Using Cognitive Measurement Models in the Assessment of Cognitive Styles

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> Somehow styles and abilities need to be disentangled to improve the valid measurement of each.
>
> Messick, 1996, p. 92

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Sam Messick has long championed the cause of cognitive styles -- at once carefully distinguishing entangled style constructs yet simultaneously tracing their path through an immense field of research on the psychology of human differences (Gardner, Jackson, & Messick, 1960; Messick & Kogan, 1963; Messick, 1984; 1987; 1996). Indeed, the influence of cognitive styles extends well beyond the boarders of differential psychology. Characteristic ways of perceiving and organizing experience represented in cognitive style constructs are important not merely for understanding how individuals differ, but for understanding belief conflict and in science itself. In other words, cognitive styles are not just an interesting subfield of differential psychology, but are more like foundational elements that critically shape the sorts of theories we build, the methods we use to test them, and, perhaps most importantly, cause conflict among those who hold different beliefs. One of our themes will be the confusions that have resulted from our failure to attend more closely to these differences in philosophy, procedure, and statistical methodology. In this chapter, however, we will discuss--not so much the broad sweep of theorizing about cognitive styles--but rather the much narrower topic of how they might be measured. We emphasize the limitations of trait-factor models and the potential contributions of cognitive models for the measurement of cognitive styles. We hope to hasten the arrival of the day when the sophistication of techniques for measuring style constructs catches up with the sophistication of theorizing about them that Messick has championed. One avenue for improved measurement is through the use of measurement models derived from cognitive psychology.

However, before we discuss how such models can aid in the measurement of style constructs, it is necessary to understand why they have not had much impact on the measurement of ability constructs. Thus, first abilities, then styles.

Cognitive Psychology and Testing

A new enthusiasm invigorated discussions of ability measurement in the 1970s. For the first time in a very long time, experimental psychology saw more than error in individual differences. To name a few of the many contributors: Estes (1974) proposed studying cognitive tests as cognitive tasks; Hunt, Frost, and Lunneborg (1973) proposed using laboratory tests to clarify the meaning of ability constructs; Underwood (1975) proposed using individual differences as a crucible for theory construction; Chang and Atkinson (1976) investigated correlations among individual differences on a memory search task, a visual memory search task, and SAT scores. From the differential side, Carroll (1976) showed how an information-processing paradigm might help us understand ability factors and Royer (1971) showed that the Digit Symbol subtest of the WAIS could be studied as an information processing task. The new look held a particularly strong attraction for those such as Bob Glaser at Pittsburgh and Dick Snow at Stanford, who had long tried to keep a foot in both the experimental and differential camps. Finally, there were the freshly-hatched new Ph.D.'s who developed these ideas into research programs of their own (again to name a few): Bob Sternberg, Jim Pellegrino, Pat Kyllonen, and Phil Ackerman. But what began with parades down Main Street eventually petered out in a hundred side streets. Some early enthusiasts--such as Earl Hunt--once again wondered aloud whether experimental psychology and differential psychology were fundamentally incompatible. After years of effort that produced, at best, a scattering of small correlations, Hunt (1987) concluded: "It does not seem particularly fruitful to try to derive the dimensions of a [trait model] of abilities from an underlying process theory" (p. 36). Although this surely overstates, we believe Hunt's pessimism is closer to the truth than the naive optimism of many would-be bridge builders, whether they begin their efforts from the precipitous cliffs that ring the tight little island of experimental psychology or from the sprawling beaches of the seemingly borderless empire of differential psychology (cf. Cronbach, 1957).

Of the many differences between the two disciplines that could be discussed, we believe two are central. The first concerns how researchers think about variation. One could call it a difference in philosophy or cognitive style. The second difference stems from the fact that constructs in the two disciplines are defined by quite different--often largely independent--aspects of score variation. We will discuss each of these in turn.

Essentialism versus Population Thinking

In his efforts to explain the rift between experimental and evolutionary biology, Mayr (1982) distinguishes between what he calls "population thinking" and "essentialist thinking." Variation and diversity are the stuff of population thinking; categories and typologies are the stuff of essentialist thinking. Population thinking uniquely characterized the Darwin-Wallace theory of natural selection, and later Galton's studies of the inheritance of mental and physical traits. Essentialist thinking, on the other hand, has ever guided experimentalists in biology, physics, and psychology. Essentialism, a philosophy originating with Plato and Aristotle, asserts that observable characteristics of objects in the world are but imperfect shadows of more perfect forms or essences. These essences are more permanent and therefore more real than the particular objects through which we conceive or deduce them. Importantly, then, essentialists thinkers assume variation among category members reflects error or imperfection in the manifestation of the essential form.

