

## Author's Response

### Three Methodological Core Issues of Comparative Personality Research

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#### *Abstract*

*Comparative personality research in human and nonhuman species advances many areas of empirical and theoretical research. The methodological foundations underlying these attempts to explain personality, however, remain an unpopular and often ignored topic. The target paper and this rejoinder explore three methodological core issues in the philosophy of science for comparative personality research: Conceptualising personality variation, identifying domains of variation and measuring variation. Clear distinctions among these issues may help to avoid misunderstandings among different disciplines concerned with personality. Copyright © 2008 John Wiley & Sons, Ltd.*

I am delighted that colleagues from different disciplines commented on my target paper and I sincerely thank all commentators for their insightful contributions. Personality is studied from very different viewpoints; my attempt to consolidate some basic methodological issues across disciplines was therefore predestined to meet with some scepticism. The pattern of agreement and objection raised in the commentaries thus closely reflects the field's current fragmentation across different disciplines and demonstrates much better than any single author could do how largely unaware most disciplines are of developments in neighbouring fields. None of the methodological issues I proposed was criticised by all disciplines and the objections raised by some are countered by commentaries of others. What a potential for synergy! Concepts and findings of different disciplines are waiting to be systematically integrated to form a multidisciplinary and more complex knowledge base that has the potential to advance the field significantly.

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Removing the invisible barriers between disciplines is a major challenge. Not only is there a Babylonian gap that could be crossed by simple dictionary-like translation; but there are also difficulties understanding similarities and differences in the concepts underlying the disciplines' standard terms. Since each discipline has its own good reasons for its specific perspective on personality, attempts for conceptual integrations across disciplines are only possible with risk taking, openness to other perspectives and compromise. Unlike empirical findings, concepts and methodologies are designed to be modified and changed as empirical facts accumulate and alternative perspectives are proposed. It was my aim to encourage this kind of discussion by addressing a multidisciplinary audience.

In my rejoinder, I discuss the issues raised by the different commentators from animal personality psychology (**Weiss & Adams**), behavioural ecology (**van Oers**), behaviour genetics (**Johnson**), cross-cultural psychology (**Realo & Allik**), developmental psychology (**van Aken**), human personality psychology (**Nave, Sherman & Funder; Nettle**), neurobiology and psychobiology (**Carere & Maestripieri**) within a common methodological framework, and highlight perspectives for future research.

### INTEGRATING THREE EPISTEMIC ISSUES WITHIN A COMMON METHODOLOGICAL FRAMEWORK

Personality in the broadest sense is the internal organisation of behaviour that is stable over considerable time periods in the individual yet varies among the individuals of a population on latent dimensions. To identify such dimensions, I offered several methodological suggestions based on pertinent approaches in cross-cultural research on the one hand and on philosophical traditions of science and well-established findings in trait psychology on the other hand.

The overall methodological framework I proposed integrates three different core issues that have to be distinguished from one another and that require different types of approaches. The first is a methodology to *conceptualise* the basic phenomenon of personality variation in different populations within and across species as structures recurring in the same qualitative form in different individuals but at different quantitative levels that constitute dimensions across the composite of a population. The second is a methodology to *identify* in which domains (e.g. in shyness–boldness, sociability or conscientiousness) such dimensions are exhibited by a particular population. The third covers methodological approaches to *measure* such dimensions in these domains in the given population empirically. It is obvious that all three issues are necessarily interdependent but refer to different epistemological stages that merge together in the concept of hierarchical trait taxonomies (Figure 1).

Dimensional conceptions of personality vary greatly in complexity across different disciplines. In biological disciplines, they range from variation in single behavioural measures (called proxies, **van Oers**) to more complex dimensions (called continua or axes), which also underlie the recent concept of behavioural syndromes as clusters (or suites) of correlated behaviours (also called traits or characters; Sih, Bell, Johnson, & Ziemba, 2004). This latter concept explicitly incorporates the pervasive empirical finding that single behavioural dimensions often covary empirically, thus forming a more complex higher order dimension. Psychological disciplines study dimensionality of high complexity and therefore obtain many different trait indicators. In *trait taxonomies*, narrow trait

## Three methodological core issues of comparative personality research

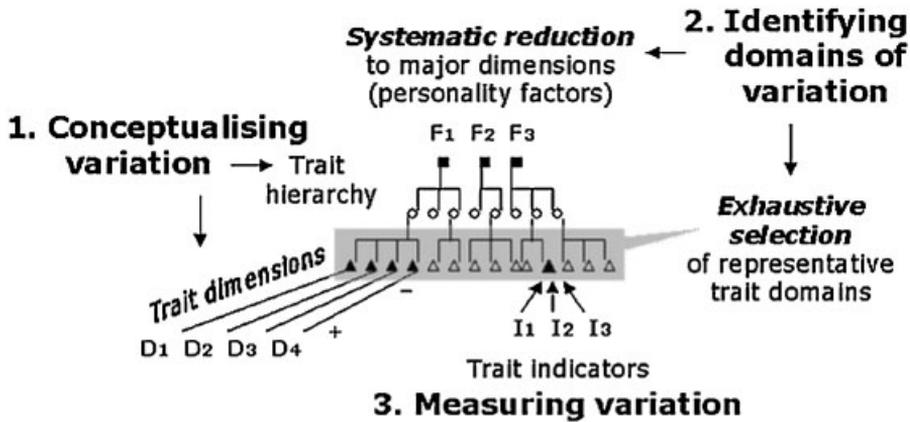


Figure 1. The three methodological core issues merging in the concept of hierarchical trait taxonomies.

dimensions are hierarchically subsumed within broader trait dimensions making the less complex dimensions sub-dimensions of the emergent more complex major dimensions (see Figure 1). With increasing complexity on higher order taxonomic levels, the shared variance of the summarised primary-level dimensions decreases and culminates in the statistical extraction of a few, statistically relatively independent, that is orthogonal, personality factors (such as the Big Five factors; Allport, 1937; Matthews, Deary, & Whiteman, 2003). Psychological disciplines therefore frequently use factor-analytic methods, whereas they are less common in biological disciplines (but see, e.g. Ibáñez, Ávila, Ruipérez, Moro, & Ortet, 2007; Sinn et al., 2006). Extending the complexity of the dimensions studied by biological disciplines, and thus the breadth and depth of correlational structures to analyse, will inevitably lead to the more frequent use of factor-analytic methods and the identification of different, independent behavioural syndromes in those disciplines as well.

