# A Trio of Concerns

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ABSTRACT—*This essay assesses the two most significant changes in psychology over the past century: the attempt to localize psychological phenomena in restricted brain sites and the search for genetic contributions to behavior and psychopathology. Although there are advantages to these new developments, they are accompanied by some questionable assumptions. Because the investigators in these domains often relate variation in their biological measures to variation in personality traits evaluated with questionnaires, an analysis of the unique properties of the verbal-report questionnaires is presented. It is suggested that future research on human personality should try to combine semantic reports with behaviors and biological data in order to arrive at more fruitful constructs.*

It is useful to reflect occasionally on the current state of a life, social institution, culture, or scientific domain and on the possible constellation of forces responsible for its transformation over a period of time. Scientific disciplines are defined by the relations they seek to discover and by the methods used to make the discoveries. A large number of contemporary psychologists have become interested in the relations between biological states (primarily genetic features and brain states), on the one hand, and behaviors, emotions, and cognitive processes, on the other. However, contemporary research on the relationship between biological processes and personality often rely on questionnaires to index the psychological concepts. Because these questionnaires assume a narrow and specific conceptualization of these concepts, this issue deserves analysis. Second, unlike physicists, chemists, and biologists, psychologists often use the same concepts for observations that are based on different sources of evidence before it has been shown that the sources are compatible: for example, labeling a brain profile, facial expression, avoidant action, and semantic report as "fear." This practice can have misleading consequences, as the validity of a concept rests with the referential meaning of a term, as well as its sense meaning. This habit is common in two popular areas of inquiry: localizing psychological functions in select brain areas and searching for the genetic contributions to psychological properties. Although most scientists working within each of these specialized areas are aware of the issues to be discussed, investigators probing related domains and the public do not always appreciate the conceptual problems that follow the conclusions of this research. This article, by an aging member of this young, vital field, is addressed primarily to these latter two groups.

The most significant change in psychology over the past century is the search for biological, rather than experiential, contributions to human cognition, behavior, and emotion. There are obvious advantages to the new biological perspective. Most psychologists working during the early decades of the last century were certain that experiences were the primary causes of change and variation in behavior, thought, and emotion and were generally unconcerned with where those experiences were represented in brain because there was no way to measure brain activity. The extraordinary advances in technology over the past few decades have allowed the current cohort of researchers to offer better answers to a pair of questions that have piqued human curiosity: How are experiences represented in the brain and to what degree does a person's inherited biology interact with their experiences to affect their behaviors and moods? These questions have the same degree of mystery that used to surround the puzzles of why like begets like, why some species become extinct, and why the sun and moon appear to change their locations on a regular schedule. Although the contemporary enthusiasms have obvious advantages over past ideologies, they are not free of flaws. This should not be surprising. Psychology is a young discipline, and the histories of biology, chemistry, and physics reveal that most initial premises turned out to be mistaken. Mars does not move at a constant velocity in a circular orbit around the sun; the fertilized egg does not contain a miniature human being.

## LOCALIZATION OF FUNCTION

The search for restricted neuronal clusters that may be the foundations of equally specific psychological functions or representations of knowledge is not a novel pursuit but is part of a continuing effort to assess the biological contributions to all psychological phenomena (Campbell, 1905). The phrenologists of the late 18th and early 19th centuries, who enjoyed sufficient

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popularity to warrant the establishment of schools to train new members of this profession, argued that abstract psychological characteristics, including love, resided in specific places in the brain. Freud, who also believed that the id, ego, and superego were instantiated in nervous tissue, was friendly to Wilhelm Fliess's assertion that vascular changes in nasal tissue were a valid sign of genital arousal (Sulloway, 1979). The following discussion does not address the philosophical debate over the feasibility of replacing psychological terms with biological ones. Rather, this discussion deals with an issue that empirical evidence can inform: Could any psychological function be mediated by a single restricted set of neurons? The answer to this question is independent of whether or not psychological phenomena can be "reduced" to a biological vocabulary.

It is worth noting that the attraction to localization is enhanced by the wish to find a single cause for each distinct event. During the years following the initial positing of the gene a century ago, most biologists were friendly to the premise that each biological function could be localized in a specific gene. The Nobel Laureate Herman Muller penned an oft-cited phrase, "One gene, one enzyme." One possible basis for this bias to attribute each effect to a single cause is the universal experience of noting that the conscious awareness of a particular object, say a spoon, is almost always caused by the actual presence of a spoon in the visual field; hallucinated spoons are rare events. There is a perfect correlation between the perception of a white lawn in the morning and of a snowfall during the previous night.

However, the histories of the natural sciences have repeatedly taught scholars that many intuitions that originate in everyday experience are flawed guides to the most powerful explanatory ideas. Aristotle thought that emotions were localized in the chest area because this was the apparent location of strong feelings. Nothing in Murray Gell-Mann's experiences could have led him to posit the concept of quarks. Darwin could not have imagined that the extraordinary variation among animals is traceable to the different arrangements of only four bases.

Nonetheless, the idea of localization met little resistance when the availability of magnetic resonance scanners during the early 1990s made it possible to measure the places where blood flow was greater when a psychological function was activated. During the following decade, this hope led to an extraordinary increase (by a factor of 90) in the number of articles on the relation between profiles of brain activity and psychological processes. Though earlier attempts to find the origin of hunger in select neurons in the hypothalamus were abandoned as the location turned out to be a component of a much larger circuit that mediated the consummation of many actions other than eating, the number of reports claiming localization of some psychological construct increases each year (Berridge & Valenstein, 1991; Valenstein, Cox, & Kakolewski, 1970). The total corpus of evidence, however, has led most neuroscientists to a skeptical view of this idea and to acknowledge that most psychological processes are accompanied by a cascade of brain states in circuits involving diverse areas of the cortex and brain stem (Cabeza & Nyberg, 2000; Engels et al., 2007). An event as simple as the unexpected sound of a whistle activates 24 different brain areas (Kiehl et al., 2005). The acquisition of a conditioned eyeblink reflex in mice generates activity in different genes and brain sites during the early phases of conditioning but not during the later phases (Park, Onodera, Nishimura, Thompson, & Itohara, 2006).

