants* or commonly *experiences* (Erfahrung; e.g. mental and sensory representations, capacities for reasoning, mood tendencies with memorization broadly referring to any retention process).

(iii) Composite kinds of phenomena

Three further kinds of phenomena are conceived as *composite*—semiotic representations (e.g. language), artificial outer-appearance modifications (e.g. clothes) and contexts (e.g. situations), the first two particularly important for humans. In composites, phenomena of different kind (distinguished by the three abstract properties) are tightly interrelated, forming a functional whole from which new properties and functions not present in their constituents emerge. These new properties can be explored only if the constituents are studied in their functional interdependence within the composite. A peculiarity is that these composites lack physical boundaries demarcating them (e.g. cell membranes); instead, the phenomena involved are often located apart from one another making their functional interdependence not readily apparent. Semiotic representations illustrate this.

Semiotic representations (e.g. spoken, written language) are composites in which psychical phenomena (e.g. meanings, mental representations) are tightly interrelated with physical phenomena external to individuals' bodies (e.g. vocal sounds, ink, paper) that are used to represent in publicly accessible ways the meanings and referents to which they refer, forming a functional whole from which new properties emerge. This interrelation is so deeply embedded in our everyday thinking that its composite nature does not become readily apparent and may sometimes create the illusion meanings are contained in the spoken and written words themselves. But meanings and mental representations are internal 'non-physical' phenomena, whereas speech and writing are external physical phenomena and therefore perceivable for others who can infer from them the meanings referred. For example, the word 'bird' can be composed of visible patterns on paper shaped like 'BIRD' or '*OISEAU*' (French for bird) or the vocalizations [bɜːd] or [wa.zo]. In the composite, these external physical elements (e.g. graphemes) carry meanings not inherent to them in themselves, but that individuals only a*ssign* to them. When multiple individuals mentally represent such a*ssign*ments in socially shared ways, the composite's physical elements become *signs*. Assignments of meaning are generally arbitrary and hence vary. Nobody can straightforwardly recognize the meaning of 'oiseau' just from the word itself without knowing the meaning French speakers assign it. Thus, whether or not a particular physical element constitutes a sign for an individual is determined by psychical properties inseparable from that individual. This has important implications for language-based research on individuals (§3).

Artificial outer-appearance modifications denote the parts of natural outer morphology that individuals modify themselves (e.g. hairstyle) and the physical objects they attach to their bodies (e.g. clothing). These modifications are external and (primarily material) physical. They are temporally more extended than behaviours but often less extended than natural outer morphology (e.g. tattoos). Appearance modifications are often used to convey meanings, and thus constitute special kinds of semiotic representations. They are treated separately because their physical attachment to individuals influences their social perception, which plays an important role in research on individuals.

Environments are commonly conceived as surroundings external to and separate from the individual as seen from the researchers' perspective (e.g. nature-nurture and person-situation concepts). But system theories highlight that individuals of all species, given their particular physical and psychical abilities, interact only with external elements relevant to them [17]. Thus, what constitutes an environment for an individual cannot be defined independent of it. This subjective component can but need not be shared by others (i.e. be inter-subjective). To reduce misunderstandings, the TPS-Paradigm uses the term *context* conceived as composites involving at least one phenomenon inseparable from the individual studied (a basic one). Contexts can be considered on all levels, involving both external and internal phenomena. Researchers must specify which kinds of phenomena are in the focus and which ones are explored as their context in given studies. Contexts of special kind are situations.

A *situation* is defined as 'the particular constellation of events (elements) of all kinds of internal and external phenomena that are present in a given moment and that the individual can directly perceive, consciously or not' [5,10]. This comprises not only external but also internal physical phenomena because the individual's body is always present (e.g. hormonal status) as well as all ongoing psychical events[4].

These concepts are now applied to explore individual differences research.

(c) Metatheoretical ideas underlying personality and temperament

(i) Blended concepts

The TPS-Paradigm's frameworks highlight that basic concepts of individual differences research, such as personality, temperament and 'traits', commonly refer to *various* kinds of phenomena. Personality defined as 'an individual's characteristic patterns of thought, emotion, and behavior, together with the psychological mechanisms–hidden or not–behind those patterns' [18] refers to psyche and behaviour. Allport's [1] widely used definition as 'the dynamic organization within the individual of those psychophysical systems that determine his unique adjustments to his environment' mentions psyche,

physiology, internal morphology and contexts. Other definitions also include outer morphology and appearance [19].

But researchers disagree which kinds of phenomena they consider as part of personality and which ones as its causes or consequences. 'Those characteristics that account for a person's consistent patterns of feeling, thinking, and behaving' [20] treats behavioural and psychical patterns as *outcomes* of 'those characteristics' that are conceived as personality but left undefined. Allport's definition, by contrast, treats psyche, physiology and inner morphology as *integral parts* of personality and behaviours as outcomes. The definition as 'patterns of thought, emotion, and behaviour', in turn, treats behaviours as integral parts of personality—an understanding in which studies on 'behavioural outcomes of personality' entail circular explanations.

Temperament commonly denotes biologically based individual patterns that occur early in life, are more strongly genetically influenced, long-term consistent and linked to neurotransmitter, neuropeptide and hormone systems, and that are therefore differentiated from socially influenced and learned individual patterns conceived as personality [2]. But there is no general consensus about the particular phenomena involved in temperament and their concrete differentiation from personality. Conceptual understanding also varies for many other terms (e.g. 'character', trait, 'disposition', 'individuality') [3].

Proponents of different concepts all have their points and rationales. But this diversity in the conceptual understanding of the *same* terms hinders theoretical integration. Identifying basic ideas underlying common definitions and concepts, the TPS-Paradigm's frameworks can help to unravel commonalities, differences and interrelations.