Hierarchical trait taxonomies provide specific answers to the three methodological core issues. Trait taxonomies can vary across different populations according to their patterning effects. Understanding these patterning effects is necessary for a sound comparison of trait dimensions across populations (first core issue). It is obvious that the comprehensiveness of the empirical representation of a population's trait taxonomy depends on the selection of trait domains that determine its foundation and on the reduction processes that extract its major dimensions (second core issue). Trait taxonomies also help differentiate theoretical concepts from their empirical measurements, for which the terms construct and operationalisation are well established in psychological disciplines (third core issue). This distinction is the epistemic necessity for any scientific research on complex, not directly observable phenomena such as personality or cognition whose existence can only be inferred from repeated and systematic measurement of composite indicators (see Figure 1).

## CONCEPTUALISING PERSONALITY VARIATION

I proposed to generalise the concept of dimensional personality variation within and across human cultures (Leung & Bond, 1989) to comparisons on other population levels including species by contrasting population-specific, weak and strong universal trait dimensions. This methodology requires distinguishing behaviours varying between populations but not within from those showing inter-individual differences both within and across populations; only the latter meet the criteria of personality variation (**Johnson**).

### Universality of personality dimensions—a mad pursuit?

**Realo and Allik** objected to the idea that cross-cultural psychology could serve as a foundation for comparisons on other population levels, particularly across species, by illustrating the difficulties cross-cultural psychology has encountered in the attempt to identify pan-cultural human universals. Before I discuss this point, I want to warn against a misinterpretation of the distinctions among the three methodological core issues. The conceptualisation of personality variation that I borrowed from Leung and Bond (1989) has to be clearly distinguished from the behavioural repertoire approach I suggested as a methodology to identify trait domains in a species or population. Unlike Fiske's (1991) social relations model in the example given by **Realo and Allik**, the behavioural repertoire approach requires no assumptions about uniqueness or universality of the potential trait constructs it generates; instead, dimensionality and uniqueness versus universality are left entirely to empirical analysis. The approach is rooted in the emic–etic concept of cross-cultural psychology that can be generalised to bottom-up and top-down approaches in cross-species research (Gosling, 2008; **Weiss & Adams**; Weiss et al., 2006). Both in turn have to be clearly distinguished from any methodologies aimed at operationalising trait constructs. The behavioural repertoire approach neither specifies any particular assessment method nor any trait indicators to be used. Compared to lexical approaches, it facilitates the use of behavioural indicators that are needed to quantify the populations' positioning effects and that may be more appropriate for many species than single trait-descriptors like adjectives, but it does not exclude lexical indicators either. Similar to controversies between emic and etic traditions in cross-cultural research, achieving comparability and cross-population equivalence is a challenging issue that refers to both trait concepts and their operationalisations as I will discuss further below.

**Realo and Allik** illustrate nicely the difficulties encountered by cross-cultural research to identify universal psychological processes in view of their culturally influenced development and display; cross-species research encounters very similar difficulties given species-specific ontogenies and externalisations. The approach of Leung and Bond (1989) was successfully applied to identify different emic and etic dimensions in some cross-cultural studies (e.g. Triandis et al., 1993). As **Realo and Allik** emphasise, however, no universal dimension proposed by cross-cultural psychology 'has won an overarching support across different research schools and subfields of cross-cultural psychology'. Yet these difficulties may arise from the nature of culture, that is the studied constructs, rather than from the analytical methodology.

In its broadest sense, culture refers to 'symbolically mediated, shared systems of meaning' (Tuttle, 2001) that are arbitrary and therefore vary geographically. At their core are socially transmitted innovations spreading until they hit some barrier, thereby producing geographic differentiation (van Schaik, 2004). Compared to evolutionary

changes, cultural variations can evolve and change quite quickly (Chen, Cen, Li, & He, 2005; Lewin, 1947). Both arbitrariness in the meaning of behaviours and artifacts, and their rapid changeability suggest that pan-cultural findings on culturally derived traits may be much more unsteady than evolutionarily derived and thus neurobiologically influenced traits. Yet, the emergence of cultures itself is seen as an evolutionarily adaptive strategy used by human and nonhuman species (e.g. chimpanzees and orangutans), and may thus be a universal property of these species. Given that the cultures of different species (and maybe also of different same-species populations) can rely on different processes of social transmission, they can exhibit different global properties (Boesch & Tomasello, 1998). This may hinder identifying pan-cultural universals across the specific cultural systems that different populations produce.