The argument against a strict interpretation of localization does not deny that some properties of sensory events are processed in particular neuronal sites; for example, the perception of contour, motion, high frequency tones, the fragrance of roses, and the taste of sugar is dependent on activity in restricted areas, even though every visual perception requires both the thalamus and the visual cortex. But the more abstract psychological functions and representations that are constructed from these elementary sensory components are usually mediated by many sites and do not appear to be seriously localized.

The error in the argument for localization is the assumption that if a select area of the brain is reliably activated by an event or task, then the psychological process being engaged by the event is probably localized in that same area. For example, the presentation of pictures of objects that are associated with well-learned motor movements activate both the brain areas mediating motor behavior (e.g., premotor cortex) and the areas activated by the visual perception of objects (e.g., fusiform area in the posterior cortex; Weisberg, van Turennout, & Martin, 2007). The nucleus accumbens is usually activated when animals or humans prepare to make a response in order to gain a reward. However, that empirical correlation does not require the conclusion that this structure contributes to the hedonic component of reward, as one must distinguish between the effort expended to obtain a reward and the sensory experience of reward (Baldo & Kelley, 2007; Salamone, Correa, Farrar, & Mingote, 2007). In addition, other areas, especially the orbitofrontal prefrontal cortex, are necessary for evaluating the reward value of an event (Jensen et al., 2006). Adults showed increased blood flow to six different areas when judging the semantic relation between words referring to social traits (e.g., honor–brave). However, the investigators who made this discovery could not resist the temptation to localize the cognitive structures they thought were engaged by the task; hence, they titled their paper "Social Concepts are Represented in the Superior Anterior Temporal Cortex" (Zahn et al., 2007). This inconsistency between a private belief in distributed neural systems and the prose used in titles and discussion sections of papers is not uncommon.

A particularly popular endeavor is the attempt to prove that the amygdala is required for a state of fear in animals and humans. One problem with this position is that the separate components of this structure are activated by many incentives that have absolutely no relation to fear, such as neutral and happy faces (Bray & O'Doherty, 2007; Britton, Taylor, Sudheimer, & Liberzon, 2006; Schwartz et al., 2003); erotic scenes (Gizewski et al., 2006); minor musical chords (Palleson et al., 2005); and, in studies in which the participants were hungry adults, pictures of food (Cheng, Meltzoff, & Decety, 2007). Furthermore, neurons in the monkey amygdala are activated not only by conditioned stimuli that signal an aversive outcome, but also by conditioned cues signaling a desirable experience (Paton, Belova, Morrison, & Salzman, 2006).

A second problem is that there are many fear states (not just one), and it is unlikely that a single site could represent all of these states. The heritability of self-reported fears, for example, varied with the nature of the feared targets, with unrealistic fears (dying in a plane crash) having much higher heritability values (Sundet, Skre, Okkenhaug, & Tambs, 2003) than realistic fears (breaking a leg while on skis) do. Furthermore, the human states of anxious apprehension and anxious arousal are associated with different activation profiles (Engels et al., 2007). Removing a monkey from its familiar cagemates leads to behaviors that scientists regard as signs of fear. However, some monkeys emit the distinct calls called coos, whereas others become immobile. Because these two responses are accompanied by different profiles of brain activation, there can be no clear answer to the question, "Which group is more fearful?" (Fox et al., 2005). The combinations of behavior and brain activity in these two groups of monkeys reflect different states of fear.

The complete corpus of evidence implies that an important function of the amygdala is to respond to unexpected, unfamiliar, or ambiguous events, whether they are safe, pleasant, aversive, or potentially dangerous (Garavan, Pendergrass, Ross, Stein, & Risinger, 2001; Winston, Gottfried, Kilner, & Dolan, 2005). That is why activation of the amygdala is muted when individuals expect to see an aversive stimulus, but the activation is enhanced when the same aversive scenes are unexpected (Herwig, Abler, Walter, & Erk, 2007). Furthermore, the state induced by an unexpected or unfamiliar event is not localized in the amygdala, as the locus ceruleus and the parahippocampal and prefrontal cortex, which project to the amygdala, are activated by similar events. Because most observed brain patterns are modulated by the agent's attentiveness, expectations, and mental set, and these psychological processes are mediated by sites different from those participating in the processing of the event's emotional meaning, it is not reasonable to argue that any emotion could be localized in a single place or mediated by only one circuit (Gur et al., 2006).

The attractiveness of the doctrine of localization owes its vitality, in part, to the suggestion, proposed earlier by Broca and elaborated on a century later by Chomsky (1980), that linguistic competences are autonomous, or modular, systems governed by special principles. One implication of this hypothesis is that language abilities are mediated by specific neuronal clusters. Dehaene (1997) extended this perspective to a number sense that is presumably localized in the inferior parietal cortex. However, the concept of an autonomous psychological system, even if valid, does not necessarily imply a restricted neuronal location as its foundation.

The error in this inference, which slipped into contemporary thinking, is easy to articulate. The fact that the loss of a restricted brain area eliminates a psychological function that its presence is required for, which is true for language and other psychological abilities, does not mean that the function is mediated only by that area. Rather, it usually means that one phase in a temporal cascade of spatially distributed processes requires the integrity of that particular tissue. Each brain location participating in the cascade is associated with a distinct set of hypothetical processes, but activation of the function requires the integrity of the neurons in all the locations that participate in the complete cascade.