(ii) Core concept: individual-specificity

These frameworks also help scrutinize the common notions of 'individual differences' (differential patterns) and 'individuals' characteristic patterns'. Specifically, when are patterns characteristic enough to warrant their interpretation as personality or temperament? Not all individual variations are meaningful for the field. Occurrences of fluctuating phenomena (e.g. behaviours) can change from moment to moment, entailing considerable within-individual and thus between-individual variations. But causes, functions, development and evolution of individual differences can only be explored if these variabilities are *specific to the individual*, thus differ among individuals over some time.

To disentangle *individual-specific* from moment-to-moment variations in dynamic and transient phenomena, measurements must be aggregated over several occasions to determine individuals' probabilities for showing particular phenomena (e.g. heart beats). Differential patterns therein—in both individuals' averages and variability (§3a*ii*)—must be substantially temporally reliable. Thus, *temporal patterns are to be identified in patterns that are defined by a certain temporal stability in themselves*. This is not always well considered. Animal researchers increasingly interpret any between-individual variation as reflecting personality even variations not sufficiently stable, thus variations considered random in biology until the 1990s [3–5].

The concept of individual-specificity highlights important distinctions. In itself, it denotes an individual-level concept (as all personality definitions above) that, however, presupposes the existence of individual differences explored with population-level concepts. But taxonomies of a population's individual differences (*differential research*) do not reveal anything about the single individual, neither about its particular configuration of scores on various differential dimensions nor about the intra-organismal organization of this configuration (*personality research*). The word personality derives from person, not from population; therefore, the term 'personality taxonomy' is misleading and 'personality structure' is ambiguous.

Inconsistent terminology caused profound misunderstandings across disciplines. For example, the term 'animal personalit*ies*', coined in behavioural ecology, denotes between-individual variations but not groups of individuals with similar configurational patterns as the word 'personalities' implies [3]. These differentiations are not trivial. As living organisms, individuals are largely self-organizing. At any one level of their complex intra-organismal organization, presence or absence of single elements or single interrelations among them may change the composite's overall transactions, yielding different phenomena, properties and functionings. Knowledge about individual differences cannot reveal the intra-organismal structures and processes from which they emerge. Terminological precision is needed to minimize conceptual misunderstandings and to enable integrations across disciplines, although differentiating personality from 'personality differences' and traits from 'trait dimensions' is linguistically more cumbersome.

(d) Metatheoretical definition: individual-specificity in all kinds of phenomena

Embracing the basic ideas contained in previous definitions, the field's object of research can be meta-theoretically defined as *individual-specificity in ALL kinds of phenomena* studied in individuals, thus in physiology, psyche, behaviours, morphology, semiotic representations, artificial outer-appearance modifications and contexts. This broad definition avoids arbitrariness and implicit assumptions in deciding which kinds of individual-specificity form part of personality or temperament and which ones do not. Ultimately, what could justify such a decision given that causes and consequences of personality can only be identified if they, too, feature individual-specific patterns? It also avoids a-priori assumptions about which kinds of individual-specificity are more biologically or more socially influenced to justify their interpretation as temperament or personality, respectively. After all, if causal explanations constitute defining criteria of an object of research, what then could explain the object thus-defined? Such definitions are inherently circular [10].

But instead of creating an even more abstract construct, it is broken into sub-constructs of individual-specificity that each refer to *just one kind of* phenomenon. Accordingly, one can distinguish from one another individual-specific physiology, individual-specific psychical phenomena, individual-specific behaviours, individual-specific morphology, individual-specific artificial outer-appearance modifications, individual-specific contexts, individual-specific use and understanding of semiotic representations as well as semiotic representations about individual-specificity. In their entirety, all these different kinds of individual-specificity make up an individual's uniqueness. The meta-theoretical definition allows researchers to specify in which particular phenomena they study individual-specificity rather than using the abstract terms personality or temperament uniformly for

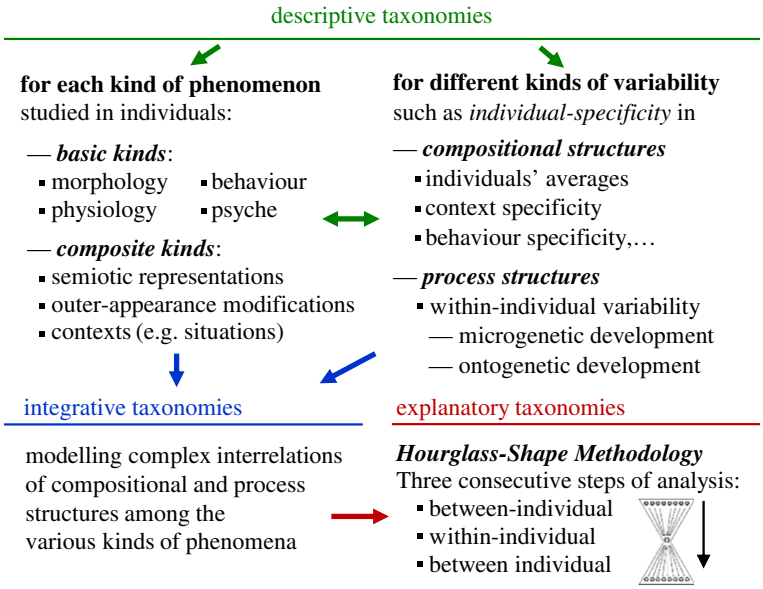

Figure 1. Different types of taxonomies are needed to comprehensively explore individual-specificity. In the Hourglass-Shape Methodology, between- and within-individual analyses are applied complementarily to identify compositional structures of individual-specific and population/species-typical patterns as well as basic process structures of their functioning and development in individuals. (Online version in colour.)

phenomena of different kinds that, given their different perceptibility, require different methods of investigation and thus cannot be studied all at once.