Behavioural approaches may be more appropriate to identify human universals than language-based approaches such as lexical approaches given that people can communicate with hands and feet all over the world but not in their mother tongues. Behavioural approaches may also facilitate identifying cross-species universal trait dimensions (**Johnson**), for which there is already empirical evidence from animal personality psychology (Gosling, 2001; King & Figueredo, 1997; Weiss et al., 2006) and from biological disciplines that have established a substantial body of evidence for the existence of a shyness–boldness dimension in a number of species (Wilson, Clark, Coleman, & Dearstyne, 1994) including species of molluscs (Sinn et al., 2006), spiders (Riechert & Hedrick, 1990), crustaceans (Briffa, Rundle, & Fryer, 2008), fish (Bell & Sih, 2007; Sneddon, 2003), reptiles (Brodie III. & Russell, 1999), birds (Carere & van Oers, 2004) and mammals (Réale, Gallant, Leblanc, & Festa-Bianchet, 2000). Moreover, striking observable differences in shy–bold behaviour between species (*cf.* antelopes with lions) suggest that shyness–boldness may be even a strong universal trait dimension that differentiates individuals not only within but also across species depending on their degree of being prey or predator species. Given the present within-species data, it seems possible that such a strong universal shyness–boldness dimension spans even different animal *phyla* from *mollusca* and *arthropoda* to *chordata* covering both invertebrates and vertebrates. Studies testing this hypothesis empirically using universal and species-comparative analyses (see my target paper) to identify the species’ positioning effects seem promising but a little ‘mad’ indeed given the enormous effort required for this task.

### Universality and uniqueness in a population’s personality structure

Beyond the evidence for specific cross-species universal trait dimensions such as shyness–boldness, phylogenetic continuities implying homologous features inherited from common ancestors also suggest the existence of some universal trait dimensions (John & Srivastava, 1999), whereas niche-differentiated adaptations suggest the existence of species-specific trait dimensions (Tooby & Cosmides, 1989). Because all species have a phylogenetic history and show adaptations to a particular ecological niche, most species exhibit both universal *and* unique trait dimensions in their personality structure. For example, present results on the human personality structure suggest that fundamental common biological processes may underlie universal trait dimensions that are shared with other species (**Johnson**), whereas species-specific mechanisms such as cultural socialisation or higher cognitive information processing may underlie uniquely human dimensions (**Realo & Allik**). That is, both universal and unique dimensions co-occur in the human personality structure. Nevertheless, it is conceivable that some species share

exactly the same set of major dimensions without exhibiting any species-specific dimensions; given the diversity of species-specific adaptations and mechanisms such cases of universal personality structures may be rare.

## IDENTIFYING DOMAINS OF VARIATION

Assumptions of phylogenetic continuities between species are also sometimes used as rationale to identify *domains* of trait dimensions (Weiss & Adams). I proposed a taxonomy differentiating basic types of approaches commonly used to identify trait domains at the population level in human and nonhuman species (ignoring theoretical approaches that start from intra-individual processes to derive personality traits, for example Smillie's target paper, this issue). These methodological approaches differ in starting points based on particular rationales.

### A taxonomy of rationales to identify trait domains

Whereas some rationales refer to *strategies to overcome the selection bottleneck* (see my target paper), others focus primarily on the *content of the domains* to be studied for dimensionality. For example, the rationale behind lexical bottom-up approaches, that is the assumption that important human traits are socially perceived and lexically encoded (Allport & Odbert, 1936; Goldberg, 1990), formulates an exhaustive selection strategy; but it does not specify *which* domains this selection should cover. The assumption of phylogenetic continuity between different species, by contrast, suggests that the content of *specific* trait domains could be applied top-down to other species (John & Srivastava, 1999).

**Weiss and Adams** argue for the validity of a phylogenetic approach to animal personality at least for closely related species, which raises the question of where exactly on the phylogenetic continuum one should draw the line between 'closely' and 'distantly' related species. For example, one could argue that chimpanzees are more closely related to humans than are orangutans but compared to dogs orangutans are the more closely related species. Which criteria should we use to decide whether dogs or horses are related closely enough to humans to justify adapting the content of human trait domains top-down to these species?

Content-related rationales like that of the phylogenetic approach are problematic on two fronts. First, they may fail ecological validity (Gosling, 2001) and comprehensiveness (Uher & Asendorpf, 2008). That the primary-level trait dimensions covered by the human Big Five factors (even if complemented with elements of nomination approaches) cluster empirically into different higher order dimensions in different species (**Weiss & Adams**) does not show that these species-specific factor structures represent the species' true trait taxonomies appropriately. Instead, when applied top-down from humans some dimensions may suffer anthropomorphic or other biases while others may be even completely missing because they either are not exhibited by humans or were systematically excluded by non-empirical reduction in Big Five traditions (Saucier & Goldberg, 1998; Uher & Asendorpf, 2008). Failure to identify species-specific primary-level or even higher order dimensions results in biased or missing representations of the species' true major dimensions. Unless assumptions on the concurrent validity and comprehensiveness of the lexically derived Big Five domains for human and nonhuman animals are tested, which ultimately requires

convergence from different, independent approaches (**Nave, Sherman & Funder**), it is 'particularly difficult to justify the common claims that results from these approaches reflect underlying temperament or biology' (**Johnson**).

The second limitation of content-related rationales refers to the interpretation of empirical outcomes. A mere phylogenetic approach imposes an *a priori* theoretical explanation of any possible result ignoring alternative explanations. Rather than *homologues* indicating phylogenetic continuity (**Weiss & Adams**), similarity of personality traits among species could likewise indicate *analogues* that reflect shared adaptation to similar environments (Immerman & Mackey, 2003; Rychlak, 1968). For example, whereas orangutans share large parts of our phylogenetic tree but have adapted to swampy rain forests (van Schaik, 2004), dogs share much less of our phylogenetic tree but have adapted to our environments (Hare & Tomasello, 2005; Trut, 1999). Interpreting findings on factors resembling some of the human Big Five in orangutans (Weiss et al., 2006) and dogs (Gosling, Kwan, & John, 2003) alike as evidence of their phylogenetic origins (**Weiss & Adams**) ignores that this similarity could likewise result from evolutionary convergence (Gosling, 2001; Gosling & Graybeal, 2007). Evolutionary convergence may have happened not only in cognitive abilities (Hare & Tomasello, 2005) but also in personality traits given that initial domestication processes are based on artificial selection for personality traits (Belyaev, 1969) and that in dogs selective breeding for behavioural dispositions shows effects in only a few generations (Svartberg, 2006). It may therefore be not by chance that top-down approaches from the human Big Five factors concentrate either on closely related primate species or on domesticated species, whereas investigation of other species has largely evaded this tradition so far.