The comprehension of oral communications requires an intact basilar membrane, an auditory nerve, several brain stem nuclei, a thalamus, and parts of the frontal lobe, as well as Wernicke's area in the temporal cortex. Even though removal of Wernicke's area in the left hemisphere leads to the loss, or a serious compromise, in the comprehension of spoken language, this fact does not mean that language comprehension is localized in Wernicke's area (Kosslyn & Koenig, 1992). The thalamus, the primary visual cortex, and a small ventral area in the border between parietal and visual cortex called the fusiform area appear to be necessary for the processing of frequently encountered events that contain detailed features (Gauthier & Curby, 2005; Hofer et al., 2007). Because faces are an obvious member of this category and faces reliably activate this area, it is reasonable to argue that the fusiform area is required for facial recognition (Kanwisher, Mc Dermott, & Chun, 1997). But the fusiform area is also activated in adults watching films of faceless human bodies displaying gestures suggestive of fear or anger (Grezes, Pichon, & de Gelder, 2007) or imagining that a face, which cannot be seen, is present behind an occluding object (Hulme & Zeki, 2007).

Similarly, the brain's response to painful electrical stimulation of a nerve, the implementation of a sequence of well-practiced finger movements, and faces with various emotional expressions are accompanied by distinct cascades of sequential activations involving more than one location in the human brain (Alpert, Sun, Handwerker, D'Esposito, & Knight, 2007; Dowman, Darcey, Barkan, Thadani, & Roberts, 2007). Vuilleumier and Pourtois (2007) wrote, "Emotion-face perception is a complex process that can not be related to a single neural event taking place in a single brain region, but, rather, implicates an interactive network with distributed activity in time and space" (Vuilleumier & Pourtois, 2007, p. 174). This conclusion mirrors similar declarations by Hampton and O'Doherty (2007) and by Uttal (2001), who argued "Although the brain is certainly differentiated, most high level cognitive functions cannot be justifiably associated with localized brain regions" (p. 25). Thus, the position argued here is shared by a number of experienced neuroscientists in this area, but not by all newcomers or journalists presenting scientific advances to their readers.

It is also relevant that the specific location nominated as the foundation of a psychological property depends on the source of evidence. Miller, Elbert, Sutton, and Heller (2007) have written a useful summary of the bases for the major sources of evidence. Profiles of blood flow measured with functional magnetic resonance imaging scanners, event-related potentials, and magnetoencephalograms (MEGs) to the same stimulus or task assignment do not always invite the same inference because each technique reflects different physiological events. Event-related potentials primarily reflect extracellular currents generated mainly, but not exclusively, in gyri; MEGs reflect intracellular current flows, especially in sulci; and functional magnetic resonance imaging protocols evaluate patterns of blood flow to an area that bear a nonlinear relation to the amount of neuronal activity or to output from that area. Thus, it is not surprising that although MEG evidence revealed that tactile stimulation of the ear activated the neck and face areas in the primary somatosensory cortex, not all participants showed this profile when blood flow data from the same stimulation were quantified (Nihashi et al., 2002). Almost 20% of a large sample of epileptic patients given language tasks showed either increased blood flow or MEG activity in temporal sites, but not both (Grummich, Nimsky, Pauli, Buchfelder, & Ganslandt, 2006; see Tuunanen et al., 2003, and Winterer et al., 2007, for similar results). Finally, Huettel et al. (2004), using indwelling subdural electrodes in patients ready for surgery, found a poor relation between the magnitude of evoked potentials to checkerboard stimuli and patterns of blood flow to two theoretically appropriate areas. It is not obvious that the evidence provided by one technology is a less valid index of the contribution of a brain site to a psychological function than is evidence provided by a different technique.

This problem was nicely illustrated in a study in which adults viewed unpleasant, pleasant, and neutral pictures. Unpleasant scenes typically elicit the largest potentiated eyeblink startle responses to loud sounds (the potentiated startle is mediated by projections from the amygdala). However, in this study, the pleasant scenes produced the largest increase in blood flow, but the magnitudes of the late positive waveform in the event-related potential (at 600 to 800 ms) were equivalent to the unpleasant and pleasant pictures (Sabatinelli, Lang, Keil, & Bradley, 2007). Thus, investigators wondering whether unpleasant or pleasant scenes produced different or equivalent levels of brain activation or psychological arousal would arrive at different conclusions depending on the evidence they used.

At the moment, profiles of blood flow comprise most of the evidence used to defend localization. There are many reasons why the relations between patterns of blood flow accompanying psychological processes do not warrant confident conclusions regarding the localization of the process. The first problem is that subtraction methods are typically used to arrive at inferences. If an area that contributed to a psychological process also showed high levels of blood flow during the baseline condition, it might not reveal significant activation to an experimental intervention, and investigators would conclude that it did not participate in the psychological function.

Second, individuals with low baseline values for blood flow, often correlated with a low heart rate and low blood pressure, show larger increases in blood flow in response to an event because of the law of initial values (Shulman, Rothman, & Hyder, 2007; Windischberger et al., 2002). Thus, individual differences in the magnitude of changes in blood flow to an incentive presumed to index an emotion or cognitive process are also influenced, in part, by each individual's autonomic physiology, and not only by the psychological reaction to the incentive.

Third, the magnitude of blood flow is typically correlated with the degree of unexpectedness of an event and/or the amount of mental work the incentive requires, independent of the event's psychological meaning. However, the effects of the first two processes can swamp the influence of the third (Mitchell et al., 2007; Miyakoshi, Nomura, & Ohira, 2007). Fourth, blood flow is not highly correlated with the synchronous firing of neurons at lower frequencies (<40 Hz), which typically reflect the activation of more extensive areas of the cortex (Niessing, 2005).

Finally, an increase in blood flow to an area is correlated with the amount of input to that site and is poorly correlated with the output activity of those neurons (Logothetis, Pauls, Augath, Trinath, & Oeltermann, 2001; Raichle & Mintun, 2006). That is why the amplitude of the P300 waveform to an oddball tone had its highest correlation with the change in blood flow to the insula. This observation does not mean that the insula is the place where perception of deviant tones occurs, but it does reflect the fact that the insula receives a great deal of input from sites that do process deviant tones; hence, blood flow was enhanced to that location (Horovitz, Skudlarski, & Gore, 2002).

