Cognitive Variation: The Philosophical Landscape

Zina B. Ward

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Abstract: We do not all make choices, reason, interpret our experience, or respond to our environment in the same way. A recent surge of scientific interest has thrust these individual differences into the spotlight: researchers in cognitive psychology and neuroscience are now devoting increasing attention to cognitive variation. The philosophical dimensions of this research, however, have yet to be systematically explored. Here I make an initial foray by considering how cognitive variation is *characterized*. I present a central dilemma facing descriptions of individual differences, discuss several distinctions used to categorize variation, and show that these distinctions require further elaboration. Finally, by canvassing several philosophical topics for which the characterization of cognitive variation may have significant implications, I argue that philosophers should take note of how and why our minds differ.

Keywords: individual differences, variation, cognition, natural kinds, explanation, rationality, multiple realization

1. The Ubiquity of Cognitive Variation

Differences abound in human cognition. Priming effects have a large impact on some people and a marginal effect on others (Andrews et al. 2017). Some speakers plan their sentences well in advance, while others display less advance speech planning (Swets 2015). Hearing something repeatedly makes some people more likely to believe it but others less (Schnuerch et al. 2021). Far from being the exception, cognitive variation appears to be the rule. Such variation has long been of interest to psychologists, though often for unsavory reasons. Francis Galton and his fellow eugenicists studied race and class differences in service of social Darwinism, laying the foundation for contemporary statistics in the process (MacKenzie 1981, Gould 1981, Gillham 2001). After a period of deemphasis in the mid-twentieth century, during which time psychological regularities took center stage, cognitive variation is currently experiencing a scientific renaissance, now with less overtly exclusionary overtones.[1]

Many contemporary cognitive psychologists and neuroscientists are interested in how and why people differ from one another. Recent research has probed individual differences in attention (Unsworth and Miller 2021), belief updating (Douven and Schupbach 2015), creative cognition (Dygert and Jarosz 2020), fear acquisition and extinction (Lonsdorf and Merz 2017), language processing (Kidd et al. 2017), mental imagery (Reeder et al. 2017), pain sensitivity (Mogil 2021),

[1] Whether newer research on cognitive variation has shed its prejudicial past is an important topic, but not one I will discuss (see, for instance, Fine 2010, Bluhm 2013, Winston 2020). Even during the mid-twentieth century, the study of variation remained at the fore of "differential psychology," which primarily studies personality and intelligence, and which traces its roots back uncritically to the "amazing contributions" of Galton (Revelle et al. 2011, 8).

visual categorization (Shen and Palmeri 2016), and working memory (Vogel and Awh 2008). Of special interest to philosophers may be variability in causal cognition (Buehner et al. 2003), inductive generalization (Navarro et al. 2006), and moral decision-making (Gawronski et al. 2017). Optimism among scientists about the potential fruits of individual differences research has fueled this explosion of work. Seghier and Price (2018), for instance, argue that variation is key to understanding the relationships between behavior, brain structure, and function, and so should be "celebrated" rather than suppressed.

This surge of scientific interest calls for a survey of the philosophical landscape surrounding cognitive variation. By "cognitive variation," I mean between-individual differences in human cognitive processes or their neural underpinnings. Much existing research focuses on variation that falls along demographic lines, like sex, gender, race, culture, and age. These differences raise many thorny issues all their own that I will not address (Kitcher 2001, Wilson 2018). For example, I won't discuss whether there is a "male/female brain" (Joel et al. 2015), nor whether cross-cultural diversity is an obstacle to psychological generalization (Henrich et al. 2010, 2022). I will also put aside questions about the extent of (particularly cross-cultural) variability in philosophical intuitions (Knobe 2019, Stich and Machery 2022), as the validity of armchair methods in philosophy is not my focus.

The epistemic, conceptual, methodological, and ethical issues surrounding cognitive variation are many, though the philosophical territory has yet to be charted. My aims in this paper are modest. I focus on how we *characterize* the individual differences that exist in a psychological domain. I argue in Section 2 that characterizing variation requires navigating between the twin dangers of assuming uniformity and treating every individual as unique. Section 3 turns to dichotomous categories used to classify individual differences: continuous or discrete, fundamental or evoked, noise or variation. These distinctions require clarification and elaboration. This is an important task because the nature of cognitive variation has many philosophical implications, which I briefly survey in Section 4. I hope to show that both psychology and philosophy stand to benefit from greater attention to how the differences between our minds are described and categorized.

2. The Uniformity/Uniqueness Dilemma

Cognitive variation presents a number of methodological challenges. This is, in part, because scientific tools are often geared toward the study of cognitive regularities rather than variation (Cronbach 1957, Hedge et al. 2017). It is also because research on variation faces a fundamental challenge, which I will call the "uniformity/uniqueness dilemma." Psychologists must neither assume that all people are the same, nor treat each individual as unique.

The first step in any investigation of cognitive variation is describing the individual differences that exist. We must understand what sort of variation there is before we can determine its causes, offer an explanation, or explore its implications. Bogen and Woodward (1988) characterize this descriptive task as one of "formulating the phenomenon." Moving beyond raw data, scientists must identify a phenomenon in order to make contact with theory. Variation presents a central challenge in the formulation of psychological phenomena. On the one hand, researchers can't treat every subject as the same if their behavior is sufficiently variable. Empirical adequacy and predictive success suffer when a model wrongly assumes uniformity. Aggregation can also be theoretically misleading, since averaging over variation can yield a model that doesn't capture individual behavior (Sidman 1952, Hayes 1953, Estes 1956). This is the "uniformity" pole of the dilemma. On the other hand, treating each person as entirely unique is incompatible with scientific generalization. It would rule out projecting results to new subjects or offering a common explanation of behavior. Modeling each individual separately is also likely to confuse measurement noise with genuine variation. This is the "uniqueness" pole of the dilemma. Psychologists' task is to navigate between the Charybdis of ignoring individual differences and the Scylla of treating each person as unique (Ward 2020).[2]

Determining the best way of navigating the uniformity/uniqueness dilemma is a central challenge in cognitive psychology and neuroscience. Although there are a number of ways of solving it, ongoing work aims to refine these approaches and determine which strategy works best in each context.