Given the complexity of the human brain and the diversity of habitats to which *Homo sapiens* has successfully adapted, there is little doubt that humans have developed the most complex personality structure of all species. But this does not mean that it covers *all kinds* of personality variability that possibly exist in the animal kingdom. An anthropocentric phylogenetic approach that is applying concepts just one-way from human to nonhuman species may therefore be misleading and may be prone to overlooking species-specific traits that humans do not exhibit but that even closely related species such as orangutans may have developed in adaptation to their particular ecological niches. It would be thus more consistent with evolutionary theory to complement phylogenetic approaches with adaptive approaches.

Strategy-based rationales such as those of systematic bottom-up approaches avoid restrictions to any particular theory in regard to the content of trait domains to be selected. Instead, they tackle the merely descriptive task of measuring and cataloguing observable personality variability in a population to provide this information for subsequent theoretical and further empirical analyses covering Tinbergen's (1963) four interrelated key questions (**Nettle**) of function (**van Oers**), evolution (**Johnson; Weiss & Adams**), causation (**Carere & Maestripiéri; Nave, Sherman & Funder**) and development (**van Aken; Realo & Allik**). Strategy-based rationales thus distinguish descriptive methodology from any theoretical explanations and further empirical explorations of the yielded primary results. The most successful methodology applied to map trait taxonomy, the lexical bottom-up approach, was based on such a rationale. It established a reference model for theoretical and empirical developments in various fields including behaviour genetics (Jang et al., 2006; Yamagata et al., 2006), personality development (Roberts et al., 2005), evolutionary personality psychology (Buss, 1999; Nettle, 2006) and animal personality psychology (Gosling, 2001; King & Figueredo, 1997; Weiss et al., 2006). The

behavioural repertoire approach is also based on a systematic strategy-related rationale and thus constitutes an independent alternative to this approach.

### **The person–situation controversy 40 years after Mischel (1968)**

Ultimate explanations of behaviour on the population level, that is phylogeny and adaptivity, require proximate explanations, that is proximate mechanisms and ontogenetic development, on the individual level (Tinbergen, 1963). Therefore, comparative personality research considers not only the environment of evolutionary adaptedness but also the individual's immediate and developmental environment (**Nave, Sherman & Funder; van Aken; van Oers**). **Van Aken** nicely illustrates the tight interrelations among individual–situation interactions, individual personality development and individual adaptation throughout different ontogenetic transformation periods affecting an individual's course of life. Pertinent empirical research is also beginning to emerge in the nonhuman domain (e.g. Bell, 2007a; Frost, Winfrow-Giffen, Ashley, & Sneddon, 2007). Ultimately, adaptation on the individual level underlies adaptation on the species level, of which successful adaptive variants are retained phylogenetically (**Johnson**).

All disciplines incorporate situations at least implicitly in their empirical research. For example, crabs and squids are exposed to threatening anti-predator situations (Briffa et al., 2008; Sinn, et al., 2006), birds and fish to novel objects (Carere & van Oers, 2004; Frost et al., 2007), mice and cattle to open field tests (Ibáñez et al., 2007; Müller & von Keyserlingk, 2006) and monkeys to social strangers (Fairbanks, 2001). Situations are also incorporated in animal personality ratings either explicitly in the items (Uher, under review), in clarifying sentences (**Weiss & Adams**) or implicitly in adjectival connotations (**Weiss & Adams**). Disciplines differ, however, in how explicitly they incorporate situations in their theoretical conceptions (see, e.g. **Carere & Maestriperi; Weiss & Adams**). They also differ in the standard terminology they use (**van Oers**), which requires first awareness that such differences exist at all, and second careful explanation and consideration of the concepts and terms used by different disciplines to facilitate mutual understanding. How easily communication across disciplines can go awry is shown by the commentary by **Carere and Maestriperi**.

**Carere and Maestriperi** wrote that to them as biologists it remained unclear what I meant by situations, universality and domains—terms that are commonly used in cross-cultural and mainstream psychology. Although these are just a very few terms, they proved to be so central that misunderstanding them let **Carere and Maestriperi** misunderstand the methodological approach that I proposed. The psychological notion of a situation is quite broad; for example 'absence of specific situational stimuli' as discussed by **Carere and Maestriperi** also characterises a situation, one of deprivation. An individual is always in some kind of immediate environmental situation with which it interacts and in which it thus behaves; situations provide the proximal triggers for behaviour (**Nettle**). That situations can be classified by their specific psychological properties for a particular individual or population (**Nave, Sherman & Funder; Ten Berge & De Raad, 1999**) has nothing to do with 'Skinnerian' views on behaviour (**Carere & Maestriperi**). Instead, situations are vital for personality research because individuals vary in how they perceive and respond to them, and which situations they seek out and shape (**Carere & Maestriperi; Fleeson, 2004; Funder, 2006; Nave, Sherman & Funder; Nettle; van Aken; Weiss & Adams**).