These facts invite a modification of the popular belief that the amygdala is the site of, or is required for, a fear state. Blood flow to the amygdala following an encounter with conditioned cues for an aversive event, unpleasant scenes, or unexpected pictures is extensive because the many sites that process this information send their projections to the amygdala. Most of the operational signs of fear in animals are the products of output projections from the central nucleus of the amygdala to the autonomic nervous system, bed nucleus, ventral striatum, nucleus pontis reticularis, and prefrontal cortex. The reactions of these sites contribute to the visceral sensations that humans often interpret as reflecting fear or excitement, depending on the context and/or setting. These caveats explain why two scholars, who enjoy high respect from their colleagues in this area of research, cautioned that the physiological or psychological meanings of changes in blood flow are still not well understood (Raichle & Mintun, 2006). This skeptical position is reasonable because the recorded brain reaction to an incentive, whether based on blood flow, MEG, or event-related potentials, represents the combination of at least four independent factors: the physical features of the event, the degree to which the event was expected (or was unfamiliar), the preparation for any motor or cognitive response requested by the investigator, and, the psychological meaning of the event. If any of these contributions were changed, the brain profile would likely change as well. Hence, the observed pattern has to be decomposed into its components, as investigators decompose the complex wave form of a chord played by a symphony orchestra into its separate spectral components.

This critique of localization does not imply that study of the correlations between brain activity and psychological phenomena is without value. This evidence will deepen our understanding of the latter events. It is helpful to know, for example, that blood flow is greater to the left entorhinal and temporal cortex than to the parietal lobe when participants are memorizing words because that observation, combined with knowledge of the structure and connections of the entorhinal and temporal cortices, can guide theoretical accounts of the mechanisms of storage and retrieval of words.

Hofer et al. (2007) reported that sites in the thalamus, anterior cingulate, temporal lobe, cerebellum, and the fusiform area were activated when participants encoded faces they knew would be shown later on a test of recognition memory, but the brain profiles were different when their recognition memory was actually tested. This result affirms the intuition that the perceptual registration of faces in the service of later remembering them differs in an important way from the retrieval process.

A second advantage of gathering information on brain activity is that the data can cast doubt on popular, but invalid, hypotheses, a strategy that Karl Popper (1972) advocated. For example, as late as 1935, a majority of brain scientists, including John Eccles, did not believe that chemicals played any role in neuronal communication in the brain. Later research on neurotransmitters required a rejection of that idea (Valenstein, 2005). The fact that unexpected stimuli, especially those that are unfamiliar or evoke a state of puzzlement because they are ambiguous, regularly produce increased blood flow to the amygdala and a distinct waveform in the electroencephalogram (EEG), independent of their aversive or unpleasant valence, invites a questioning of the hypothesis that snakes or faces with fearful expressions evoke a fear state in viewers. Most participants did not expect the examiner to show them these forms, and therefore, they are surprised or puzzled when they appear (Schwartz et al., 2003; Whalen, 1998).

A more productive strategy for illuminating the relations between brain and psychological processes is to discover the magnitudes of covariance or coherence among a category of event, a resulting brain profile, and any psychological reaction. If scientists presented varied classes of events (for example, sweet tastes, pictures of snakes, conditioned cues for electric shock) and quantified the resulting brain profiles using several methodologies with populations varying in ethnicity, age, and gender, they would obtain a large number of different probability profiles. Epidemiologists who gather information on the prevalence of particular diseases as a function of both the predominant genomes within the population, as well as their diets, life styles, and ecologies, do not localize the cause of a disease in a person or in an ecology. I suspect that if the current advocates of localization implemented such a set of studies, they would discover the need to attach caveats to any synthetic statement claiming a relation between brain activity and a psychological phenomenon (Peissig & Tarr, 2007). This suggestion is especially relevant when the psychological construct is a structure, such as a face schema or the concept of number, because functions (such as blood flow) rarely reflect structures.

In summary, study of the complex relations between brain states and psychological phenomena has extraordinary value. What is being questioned is the assumption that most psychological constructs, such as face perception, memory for words, the concept of number, moral judgments, or an emotion, are mediated by a segregated neuronal cluster or, more permissively, by a particular circuit in the central nervous system.

## GENETIC DETERMINISM

The 19th century physicians who believed that a person's heredity increased their risk for alcoholism or criminality did not enjoy the elegant technological developments in molecular biology that allow contemporary investigators to evaluate these bold ideas. However, as with the doctrine of brain localization, the accumulating evidence has convinced most scientists laboring in this vineyard that most brain states, psychological traits, or pathological symptoms are the result of the psychological products of individuals' early and current environments selecting the phenotypes that their particular genome made it easier to acquire (Smolka et al., 2007). This is a long-winded way of saying that gene–environment interactions are to be expected. No investigator has discovered any component of personality or psychopathology that is consistently traceable to particular genes (Abdomaleky, Thiagalingam, & Wilcox, 2005).

One reason for this frustrating state of affairs is that the genetic contributions to a trait or symptom can take many different forms, including the varied alleles of the exons responsible for proteins; alleles in the promoter or enhancer regions that regulate the expression of the exon; alleles responsible for the many molecules that degrade or absorb a brain molecule after it has been released into the synapse; and, finally, the type, density, and location of the multiple receptors for the large number of molecules that modulate the excitability of brain cells. Given this complexity and the difficulty in measuring all of this variation in one study, it is premature to have a high level of confidence in any current conclusion pertaining to the genetic contribution to a psychological function.