This differentiation also allows researchers to specify the phenomena to be explained (explananda) and those explored as their causes (explanantia) and outcomes in given studies. For example, researchers may explore how individual-specific patterns in physiology (e.g. neurotransmitters) influence individual-specific behaviours (e.g. impulsiveness), or, conversely, how individual-specific behaviours (e.g. eating) may influence individual-specific physiology (e.g. hormones), or—considering complexity—what transactional feedback processes occur between both (§3e–f). Such analyses are precluded when causal directions are predefined (e.g. behaviours as outcomes of personality).

3. Taxonomies of individual-specificity: methodological foundations

Valid taxonomies of individual-specific variations are important because they serve as reference models for research and applied settings. Any biases can therefore compromise findings and theories in many fields. TPS-Paradigm's frameworks are now applied to elaborate the methodological foundations of taxonomy development.

(a) Types of taxonomic models

(i) Taxonomies for each kind of phenomenon

The various kinds of phenomena explored for individual-specificity require different methods of investigation. But different methods, such as those needed to study physiology, behaviour and semiotic representations, generate different kinds of data that cannot be analysed jointly for taxonomic structures. Such blended analyses also impede explorations of their complex causal and functional interrelations (§2c–d). Thus, contrary to common assumptions, *one* single taxonomy that best describes (and even explains) individual-specificity in *all* kinds of phenomena cannot be developed with one single methodological approach and one single method. Instead, taxonomic models first have to be developed for *each* kind of phenomenon *separately* and using phenomenon-specific methodologies and methods, thus taxonomies for each sub-construct of individual-specificity (e.g. taxonomy of individual-specific physiology, taxonomy of individual-specific behaviours, taxonomy of semiotic representations about individual-specificity).

These different *phenotypical taxonomies* are first steps to describe the complex diversity of individual-specificity in parsimonious ways. They are then used, in subsequent steps, to explore the interrelations among individual-specific patterns in different kinds of phenomena that are modelled in *integrative and explanatory taxonomies* (§3a*iii*, figure 1). Parsimonious overarching models can be developed only stepwise and by capitalizing on different fields' expertise and efforts.

This insight may puzzle many psychologists who, so far, have aimed to develop a 'universal taxonomy' using basically just one method—assessments. Human language seemed to make this feasible because it contains a rich vocabulary for socio-culturally important individual-specific variations. These person-descriptors and the ability of language to denote phenomena abstracted from their perceivable properties and from the contexts in which they occur (decontextualized), promoted the large-scale application of assessment methods. The most popular taxonomies of human individual differences, even models based on biological theories (e.g. [21,22]), were so far developed with assessments.

The conceptual blending of various kinds of phenomena in common concepts of personality and temperament, enabled through linguistic abstraction, resulted in highly interpretive conglomerates of ideas about individual-specificity—in everyday life and in science. Thus, language seemed to enable scientists to meet the principle of parsimony in highly efficient ways. But words are often uncritically assumed to correspond to real entities. This may be possible for physical events directly perceptible without reflection but not for abstract ideas [23]. Individual-specificity is an abstract concept involving the joint consideration of temporal, differential and (in fluctuating

phenomena) also probabilistic patterns, none of which can be directly perceived at any given moment.

Assessments are *retrospective*, evaluative and memory-based, and therefore capture people's ideas, beliefs and knowledge, thus their semiotic representations *about* individual-specificity. But assessments cannot capture any other kind of phenomenon, neither transient phenomena perceivable in others (e.g. behaviours) or in oneself (e.g. experiencings) nor any phenomenon not directly perceivable in anyone in everyday life (e.g. physiology; [9,24]). This means that people's everyday ideas *about* individual-specificity underlie assessment-derived models, rather than any biological individual differences as often assumed. Taxonomies of individual-specificity in physical, behavioural and psychical phenomena, often conceived as personality, are still largely missing [2,4,9,25].

(ii) Taxonomies for compositional structures and process structures

Decontextualization enabled by language shifts researchers' and raters' focus away from the facts that, in humans and other species, individuals behave differently in different nominal settings and that these within-individual variabilities often differ among individuals in temporally reliable ways. This *individual-specific context/situation specificity* (context-dependence) entails that, on the sample level, cross-situational consistency is often only moderate [3,26]. Individual-specificity also occurs in the specific behaviours of similar function and meaning that individuals show in given contexts (e.g. different anxiety-related behaviours); this *individual-specific behaviour specificity* entails that internal consistencies are often only low [27–29].

The abstracting abilities of language shift the focus of assessment studies towards *individuals' averages*, prompting researchers and raters to conceive processes as entities—such as those labelled as traits, temperament or personality [4,30]. Averages allow researchers to explore basic *compositional structures* of individual differences in populations (differential taxonomies) and of single individuals' specific constellations of deviations from their population's averages (personality profiles). But averages do not reveal how the identified components emerge, function and develop together in the individual. This requires analyses of within-individual variability over shorter and longer periods of time to identify *process structures* (figure 1).

In transient and dynamic phenomena, within-individual variations reflect these phenomena's processual nature rather than just random variation and measurement error [31]. Measurements may therefore not show high temporal and internal reliability as required for standardized assessments [28,32]. Individual-specificity emerges in *within-individual variability* indicating *microgenetic processes of development*. It also emerges in the stability of individual-specific variations over longer periods of time, indicating *individual-specific trajectories of ontogenetic development* [33]. These different kinds of individual-specific variability provide important insights into the causes, functions and development of individual-specific phenomena [4,34,35].

Taxonomizing process structures requires models and methods other than those used for taxonomizing compositional structures (§3e). The popular Five Factor Model of human personality merely taxonomizes individual differences; it is different from Five Factor Theory describing intra-individual processes that are assumed to contribute to their emergence [36], yet without modelling such processes empirically.