Whereas behavioural biology and general psychology study the general behaviour of the *average* individual, comparative personality research explores *inter-individual variability* in this general behaviour of a species or any other population. This differential perspective inevitably requires more fine-grained analyses of behaviour and the situations in which it occurs because not every behaviour is informative about inter-individual differences in personality and neither is every situation suited to the differential expression of behaviour. It is well established in psychology that the trait relevance of a situation and how much it restricts behaviour, that is situational strength, determine whether personality differences can be observed, and that individual situational responsiveness shows up in stable patterns of individual–situation interactions resulting in only moderate cross-situational consistency on the population level (Mischel, 1977; Mischel et al., 2002; Tett & Gutermann, 2000). These findings are also informative for animal personality research (Uher, under review; Uher et al., 2008).

In biological personality research, theoretical conceptions of context dependence and limited behavioural plasticity in regard to consistency across situations emerged only relatively recently (DeWitt, Sih, & Wilson, 1998; Sih et al., 2004). The growing number of pertinent empirical studies (e.g. Briffa et al., 2008; Spooler, Burbidge, Lawrence, Simmins, & Edwards, 1996; van Oers, Klunder, & Drent, 2005) indicates an increasing awareness of the role of environmental situations in basic concepts of personality. As the commentaries show, animal personality research seems to go through exactly the same controversies arising around individuals, situations and personality as human personality psychology did throughout the last four decades. This suggests that, in contrast to **Nettle's** assumption that 'the controversy would probably never have arisen if personality studies were largely based on direct measurement of behaviour, in which the interplay of triggering situations and individual variability in thresholds is easier to assess', the person–situation controversy seems in fact to be a profound conceptual issue, not one of measurement. While human personality psychology now regards the controversy as coming to an end (Fleeson, 2004) and being resolved (Funder, 2006; **Nettle**), it still needs much more attention in animal personality research. Animal researchers could profit greatly from the lessons learned by human personality psychologists, who in turn can use results gained in animal research to broaden and sharpen their concepts (**Nave, Sherman & Funder**).

### The behavioural repertoire approach

The strategy-related rationale of the behavioural repertoire approach explicitly considers the triad of behaviour, situation and personality (Funder, 2006) and may be best expressed by Mischel's notion of personality traits as the 'conditional probability of a category of behaviours in a category of contexts' (Wright & Mischel, 1987). It thus reflects the basic nature of personality as inter-individual differences in the dynamic internal organisation of the individual's behavioural interactions with its environment *without* specifying any particular domains. Whereas animal researchers unanimously demand trait identification to be mandatorily linked with assumptions about underlying mechanisms (**Carere & Maestripieri**), processes of maintenance (**van Oers**) or phylogenetic origins (**Weiss & Adams**), the behavioural repertoire approach is stripped of any such beliefs as is the most widely used lexical bottom-up approach in human personality psychology. Instead, it explores the personality variability of a population descriptively as a first step *prior* to any

explanatory analyses aimed at answering Tinbergen's four key questions with respect to personality functioning (see also my target paper; Bell, 2007b; **Nettle**).

Unfortunately, terminological misunderstandings hindered **Carere and Maestripieri** from fully understanding the methodology of the bottom-up approach I suggested so that they relied instead on one of my empirical studies (Uher et al., 2008) in which I tested its viability. Because they picked the behavioural study and not the rating study (Uher, under review; Uher & Asendorpf, 2008), they erroneously concluded that the approach would be based on an ethogram, which is not the case. In contrast with most other behavioural or lexical bottom-up approaches, the behavioural repertoire approach starts at the *conceptual* level, not at the *operationalisational* level, which **Nave, Sherman and Funder** described as 'a step up from and an improvement upon truly bottom-up approaches that start from scratch, measuring many behaviours which may have little or no psychological meaning'. This again refers to the importance of distinguishing the three methodological core issues clearly. The behavioural repertoire approach itself only generates potential trait *constructs*. To analyse these theoretical concepts empirically for dimensionality and their hierarchical structure, they must then be operationalised for empirical tests, for example with rating items but also with behavioural measures that could be compiled in one or even several different ethograms (considering different situational properties).

Several steps are needed to generate potential trait constructs systematically. First, all important behavioural domains and related situational properties known in a species must be identified. I have already highlighted the broad psychological notion of situations and their role in personality research. The notion of domains is similarly very broad in psychology (e.g. cognitive, emotional or motivational domains of personality in Chen & West, 2008) and is more abstract than that of homogeneous and disjunctive categories. Behavioural domains broadly refer to groups of different behavioural categories that are meaningfully related but do not necessarily share the same type of category and interrelatedness. This notion of domains is very similar to that incorporated in the widely discussed concept of domain-specific versus domain-general expression of personality traits in both biological and psychological disciplines (Carere, Drent, Privitera, Koolhaas, & Groothuis, 2005; Chen et al., 2005; Sih et al., 2004; Sinn & Moltschaniwskyj, 2005; van Oers et al., 2005).

**Carere and Maestripieri** are completely correct in saying that one and the same behaviour can be studied from various perspectives (e.g. as social or motor behaviour) for which different ethograms are needed. This is exactly the reason that single ethograms are insufficient for comprehensive attempts to map a species' personality structure. I therefore argued for relying on the existing expert knowledge gathered on the particular species' behavioural repertoire instead of studying behaviour from scratch (**Nave, Sherman & Funder**). Figure 2 of the target paper relies on four decades of behavioural research in great apes predominantly done in their natural environments to ensure capturing all known important parts of their natural behavioural repertoires (for references see my target paper). Under natural conditions, aberrant behaviours occur only infrequently and are considered by many as having little relevance for personality research that focuses on normal variation, not on pathological deviation. Figure 2 in the target paper thus summarises the domains of expert knowledge gained from countless different ethograms and research agendas studying very different aspects of these species' behaviours covering diverse functional and conceptual behavioural categories, societal structures and different periods of life. I referred to these domains as the 'biological classification of the species'

universal behaviours' because these are the topics primatologists typically identify as important. I also used all labels from this literature.