Moreover, a particular polymorphism creates an envelope of brain states rather than one particular state. Both the biological state that is actualized and its consequences for a psychological phenotype depend on a host of conditions that include the immediate setting; the individual's past history; and especially his or her social class, ethnicity, gender, and cultural background (Barnett et al., 2007; Gelernter, Cubells, Kidd, Pakstis, & Kidd, 1999; Manuck, Flory, Ferrell, & Muldoon, 2004). The brain profiles of 100 individuals, each with a unique genome, responding to an incentive can be likened to 100 sound spectrograms of the utterance, "Please pass the salt" spoken in different intensities by Americans with different dialects. These sound spectrograms would eliminate a very large number of possible meanings, but a reasonable number of alternative meanings would remain.

Furthermore, when investigators do find a relation between an allele (or alleles) and a psychological measurement, the amount of variance attributable to the polymorphism is usually quite small, typically between 5% and 10%. I now consider some examples of the state of knowledge in this domain. Catechol-o-methyltransferase (COMT) degrades dopamine and norepinephrine in the synapses of the prefrontal cortex. Hence, alleles of the COMT gene that produce a less efficient COMT enzyme create a situation in which dopamine and norepinephrine remain in the synapse for a longer time (Bilder, Volavka, Lachman, & Grace, 2004). These alleles should affect prefrontal cognitive functions, such as working memory. One allele of the COMT gene, which results in the amino acid valine in a particular location in the exon, is associated with faster degradation of dopamine and norepinephrine and, therefore, with a possible compromise in prefrontal functions, whereas the allele that results in the amino acid methionine in this position is associated with slower degradation (this profile is called $Val^{158}Met$). Although prepubertal boys with the methionine had higher scores on working memory than did those with the valine allele, as theory would have predicted, no such relation occurred for girls, perhaps because females have higher levels of dopamine activity in the prefrontal cortex (Barnett et al., 2007). Unfortunately, other investigators failed to replicate this relation (Craddock, Owen, & O'Donovan, 2006). Even when an investigator finds a relation between possession of the methionine allele and quality of performance on tasks requiring the manipulation of information in working memory, the amount of variance accounted for is less than 5%, and individuals with the methionine allele often differ in physical characteristics, such as body mass, that could be correlated with traits that influence the psychological outcome (Gunstad et al., 2006).

Social class often modulates the relation between genes and psychological functions. Upper-middle-class adults with two or five (rather than seven) tandem repeats of the gene for the D4 dopamine receptor (DRD4) had high scores on measures of novelty seeking. But, surprisingly, individuals with two or five repeats who grew up in economically disadvantaged homes were not high on this trait (Lahti et al., 2006). Both social class and gender modulated the relation between the number of repeats of the DRD4 gene and aggression (DeYoung et al., 2006).

Monoamine oxidase (MAO-A and MAO-B) degrades dopamine, serotonin, and norepinephrine. The genes controlling the production of this enzyme vary in the number of repeats, with a smaller number associated with less efficient degradation of the three molecules. Caucasian adolescents who inherited a smaller number of repeats and experienced a harsh childhood environment were more likely to display antisocial behavior (Caspi et al., 2002). However, an independent study failed to replicate this result (Young et al., 2006), and in both studies the combination of a disadvantaged background and maltreatment was a far better predictor of conduct disorder or criminality than was the number of repeats in the MAO-A allele.

Alleles in the promoter region of the gene for the serotonin transporter molecule (5-HTTLPR) are a fourth popular target of inquiry. Individuals with fewer repeats have less effective transcription of the gene, and, because of this, serotonin remains in the synapse for a slightly longer time. Although three different research groups had reported that adolescents who combined one or both of the two short alleles in the promoter region with a history of poverty and stress were more likely than others to report a depressed mood (Caspi et al., 2003; Eley et al., 2004; Kaufman et al., 2004), data from a much larger sample with a different cultural background failed to replicate this association (Surtees et al., 2006). The inconsistency in the psychological correlates of the alleles of this gene is revealed in evidence indicating that college age Polish women with the two long alleles were less neurotic (based on a questionnaire) but that Polish males of the same age who also had the long alleles were not less neurotic than those with the two short alleles (Dragan & Oniszczenko, 2005, 2006). When the sample consisted of adolescents who had been arrested for a crime, along with their genetic siblings, the short allele was associated with conduct disorder rather than depression or anxiety (Sakai et al., 2006). When the participants were Italians with bipolar disorder, the short alleles were correlated with low scores on novelty seeking (Serretti et al., 2006), and when the participants were well-educated Koreans with obsessive–compulsive disorder, the short alleles were associated with fewer religious obsessions (readers should know that Far East Asians are far less likely than are European Caucasians to possess the long alleles; Kim, Lee, & Kim, 2005). When the participants were Taiwanese men who had committed violent crimes, the heterozygous condition of one short and one long allele distinguished this group from others (Liao, Hong, Shih, & Tsai, 2004), but when they were Russian women who had made suicide attempts, the two long alleles were the distinguishing feature (Gaysina, Zainulinna, Gabdulhakov, & Khusnutdinova, 2006). To add to the confusion, one team of investigators studying the relations between the alleles of this gene and psychological traits in twins, siblings, and their parents rejected the hypothesis of any straightforward association between any one of these alleles and neuroticism, anxiety, or depression (Middeldorp et al., 2007). Finally, as with MAO-A, social class modulates the effect of this allele. Individuals with the short form of the allele who had many years of education and a higher income had a brisker reaction to a drug than did those with less education and a more restricted income (Manuck et al., 2004).