One intuitive way of navigating the dilemma is to assume that all subjects conform to the same psychological model, but that they have different values for one or more parameters. For instance, a simple model of a memory task might contain a parameter representing the speed at which subjects forget the stimuli. Differences in task behavior can be captured by assigning different subjects different values to this forgetting parameter. This strategy avoids both horns of the dilemma since it makes room for both similarity (in model structure) and difference (in parameter values) across people. There are, however, a number of complications that arise in its implementation. For one thing, directly estimating each individual's parameter values in an unconstrained manner threatens overfitting, with the estimated parameters reflecting noise as well as variation. To address this problem, psychologists have turned to hierarchical (or "multi-level") models, in which some parameters are determined by others (Shiffrin et al. 2008). Hierarchical modeling produces "shrinkage," biasing individual parameter estimates toward the population mean. Shrinkage is thought to lead to more accurate parameter estimates, since it makes overfitting less likely (Farrell and Ludwig 2008). There is also ongoing debate about whether to use Bayesian or frequentist techniques for fitting hierarchical models that capture variation (Lee 2011, Lee and Wagenmakers 2013, Bartlema et al. 2014).

Instead of positing individualized parameter values, another family of solutions to the uniformity/uniqueness dilemma involves identifying fixed groups of subjects and modeling each separately. By positing stable groups and assuming within-group homogeneity, psychologists avoid treating individuals as either unique or identical. One can find examples of this strategy in action in a number of domains, from category learning (Lee and Webb 2005) to perceptual decision-making (Navajas et al. 2017) to feature processing (cf. Thiele et al. 2017). In each case researchers partition variation by attributing it to discrete (sometimes latent) groups of individuals, characterizing each group independently. Navajas et al. (2017), for example, find variation in people's confidence reports in a perceptual decision-making task. They describe the variation by reference to two latent groups which are stable across testing sessions: confidence judgments by subjects in the first group depend on the perceived probability of being correct, whereas confidence judgments in the second group also reflect perceived uncertainty in task-relevant variables.

Philosophers have pursued a stable grouping approach to variation as well. Viola (2021) is critical of what he calls the "Platonic Brain model," the default assumption in cognitive neuroscience that every human's brain exhibits the same correspondences between neural structures and cognitive functions. Viola points out that structure-function mappings exhibit systematic individual differences. Using the Fusiform Face Area as a case study, he proposes that researchers identify structure-function mappings indexed to particular sub-populations, such as

[2] Coninx (2021) touches on similar ideas in her discussion of the trade-off between "idiosyncracy" and "generalizability" in research on pain.

experts and non-experts, demographic groups, or clinical populations. Viola is effectively proposing to resolve the uniformity/uniqueness dilemma for structure-function mapping by identifying groups in the population and separately representing the relationships they exhibit between brain structure and function.

Instead of ascribing variability to fixed groups, scientists also sometimes appeal to groups whose members change over time. The clearest example of this fluid grouping approach comes from the longstanding tradition in psychology of distinguishing between different strategies that subjects employ in performing a task (e.g., Chi et al. 1981, Payne et al. 1993, Scheibehenne et al. 2013). Siegler's (1987) classic study distinguishes between several strategies that young children use to answer addition problems. Earlier accounts had claimed children use the *min* strategy, counting up from the larger of the two numbers being added together. Siegler suggests that four other strategies are employed as well, with children often switching between strategies. Moreover, he argues that the appearance of uniform adoption of the *min* strategy is an artifact of averaging over multiple trials (Estes 1956). By attributing behavioral variation to the use of a small number of strategies, Siegler constructs transient groups of subjects whose behavior is uniform, evading the uniformity/uniqueness dilemma.[3]

This brief survey of ways in which the dilemma can be navigated is neither exhaustive nor exclusive (Bartlema et al. 2014). The development of different approaches for capturing cognitive variation, and debate about which approach is suitable in which domain, are ongoing.

3. Types of Cognitive Variation

Although individual differences are ubiquitous in psychology and neuroscience, not all heterogeneity is methodologically, theoretically, or philosophically significant. Its significance often depends on whether it constitutes noise or variation, and if it is true variation, whether it is evoked or fundamental, discrete or continuous. Understanding variation requires getting a firmer grasp of these three distinctions, none of which have a settled meaning.[4]

3.1 Noise vs. Variation

Researchers frequently separate individual differences that are unstructured, uninteresting, or random, from differences that are systematic, interesting, or theoretically important. The former are typically called "noise" and the latter, "variation" (Finn et al. 2017, Seghier and Price 2018; cf. Climenhaga et al. 2021). Different definitions of noise have been offered in the scientific (e.g., Faisal et al. 2008) and statistical (e.g., Upton and Cook 2008) literatures. Noise has also been a topic of discussion in philosophical debates about scientific phenomena (Bogen and Woodward 1988). McAllister (1997) claims that any dataset can be described as the sum of two components: a pattern and a level of noise. He argues that there are infinitely many such decompositions, corresponding to different noise levels stipulated by the investigator. (Phenomena are whichever patterns strike investigators as interesting.) For McAllister, then, noise is "the purely mathematical discrepancy between a given pattern and a data set" (220).

[3] Although I have treated this fluid grouping approach as distinct from the stable grouping approach, they are really opposite ends of a continuum (reflecting varying degrees of group stability).

[4] It is also common to find cognitive variation partitioned into the pathological and non-pathological. The latter is sometimes referred to as "normal variation," or variation in the neurotypical population. This distinction evokes protracted philosophical debates about disease and normality, which I will not discuss (Amundson 2000, Murphy 2021). It has also come under fire by those who reject the concepts of "neurodivergence" and "neuroatypicality" in favor of "neurodiversity" (Silberman 2015, Legault et al. 2021).

This conception of noise has been criticized on several fronts. Bogen (2010) claims that McAllister only considers "interference noise," which obscures a signal, but neglects noise as "din," which is identified without regard to a signal. Woodward (2010) argues that McAllister's account of noise makes the notion of overfitting incoherent. Overfitting is a concern only if data are taken to be indicative of phenomena that have an independent existence. But on McAllister's view, phenomena do not have an independent existence: decomposing data into noise and pattern is investigator-relative. Woodward proposes to instead think of noise (or error) as the influence of "local and idiosyncratic factors having to do with properties of instruments, measurement procedures, and the environment" (793). Data are causally influenced by both these idiosyncratic factors and the phenomena under investigation. Woodward also argues that phenomena, unlike noise, are "stable" and "repeatable" (794). This suggests individual differences must be stable and of investigative interest to count as genuine phenomena rather than noise.

While the aforementioned authors have contrasted noise with phenomena, Ward (ms) takes the foil of noise to be bona fide variation. On her view, noise is population variance in a trait or behavior that cannot be reduced by intervening on any of the variables in one's variable set. This view takes seriously the idea that noise is inimical to explanation: given Ward's account of what it takes to explain variation (see Section 4), noise is heterogeneity that cannot be causally explained. An implication of the view is that what counts as noise for one researcher may count as variation for another, depending on the variables of interest to each.