Essentialist thinking in psychology is perhaps most clearly evident in the seminal work of the Belgian statistician Quetelet and his conception of the mean of a distribution of anthropomorphic measurements as revealing the essential form of the average man ("l'homme moyen."). Variation about the mean reflected the action of accidental causes. Thus, "there is no possibility of discovering anything about the important constant [or systematic] causes in nature from the character of the error distribution, since this distribution is related only to accidental causes." (Hilts, 1973, p. 217). In its purest form, this view endures in psychometrics in what Lord and Novick (1968) call a "Platonic true score." In muted form, it characterizes all efforts to describe elements within a category by a single score, from Bacon's goal of carving nature at its joints to the more esoteric applications of the principle of exchangeability (see, e.g., Novick, 1982).

With the possible exception of quantum physics, the philosophy of essentialism has fitted well with the conceptual structure of the physical sciences. Carbon atoms are indeed alike; those that differ define new isotopes or ions (i.e., a new category). Budding chemists are not taught how to make distributions of “carbonness” from which they might infer something about the character of carbon. In psychology, those trained in experimental methods seem most comfortable with essentialist modes of thought. This is particularly evident in attempts of experimentalists to explain individual differences. Many, of course, do not get beyond the notion of individual differences as error and thus see no need to explain them. But for those who do, there is usually an attempt to impose a typology of some sort on the data; thus, we have not one type of person in the world but two types, which upon closer inspection, are further subdivided, as in stage-theoretic models of development or as in the early attempts of the Menniger group (Gardner, Holzman, Klein, Linton, & Spence, 1959) to investigate individual differences in cognitive controls. Indeed, as Kogan (1994) notes, the work of this group and others who investigated cognitive styles was anchored in the categories and tasks of experimental psychology, and in the typological thinking of Jung and other ego psychologists.

Probabilistic thinking about populations takes the opposite tack. Population thinkers stress the uniqueness of each individual. There is thus no "typical" individual; mean values are considered abstractions. Rather, variation is the most interesting characteristic of natural populations. Galton was the first to understand the error distributions of Quetelet in this way. In his memoirs he noted:

> The primary objects of the Gaussian Law of Error were exactly opposed, in one sense, to those to which I applied them. They were to get rid of, or to provide a just allowance for errors. But these errors or deviations were the very things I wanted to preserve and to know about. (Galton, 1908, p. 305)

Or, as Cronbach (1957) put it : "The correlational psychologist is in love with just those variables the experimenter left home to forget." (p. 674)

Differential psychology is, of course, grounded in population or probabilistic thinking. As such, its adherents are more concerned with variation than with means, with quantitative than with qualitative differences between individuals, and with relative rather than with absolute scales of measurement. Measures of the relative fit between persons and situations is what the discipline is all about. Even when absolute measures (such as response latency) are available, it is information about the relative standing of individuals that is its special concern. Thus, part of the difficulty in forging relationships between trait and process--that is, between differential and experimental psychology--is that adherents of the two disciplines tend to conceptualize problems and consequently to measure variables differently. Experimentalists generally prefer the neatly ordered categories of essentialism; differential psychologists prefer the unbounded multidimensional spaces of population thinking.

Construct Confusions

These differences in cognitive style translate into much more profound differences in the type of information (or variation) used to define constructs in the two domains. Consider, for example, the most important (or at least the most well-studied) construct in each domain: learning in experimental psychology and intelligence in differential psychology. Learning is defined by changes over trials (or columns in a basic person-by-item data matrix). Intelligence is defined by variation between persons (or rows in that same matrix). In other words, constructs in experimental and differential psychology are often defined by partitioning the basic data matrix in different ways. Failure to appreciate the statistical independence of row and column deviation scores has lead to much confusion in attempts to relate these two domains, from Woodrow's (1946) failure to find much relationship between learning on laboratory tasks and intelligence, to the efforts of Gulliksen and his students (e.g., Allison, 1960; Stake, 1961) to relate learning rate measures to a Thurstonian model of abilities, to the more recent efforts of

Sternberg (1977) and Hunt, Frost, and Lunneborg (1973) to correlate scores for component mental processes and ability constructs.