An important reason for the inconsistent results across laboratories and societies is that possession of the short allele does not render individuals vulnerable to a particular emotion, symptom, or personality trait but rather to a more general state of uncertainty in ambiguous situations, perhaps because this allele is associated with greater excitability of the amygdala (Heinz et al., 2007). A state of uncertainty can result in very different phenotypes. Thus, the brain states created by a particular genetic profile can be likened to verbs such as *kiss*, *give*, or *hit*, whose meaning depends on the agents and objects to which the predicate applies. Even when the psychological profile is traceable to a gene or genes in one location, which is true for the rare syndrome called Fragile X, there is considerable variation in the cognitive and behavioral phenotype the afflicted child displays (Kaufmann et al., 2004). It is fair to conclude, therefore, that no single allele independent of the person's total genome, gender, social class, and culture has been found to be consistently associated with a particular mood, personality, or mental illness.

The amount of variance in the cognitive abilities and behaviors of most individuals that can be assigned to differences in class, culture, gender, or ethnicity is usually far greater than is the variance assigned to any gene. And these four psychological influences, alone or together, can swamp the smaller effect of an allele. The movement patterns of tiny pollen grains in an open-air swimming pool provide an analogy. Under natural conditions, the wind is the major determinant of the movements of the pollen grains. Only when its influence is removed do the movements primarily reflect the contacts of the pollen with the water molecules; this idea was the heart of Einstein's famous 1905 paper on Brownian movement as an existence proof for atoms. To find stronger relations between psychological functions and genes, investigators will have to control for the effects of class, gender, ethnicity, and culture, which they usually do not do. Remember, the heritability of a trait is restricted to a particular population living under particular conditions. The heritability of the sex ratio in the developing eggs of turtles is close to zero for most of the temperatures under which the eggs develop, but it rises to 0.8 when the temperature falls in the narrow range between 28–30 °C (West-Eberhard, 2003).

Given the fact that more instances of academic failure, conduct disorder, delinquency, substance abuse, anxiety disorder, and depression are traceable to the education and income of the person or their family of rearing than to a particular allele or set of alleles, our society has a choice of strategies (Lorant et al., 2007). At the moment, most public and private agencies allocate more funds for research devoted to study of the latter condition than to the former. This imbalance is odd in a society that prides itself on being practical and inoculated against philosophical arguments. But the American attraction to material causes and the certainty they promise sustains the belief that biological interventions will be more effective and easier to implement than will sociological or psychological ones. The wish for certainty among those advocating a strong biological basis for all forms of deviance has defeated the motivation to alter the life conditions of the economically compromised members of our society or to improve the quality of the schools they attend. The latter regimens would probably help more troubled youth, but with less certainty and without an explanation of remission that referred to the material concepts of neurons, circuits, and neurotransmitters. Nineteenth-century French authorities also found it convenient to attribute most forms of prostitution to heredity rather than to social conditions.

The current ideology is so entrenched it is difficult to persuade state or federal legislators to allocate public funds for the prevention of psychopathology if they are told that neglect, poverty, and abuse place children at risk for the development of symptoms of anxiety, anger, or depression. However, these same legislators become enthusiastic advocates of prevention if they are told that these same environmental conditions alter children's brains (Shonkoff, personal communication, October 2006). Apparently, the latter description implies that the consequences of early experience are permanent. Descartes' unfortunate division between soul and body is alive and well in the ideology of most citizens. The current emphasis on the biological contributions to psychological outcomes has the disadvantage of inviting a conceptualization of social interventions or therapeutic regimens as pills for an organic condition. Even though experienced psychotherapists and administrators of social intervention programs (e.g., Head Start) appreciate that the most effective therapists or teachers accommodate their communications and rituals to the beliefs, needs, and moods of the client, the rhetoric in their progress reports excludes this variation in actual practice and describes the intervention as if it were a particular chemical solution designed to kill the bacteria on any surface to which it was applied.

Nonetheless, deeper knowledge of the genetic contribution to a psychological phenotype often enhances understanding, even if the person's history, gender, culture, and the local setting are influential. The discovery that Asians and Caucasians differ in about one fourth of the alleles that modulate the expression of exons may help to explain why these two reproductively isolated groups differ in infant behavioral profiles, diseases, and responsiveness to psychotropic drugs (Kagan & Snidman, 2004; Spielman et al., 2007). Caucasian infants are far more likely than are Asian infants to display high levels of excitability to novel stimuli and are also more likely to possess the long allele of 5-HTTLPR and the allele of the COMT gene associated with slower degradation of catecholamines in the synapse (that is, methionine rather than valine; Palmatier, Kang, & Kidd, 1999). The renewed interest in the influences of early temperamental biases on development will also be aided by study of the genetic profiles that are the foundations of the large number of temperamental categories. Because social phobia or social anxiety can be developmental outcomes of a high reactive temperament in infancy or the result of experience without any special temperament, future investigators might perform genomic analyses to determine which patients with social anxiety possess a temperamental bias and which do not. That knowledge could be useful to therapists deciding on the best therapeutic regimen.

## MEASURING PERSONALITY

The current conceptualization and measurement of human personality warrants a serious analysis because most investigators probing the relations between genetic polymorphisms or profiles of brain activity, on the one hand, and one or more components of personality, on the other, often rely only on questionnaires to quantify the latter concepts. However, the rationale for the constructs derived from verbal reports is vulnerable to critique.

American psychologists interested in personality during the early decades of the 20th century regarded the vague, "wholeistic" concept of self, rather than single traits, as a central idea. Historical events, especially the rejection of traditional Freudian theory, eroded the attractiveness of this position. Moreover, the early cohort of investigators sensed that asking people to describe themselves on questionnaires was unlikely to reveal their most profound dispositions. Hence, they experimented with indirect techniques, such as the Rorschach ink blots; Thematic Apperception Test; analyses of handwriting, perceptual biases, autonomic reactions; and observed problem solving styles in laboratory situations. Unfortunately, none of these procedures proved sufficiently sensitive and, in the mid 1990s, a few psychologists simply declared that factor analyses of questionnaire replies, often provided by middle-class, White college students, revealed the fundamental dimensions of personality.