3.2 Evoked vs. Fundamental

Putting noise aside, the remainder of this section will focus on two distinctions within the realm of variation. First, one can distinguish individual differences based on their *origin.* One such distinction has roots in Cosmides and Tooby's (1992) notion of evoked culture. On their view, cultural variation is often produced by universal psychological mechanisms that are "activated" differently in different circumstances. Schulz (2021) has recently adapted the notion of evoked variation, highlighting the distinction between cognitive (and behavioral) variability caused by people possessing genuinely different psychologies, and variability that is the result of a shared psychology being "triggered" differently by the environment. He calls the former "fundamental diversity" and the latter "evoked diversity." Crucially, this distinction is always relative to a "bedrock level of analysis, the origin of which does not need to be further explained" (3). In psychology, Schulz suggests that psychological mechanisms are the bedrock: cognitive variability is fundamental if it is produced by different psychological mechanisms, but evoked if it results from "the same psychological mechanisms operat[ing] over different inputs" (4).

While useful, Schulz's distinction raises a number of questions. First, one might worry that it puts pressure on mechanism individuation. Figuring out whether cognitive variation is fundamental or evoked requires clear and univocal divisions between psychological mechanisms. Such divisions may not be available if mechanism boundaries are interest-dependent or if there are different mechanisms at different levels of abstraction (Craver 2009, Francken et al. 2020). There may also be variation that straddles the boundary between evoked and fundamental. Consider a case in which the development of a psychological mechanism itself is triggered by a feature of the environment. In one environment, the triggering conditions are met, but in another they are not. As a result, behavior differs across environments. Is this variation evoked or fundamental? Everyone had the potential to develop the psychological mechanism, but some did and some did not. Or consider a case in which everyone possesses the same suite of psychological mechanisms, but members of different populations use different mechanisms to accomplish a given task. Is this variation fundamental, since behavior is caused by different psychological mechanisms? Or is it evoked, since people simply deploy shared mechanisms differently? These questions suggest that the distinction between evoked and fundamental variation may not be clear-cut in practice.

3.3 Discrete vs. Continuous

In my view, the most important distinction to be drawn concerns the *structure* of cognitive variation. On the one hand, there are individual differences that are (or are best described as) discrete, qualitative, or categorical; on the other hand, there are individual differences that are continuous, quantitative, or dimensional. (I use these labels interchangeably here.) Psychologists trace this distinction back at least as far as Thurstone (1935) and Allport (1937). Many statistical methods have been proposed for determining whether variability in a dataset is discrete or continuous: from cluster analysis techniques (Sneath and Sokal 1973) to taxometric methods (Meehl 1999) to model comparison approaches (Bolger et al. 2019). My focus will not be on these methods, but rather on how the distinction is conceptualized. Making it precise, and determining if there is really just one distinction here or multiple (Serpico 2020), are important and unfinished tasks.

The distinction is most prominent in disciplines like neuropsychology and personality psychology, where variation is central. A primary aim of neuropsychologists is to determine whether each psychiatric disorder is "categorical or dimensional" (e.g., Muthén 2006, Trull and Durrett 2005). According to Haslam et al. (2012), the default assumption in neuropsychology has been that psychiatric conditions are categorical, while in personality psychology the situation is reversed, with researchers assuming personality differences are dimensional. Dimensional variation is understood to consist of differences in degree, or differences in characteristics possessed to some extent by everyone. Categorical variation, which involves discrete groups or categories, is captured by everyday talk about "two types (or, for that matter, any finite number of) types of people in the world" (Gangestad and Snyder 1985, 317).[5]

The distinction between discrete and continuous variation is now applied widely. Different psychologists characterize the distinction differently, sometimes incorporating additional commitments. Bartlema et al. (2014), for instance, argue that discrete differences are "more fundamental" and "correspond to major differences in cognitive processes," while continuous differences are constituted by "more minor parametric variation within a process" (133). Associating continuous variation with different individual parameter values is a recurring theme. Danks and Eberhardt (2009) distinguish between cases where individuals "have the same algorithm, but different parameter values" and those where individuals "have different underlying algorithms" (218). Note that conceiving of continuous variation in terms of differing parameter values makes the distinction model-dependent. Algorithms or processes may be parameterized in one model but not another.

The distinction between discrete and continuous variation is also fleshed out differently in different domains. In cognitive neuroscience, Viola (2021) and others take quantitative variation to involve differences in the degree to which a particular brain region or network is engaged during

[5] One might argue that neuropsychology shows that it is a mistake to equate discrete variation with qualitative variation. Many psychiatric categories are assessed using quantitative measures (e.g., anxiety scales). Kendell and Jablensky (2003) have argued that such disorders are valid categories if there is a "zone of rarity" between different parts of the scale (e.g., if individuals cluster at low or high values on an anxiety scale). One might argue that these cases feature quantitative variation that is nevertheless discrete or categorical. Thanks to Joe McCaffrey for raising this point.

task performance. Qualitative variation, on the other hand, consists in the engagement of different brain areas or networks. In psycholinguistics, Just and Carpenter (1992) deem variability in the speed and accuracy of reading comprehension quantitative. They discuss two examples of qualitative differences. First, when reading a syntactically ambiguous sentence, some people maintain two alternative interpretations of the sentence. Others simply select a single interpretation. Second, some readers' syntactic processing is influenced by pragmatic information, while others' is independent of anything nonsyntactic. It is notable that Just and Carpenter label these two sorts of variability qualitative, since others might conceive of them as matters of degree: in the number of interpretations of ambiguous sentences retained, and in the degree of "permeability" of syntactic processing to pragmatic information (134).

In a series of recent methodological papers, psychologists Julia Haaf and Jeffrey Rouder put their own spin on the distinction between qualitative and quantitative variation (Haaf and Rouder 2017, 2019; Rouder and Haaf 2019, 2021). They see psychology as a science of effects: the Stroop effect, the truth effect, priming effects, and so on. They argue that once psychologists establish the existence of an effect, they should turn their attention to the question, "does everybody have an effect in the same direction or is there variability in the direction of effects" (Rouder and Haaf 2021, 13)? Because psychological theory is coarse, individual differences in the magnitude of effects don't matter as much as individual differences in their sign. When there is variability in whether people's true effects are positive, negative, or null, Haaf and Rouder say the effect exhibits "qualitative variability." When every individual has a true effect in the same direction, there can only be "quantitative variability."[6] Qualitative differences are more theoretically significant, they argue, because psychological tasks often have a "natural zero point" (Haaf and Rouder 2019, 772). When true effects lie on both sides of the zero point, the phenomenon is "rich and complex" and implicates multiple theories. When individual differences are merely quantitative, a theoretical account of the phenomenon "should be relatively simple" (Rouder and Haaf 2021, 3). Haaf and Rouder develop model comparison techniques to help researchers determine whether variability is qualitative or quantitative. They suggest that true qualitative variation is probably rare (Haaf and Rouder 2019).