(iii) Integrative taxonomies and explanatory models developed using the Hourglass-Shape Methodology

In subsequent steps, taxonomies modelling compositional structures and process structures in the various kinds of phenomena are used to empirically explore their complex interrelations that are modelled in *integrative taxonomies*. Phenomenon-specific models will allow to unravel how accurately taxonomies derived from everyday language actually represent individual-specificity in kinds of phenomena observable (e.g. behaviour, outer morphology) and non-observable in others (e.g. psyche, physiology), the ways in which lexical models may reflect sociocultural perceptions, interpretations and appraisals; and how individual-specificity in the different kinds of phenomena may actually vary within and among sociolinguistic communities [4,7,37,38].

Such integrative models are, for a start, only phenotypical descriptions, just as the phenomenon-specific models from which they are derived (figure 1). Moreover, and importantly, individuals function and develop not primarily on the basis of what differentiates them from others but on the basis of structures and processes that are highly similar in all individuals (*normative*) and that are thus *population- or species-typical*. This requires models describing interrelations among both individual-specific *and* population-/species-typical phenomena [7,9].

To explain processes of microgenesis (Aktualgenese[5]) and ontogenesis, researchers must consider the complex pathways of causation emerging from the dynamic and nonlinear multi-level transactions occurring in living organisms. The common nomothetic strategy to dissect the complexity of individual-specific phenomena into a few individual difference constructs therefore cannot explain how any thus-dissected elements function and develop together in each individual [1,40]. *Inter*-individual differences cannot explain *intra*-individual organization. Recognizing this, idiographic approaches focus on the single individual [39]. But idiographic single case studies cannot disentangle individual-specific from population-/species-typical patterns [7].

This nomothetic-idiographic problem is solved in the TPS-Paradigm by implementing the principle of epistemological complementarity in the Hourglass-Shape Methodology [7]. It systematically combines between-individual and within-individual methodologies in three consecutive steps of exploration, shifting the focus of analysis stepwise from many to single and then again to many individuals (therefore its name; figure 1). In Step 1, between-individual analyses identify *compositional structures* of individual-specific and population-/species-typical patterns in given kinds of phenomena in given populations. In Step 2, within-individual analyses explore the processes by which (selected sets of) individual-specific and population-/species-typical structures (identified in step 1) function and develop together in single individuals, microgenetically and ontogenetically. In Step 3, between-individual analyses explore the within-individual processes (identified in step 2) for commonalities and differences across many individuals to identify basic *process structures* of functioning and development that are similar or different for particular groups of individuals (figure 1). These

three steps reveal different kinds of information that are mutually exclusive but all needed for a comprehensive understanding of individuals and that are therefore complementary to one another. Hence, nomothetic and idiographic approaches, although apparently incompatible, are both essential for exploring individuals and must be purposefully combined with one another in complementary orderly steps.

The Hourglass-Shape Methodology outlines a transdisciplinary research agenda that requires the joint efforts of multiple research programmes and disciplines. Such methodologies are already applied in many biological and medical fields that have developed not one general model of human biology or physical health comprising a few dimensions assumed to describe and even explain individual functioning and development. Instead, these fields established a multitude of models about specific structures and processes in specific kinds of phenomena in relevant groups of individuals. Researchers in psycho-neuro-immunology have modelled microgenetic and ontogenetic processes in the interactions among the psychical, the nervous and the immune systems. Such integrative and explanatory models provided new knowledge about the molecular mechanisms mediating the still largely unknown body–mind interrelations and opened new perspectives for unravelling mechanisms underlying healthy and pathologic functioning and development [41].

(b) Comprehensiveness and representativeness

Taxonomizing the complexity of individual-specific variations in the different kinds of phenomena is challenging. The enormous diversity requires taxonomists to decide which phenomena to study (*selection approaches*) and how to identify variations that are individual-specific and those that are 'most important' (*reduction approaches*). Any differences in these decisions can change the taxonomies derived, thus compromising findings and comparisons among populations (e.g. cultures or species). Therefore, systematic approaches are needed.

To elaborate the methodological foundations of taxonomy development, two concepts are introduced here. *Comprehensiveness* denotes that a taxonomic model for a given kind of phenomenon (e.g. behaviour) includes the full range of phenomena in which individual-specific variations occur in the study population (e.g. all relevant behavioural domains). *Representativeness* denotes that the individual-specific variations included in a model within each domain reasonably reflect the study population's diversity. For example, including only variables that produce norm-distributed data creates models that may not adequately represent the actual distribution patterns occurring in given phenomena (e.g. skewed distributions of aggressive behaviours). Comprehensiveness is influenced by both selection and reduction approaches; representativeness only by reduction approaches.

(c) Selection approaches

Selection approaches are all operations and practices taxonomists use to decide about which specific phenomena to study (e.g. which behaviours), thus what is included in model development. Comprehensive taxonomization requires approaches enabling systematic selections from the *universe* of all phenomena in which individual-specific variations occur in given kinds of phenomena in given populations. This universe can be determined in physical phenomena (depending on the state of knowledge) because their spatial extension allows elements to be to demarcated (e.g. single behavioural acts, single cells). But in psychical phenomena, the universe of phenomena cannot be determined because their 'non-physical' properties do not allow elements to be demarcated (e.g. single thoughts, single emotions). This also concerns composites involving psychical phenomena, such as semiotic representations. The physical parts of language allow separate 'words' to be clearly demarcated, but this is not possible for the meanings assigned to them. Meanings are fluid and vary across regions and time; but these variations may not be reflected in the spelling, pronunciation and composition of words. This imposes challenges to all language-based approaches (§3c*iii*).