This evidence is the foundation of the popular Big Five personality dimensions of extraversion, conscientiousness, agreeableness, openness to new ideas, and neuroticism, measured with the Neuroticism, Extraversion, and Openness to Experience (NEO) questionnaire, that currently dominate research in this domain (Costa & McCrae, 1992; McCrae & Costa, 1997). This idea did not suddenly appear as a brilliant insight. Its origin is a list of 17,953 English words describing human behavior that Allport and Odbert (1936) compiled a half century earlier and reduced to over 4,500 terms for personality traits. Because this number is far too large for empirical work, various psychologists have tried to prune the list to a small number of manageable dimensions.

A second popular instrument is the Temperament and Character Inventory (TCI) developed by Cloninger and his colleagues (Cloninger, 2006; Cloninger, Bayon, & Svrakic, 1998). This questionnaire measures four temperaments (harm avoidance, novelty seeking, reward dependence, and persistence) and three character traits (self directedness, cooperativeness, and self transcendence). Examination of the items reveals the overlap between the NEO and the TCI—harm avoidance shares a meaning with neuroticism, persistence and self directedness share meanings with conscientiousness, self transcendence shares a meaning with openness, and cooperativeness shares a meaning with agreeableness.

More important, the concepts assessed with either of these questionnaires are naked predicates that fail to specify the settings in which a person is presumed to behave in accord with their assigned trait and, therefore, are incomplete descriptions (Fiske, 2005). An individual can be agreeable or cooperative with same-sex peers, but not with authority figures; conscientious or persistent in the pursuit of personal achievement, but not when in the role of spouse or parent; or open to new ideas or self-transcendent in one's professional work, but not to new conclusions in the biological sciences. Most Chinese and Japanese do not describe others as conscientious but rather as serious in their job, responsible as a parent, or committed to their hobby, because members of Asian cultures understand the importance of the context in which an individual acts (Maass, Karasawa, Politi, & Sauga, 2006). Furthermore, the cross-situation consistency of reported emotions varies with the cultural setting (Oishi, Diener, Scollon, & Biswas-Diener, 2004).

Investigators who study members of other cultures usually find more than five personality dimensions (Church, Reyes, Katigbak, & Grimm, 1997; Lee, Ogunfowora, & Ashton, 2005; Saucier, Georgiades, Tsaousis, & Goldberg, 2005). Two active investigators noted, "There are plenty of dimensions of behavior beyond the Big Five" (Paunonen & Jackson, 2000, p. 821). Despite this evidence, a pair of respected psychologists argued recently in *American Psychologist* that the Big Five concepts should replace the current psychiatric categories because any quality that is of interest or has meaning to members of a community is encoded within their language (Widiger & Trull, 2007). This statement fails to recognize that the popular concepts in a language need not be valid theoretical categories. Concepts like *bewitched*, *constitutionally defective*, and *anal type*, which were popular at earlier times, were later excised from the language because they proved to have no coherent referent and were therefore invalid.

Furthermore, both the Big Five and the TCI dimensions, fall on an ethical good–bad scale with respect to the values of contemporary North Americans and Europeans. Most North Americans and Europeans agree, at least at present, that it is good to be extraverted, conscientious, agreeable, and intellectually open and that it is bad to be neurotic. Tibetan Buddhist monks would question the desirability of extraversion, and Orthodox Muslims and Catholics would question the desirability of openness to ideas challenging the existence of Allah or God.

A person's scores on the Big Five dimensions help to answer three questions one might wish to know about a single woman who moved into the neighborhood or joined the staff of an office:

"How easy is it to interact with her?", "Will she carry out her responsibilities with care?", and "Will she entertain opinions that conflict with her beliefs?" These are not unimportant traits, but they do not exhaust all psychologists need or want to know about a person. I suggest that there are some serious omissions, including (a) the consistency between what a person declares to a stranger verbally and their usual behavior, which is a component of honesty; (b) the separate capacities for empathy, love, shame, and guilt; (c) the degree of identification with, and loyalty to, the values associated with an individual's social categories, especially gender, class, ethnicity, religion, and culture; (d) the capacity for sustained expenditure of physical energy during prolonged periods of challenge; (e) the strength of the motives for fame, power, or enhanced status; (f) the intensity of hostility toward legitimate authority; and (g) one's sexual orientation and strength of sexual desires.

Personality categories or dimensions refer to characteristics that separate large groups of individuals within a society on the basis of properties that facilitate or interfere with adaptation to the demands of their community. Because societies pose different challenges to their members during particular historical eras, it is unlikely that there exists a universal set of personality dimensions. The most important personality traits within any society share features with its basic foods and forms of weather. Hot dogs and pizza are basic foods and snow and hurricanes are fundamental forms of weather for North Americans and Europeans, but not for Saudi Arabians or Sudanese. Variation in feelings of intimidation would have been a primary trait in Plato's Athens because slaves and women had little power; variation in religious piety would have been a significant trait in colonial New England.

A serious problem with the reliance on questionnaire indexes of personality is that the scientists interested in the biological correlates of a personality trait typically relate a profile of blood flow or a genetic polymorphism, each requiring many hours of tedious laboratory work and each based on a rationale resting on years of prior research, with a questionnaire measure that can be obtained in less than an hour and lacks an equally sound theoretical background. Because the questionnaire data are too crude an index of the psychological correlates of a genetic feature, biochemical profile, or brain state, this strategy is unlikely to reveal strong relations between the biological and psychological measures. This asymmetry in the sensitivity of the two measures is analogous to using an atomic clock to determine if a person is walking very slowly, slowly, moderately fast, or very fast.

## THE SPECIAL PROPERTIES OF WORDS

On reflection, it is odd that the most popular current conceptions of personality are based on answers to questionnaires. No biologist would use only the verbal reports of informants to determine the basic human diseases; no economist would rely only on interviews to discover the fundamental economic concepts; and no cognitive psychologist would trust only adult descriptions of their perceptions, memories, and problem solutions to infer basic cognitive competences. Nonetheless, psychologists interested in personality have trusted semantic evidence alone as a valid foundation for the constructs of this domain. Over 95% of the empirical papers in the *Journal of Personality* and 50% of those published in the journal *Child Development* in 2006 used self-report instruments as a source of information or as the only source.