Intersections of the Sets

But the two disciplines do meet, or overlap. Non-independence of row and column variation shows up in the interaction term. When considering the relationship between learning and intelligence, the most important cause of the interaction is an increase in score variation across trials, or what Kenny (1974) called the fan effect. Statistically, the fan effect occurs when true gain on the learning task is positively related to initial status on the learning task. If initial status on the learning task correlates with intelligence, then gains will also show a correlation.

There are, of course, other possibilities, but this is a common scenario. Thus, the interaction term is the key to a better understanding of styles. Unfortunately, both differential and experimental psychologists have been taught to minimize the interaction term. Differential psychologists evaluate the dependability or reliability of individual differences by the proportion of the between-person variance attributable to the person variance component (Cronbach, Gleser, Nanda, & Rajaratnam, 1972). A large person variance component and a comparatively small person x item interaction variance component are the goal. For the experimentalist, differences between conditions (or items, i) are judged relative to the size of the p by i interaction. On the other hand, diagnostic information about how subjects solved tasks is most informative when the interaction term is large. In such cases, a single rank order of individuals or of conditions does not give all of the interesting information. Influential developmental psychologists have long built their psychology around tasks that induce subjects to reveal important, preferably qualitative differences in knowledge or strategy by the type or pattern of responses they give. Furthermore, these differences in knowledge or strategy must then be shown to generalize to other tasks or even to be indicative of broad thinking competencies. Piaget was particularly clever in inventing or adapting such tasks for use with children. Siegler (1988) and others have continued the tradition.

The primary contribution of an information-processing analysis of a task or problematic situation is information on how subjects understood that situation or solved that task. Although such analyses usefully inform interpretation of test scores even when all subjects follow a uniform strategy, process models are most useful for understanding individual differences when there are interesting differences in the way subjects perceive a situation and in the strategies they deploy when attempting to solve a task. However, most tasks studied by experimental psychologists and most tests developed by differential psychologists are not designed to elicit such qualitative differences in type of knowledge or strategy use or to reveal them when they do occur. In fact, tasks and tests are usually constructed with exactly the opposite goal in mind. When such tests or tasks are subjected to an information-processing analysis, the results are not exactly earth shaking. For example, information processing analyses of spatial tasks that require the mental rotation of figures tell us that a major source of individual differences on such tasks is to be found in the speed and accuracy of the rotation process. Did anyone seriously doubt this? What is news is when we find subjects who do not rotate stimuli, or who persist in rotating them in one direction when rotation in the other direction would be shorter, or when some rotate along rigid axes while others perform a mental twisting and turning at the same time. Yet even these strategy differences are of no enduring interest unless they can be related to more global indices of ability or some personological attribute such as conation.

Most research in the past 20 years attempting to relate cognitive and differential psychology has assumed that connections between the two disciplines would be more straightforward. Investigators fitted information processing models to each subject's data, then estimated component scores for different mental processes (such as the slope parameter from the regression of latency on angular separation between stimuli in the rotation paradigm), and then used these process-based parameters as new individual difference variables. However, individual differences that are consistent across trials are located in the intercepts of the individual regressions, not in the slopes or other component scores, as commonly assumed (Lohman, 1994). Such complexities complicate but by no means embargo traffic between the two disciplines of scientific psychology. The main avenue of contact is through tasks or measurement procedures designed to elicit rather than to prohibit (or obscure) differences in strategy or style, which brings us back to cognitive styles.

Cognitive Styles as Constructs

Cognitive styles include constructs such as field articulation, extensiveness of scanning, cognitive complexity versus simplicity, leveling versus sharpening, category width, reflection versus impulsivity, automatization versus restructuring, and converging versus diverging. Messick (1996) argues that cognitive styles reflect consistent individual differences in the manner or form of cognition as distinct from the content or level of cognition. As such, cognitive styles are often viewed as performance variables rather than as competence variables. The division is not sharp, however, because styles are generally thought to be interwoven with personological characteristics and to function mainly as conative mechanisms that regulate cognitive processes, learning strategies, and affect. In this way, styles may also impact competence as well as performance (Messick 1989). Within an information processing framework, however, cognitive styles are interpreted more narrowly as consistencies in modes of perception, memory, and thought (Miller, 1991). For example, field articulation, as a component of attention, would fall under the category of perceptual styles. Individuals with early perceptual attention control may be less prone to distraction by irrelevant information than those who do not exhibit such a level of control.