Various selection approaches are used. They can be classified by their underlying *selection principles* and the kinds of phenomena they allow to select. Two previous schemes to classify selection approaches from primate personality research [3,37,38,42] and human personality psychology [6] are now integrated and refined into a basic scheme covering approaches used in various disciplines for studying humans and other species. Three basic principles can be distinguished, content-based, strategy-based and partial strategy-based.

(i) Content-based selection principles

Approaches in which the phenomena to be studied for individual-specific variations are selected on the basis of their particular qualities (content domains) rely on content-based principles (figure 2). Such principles underlie *nomination approaches*, in which experts nominate individual-specific variations they deem important for a population (e.g. insiders of indigenous communities in cross-cultural psychology or keepers in animal research).

In *cumulative-gain-in-knowledge approaches*, researchers aim to develop comprehensive models by selecting constructs already established for the study population, thus capitalizing on findings derived from other approaches. In psychology, the Five Factor Model was developed by compiling the long-studied constructs Neuroticism and Extraversion first with Openness to Experience and later with Agreeableness and Conscientiousness[6] [43] after these constructs have become established in the Big-Five Model ([44]) through lexical approaches (§3c*iii*).

In *top-down* (*etic*[7]) *approaches*, researchers select constructs originally developed for other populations. For example, the Five Factor Model was applied to sociolinguistic communities other than those for which it was developed [6,45] and even to other species [38,46,47].

In *theory-driven approaches*, researchers use specific theories to deduce (and explain) the occurrence of particular individual-specific variants in given populations. Freud used his topographic model of mind and his theory of psychosexual development to derive (and explain) the existence of particular individual-specific types. Galen used his theory of physiological systems to deduce four temperament types [2]. Theories about adaptive problems encountered by a species are used to deduce particular individual differences occurring in adaptation to them (e.g. [48]).

In *mixed approaches*, researchers combine elements of different selection approaches, such as by combining established constructs with nominations or top-down approaches (e.g. [49]).

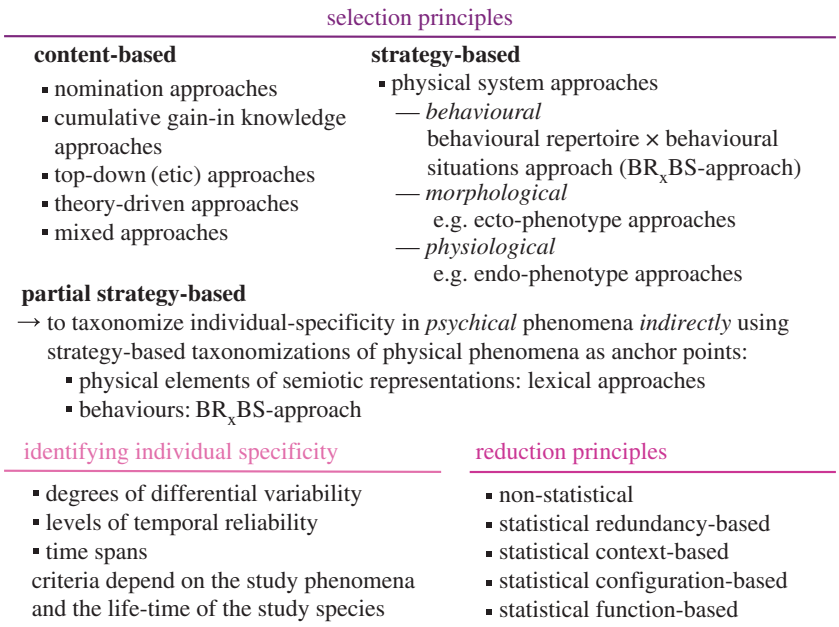

Figure 2. Selection and reduction approaches to taxonomize individual-specificity in various kinds of phenomena can be classified by their underlying rationales and principles. (Online version in colour.)

Selecting phenomena in which individual-specific variations are salient to people, theoretically plausible or already described for given populations requires researchers to focus on the qualities (content domains) of these variations. This means, individual-specific variations *have to be specified before taxonomists can even begin to identify and taxonomize such variations* in their study population. As individual-specificity cannot be directly perceived at any given moment, taxonomists (and nominators) necessarily rely on their pertinent ideas and (implicit) beliefs. But as the universe of ideas and knowledge from which to sample cannot be determined, approaches enabling comprehensive selections cannot be devised. This renders content-based selection principles susceptible to biases that researchers (and their informants) may (unintentionally) introduce. The focus on contents also prompts them to select highly interpretive conglomerates of ideas about individual-specificity, in which phenomena of different kind are conceptually blended although they differ in perceptibility by humans and thus require different methods of investigation. These factors limit the comprehensiveness of taxonomizations.

(ii) Strategy-based selection principles

Strategy-based principles, by contrast, provide explicitly formulated frameworks and strategies on which researchers can base their selections *without already specifying any particular ones* and thus without compelling researchers to focus on the qualities of the individual-specific variants to be studied. This eliminates the necessity to rely unintentionally on preconceived ideas, thus reducing risks for biases. Therefore, strategy-based principles enable comprehensive selections. However, such principles can be formulated only for physical phenomena because their spatial properties allow researchers to determine the universe of phenomena from which to sample. Pertinent approaches are therefore called *physical system approaches* (previously called 'manifest system approaches' [4] and 'bottom-up approaches' [3,37]). Various kinds of physical system approaches exist that are each targeted at one kind of phenomenon (figure 2).

A *behavioural physical system approach* is the Behavioural Repertoire × Behavioural Situations Approach[8] (BR_xBS-Approach; [3,4,6,37,38] developed within the TPS-Paradigm to comprehensively taxonomize individual-specific behaviours in human and nonhuman populations. It specifies a multi-step procedure in which the behaviours to be studied for individual-specificity are selected systematically from the known universe of a species' behaviours (its behavioural repertoire) as described in the existing ethological and behaviour-scientific literature that is unconcerned with individual differences and personality.