Rouder and Haaf (2021) also make a further distinction within qualitative variation: there are qualitative differences that can be "reduced" to quantitative differences, and those that cannot. They use research on the viral #TheDress image to illustrate the former. Qualitative differences in how people perceive the colors of the dress are caused by quantitative variability in lower-level perceptual mechanisms. Rouder and Haaf discuss *reducible* and *irreducible* qualitative variation only briefly; philosophical work on reduction could help fill out the distinction (Nagel 1961, van Riel and van Gulick 2019).

4. Philosophical Implications of Cognitive Variation

There is much work to be done refining strategies for navigating the uniformity/uniqueness dilemma and distinguishing between different types of cognitive variation. In this final section, I'll turn to the philosophical payoffs of these projects. Understanding cognitive variation has the potential to reshape our thinking about a variety of topics in the philosophy of science and mind.

[6] Note that these labels do not align with others' understanding of the distinction. Schubert et al. (2021) and Stocco (2021) claim that what Rouder and Haaf call qualitative variability is actually quantitative, since different individuals have different values along a single dimension, i.e., effect magnitude.

I'll focus on five such topics here. As my discussion is necessarily cursory, I hope only to survey existing work and convey the far-reaching significance of cognitive variation.

First, the nature of cognitive variation has implications for thinking about human nature (Machery 2008, Kronfeldner et al. 2014) and what is sometimes called human "psychic unity" (Lloyd 2007, Schulz 2021). Schulz (2021) argues that, if cognitive variation in a particular domain is merely evoked, humans are essentially alike with respect to that domain. By contrast, the discovery of fundamental variation between human populations would undermine the psychic unity of humankind (Machery 2010). Something similar can be said about continuous versus discrete variation. Many claim that discrete variation is more theoretically significant than continuous variation (Gangestad and Snyder 1985, Haaf and Rouder 2019; cf. Schubert et al. 2021). It's not a far leap to suggest that the existence of discrete differences would support a disunified picture of the human mind. If instead all cognitive variation consists in differences in degree, there is a sense in which our minds are deeply similar.

Whether individual differences are discrete or continuous also bears on questions about psychological kinds. As mentioned above, neuropsychologists distinguish psychiatric conditions that are categorical (true taxa or psychiatric kinds) from those that involve patients occupying the extreme end of psychological continua (Machery 2017). Diagnosing the latter, dimensional type of condition seems to require an element of convention. As Haslam et al. (2012) explain, if a latent variable is taxonic (i.e., discrete), "it must be conceptualized as an entity with real category boundaries that exist independent of social convention or descriptive convenience. If it is not taxonic then no boundary exists unless a manifest distinction such as a diagnostic threshold is imposed on arbitrary or pragmatic grounds" (903). Haslam and colleagues claim that most mental disorders are of the dimensional variety, failing to meet strict philosophical standards for natural kinds (Haslam et al. 2012, Haslam 2014).

Even within neurotypical populations, the nature of cognitive variation has implications for theorizing about kinds. Serpico (2018) claims that a "quantitative" conception of intelligence is incompatible with its being a kind. He draws on existing philosophical theories of natural kinds to argue that intelligence does not qualify. Coninx (2021) reaches the opposite conclusion in her study of pain. Some theorists reject pain as a kind because of "idiosyncratic differences" between its instances, both within and across individuals (8). While acknowledging this variability, Coninx argues that we can rescue pain as a scientific kind by appeal to Wittgenstein's notion of family resemblance. These examples show how cognitive variation enters in to arguments for and against particular kinds. It can also be seen to present a broader challenge to psychological taxonomy. Buckner (2015) argues that psychology is rife with "transitional gradation," which occurs when "the extension of one category blurs into the extension of another category or categories without an obvious dividing line" (1096). Although Buckner is not focused only on individual differences, continuous cognitive variation between people is surely one source of transitional gradation. Buckner claims that transitional gradation undermines the identification of kinds in psychology, at least if one endorses a similarity-based account of natural kinds (Boyd 1999). The paper therefore raises an urgent question: how can we reconcile continuous cognitive variation with talk of mental kinds?

We can also ask how cognitive variation is to be accommodated in philosophical theories of scientific explanation. Tabery (2009) argues that such theories neglect the question of what it takes to explain variability. Combining insights from the "new mechanist" tradition (Machamer et al. 2000) with Waters' (2007) concept of actual difference-making, Tabery proposes the concept of a "difference mechanism," which is a "regular causal mechanis[m] made up of difference-making variables" (648). He argues roughly that behavioral variation can be explained by appealing to underlying mechanisms whose component parts or processes differ, causing differences in the organisms' behavior. A contrasting approach, which rejects actual difference-making as a basis for a theory of explanation, is proposed by Ward (ms). Ward claims that explaining psychological variation requires exhibiting factors which can be intervened on to reduce the population variance in the trait or behavior of interest.

Although the presence or absence of cognitive variation may be thought to be a descriptive matter, it has several potential (if contentious) links to normative theorizing about rationality. Stanovich (1999) and Stanovich and West (2000) bring individual differences to bear on "the Great Rationality Debate," a controversy about whether human cognition is subject to systematic irrationalities. A key observation fueling the debate is that people's responses on reasoning tasks often deviate from what is considered correct. Theorists disagree about what to make of this "normative/descriptive gap." Some think that researchers fail to understand how subjects construe the reasoning tasks, and as a result are mistaken about which responses are in fact correct (e.g., Oaksford and Chater 1994). Stanovich and West (2000) reject this approach. They show that performance on the SAT, claimed to be a measure of cognitive ability, correlates with what is traditionally taken to be correct responding on those tasks (cf. Goodie and Williams 2000). They argue that this correlation vindicates the traditional standards of correctness, since "more reflective, engaged, and intelligent reasoners are more likely to respond in accord with normative principles" (Stanovich and West 2000, 652). The normative/descriptive gap is therefore best explained by the simple fact that people's computational limitations often hamper their reasoning.