A variety of learning styles, or consistencies in strategies employed in learning and studying, have also been hypothesized (Weinstein, Goetz, & Alexander, 1988). The most general distinction concerns whether particular learning styles lead to learning strategies that produce deep versus surface processing during learning (Entwistle, 1987; Snow & Swanson, 1992) . However, such strategies cannot be understood in isolation from motivation for learning (Biggs, 1987; Ainley, 1993). Further, different subject-matter domains may also require or lead learners to develop different global strategies for organizing their knowledge (Pask, 1976).

Finally, defensive styles refer to consistent ways of organizing and channeling affect in cognition (Messick, 1987). As such, they are primarily ego-protective, but also serve the important adaptive function of maintaining cognition, often in the face of intense affect. Four broad defensive styles have been proposed: obsessive-compulsive, hysterical, paranoid, and impulsive, which, in the normal range of personality, are called rigid, impressionistic, suspicious, and unintegrated cognition, respectively.

Styles and Strategies

In one way or another, the notion of strategy enters into all of these style dimensions. What, then, is the relationship between the two? Style is clearly a more general term than strategy. Strategy may signify no more than a particular way of solving a task. When the term is used in this way, there is no requirement that individuals choose or even be aware of the strategies they adopt. However, strategy use can also imply choice in action or thought. When the term is used in this way, listing strategies as exemplars of styles implies the presence of some form of executive or self-regulatory processes. The range of situations in which particular processes are used and the flexibility with which they are used may depend on an individual's cognitive style. Therefore, cognitive styles contain conative and volitional components that have implications for their assessment. These components involve, in the case of volition, mechanisms for the self-control of cognition and affect in regulating action or behavior, or in the case of conation, mechanisms for the initiation and maintenance of action-appropriate thought. Thus, one way to observe styles is through consistencies in the application of strategies across tasks or situations. For example an obsessive-compulsive style may be inferred from consistencies in the coping strategies used to fend off the influence of negative affect.

The style-strategy distinction is perhaps most salient in the cognitive style constructs of field dependence and field-independence. A crucial aspect of strategy control is not so much the purposeful disposition to facilitate performance through task-relevant cognitions but rather to inhibit irrelevant or misleading cognitions (see Kuhl, 1992, and Pascual-Leone, 1989, for two perspectives on the role of inhibition and facilitation in strategy use). Self-regulation suggests a situationally sensitive and adaptable approach to the planning, initiation, and maintenance of context appropriate (or disengagement from context inappropriate) intentions. Field-independent and field-dependent learners can be distinguished in this respect. The former are more able to make use of appropriate (inhibitory or facilitatory) strategies. The latter are more oriented toward situational cues and make less use of appropriate strategies, even when they are available. It is the differential effect of the internal versus external situation that appears to distinguish between the obsessive-compulsive and field-dependent--field-independent dimensions. In the first case, internally generated affect influences strategy, whereas in the second case, the external cues influence strategy. In one, the individual keeps the world at bay by inhibiting external influences; in the other, the individual keeps inner demands at bay by inhibiting affect. In both cases, style facilitates cognition and so the type of strategy used can indicate broader dispositional style.

This brings us to the issue of conscious control or choice in strategy use, a topic briefly alluded to earlier. Control appears to be a question of degree, ranging from unconscious and automatic control to fully conscious control. For our purposes, we assume that control can be exerted at any of these levels and reflects the action of a higher order self-regulatory system. However, for the valid measurement of cognitive styles, there is no prerequisite that an individual be consciously involved in the application of any particular strategy.

Since strategies and--to a lesser degree--styles can be perceived as being part of a self-regulatory system, they can be situated within a larger cognitive-conative-affective framework (Snow, Corno, & Jackson, 1996; see also Miller, 1991). In Snow's taxonomy the conative domain is situated between the cognitive and affect domains, and represented by a motivation-volition continuum. Strategies are mostly subsumed under the more cognitive-volitional pole and, to a lesser degree, under the affective-motivational pole. Styles, on the other hand, are distributed more evenly across volition and motivation.