The approach therefore starts with a systematic review of this literature in which researchers compile in a database all behaviours and the situations in which they are reported to occur in each publication. Then this compilation is reorganized and sorted by behaviours, grouping more specific ones (e.g. slap, bite) into the more abstract categories used in the literature (e.g. social aggression) and eliminating redundancies across studies. By hypothesizing occurrence of individual-specific variations in each behavioural category, *working constructs of individual-specificity* are generated (e.g. aggressiveness to conspecifics). Their meaning and content are defined by the specific behaviours and situations from which they were derived and that can be used to select variables for empirical studies.

The working constructs are used to empirically explore if in the given population or species individual-specific variations do in fact occur that are then taxonomized using various reduction approaches (§3e). By building on the established knowledge base about a species' behavioural repertoire rather than on previous descriptions of individual variations or on researchers' or nominators' pertinent ideas, the BR_xBS-Approach enables comprehensive taxonomizations, which are needed for valid comparisons. Applications in various primate species yielded evidence for individual-specific variations across these species' behavioural repertoires, among them variations not previously identified with other approaches (e.g. with top-down approaches from the Five Factor Model [27,28,32,42]).

Analogous strategy-based approaches can be devised to comprehensively taxonomize individual-specificity in physiology and morphology. Examples are endo-phenotype approaches in molecular psychiatry [50], approaches taxonomizing individual-specific brain morphology [51], and ecto-phenotype approaches taxonomizing individuals' face or body morphology [52,53].

(iii) Partial strategy-based selection principles

Challenges arise for taxonomizing individual-specificity in psychical phenomena because their indeterminable universes preclude comprehensive selection approaches. Moreover, psychical phenomena are imperceptible for others and can be explored only indirectly through externalizations in language and behaviour, but straightforward inferences cannot be made [10,54]. A third selection principle therefore uses strategy-based taxonomizations of physical phenomena *as anchor points to taxonomize* individual-specificity in psychical phenomena *indirectly*. This does not allow psychical phenomena *in themselves* to be selected comprehensively, but provides a systematic strategy for exploring individual-specific variations without compelling researchers to focus on specific ones. Such selection principles are therefore called partial strategy based (figure 2).

Lexical approaches are based on partial strategy-based selection principles. They build on the hypothesis that important individual differences are encoded in everyday language [55]. Accordingly, the lexica constitute the universe of elements from which to sample without suggesting any particular ones. In the 1930s, Allport and Odbert [56] filtered 17 953 person-descriptors from the English dictionary. This comprehensive selection formed the basis for various lexical models (e.g. Big-Five Model, Hexaco-Model, Big Seven Model [6,44]). Lexical approaches enable systematic but not comprehensive approaches to taxonomize individual-specificity in psychical phenomena because word meanings vary and not all experiencings can be verbalized.

Partial strategy-based selection principles can also be implemented using comprehensive *behavioural* taxonomies. For example, BR_xBS-Approach-derived taxonomies were used to systematically explore observers' beliefs about individual-specific behaviours [24,32,42,46]. Taxonomies of individual-specific *artificial outer-appearance modifications* and *contexts* can be developed analogously by first taxonomizing comprehensively the physical components involved that are then used to systematically explore the meanings and functions they have for individuals. Findings from various partial strategy-based approaches involving different kinds of physical phenomena (e.g. lexical and behavioural) can then be integrated into overarching models of individual-specificity in psychical phenomena (within the limitations of their only indirect explorability).

After selecting the specific phenomena to study, taxonomists must define how to identify individual-specificity in them.

(d) Identifying individual-specificity

Individual-specificity implies temporal and differential patterns that cannot be directly perceived at any given moment. Still, raters are asked to judge individual-specificity on questionnaire scales. A single rating score can reflect differential, temporal and even individual-specific patterns in itself because language and assessments reflect sociocultural beliefs and ideas people have about individual-specificity in various kinds of phenomena (e.g. behaviours, morphology). But assessments cannot capture these latter in themselves. In transient phenomena (e.g. behaviours, physiology), any single recording can capture only occurrences or non-occurrences of events (e.g. heart beats) and their physical intensity (e.g. electric potentials). But to generate data about individuals (e.g. heart rate), these raw data must first be aggregated within each individual over time before they can be explored for individual-specific patterns [9,28].

Given this, researchers must decide and explicitly define what empirical degrees of differential variability and what empirical levels of temporal reliability are needed to warrant interpretation as individual-specificity (figure 2). This has not yet been formally done. These fundamental questions do not arise in assessment research because every raw datum already implies assumptions of temporality of the phenomena described, which is a property of raters' beliefs, not of the individual-specific phenomena described.

So far, taxonomic research in humans has strongly relied on assessments. Degrees of differential variability and levels of stability of individual differences in everyday behaviour, many phenomena of physiology, appearance modifications, contexts and even people's use of semiotic representations are therefore not well known. Researchers must specify criteria, considering that these depend on the studied phenomena' properties (figure 2).

(i) Degrees of differential variability

In most kinds of phenomena, differential variability is continuous. Researchers must define what degree of between-individual variability is necessary to warrant interpretations as individual-specific. What could be a legitimate basis for defining cut-off points for minimum degrees of differential variation? Should they be higher in phenomena individuals can (partially) control themselves (e.g. behaviours) than in phenomena they cannot control (e.g. morphology)? Should degrees of differential variability in temporally extended phenomena (e.g. morphology) be higher or lower than in momentary and fluctuating phenomena? Should other criteria be considered, for example, effects that differential variability may have on outcomes in individuals' external surroundings or in relations to them? Or is just any degree of differential variability meaningful as long as it is sufficiently stable?