Critics quickly responded (convincingly, I think) that one cannot draw normative conclusions about what is rational just by looking at what people with high SAT scores do. The SAT tests many of the very same skills as reasoning tasks, so it is not an independent measure of cognitive ability capable of explaining successful performance in those tasks (Jou 2000, Manktelow 2000). Moreover, it is unreasonable to think that people with SAT scores have a "monopoly on quality of thinking [or]…truth" (Sternberg 2000, 698). In claiming that patterns of individual differences can directly vindicate standards of rationality, Stanovich and West have committed an "elitist naturalistic fallacy" (Schneider 2000).

Nevertheless, there might be less direct ways of bringing cognitive variation to bear on theorizing about rationality. Some theorists believe we should try to avoid massive attributions of irrationality: the principles of rationality we formulate should ideally not imply that people behave irrationally most of the time. When combined with recognition of cognitive variation, this desideratum on a theory of rationality pushes us toward what Douven (2022) calls anti-"universalism," the idea that "at different times and for different people, different practices may count as rational" (156). Widespread variability can be understood as rational if we recognize that different people find themselves in different situations, so it is reasonable for them to act (or cognize) differently. Psychologists have pioneered this context-sensitive notion of rationality (Gigerenzer 2010; Elqayam 2011, 2012; Lieder and Griffiths 2019). It largely remains to be seen what an anti-universalist, variation-sensitive approach to rationality would look like in philosophy (Douven 2022, Dorst ms).

A final philosophical topic for which individual differences may have implications is multiple realizability. Historically, philosophers of mind have been most interested in the possibility that mental states found in humans could also be realized in very different sorts of creatures, such as machines, aliens, or octopi (Putnam 1975). In recent years, they have become less interested in the in-principle possibility of multiple realiz*ability*, and more in assessing the empirical evidence for claims of multiple realiz*ation* (Bechtel and Mundale 1999, Polger and Shapiro 2016). Concurrently, attention has shifted away from science fiction and toward comparisons of known species. Within-species comparisons are arguably just as relevant as between-species comparisons to the question of whether mental states are multiply realized (Figdor 2010). Indeed, many have suggested mental states might be multiply realized between (or within) human beings (Horgan 1993, Endicott 1993). Aizawa and Gillett (2009, 2011), for instance, present evidence from neurophysiology and vision science that normal human color vision is multiply realized (cf. Polger and Shapiro 2016). In the ongoing search for such examples, qualitative variation warrants extra scrutiny, as it could point to the presence of distinct neural realizers underlying mental states (Strappini et al. 2020).

These five topics – human mental unity, psychological kinds, explanation, rationality, and multiple realizability – illustrate the philosophical import of cognitive variation. Psychology stands to benefit from a clearer understanding of different types of individual differences and a wider catalogue of solutions to the uniformity/uniqueness dilemma. But philosophy too is implicated in questions about how and why our minds differ. Philosophers have much to gain from careful thinking about cognitive variation and its consequences.

References

Aizawa, Kenneth, and Carl Gillett. 2009. "Levels, Individual Variation and Massive Multiple Realization in Neurobiology." In *The Oxford Handbook of Philosophy and Neuroscience*, edited by John Bickle, 539–82. Oxford University Press.

———. 2011. "The Autonomy of Psychology in the Age of Neuroscience." In *Causality in the Sciences*, edited by Phyllis McKay Illari, Federica Russo, and Jon Williamson. Oxford: Oxford University Press.

Allport, G. W. 1937. *Personality: A Psychological Interpretation*. Personality: A Psychological Interpretation. Oxford, England: Holt.

Amundson, Ron. 2000. "Against Normal Function." *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences* 31 (1): 33–53.

Andrews, Sally, Steson Lo, and Violet Xia. 2017. "Individual Differences in Automatic Semantic Priming." *Journal of Experimental Psychology: Human Perception and Performance* 43 (5): 1025–39.

Bartlema, Annelies, Michael Lee, Ruud Wetzels, and Wolf Vanpaemel. 2014. "A Bayesian Hierarchical Mixture Approach to Individual Differences: Case Studies in Selective Attention and Representation in Category Learning." *Journal of Mathematical Psychology* 59 (April): 132–50.

Bechtel, William P., and Jennifer Mundale. 1999. "Multiple Realizability Revisited: Linking Cognitive and Neural States." *Philosophy of Science* 66 (2): 175–207.

Bluhm, Robyn. 2013. "New Research, Old Problems: Methodological and Ethical Issues in FMRI Research Examining Sex/Gender Differences in Emotion Processing." *Neuroethics* 6 (2): 319–30.

Bogen, James, and James Woodward. 1988. "Saving the Phenomena." *Philosophical Review* 97 (3): 303–52.

Bogen, Jim. 2010. "Noise in the World." *Philosophy of Science* 77 (5): 778–91.

Bolger, Niall, Katherine S. Zee, Maya Rossignac-Milon, and Ran R. Hassin. 2019. "Causal Processes in Psychology Are Heterogeneous." *Journal of Experimental Psychology. General* 148 (4): 601–18.

Boyd, Richard. 1999. "Homeostasis, Species, and Higher Taxa." In *Species: New Interdisciplinary Essays*, edited by R. A. Wilson, 141–85. Cambridge, MA: MIT Press.

Buckner, Cameron. 2016. "Transitional Gradation in the Mind: Rethinking Psychological Kindhood." *British Journal for the Philosophy of Science* 67 (4): 1091–1115.

Buehner, Marc J., Patricia W. Cheng, and Deborah Clifford. 2003. "From Covariation to Causation: A Test of the Assumption of Causal Power." *Journal of Experimental Psychology. Learning, Memory, and Cognition* 29 (6): 1119–40.

Chi, Michelene T. H., Paul J. Feltovich, and Robert Glaser. 1981. "Categorization and Representation of Physics Problems by Experts and Novices." *Cognitive Science* 5 (2): 121–52.

Climenhaga, Nevin, Lane DesAutels, and Grant Ramsey. 2021. "Causal Inference from Noise." *Noûs* 55 (1): 152–70.

Coninx, Sabrina. 2021. "The Notorious Neurophilosophy of Pain: A Family Resemblance Approach to Idiosyncrasy and Generalizability." *Mind & Language*.

Cosmides, Leda, and John Tooby. 1992. "Cognitive Adaptations for Social Exchange." In *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*, edited by Jerome H. Barkow, Leda Cosmides, and John Tooby, 163–228. Oxford University Press.

Craver, Carl F. 2009. "Mechanisms and Natural Kinds." *Philosophical Psychology* 22 (5): 575–94.

Cronbach, Lee J. 1957. "The Two Disciplines of Scientific Psychology." *American Psychologist* 12 (11): 671–84.

Danks, David, and Frederick Eberhardt. 2009. "Conceptual Problems in Statistics, Testing and Experimentation." In *Routledge Companion to the Philosophy of Psychology*, 214–30. New York, NY: Oxford University Press.