One advantage of Snow's scheme is that different style constructs (and their concomitant strategies) are not operationally dependent upon an overarching and rather conceptually nebulous cognitive-personality system. Messick takes a somewhat different approach. Whereas Snow argues for a specific set of variables spanning the space, but excluding the superordinate constructs of cognition and personality, Messick (1989) prefers a greater inclusion of personality variables. He writes:

> The human personality is a system in the technical sense of something that functions as a whole by virtue of the interdependence of its parts.... Personality may influence the organization of cognition, the dimensionality and stability of structure, and the nature and course of cognitive processes, as well as the of level of measured ability. (p. 36)

Accordingly, styles should be treated, not as cognitive, affective, or behavioral variables related to personality, but as "manifestations of form-giving personality structures in cognition, affect, and behavior." (Messick, 1994, p. 133).

An important question then is, Do we include personality characteristics when attempting to assess styles and, if we do, at which point do we integrate them into our measures? This question can be answered from either a top-down or bottom-up analysis, with the former linking personality to performance and the later performance to personality. From the top-down perspective, styles are considered the superordinate tier subsuming and instantiating strategies. Most likely they do so differentially across situations and tasks, not unlike the personality constructs to which they are presumably affixed. Our tack will take us through the bottom-up analysis: we try to determine how individuals process information in particular contexts, and then look for consistencies in the strategies used.

Using Cognitive Measurement Models to Measure Styles

By definition, styles concern not "how much" but "how." As Messick (1976) observed:

> Cognitive styles differ from intellectual abilities in a number of ways... Ability dimensions essentially refer to the content of cognition or the question of what--what kind of information is being processed by what operation in what form? ... Cognitive styles, in contrast, bear on the questions of how--on the manner in which behavior

occurs....

(pp. 6-9)

Measures of style should yield scores that are bipolar and value differentiated rather than unipolar and value directed (Messick, 1984, 1996). Messick proposes that we examine typical performance (see also Goff & Ackerman, 1992) and use ipsative or contrasted scores to measure styles. There are a variety of ways to do this. However, most attempts to measure cognitive styles have inappropriately followed the ability-factor model, which is better suited to value directional questions about unipolar, maximal performance constants that ask how much.

The subversion of questions about how by methods better attuned to how much is but one example of how the application of elegant statistical techniques that do not really answer the questions posed can unwittingly reshape a discipline. Early mental testers--particularly Binet, but others as well (see Freeman, 1926)--were as much concerned with how children solved problems as with the answers they gave. This concern with process was picked up by developmental psychologists, but gradually abandoned by psychometricians, especially with the rise of group-administered tests that could be scored by a clerk, and then later, by a machine. Tests became increasing efficient vehicles for identifying those who were more (or less) able, but increasing uninformative as to what abilities might be (Lohman, 1989). Issues of process were exiled to the land of cognitive styles. There, isolated from the mainstream of differential psychology, promising style constructs were gradually ground into traits already known to ability theorists, but by other names. When the redundancy was finally discovered, ability theorists claimed priority and style theorists were left with the residue.

The key to measuring style lies in measuring how rather than how much. But, how can one measure how? First, one needs tasks in which individual differences are clearly reflected in measures of how rather than in measures of can, that is, tasks that everyone solves in some sense but which are amenable to different solution strategies. Second, one must have some way of making clear inferences about strategy from responses that are given. This is important. We often find that, even though there are different ways of solving a task, the different methods are not distinguishable with our dependent measures. For example, different ways of solving a problem that requires mental rotation of a figure may all show increases in response latency with amount of rotation required. It may be difficult or impossible to detect such strategy differences using response latencies. (Although other measures, such as self-reports, patterns of eye fixations, or response errors--particularly the nature of the foil chosen--may provide such evidence.) Third, one needs not only tasks that elicit strategy differences, and dependent measures that are sensitive to them, but also measurement models that can represent them. Measurement models developed in cognitive psychology to estimate consistencies in strategies are, in fact, much better suited to the task of measuring how (Lohman & Ippel, 1993). Therefore, one of the more straightforward contributions cognitive psychology can make to measurement is through improved measures of cognitive styles. Fourth, one needs a scheme (or, more formally, a measurement model) whereby different strategies can be mapped on to one or more style constructs. Strategy is a narrower term than style. Put differently, many different strategies could be classified as indicators of a particular style. There are many different ways to solve problems that might be termed "analytic" or "impulsive." Importantly, though, not all of these strategies will represent the style with equal clarity. Again, typological thinking would mislead us into trying to classify each strategy as belonging or not belonging to a particular style category. A spatial metaphor would envision strategies as distributed throughout a continuous, multidimensional space defined by different style constructs. Just as different birds are not equally good indicators of the category "bird," so too are some strategies better indicators of particular style constructs. But even those strategies that well characterize a style cannot be equated with it. "Bird" implies more than "robin," even though for most North Americans, "robin" exemplifies the category "bird."