The rigid thinking in terms of homogeneous and disjunct categories inherent to ethograms is helpful for collecting behavioural data for a particular research question, but hinders a comprehensive selection of domains of potential behavioural variability in a population on the *conceptual* level. **Carere and Maestriperi** asked why the grouping of the behavioural domains and subdomains in Figure 2 of the target paper is not considered in the behavioural repertoire approach. The reason is that morphological and functional interrelations of observable behaviour need not be related to underlying personality variation (see also Bell, 2007b). This is consistent with the notion that personality pervasively influences behaviour in all areas of life and is thus not limited to particular types of behavioural categories to which ethograms are confined.

Each of the domains and sub-domains in Figure 2 of the target paper comprises several broader behaviour categories that are not necessarily of the same type and that might not necessarily fit into one single ethogram. I referred to them as universal behaviours because these behaviours are generally shown by most if not all members of a species, rather than only by certain individuals (e.g. approach, investigation, play, attack). This is consistent with the usage of this term in cross-cultural and human personality psychology, which is also reflected in the proposed conceptualisation of universal trait dimensions within and across populations (see my target paper).

In the last step of trait generation, these universal, psychologically meaningful behaviours and related situational properties are then plotted against each other to derive potential trait *constructs*. Merging both behavioural *and* situational categories is central to the strategy-based rationale of the behavioural repertoire approach; this point seems partly misinterpreted by some commentaries. Instead, it explicitly considers individual–situation interactionism, which has arisen as the resolution of the person–situation controversy in trait psychology (Fleeson, 2004; Funder, 2006; **Nettle; Nave, Sherman & Funder**; Ten Berge & De Raad, 1999; see above and my target paper).

## MEASURING VARIATION

After conceptualising personality variation (first core issue) and identifying *potential* trait domains (second core issue), the next epistemological step concerns measuring *empirical* variability in the selected domains in the given population with suitable trait indicators (third core issue). Hierarchical trait taxonomies are again useful to highlight basic principles (see Figure 1). The more primary-level dimensions located near to the bottom of the hierarchy such as specific habitual acts and trait facets can be measured with homogeneous and less diverse trait indicators, whereas the broad personality factors near to the top of the hierarchy can only be inferred from diverse, more heterogeneous trait indicators (Costa & McCrae, 1995; Eysenck, 1990).

### Ratings and behaviour observations

Extracting personality traits as stable individual *tendencies* from the fluctuations of spontaneous behaviour requires (unlike transient states) extensive direct observation. Behaviour measures must therefore rely on sufficient aggregation at least across multiple occasions if not even across different situations and behaviours (Epstein, 1979, 1980).

Personality ratings capitalise on the human ability to aggregate such observations mentally to form overall judgements (Funder, 1995, 1999), which facilitates the large-scale data collection needed to establish trait taxonomies but renders ratings prone to bias and leaves their validity open to some extent. Therefore, ratings should be validated through convergence with observable behaviour measures of personality (Baumeister et al., 2007; **Johnson; Nave, Sherman & Funder; Nettle**). For nonhuman research, this step is indispensable (Uher & Asendorpf, 2008). Researchers favouring ratings often seem to forget that this method's economy largely derives from the division of labour with those colleagues who make the extensive and long-lasting empirical effort to validate them in the first place. In animal personality psychology, such efforts are still missing (Uher, under review).

Behaviour measures have high ecological validity and can be obtained as reliably as ratings (Uher & Asendorpf, 2008; Uher et al., 2008) provided they have sufficient levels of aggregation, for example regarding the number of occasions or the diversity of situations they reflect (the so-called principle of symmetry, Wittmann, 1987). Behaviour measures are neither inferior nor poor measures of personality (Gosling, 2008; Vazire et al., 2007); instead, they are essential to quantify positioning effects of populations, which are biased by reference group effects on the part of the raters (see my target paper; Heine, Lehman, Peng, & Greenholtz, 2002). Moreover, behavioural personality measures can be obtained in all species, whereas ratings may overextend human ability to differentiate larger numbers of individuals reliably and to aggregate their behavioural differences mentally, for example in morphologically small or distantly related species such as of molluscs, insects, spiders or fish. Such species are typically not among those studied with ratings; the majority of species studied with this method (developed in human personality psychology) constitute again primate and domesticated species (see for an overview Gosling, 2001, pp. 48–57).

### Levels of comparability

To be meaningful at all, trait measures must consider differences in trait expression among populations, particularly among species. **Weiss and Adams** and to some extent also **Realo and Allik** objected that the lack of a common metric would render such measures incomparable. However, populations are compared on the *conceptual* level, not on the operationalisational level; this again refers to the distinctions among the three methodological core issues (see Figure 1). Neither making trait indicators more specific (**Realo & Allik**) nor relying on identical indicators (**Weiss & Adams**) will automatically achieve comparability of trait constructs; instead, congruence must be established *empirically* for each set of indicators in each population anew. The same argument applies to the comparability of situations across different populations (**Nave, Sherman & Funder**).

The issue of trait operationalisation across populations, especially species, involves one of the most fundamental issues in the philosophy of sciences: How can we pursue objectivity? What does it mean to peer into the world scientifically (Daston & Galison, 2007)? Identical trait expressions never occur among species (and in fact often not even among same-species individuals). Attempts to generate trait indicators as 'common metrics' that are comparable across species by filtering out these obvious incongruities *implicitly* are therefore prone to bias (Uher & Asendorpf, 2008). Such trait indicators are the results of 'fallible human' researchers 'who impose regularity and comparability that

shuns incongruence' in trait expressions and may never be accurate for all species (Daston & Galison, 2007, p. 15). Instead, operationalisations of the same trait constructs have to be (and often can be) adjusted to the specifics of each population.