Dorst, Kevin. ms. "Rational Polarization."

Douven, Igor. 2022. *The Art of Abduction*. Cambridge, MA, USA: MIT Press.

Douven, Igor, and Jonah N. Schupbach. 2015. "The Role of Explanatory Considerations in Updating." *Cognition* 142 (September): 299–311.
Dygert, Sarah K. C., and Andrew F. Jarosz. 2020. "Individual Differences in Creative Cognition." *Journal of Experimental Psychology: General* 149 (7): 1249–74.
Elqayam, Shira. 2011. "Grounded Rationality: A Relativist Framework for Normative Rationality." In *The Science of Reason: A Festschrift for Jonathan St B. T. Evans*, 397–419. New York, NY, US: Psychology Press.
———. 2012. "Grounded Rationality: Descriptivism in Epistemic Context." *Synthese* 189 (1): 39–49.
Endicott, Ronald P. 1993. "Species-Specific Properties and More Narrow Reductive Strategies." *Erkenntnis* 38 (3): 303–21.
Estes, W. K. 1956. "The Problem of Inference from Curves Based on Group Data." *Psychological Bulletin* 53 (2): 134–40.
Faisal, A. Aldo, Luc P. J. Selen, and Daniel M. Wolpert. 2008. "Noise in the Nervous System." *Nature Reviews. Neuroscience* 9 (4): 292–303.
Farrell, Simon, and Casimir J. H. Ludwig. 2008. "Bayesian and Maximum Likelihood Estimation of Hierarchical Response Time Models." *Psychonomic Bulletin & Review* 15 (6): 1209–17.
Figdor, Carrie. 2010. "Neuroscience and the Multiple Realization of Cognitive Functions." *Philosophy of Science* 77 (3): 419–56.
Fine, Cordelia. 2010. *Delusions of Gender: How Our Minds, Society, and Neurosexism Create Difference*. New York London: W. W. Norton & Company.
Finn, Emily S., Dustin Scheinost, Daniel M. Finn, Xilin Shen, Xenophon Papademetris, and R. Todd Constable. 2017. "Can Brain State Be Manipulated to Emphasize Individual Differences in Functional Connectivity?" *NeuroImage* 160: 140–51.
Francken, Jolien C., Marc Slors, and Carl F. Craver. 2020. "Cognitive Ontology and the Search for Neural Mechanisms: Three Foundational Problems." Preprint.
Gangestad, Steve, and Mark Snyder. 1985. "'To Carve Nature at Its Joints'. On the Existence of Discrete Classes in Personality." *Psychological Review* 92 (3): 317–49.
Gawronski, Bertram, Joel Armstrong, Paul Conway, Rebecca Friesdorf, and Mandy Hütter. 2017. "Consequences, Norms, and Generalized Inaction in Moral Dilemmas: The CNI Model of Moral Decision-Making." *Journal of Personality and Social Psychology* 113 (3): 343–76.
Gigerenzer, Gerd. 2010. *Rationality for Mortals: How People Cope with Uncertainty*. 1st edition. New York ; Oxford: Oxford University Press.
Gillham, N. W. 2001. "Sir Francis Galton and the Birth of Eugenics." *Annual Review of Genetics* 35: 83–101.
Goodie, Adam S., and Cristina C. Williams. 2000. "Some Theoretical and Practical Implications of Defining Aptitude and Reasoning in Terms of Each Other." *Behavioral and Brain Sciences* 23 (5): 675–76.
Gould, Stephen Jay. 1981. *The Mismeasure of Man*. Revised & Expanded edition. New York: W. W. Norton & Company.
Haaf, Julia M., and Jeffrey N. Rouder. 2017. "Developing Constraint in Bayesian Mixed Models." *Psychological Methods* 22 (4): 779–98.
———. 2019. "Some Do and Some Don't? Accounting for Variability of Individual Difference Structures." *Psychonomic Bulletin & Review* 26 (3): 772–89.
Haslam, N., E. Holland, and P. Kuppens. 2012. "Categories versus Dimensions in Personality and Psychopathology: A Quantitative Review of Taxometric Research." *Psychological Medicine* 42 (5): 903–20.
Haslam, Nick. 2014. "Natural Kinds in Psychiatry: Conceptually Implausible, Empirically Questionable, and Stigmatizing." In *Classifying Psychopathology: Mental Kinds and Natural Kinds*, edited by H. Kincaid and J.A. Sullivan, 11–28. Philosophical Psychopathology. Cambridge, MA, US: Boston Review.

Hayes, K. J. 1953. “The Backward Curve: A Method for the Study of Learning.” *Psychological Review* 60 (4): 269–75.

Hedge, Craig, Georgina Powell, and Petroc Sumner. 2017. “The Reliability Paradox: Why Robust Cognitive Tasks Do Not Produce Reliable Individual Differences.” *Behavior Research Methods*, July, 1–21.

Henrich, Joseph, Damián E. Blasi, Cameron M. Curtin, Helen Elizabeth Davis, Ze Hong, Daniel Kelly, and Ivan Kroupin. 2022. “A Cultural Species and Its Cognitive Phenotypes: Implications for Philosophy.” *Review of Philosophy and Psychology*, February.

Henrich, Joseph, Steven J. Heine, and Ara Norenzayan. 2010. “Beyond WEIRD: Towards a Broad-Based Behavioral Science.” *Behavioral and Brain Sciences* 33 (2–3): 111–35.

Horgan, Terence E. 1993. “Nonreductive Materialism and the Explanatory Autonomy of Psychology.” In *Naturalism: A Critical Appraisal*, edited by Steven J. Wagner and Richard Warner. University of Notre Dame Press.

Joel, Daphna, Zohar Berman, Ido Tavor, Nadav Wexler, Olga Gaber, Yaniv Stein, Nisan Shefi, et al. 2015. “Sex beyond the Genitalia: The Human Brain Mosaic.” *Proceedings of the National Academy of Sciences* 112 (50): 15468–73.

Jou, Jerwen. 2000. “Understanding/Acceptance and Adaptation: Is the Non-Normative Thinking Mode Adaptive?” *Behavioral and Brain Sciences* 23 (5): 680–81.

Just, Marcel A., and Patricia A. Carpenter. 1992. “A Capacity Theory of Comprehension: Individual Differences in Working Memory.” *Psychological Review* 99 (1): 122–49.

Kendell, Robert, and Assen Jablensky. 2003. “Distinguishing between the Validity and Utility of Psychiatric Diagnoses.” *The American Journal of Psychiatry* 160 (1): 4–12.