Observations Designs and Measurement Models

Every test may be described in terms of the observation design used to structure observations and the measurement model(s) used to map observations on to scores or categories. The observation design describes test items, their organization, and the type of responses required. The purpose of the observation design is to structure observations so as best to distinguish among categories or levels of the measurement model. When the goal is to distinguish among different ways of solving a task, the observation design must allow for such contrasts. The measurement model refers to the procedure used to assign a single value to an object of measurement. More concretely, the measurement model is used to specify the rules that will be used to score, classify, or combine objects of observation. For example, a single score for a person can be obtained by averaging performance over items. This is consistent with a measurement model that relegates variability in performance across items to the error term. Information processing accounts of task performance should result in a more complex set of measurement models in which different solutions strategies may be explicitly represented and compared. These different measurement models can be evaluated for a given observation design by combining and contrasting performance on different item sets in different ways, using regression or other model fitting procedures to do this.

The Process Model as Target Variable

The process model itself can also be the object of measurement. If subjects solve items on a task in different ways, then they can be classified on the basis of the information processing model which best describes their performance. If these process models can be ordered, then the classification scheme for ordinary models becomes a new measurement model. Developmental theories provide the most straightforward examples of how such second-order measurement models can be used to explain systematic variation in how individuals solve tasks (i.e., first-order process models). This is because they usually posit a single dimension along which information-processing models may be classified.

For example, Sternberg (1977) distinguished among four different validity models for analogical reasoning tasks. In Model I, all component processes were self-terminating, whereas in Model IV, all component processes were exhaustive. Models II and III distinguished intermediate cases. Performance of adult subjects was generally well-fit by Models III or IV. In later work with children, Sternberg discovered that the performance of younger children was better fit by models with self-terminating processes whereas that of older children was generally better fit by models that hypothesized more exhaustive processing (Sternberg & Rifkin, 1979). Thus, models could be ordered by amount of exhaustive processing required. Category score in this measurement model was then shown to be correlated with age or developmental level.

Sometimes more than one dimension is required, such as in attempts to relate strategy differences on cognitive tasks to ability constructs identified in dimensional theories. Siegler (1988) reported a nice example of how classification of measurement models along two dimensions might be accomplished. He administered addition, subtraction, and word identification tasks to two groups of first graders. Performance on each item was classified as based either on retrieval of a response or on construction of a response using a back-up strategy. Students were then classified in one of three groups depending on the pattern of response correctness overall, on retrieval problems, and on back-up strategy problems. Siegler labeled the groups good, not-so-good, and perfectionist students. Perfectionists were students who exhibited good knowledge of problems but set high confidence thresholds for stating retrieval answers. The distinction between perfectionist and good students thus mirrors the cognitive style dimension of reflectivity-impulsivity. Note, however, that the latter dimension is typically defined by performing a median split on latency and error scores on a figure-matching task and then discarding subjects in two of the four cells. Siegler, however, started with a model of strategy use that distinguished between strength of associations (a classic “cognitive” construct) and a confidence criterion for stating retrieval answers (a “conative” construct). Further, the hypothesized style dimension was shown by examining response patterns across three tasks commonly used in the classroom.

The key assumption in both the Sternberg and Rifkin (1979) and Siegler (1988) studies is that individuals can be classified on the basis of which of several models best describes their data. Once again, this is an essentialist or typological way of thinking about the issue. When tasks admit a variety of solution strategies, individuals only rarely appear to solve all items in the same way. The problem is not "which strategy does the individual use?" or even "which strategy does the individual use most frequently?" but rather "what is the probability that the individual used each of the hypothesized strategies?" When stated in this way, it is obvious that individuals may differ not only in which strategy they typically use, but also in the propensity to use a variety of different strategies. Experts not only have a broader array of strategies at their disposal than do novices; they use them more appropriately. In other words, they are tuned to environmental constraints and affordances, and to metacognitive knowledge of self. Indeed, the continued application of an ineffective strategy are hallmarks of immature and disordered functioning.