For example, the situational settings and the behavioural measures used to study shyness–boldness differ between species. Whereas squids (*Euprymna tasmanica*) are touched on their arms with eyedroppers (Sinn et al., 2006), birds (*Parus major*) are confronted with plates springing up in front of them (van Oers et al., 2005), and crabs (*Pagurus bernhardus*) are lifted out of the water and held shortly upside-down before they are replaced with their shell aperture facing upwards (Briffa et al., 2008). These different procedures simulate species-specific threat situations that are ecologically valid for each species but not identical across them. The behavioural responses elicited in these studies are likewise species specific; squids move away by jet propulsion or grab the stimuli with their arms, birds fly away and crabs withdraw into their shells; latencies to return or re-emerge respectively are measured as indicators of shyness–boldness. Despite their obvious incongruence, all these trait indicators reflect a degree of risk taking and recovery from a startle within each species' behavioural ecology. The common metric thus arises from the shared biological functions of the situations and behaviours, and from the structure of empirical convergence of the multiple indicators within each species that are used to infer the underlying trait construct.

A methodology for establishing structural equivalence of trait constructs for comparisons at different population levels *empirically* was developed in cross-cultural psychology (van de Vijver & Poortinga, 2002). These authors point out four fallacies in multi-level research due to crossing two fallacy dimensions. The first dimension refers to the kind of characteristic that is incorrectly applied to another level, which can be either a score value, that is data obtained from the individuals might not apply to the population and vice versa (*level fallacies*), or a concept (*structural fallacies*). The second dimension specifies the direction of this incorrect inference, that is to a population level of higher order (*generalisation fallacies*) or lower order (*specification fallacies*). Whether level fallacies are committed is analysed with hierarchical linear models (e.g. Bryk & Raudenbush, 1992); to analyse structural fallacies, van de Vijver and Poortinga (2002) proposed a methodology based on exploratory multi-level factor analysis.

Structural or functional equivalence of constructs across different population levels forms important evidence that these constructs have the same psychological meaning across these levels. Van de Vijver and Poortinga (2002) emphasise that even when structural equivalence was shown at the individual level, aggregation on the population level may cause shifts in the meaning of trait constructs (van de Vijver & Leung, 1997a, 1997b). This means that equivalence at the individual level is a necessary but insufficient condition for cross-level equivalence. Demonstrating factorial congruence at different levels of aggregation is both a necessary and sufficient condition for the structural equivalence of a set of indicators reflecting same meaning of the constructs across different population levels and thus an *empirical* common metric. If constructs are not structurally equivalent, scores at one level involve partially or entirely different constructs so that interpretations become vulnerable to generalisation or specification fallacies (van de Vijver & Poortinga, 2002). If a construct is not adequately measured, correlations with important external variables (e.g. environmental parameters) are also compromised (Chen & West, 2008).

Generalising the technique of Muthén (1991, 1994), van de Vijver and Poortinga (2002) proposed to examine congruence of constructs by comparing the data structure of the

studied trait indicators using three types of covariance matrices. Similar to the Leung and Bond (1989) methodology, the first is a (*universal*) common-covariance matrix of the total sample performed on all individuals ignoring their population membership; the second is a (pooled *population-specific*) pooled-within covariance matrix based on the separate populations' factor loadings (weighted by their sample size); the third is a (*population-comparative*) between-covariance matrix computed on the basis of the population means of the various indicators. After target rotation has been carried out, the degree to which the factor loadings of comparable trait indicators are equal at different population levels is then analysed statistically as agreement between the different matrices using factor congruence coefficients (for detailed descriptions on the specific procedures see van de Vijver & Leung, 1997a, 1997b; van de Vijver & Poortinga, 2002).

First steps towards full application of this methodology have already been taken in animal personality research. For example, the structures of anxiety-related behaviours in the widely used elevated plus-maze test were compared in mice (*Mus musculus*) and pigs (*Sus scrofa*), two mammalian species with different evolutionary origins, morphological sizes and behavioural repertoires (Janczak, Andersen, Frevik, Bøe, & Bakken, 2002). The similarities of the correlation matrices of these two species' behaviours were compared only descriptively in this study (due to lack of pertinent statistical methods, p. 159), but a more recent study could demonstrate a statistical analysis of the cross-setting equivalence of some Big Five factors rated in two different populations of captive chimpanzees (Weiss et al., 2007). The methodology of van de Vijver and Poortinga (2002) can be used to analyse the cross-level equivalence of trait constructs in multiple populations or species.

In principle, analyses of the equivalence of trait operationalisations across language- and culture-specific trait indicators are structurally identical to those of the equivalence of operationalisations across species-specific behavioural trait indicators. Lexical personality research can take advantage of the tremendous efforts taken in linguistic research to compile dictionaries that translate different languages into one another. To analyse the structural equivalence of species-specific behavioural trait indicators and related situational properties across species, behavioural personality research has to rely on the efforts taken in the behavioural sciences to uncover the biological functions of specific behaviours and situations in each species.