(ii) Levels of temporal reliability and time spans

Because individual-specificity implies temporal patterns in itself, researchers must distinguish two kinds of temporal analyses. *Temporal reliability* (not to be confused with measurement accuracy) refers to the primary identification of differential patterns as individual-specific. *Temporal stability*, by contrast, explores individual-specific patterns across time periods longer than those in which they were first determined (through temporal reliability), such as to explore patterns of ontogenetic development (e.g. life trajectories). Assessments cannot make the necessary distinction between reliability and stability because they rely on rater-determined implicit assumptions about temporal extensions.

Levels of temporal extension vary continuously. But how much temporal reliability is needed to warrant interpretation

of differential variations as reflecting individual-specific ones? Cut-off criteria must consider the temporal properties of the phenomena studied. Differential patterns are necessarily more temporally reliable in phenomena that are temporally more extended (e.g. morphology, semiotic representations) than in those that are dynamic and transient (e.g. behaviours; [9,24]). Therefore, researchers may want to set lower cut-off criteria for these latter.

Temporal reliability estimates also depend on the *level of aggregation* across measurement occasions and variables as well as on the *time spans* considered. In humans, researchers often study temporal reliability over four to six weeks. But animal researchers are confronted with diverse lifespans ranging from days and weeks (e.g. mayflies, bees) up to several centuries (e.g. whales). Researchers have yet to define the time spans in relation to species' lifespans needed to determine whether or not individual-specificity occurs. Special considerations may also be needed for different ontogenetic stages to account for developmental changes that are, during some periods, relatively accelerated (e.g. infancy, adolescence) and decelerated (e.g. adulthood). Thus, criteria to identify individual-specificity may vary also within lifespans.

When individual-specific variations are identified, taxonomists must decide how to categorize and reduce them to the 'most important' ones.

(e) Reduction approaches

Reduction approaches are all operations and practices taxonomists apply to identify basic structures of individual-specific variations by summarizing datasets, large amounts of selected raw materials or variables (e.g. word lists) in parsimonious ways. Reduction approaches determine what is retained during taxonomy development and how basic structures are identified and modelled. Therefore, they influence both comprehensiveness and representativeness of the models derived. Approaches can be classified by their underlying *reduction principles* (figure 2).

(i) Non-statistical reduction principles

To reduce the selected materials to sizes manageable for data collection, various non-statistical principles are used. Allport and Odbert [56], sorted their comprehensive 17 953-word list into four major categories (e.g. lasting personal traits, temporary states), noting that 'much depends upon the linguistic habits of each individual judge' and that judges were 'often forced to choose arbitrarily between several possible shades of meaning' (p. 35). This judgement-based categorization formed the basis for numerous taxonomies (e.g. Big-Five Model) that were derived with further non-statistical reduction methods, such as semantic similarity judgements or exclusion of specific content-domains (e.g. attitudes, sexuality-related attributes). Because these reductions are based on content-related decisions, it is not astonishing that taxonomies derived from the same word lists are 'remarkably different' in both general structure and specific details [55]. These differences reflect the taxonomists' different implicit and explicit concepts of personality that guided their decisions.

Other non-statistical reduction approaches involve selections of person-descriptors from just every fifth or tenth lexicon page or of only adjectives, nouns or verbs. Such reductions may be less prone to researcher-introduced biases, but are not representative of the diversity of meanings people encode in words. These biases are rarely considered because they occur *before* data generation. (Selection, reduction and identification of individual-specificity are sometimes intermingled.) But non-statistical reduction decisions restrict what can be studied at all and thus the comprehensiveness of the models derived.

(ii) Statistical redundancy-based reduction principles

Statistical methods to analyse structures in datasets are numerous (e.g. factor analysis). But statistics work without knowledge of the meaning behind the variables. Researchers must decide if the analytical procedures performed on the data are appropriate for the studied phenomena's properties encoded in the data.

Many popular taxonomies were derived from assessments because language seems to enable efficient and flexible explorations of a wide range of phenomena. Questionnaire developers create item statements describing similar attributes of individuals (and their opposites) to obtain homogeneous sets of (balanced keyed) items. The items are often presented in randomized order, thereby further decontextualizing the attributes described. In iterative processes of item selection and analysis, psychometricians retain only items that reliably produce data with particular distribution patterns (e.g. normal distribution) and 'desirable' statistical structures (e.g. internally consistent responses to similar items). In factor analyses, psychometricians select items producing high loadings on just one factor and eliminate items producing loadings on multiple factors because this facilitates interpretation. Researchers' decisions about the number and diversity of selected variables and the sighted level of data reduction determine how many factors are created.

Consequently, co-variations in assessments reflect similarities—thus *redundancies*—in the meanings respondents construct for the items statements (e.g. regarding their semantic similarity [25] or valence [32]). But by selecting only items producing data that match assumptions of statistical theories and discarding all items that do not, *psychometricians radically match the data generation to statistical theories* rather than to the properties of the actual phenomena under study. This challenges assumptions on the representativeness of many personality taxonomies. In fact, adjectives of popular questionnaires are used with disparate frequencies in online media [57].

In language, redundancies can be generated at low costs; therefore, variables can be created ad libitum. But in biological systems (e.g. behaviour, physiology), redundancies are rare probably due to ecological and evolutionary constraints [4]. Moreover, in dynamic and transient phenomena, individual-specific patterns reach degrees of complexity in which simple regular structures that could explain much of the variability observed cannot be found [7]. Intercorrelations among behavioural variables are therefore much less consistent than those among carefully selected assessment items [32] so that statistically extracted factors or principal components often account for only low to moderate percentages of the data variance [58].