Kyllonen, Lohman, & Woltz, 1984) showed how to do this in a rough way in an investigation of the solution strategies subjects used on a spatial assembly task. Consider the case in which two strategies are hypothesized: Strategy 1 and Strategy 2. Kyllonen et al. tested models that presumed subjects solved different proportions of the item using each strategy: 0%, 25%, 50%, 75% or 100% of Strategy 1 with the complement solved using Strategy 2. Of course, 0% and 100% represent single strategy models. The investigators were able to distinguish among these different models, because the characteristics of items used to predict whether subjects synthesized or did not synthesize figures varied orthogonally in the observation design. Without this, it would not have been possible to distinguish among the different process or measurement models.

Kyllonen et al. (1984) found that subjects with extreme ability profiles were more likely to use a single strategy. In particular, subjects who scored much higher on reference spatial ability and visual memory tests than on other reference tests consistently synthesized component figures into a single shape, whereas those who showed the opposite profile seemed only able to combine figures actually in view. Those who where generally the most able showed the most flexible adaptation, changing solution strategies to meet changes in item demands. Brodzinsky (1985) claims that this generalization also applies to the cognitive style construct of impulsivity-reflectivity. In particular, individuals who show extremely impulsive or reflective behavior are less able to modify their speed-accuracy trade-off across situations.

A much simpler example comes from the work of Riding and Dyer (1980). Children in their study first listened to a short story and then answered a series of questions about the passage, all of which required inference. Questions were of two types, those that depended on imagery and those that depended on semantic elaboration. For example, the story may have mentioned the fact that someone knocked on the door of a cottage. The question might be "What color was the door?" There was no right answer, since the color of the door was not specified. Response latency was recorded. However, the dependent variable of interest was an ipsative score that compared latencies on semantic and imagery questions. The idea was to identify children who were much quicker to answer one type of question than the other. Correlations were then computed between this ipsative score and the Junior Eysenck Personality Inventory. Correlations with the Extroversion scale were $r = -.67$ for boys ($n = 107$) and $r = -.76$ for girls ($n = 107$). Thus, children who showed a preference for imagistic processing were much more likely to be introverted, whereas those who showed a preference for verbal elaboration were more likely to be extroverted. One of the nice features of this study is that the correlations do not impose a typology, even though careless interpretation of them may.

Although different in many respects, the Siegler (1988), Kyllonen et al. (1984), and Riding and Dyer (1980) studies all show how consistent individual differences in strategy preference can, with proper observation designs and measurement models, define style constructs that provide one important bridge between the domains of personality and ability. It is worth noting that all of these examples use latency as the only or the primary dependent measure. One can also follow the lead of Binet and Piaget and many others in the developmental tradition who have attempted to make inferences about the nature of cognition from a classification of the response given. Many of these schemes have failed because they sought to place the child unambiguously in a category rather than to estimate the probability that the child's responses fell in each of the categories used. A good measure of style would seek to capture rather than to discard or ignore information on the consistency of behavior across trials, tasks, or contexts. It is only our fondness for typological thinking that makes inconsistency on style or strategy seem problematic.

<u>Implications</u>

Style is a second-order family resemblance concept. Individuals generally cannot be typed by strategy, and strategies cannot be typed by style. Thus, the relationship between individual and style is distal. This means that attempts to make strong predictions about behavior in a particular context on the basis of a style will generally not succeed. This does not mean that style constructs are any less real than more proximal measures of behavior. A description of the general features of the landscape is valid even if it does not well describe a particular garden.

The measurement of cognitive styles can provide a fertile ground for interaction between the two disciplines of scientific psychology. Indeed, we believe there probably is greater promise for fruitful interaction between the two disciplines in the measurement of styles than in the measurement of abilities. For this to occur, however, trait models of cognitive styles that involve a simple aggregation of item scores must give way to models that reflect qualitative differences in strategy. Further, these strategies must be mapped onto one or more style dimensions. The domain must also overcome its penchant for categorizing persons or strategies. The siren call of essentialist or typological thinking is as dangerous for the measurement of styles as is reductionism for psychology generally. Typological labels usually identify extremes on a continuum of normally distributed scores. In other words, the measurement of style must recognize that the category membership of responses or persons is a probabilistic affair. Categories are often nothing more than convenient fictions--arbitrary parsings of a continuous space that enable us to communicate with one another. But because of this need to communicate, we will always have a need for such category labels. The trick is to remember not to be misled into taking literally what we say.

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