Kidd, Evan, Seamus Donnelly, and Morten H. Christiansen. 2017. “Individual Differences in Language Acquisition & Processing.” *Trends in Cognitive Sciences* 22 (2): 154–69.

Kitcher, Philip. 2001. *Science, Truth, and Democracy*. New York, NY: Oxford University Press.

Knobe, Joshua. 2019. “Philosophical Intuitions Are Surprisingly Robust Across Demographic Differences.” *Epistemology & Philosophy of Science* 56 (2): 29–36.

Kronfeldner, Maria, Neil Roughley, and Georg Toepfer. 2014. “Recent Work on Human Nature: Beyond Traditional Essences.” *Philosophy Compass* 9 (9): 642–52.

Kronfeldner, Maria. 2018. *What’s Left of Human Nature?: A Post-Essentialist, Pluralist, and Interactive Account of a Contested Concept*. Cambridge, Massachusetts: The MIT Press.

Lee, Michael D. 2011. “How Cognitive Modeling Can Benefit from Hierarchical Bayesian Models.” *Journal of Mathematical Psychology*, Special Issue on Hierarchical Bayesian Models, 55 (1): 1–7.

Lee, Michael D., and Eric-Jan Wagenmakers. 2013. *Bayesian Cognitive Modeling: A Practical Course*. New York, NY: Cambridge University Press.

Lee, Michael D., and Michael R. Webb. 2005. “Modeling Individual Differences in Cognition.” *Psychonomic Bulletin & Review* 12 (4): 605–21.

Legault, Mylène, Jean-Nicolas Bourdon, and Pierre Poirier. 2021. “From Neurodiversity to Neurodivergence: The Role of Epistemic and Cognitive Marginalization.” *Synthese* 199 (5): 12843–68.

Lewis, David. 1980. “Mad Pain and Martian Pain.” In *Readings in the Philosophy of Psychology*, edited by Ned Block, 216–22. Harvard University Press.

Lieder, Falk, and Thomas L. Griffiths. 2019. “Resource-Rational Analysis: Understanding Human Cognition as the Optimal Use of Limited Computational Resources.” *The Behavioral and Brain Sciences* 43 (February): 1–16.

Lloyd, Geoffrey. 2009. *Cognitive Variations: Reflections on the Unity and Diversity of the Human Mind*. Oxford: Oxford University Press.

Lonsdorf, Tina B., and Christian J. Merz. 2017. “More than Just Noise: Inter-Individual Differences in Fear Acquisition, Extinction and Return of Fear in Humans.” *Neuroscience and Biobehavioral Reviews* 80 (July): 703–28.

Machamer, Peter K., Lindley Darden, and Carl F. Craver. 2000. "Thinking About Mechanisms." *Philosophy Of Science* 67 (1): 1–25.
Machery, Edouard. 2008. "A Plea for Human Nature." *Philosophical Psychology* 21 (3): 321–29.
———. 2010. "Explaining Why Experimental Behavior Varies Across Cultures: A Missing Step in 'The Weirdest People in the World?'" *Behavioral and Brain Sciences* 33 (2–3): 101–2.
———. 2017. "Kinds or Tails?" In *Extraordinary Science and Psychiatry: Responses to the Crisis in Mental Health Research*, edited by Jeffrey Poland and Serife Tekin. MIT Press.
MacKenzie, Donald A. 1981. *Statistics in Britain, 1865-1930: The Social Construction of Scientific Knowledge*. First Edition. Edinburgh: Edinburgh Univ Pr.
Manktelow, K. I. 2000. "Dilemmas of Rationality." *Behavioral and Brain Sciences* 23 (5): 687–88.
McAllister, James W. 1997. "Phenomena and Patterns in Data Sets." *Erkenntnis* 47 (2): 217–28.
Meehl, Paul E. 1977. "Specific Etiology and Other Forms of Strong Influence: Some Quantitative Meanings." *The Journal of Medicine and Philosophy: A Forum for Bioethics and Philosophy of Medicine* 2 (1): 33–53.
———. 1999. "Clarifications about Taxometric Method." *Applied and Preventive Psychology* 8 (3): 165–74.
Mogil, Jeffrey S. 2021. "Sources of Individual Differences in Pain." *Annual Review of Neuroscience* 44 (July): 1–25.
Murphy, Dominic. 2021. "Concepts of Disease and Health." In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta, Spring 2021. Metaphysics Research Lab, Stanford University. https://plato.stanford.edu/archives/spr2021/entries/health-disease/ .
Muthén, Bengt. 2006. "Should Substance Use Disorders Be Considered as Categorical or Dimensional?" *Addiction* 101 (s1): 6–16.
Nagel, Ernest. 1961. *The Structure of Science: Problems in the Logic of Scientific Explanation*. New York, NY: Harcourt, Brace & World.
Navajas, Joaquin, Chandni Hindocha, Hebah Foda, Mehdi Keramati, Peter E. Latham, and Bahador Bahrami. 2017. "The Idiosyncratic Nature of Confidence." *Nature Human Behaviour* 1 (11): 810–18.
Navarro, Daniel J., Thomas L. Griffiths, Mark Steyvers, and Michael D. Lee. 2006. "Modeling Individual Differences Using Dirichlet Processes." *Journal of Mathematical Psychology*, Special Issue on Model Selection: Theoretical Developments and Applications, 50 (2): 101–22.
Oaksford, Mike, and Nick Chater. 1994. "A Rational Analysis of the Selection Task as Optimal Data Selection." *Psychological Review* 101 (4): 608–31.
Payne, John W., James R. Bettman, and Eric J. Johnson. 1993. *The Adaptive Decision Maker*. 1st edition. Cambridge ; New York, NY, USA: Cambridge University Press.
Pearl, Judea. 2009. *Causality: Models, Reasoning and Inference*. 2nd edition. Cambridge, U.K. ; New York: Cambridge University Press.
Polger, Thomas W., and Lawrence A. Shapiro. 2016. *The Multiple Realization Book*. Oxford: Oxford University Press.
Putnam, Hilary, ed. 1975. "The Nature of Mental States." In *Philosophical Papers: Volume 2: Mind, Language and Reality*, 2:429–40. Cambridge: Cambridge University Press.
Reeder, Reshanne R. 2017. "Individual Differences Shape the Content of Visual Representations." *Vision Research* 141: 266–81.
Revelle, William, Joshua A. Wilt, and David M. Condon. 2011. "Individual Differences and Differential Psychology: A Brief History and Prospect." In *Handbook of Individual Differences*, 3–38. Malden, MA: Wiley-Blackwell.
Riel, Raphael van, and Robert Van Gulick. 2019. "Scientific Reduction." In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta, Spring 2019. Metaphysics Research Lab, Stanford University.
Rouder, Jeffrey N., and Julia M. Haaf. 2019. "A Psychometrics of Individual Differences in Experimental Tasks." *Psychonomic Bulletin & Review* 26 (2): 452–67.