(iii) Statistical context-based reduction principles

To statistically explore structures of complex phenomena *as they occur* in the individuals under study, context-based reduction principles are needed. Lexicometric analyses

reduce lexical elements on the basis not of judgements or test-theoretically desired outcomes but of their empirical co-occurrences in textual data (e.g. conversations, writings), enabling inferences to word meaning and belief structures [59]. It is surprising that lexical researchers have obviously not yet textually explored the dictionary definitions of widely assessed person-descriptors [6]. Context-based statistical analyses are also applicable to explore other kinds of phenomena encoded in textual data (e.g. behaviours [6]).

(iv) Statistical configuration-based reduction principles

Challenges occur in taxonomizations of (non-semiotic) behaviours because redundancies are rare and individual-specificity emerges also on fine-grained levels. In humans, for example, gaze aversion, hesitant speaking, long pauses in speech and restricted gestures all indicate social inhibition. In chimpanzees; vocalizing, rocking, scratching and pacing all indicate arousal. But which of these functionally related behaviours an individual frequently shows can be individual-specific so that their co-variations are often only low to moderate [28,29,42]. Statistical analysis of such patterns (types) requires configuration-based reduction principles, as implemented in configural frequency analysis [60] and Q-factor analysis.

(v) Statistical function-based reduction principles

To taxonomize individual-specific structures in broad ranges of behaviours on higher levels of abstraction, the BR_xBS-Approach comprises a two-step reduction principle that capitalizes on both behaviour-scientific knowledge and statistical methods. First, to make behaviours of different type (e.g. frequencies, durations) comparable regarding the individual differences they reflect, all variables are differentially standardized (across individuals). Standardized variables encoding behaviours known to have similar functions and meaning (e.g. all behaviours indicating arousal) are then aggregated into functionally defined *composite measures* of individual-specificity as defined by the BR_xBS-Approach-generated constructs (e.g. Arousability) and regardless of possible low internal and cross-situational consistencies. Aggregation can occur on contextualized and decontextualized levels (i.e. within and across situations). Then, the composite construct measures thus-derived, rather than the raw data, are statistically reduced using context-based or redundancy-based principles (see [24,32] for examples).

This function-based reduction principle corresponds to people's intuitive categorizations of behaviours, which are largely based on the behaviours' functionality and meaning rather than their observable physical similarity or frequency of occurrence. For example, behaviours commonly considered most indicative for given individual-specificity constructs (e.g. contact aggression for aggressiveness) may occur least homogeneously with other behaviours of similar function and meaning (e.g. associations between contact and non-contact aggression are often low [24,32]). But in contrast to intuitions, these categorizations are made explicit. This enables evidence-based approaches to explore people's perceptions of individuals and their intuitive impression formation. Such approaches revealed that assessments reflect numerous attribution biases probably derived from stereotypical beliefs about specific behaviours and the valence and salience particular behaviours have for particular sociocultural communities [24,32].

(f) Principles for explanatory modelling

Reduction principles are aimed at parsimoniously summarizing phenotypical structures of phenomena that, given the complexity of living organisms, may emerge, change and disappear again. Linear methods of analysis underlying the analyses commonly used in the field are therefore inadequate. Explanatory reduction principles are required that allow researchers to explore the complex feedback processes taking place within and among the various kinds of phenomena and to simulate the trajectories of microgenetic and ontogenetic development resulting from them. Suitable methods were developed in complexity research in various fields, such as dynamic systems modelling, time-series analyses and network modelling [2,61,62].

4. Conclusion

The common idea one big model of personality or temperament could describe and even explain inter-individual differences and intra-individual functioning is incompatible with the complexity of living individuals. Pursuit of this idea, probably promoted by the abstracting abilities of human language, has absorbed large-scale efforts over the last century. Language-based methods, like the questionnaire assessments popular in psychology, can capture only the socioculturally informed ideas people have *about* individual-specificity in various psycho-bio-socio-ecological systems but not these latter in themselves.

Multiple phenomenon-specific models and research methods are needed to phenotypically taxonomize individual-specific variations occurring in structures and processes of different kinds of phenomena. Their causal and functional interrelations and ontogenetic development are then explored and modelled in integrative and explanatory taxonomies. Contrary to common practice, such taxonomies must involve both *differential and normative* patterns because individuals largely function on the basis of mechanisms and functions common to all individuals of a species rather than solely on the basis of differences among them.

Developing such models requires the expertise of many fields and their joint efforts across disciplinary boundaries, and therefore is an inherently transdisciplinary endeavour.

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Endnotes

[1]This notion differs from various philosophical definitions (e.g. Kant's).

[2]This differentiation is often made only implicitly, such as in the vague notions of 'outer' versus 'inner' behaviours.

[3]Psych*ical* denotes the phenomena of the psyche themselves, psycho-*logical* the pertinent body of knowledge (Greek -λογία, -logia).

[4]Behavioural and psychical relevance of particular situations are further explored and differentiated in the concepts of *behavioural situations* and *psychically relevant situations* [8,10].

[5]The German term *Aktualgenese* (from Latin *actualis* for operative, in action), coined by Gestalt psychologists for perceptual processes, refers more explicitly to the time-bound properties of the phenomena under study than the corresponding English term *micro-genesis*, which

refers to the smallest, moment-by-moment transformative occurrences of continuous developmental processes of phenomena [24,32].

[6]The name of the pertinent questionnaire, NEO-Five Factor Inventory, reflects these origins [43].

[7]The terms 'etic' and 'emic' originally denoted the study of language 'as from outside' and 'inside of a particular system', respectively [63]. Cross-cultural, personality and comparative psychologists adapted this terminology to specify the generation of constructs and indicators for comparative analyses. In this field, 'emic' denotes bottom-up approaches, here categorised as physical system approaches, but also nomination approaches relying on indigenous informants [6]. Given these heterogeneous meanings, the term 'emic' is not used in the present classification system.

[8]Previously called Behavioural Repertoire Approach [37] or Behavioural Repertoire x Environmental Situations Approach [3,4].

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