Given the enormous diversity of species, this task can only advance stepwise and requires separate consideration of behaviours and situational properties that are nevertheless interdependent. The Janczak et al. (2002) study used a suitable design to compare species-typical factor structures of behavioural trait indicators in a more or less identical situation. Designs that allow comparing different situational properties across species are also needed. An often neglected but crucial aspect is situational strength. It is obvious that the proportion of individuals classified as shy or bold in a sample varies with the strength of the studied situation; too strong stimuli restrict behavioural variation too much so that most individuals will appear shy. Therefore, the strength of each studied situation has to be chosen such that similar distributions of behavioural types across species result (e.g. norm distribution). This will lay the foundations for empirical studies of universal trait dimensions (see my target paper). For example, because antelopes as a species are observably shyer than lions, the absolute situational strength needed to obtain a norm distribution of shyness–boldness behaviour in antelopes will be much weaker than that needed to obtain a norm distribution in lions. This difference in absolute situational strength is thus informative for comparisons of the species' mean scores that identify their

positioning effects on the shared dimension. These positioning effects are needed to distinguish weak from strong universal trait dimensions.

## PERSPECTIVES FOR FUTURE RESEARCH

A substantial body of methodology has been developed over the last century that permits tackling central issues in comparative personality research. But this expertise is scattered over various disciplines that are unfortunately lacking systematic exchange and collaboration. Biological disciplines that have started to study inter-individual differences only relatively recently (Sih et al., 2004) could profit greatly from the methodological and statistical advances made in psychological disciplines. Many fascinating studies are published on an ever growing number of species that often fail to unfold their full potential because suitable analytical methods are only insufficiently known. This applies in particular to factor analytic methods that are central to extract complex trait dimensions such as behavioural syndromes from a wide range of behaviours and to analyse their structural equivalence across populations.

In its relatively short history, biological personality research could nonetheless establish impressive evidence for the existence of personality differences even in distantly related species that—if someone had merely hypothesised the possibility of their existence—would have been regarded as audacious by most psychologists. Yet, human personality psychology continues to ignore this growing evidence beyond the species borders (Gosling, 2008), and only a small group of psychologists is concerned with animal personality. However, incorporating evolutionary theory into human personality research has already paved the way for broader, less anthropocentric psychological views on personality. Instead of restricting their interests to the most recent evolutionary past of one single species, *Homo sapiens*, psychologists would profit from considering the full scope of Darwinian theory to learn more about the evolutionary origins of our species and about basic mechanisms of phylogeny and adaptivity that can only be unravelled by exploring the evolved diversity of species.

It will be of foremost interest to identify comprehensive representations of the species' major dimensions of personality variation (i.e. their *hierarchical trait taxonomies*) as systematic reference models for any research aimed at their evolution, function, causation and development. Ideally, the *domains* of personality variation covered by each species' trait taxonomy should be identified through convergent evidence from different comprehensive methodologies (e.g. systematic bottom-up approaches and adaptive approaches, see my target paper). Suitable *measures* of these domains that match their specific manifestation should be identified for each studied population. Their ability to operationalise a trait construct comparably across different populations and population levels (i.e. their structural equivalence) should be analysed empirically using the methodology proposed by van de Vijver and Poortinga (2002).

A key component in such endeavours is the development of *basic principles to establish functional equivalence* and thus comparability of non-identical behavioural trait indicators and situational properties across different populations, particularly species. These principles will have to be based on the ecological properties of behaviours and situations for each population that provide the basis of cross-level comparisons of covariance

matrices. For example, functional equivalence of shyness–boldness indicators could be established by the degree of risk taking inherent to different situations for each species and by the probability to which different behaviours allow perceiving, reducing, escaping from or even repelling acute threats. More fine-grained analyses could follow that analyse the proportion of different types of risk-taking behaviours typically shown in a species as further indicators of species-level differences in shyness–boldness. For example, prey species such as antelopes will show more flight than fight behaviours, whereas predator species such as lions will show an opposite pattern, and species that are both prey and predator may show a more balanced proportion of both. Species may also be differentiated by their proportions of different types of risk-taking behaviours when seeking out situations in the first place.

Merging the evolutionary notion of personality traits as evolved strategies based on trade-offs with different costs and benefits (Bell, 2007b; Buss, 1991; Sih et al., 2004) with Mischel's notion of personality traits as the 'conditional probability of a category of behaviours in a category of contexts' (Wright & Mischel, 1987) could thus permit defining personality traits by their bio-socio-ecological functions. These functions probably become more apparent in behavioural trait indicators than in lexical indicators that are based on perceptions of lay people filtered and modified by cognitive, social and cultural appraisal processes. Concepts of folk psychology often fail to reflect underlying biological and evolutionary processes and mechanisms adequately. Defining trait constructs by their bio-socio-ecological functions may therefore help to reduce the 'present Babel' (Realo & Allik) of the predominantly lexically derived concepts and measurement scales in psychology. For more strongly biologically determined universal trait constructs, bio-socio-ecological functions are probably more obvious and more general than for predominantly culturally or cognitively determined uniquely human trait constructs, for which bio-socio-ecological functions may be much more fine-grained and therefore more difficult to unravel.

Comprehensive trait taxonomies and structurally equivalent trait constructs form the basis of systematic species comparisons to identify species-specific, weak and strong universal trait *dimensions* (see my target paper) that will be particularly illuminative in understanding evolutionary principles underlying personality variation.

I have explored three methodological core issues framing a voluminous but promising research agenda for comparative personality research that capitalises on the complementarity of the different expertises of the disciplines involved. We should start to diminish the hindering barriers and establish systematic exchange and cross-disciplinary collaborations to exploit this synergy. My suggestions of a common methodological framework within which I began to consolidate established conceptions across disciplines and to expand them to species comprehensive approaches can only be a starting point for future research.

### ACKNOWLEDGEMENTS

I thank Jens Asendorpf for helpful comments on the manuscript, and Wendy Johnson for stylistic corrections. Preparation of this paper was supported by a Ph.D. closure grant, Humboldt University Berlin.

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