———. 2021. “Are There Reliable Qualitative Individual Difference in Cognition?” *Journal of Cognition* 4 (1): 46.
Scheibehenne, Benjamin, Jörg Rieskamp, and Eric-Jan Wagenmakers. 2013. “Testing Adaptive Toolbox Models: A Bayesian Hierarchical Approach.” *Psychological Review* 120 (1): 39–64.
Schneider, Sandra L. 2000. “An Elitist Naturalistic Fallacy and the Automatic-Controlled Continuum.” *Behavioral and Brain Sciences* 23 (5): 695–96.
Schnuerch, Martin, Lena Nadarevic, and Jeffrey N. Rouder. 2021. “The Truth Revisited: Bayesian Analysis of Individual Differences in the Truth Effect.” *Psychonomic Bulletin & Review* 28 (3): 750–65.
Schubert, Anna-Lena, Dirk Hagemann, and Jan Göttmann. 2021. “Do Individual Effects Reflect Quantitative or Qualitative Differences in Cognition?” *Journal of Cognition* 4 (1): 50.
Schulz, Armin W. 2021. “Explaining Human Diversity: The Need to Balance Fit and Complexity.” *Review of Philosophy and Psychology*, August.
Seghier, Mohamed L., and Cathy J. Price. 2018. “Interpreting and Utilising Intersubject Variability in Brain Function.” *Trends in Cognitive Sciences* 22 (6): 517–30.
Serpico, Davide. 2018. “What Kind of Kind Is Intelligence?” *Philosophical Psychology* 31 (2): 232–52.
———. 2020. “Beyond Quantitative and Qualitative Traits: Three Telling Cases in the Life Sciences.” *Biology and Philosophy* 35 (3): 1–26.
Shen, Jianhong, and Thomas J. Palmeri. 2016. “Modelling Individual Difference in Visual Categorization.” *Visual Cognition* 24 (3): 260–83.
Shiffrin, Richard M., Michael D. Lee, Woojae Kim, and Eric-Jan Wagenmakers. 2008. “A Survey of Model Evaluation Approaches With a Tutorial on Hierarchical Bayesian Methods.” *Cognitive Science* 32 (8): 1248–84.
Sidman, Murray. 1952. “A Note on Functional Relations Obtained from Group Data.” *Psychological Bulletin* 49 (June): 263–69.
Siegler, Robert S. 1987. “The Perils of Averaging Data over Strategies: An Example from Children’s Addition.” *Journal of Experimental Psychology: General* 116 (3): 250–64.
Silberman, Steve. 2015. *Neurotribes: The Legacy of Autism and the Future of Neurodiversity*. Penguin.
Sneath, Peter H. A., and Robert R. Sokal. 1973. *Numerical Taxonomy: The Principles and Practice of Numerical Classification*. W. H. Freeman and Co.
Stanovich, Keith E. 1999. *Who Is Rational?: Studies of Individual Differences in Reasoning*. 1st edition. Mahwah, N.J: Psychology Press.
Stanovich, Keith E., and Richard F. West. 2000b. “Advancing the Rationality Debate.” *Behavioral and Brain Sciences* 23 (5): 701–17.
Sternberg, Robert J. 2000. “The Ability Is Not General, and Neither Are the Conclusions.” *Behavioral and Brain Sciences* 23 (5): 697–98.
Stich, Stephen P., and Edouard Machery. 2022. “Demographic Differences in Philosophical Intuition: A Reply to Joshua Knobe.” *Review of Philosophy and Psychology*, January.
Stocco, Andrea. 2021. “Qualitative Invariant Effects Arise from Neural Constraints: Common Architecture and Sources of Individual Differences.” *Journal of Cognition* 4 (1): 53.
Strappini, Francesca, Marialuisa Martelli, Cesare Cozzo, and Enrico di Pace. 2020. “Empirical Evidence for Intraspecific Multiple Realization?” *Frontiers in Psychology* 11.
Swets, Benjamin. 2015. “Psycholinguistics and Planning: A Focus on Individual Differences.” In *Individual Differences in Speech Production and Perception*, edited by Susanne Fuchs, Daniel Pape, Caterina Petrone, and Pascal Perrier, 89–122. New York, NY: Peter Lang.
Tabery, James. 2009. “Difference Mechanisms: Explaining Variation with Mechanisms.” *Biology and Philosophy* 24 (5): 645–64.
Thiele, Jonathan E., Julia M. Haaf, and Jeffrey N. Rouder. 2017. “Is There Variation across Individuals in Processing? Bayesian Analysis for Systems Factorial Technology.” *Journal of Mathematical Psychology* 81: 40–54.
Thurstone, L.L. 1935. *The Vectors of Mind*. The Vectors of Mind. University of Chicago Press: Chicago.

Trull, Timothy J., and Christine A. Durrett. 2005. “Categorical and Dimensional Models of Personality Disorder.” *Annual Review of Clinical Psychology* 1 (1): 355–80.
Unsworth, Nash, and Ashley L. Miller. 2021. “Individual Differences in the Intensity and Consistency of Attention.” *Current Directions in Psychological Science* 30 (5): 391–400.
Upton, Graham, and Ian Cook. 2008. *A Dictionary of Statistics*. 2nd ed. Oxford: Oxford University Press.
Viola, Marco. 2021. “Beyond the Platonic Brain: Facing the Challenge of Individual Differences in Function-Structure Mapping.” *Synthese* 199 (1): 2129–55.
Vogel, Edward K., and Edward Awh. 2008. “How to Exploit Diversity for Scientific Gain: Using Individual Differences to Constrain Cognitive Theory.” *Current Directions in Psychological Science* 17 (2): 171–76.
Ward, Zina B. ms. “Explaining Individual Differences.”
Ward, Zina B. 2020. “Individual Differences in Cognitive Science: Conceptual and Methodological Issues.” PhD Thesis, University of Pittsburgh.
Waters, C. Kenneth. 2007. “Causes That Make a Difference.” *Journal of Philosophy* 104 (11): 551–79.
Winston, Andrew S. 2020. “Why Mainstream Research Will Not End Scientific Racism in Psychology.” *Theory & Psychology* 30 (3): 425–30.
Woodward, James. 2010. “Data, Phenomena, Signal, and Noise.” *Philosophy of Science* 77 (5): 792–803.