It is not obvious, however, that a person's semantic descriptions of their behaviors, motives, and moods should be the primary basis for the theoretically most useful personality dimensions. If evolutionary biologists used informants' semantic classifications of animals as the basis for species assignment, size (small to large) and domesticity (tame to wild) would emerge as the primary dimensions. Chickens and calico cats would be assigned to one category, and gorillas and lions would be assigned to a different category.

The popular personality questionnaires are heirs of an earlier a priori assumption that the adjectives people use to describe self and others represent the fundamental personality concepts. However, many trait words that are used frequently to describe others are absent from most questionnaires (e.g., *born leader*, *bad seed*, *flirtatious*, *horny*, *sly*, *patient*, *sentimental*, *ingenuous*, *clumsy*, and *power-hungry*). More important, one would have thought that the most fruitful personality dimensions would be correlated with the degree of adaptation to the community in which the informants lived. Selection of this criterion for our society at the present time implies that variation in the ability to gain and to hold a job that was interesting and that paid an adequate salary; attractiveness as a love object; satisfaction in a marriage; the emotional qualities and skills needed to care for and socialize young children; and the ability to interact with strangers, cope with unpredictable challenges, and tolerate ideas that were inconsistent with one's private standards would be primary personality traits. I believe that behavioral observations would be more valid indexes of most of these traits than would self reports. It is also relevant that vocational success, marital satisfaction, and socializing children to value academic achievement and autonomy, which make adaptation easier in contemporary American society, are more common among the better educated members of our community. That is one reason why social class is a consistent correlate of many psychopathological profiles (Johnson, Cohen, Dohrenwend, Link, & Brook, 1999). Many investigators who use the Child Behavior Check List have reported that parents with less education who hold less skilled jobs were most likely to describe their children as displaying both internalizing and externalizing symptoms (Brunnekreef et al., 2007).

It should be troubling to advocates of the Big Five dimensions that a slightly different method that also relied on semantic reports was not highly correlated with the values obtained with the NEO instrument. Raggatt (2006) asked over 100 educated adults in their third decade to fill out the NEO and to recall two dozen important life experiences that reflected attachments to people, places, or objects and then to group these recollections into two to six categories that defined their conception of themselves. The point-biserial correlations between the two different sources of information were modest (from 0.23 to 0.32) for four of the Big Five characteristics and were nonsignificant for the Conscientious dimension. Thus, even when the information is semantic, the two methods lead to different conclusions regarding a person's basic traits. In light of this evidence, it would seem that the continued reliance on questionnaires as the preferred method for evaluating personality rests on a vulnerable rationale.

The decision to use questionnaire profiles rather than direct measurements of behaviors and moods in specific settings is hard to understand because the relations between the two sources of information are generally poor. The controversy surrounding the validity of verbal reports, in which direct observations are the criteria for validity, has been the subject of many reviews and empirical reports (DiBartolo & Grills, 2006; Forman et al., 2003; Seifer, Sameroff, Barrett, & Krafchuk, 1994; Spiker, Klebanov, & Brooks-Gunn, 1992). The evidence reflects a gradually emerging consensus that there is a very low to modest degree of correspondence between verbal reports and the behaviors or emotions to which the reports refer. Hence, the former measure should not be regarded as a sensitive proxy for the latter (Brackett, Rivers, Shiffman, Lerner, & Salovey, 2006; Riggio & Riggio, 2002). There was not even a significant correlation between an individual's judgment of the level of autonomic activity occurring in various targets during laboratory stressors and objective measures of the activity in these targets gathered at the same time (Edelman & Baker, 2002). Surprisingly, self-ratings of conscientiousness by individuals living in societies with poor economic development (for example, several countries in Africa) were higher than the self-ratings for conscientiousness among individuals living in the economically most developed societies (e.g., Japan; Allik & McRae, 2004). The heritability values for the Big Five dimensions generally hover around 0.5 across samples (Lensvelt-Mulders & Hettema, 2001; Riemann, Angleitner, Borkenau, & Eid, 1998). However, when individuals are filmed in a variety of situations and when judges rate each person's film records for traits related to the Big Five, the resulting heritability values are much lower (0.12) and most of the variance is unshared (Borkenau, Riemann, Rainer, Spinath, & Angleitner, in press).

Informant descriptions of others are also poor proxies for direct observations. One investigator found a poor relation between a mother's prediction of how her 2-year-old would react to a clearly described laboratory intervention and the child's actual behavior. The correlations were .07 for the child's reaction to encountering an empty box and −.07 for the child's reaction upon seeing a toy in a locked box (Kiel & Buss, 2006). A second, more elegant study that assessed 4-year-old children twice, using parent reports and observed behavioral reactions to a large number of episodes (using the LabTab), found a poor relation between the parental descriptions and the child's behaviors and a very modest cross-situation consistency for incentives presumed to reflect the same trait. Shyness and exuberance showed the best cross-situation consistency and best agreement between the two methods of measurement, although these correlations accounted for less than 30% of the variance (Majdandzic & van den Boom, 2007). A third study found little variance attributable to shared environment when parental descriptions of an infant's temperamental biases were the evidence but found that significant variance was assigned to the shared environment when observer ratings of the child's behavior were used (Roisman & Fraley, 2006).

One team of investigators who studied the long-term stability of aggression acknowledged the problems with verbal reports: "It is difficult to have parents reliably rate the behavior of their children. Some behaviors, such as rough and tumble play, may mistakenly have been interpreted as aggressive and may be motor developmental precursors of aggression." These authors acknowledged that behavioral observations would have been a preferable source of evidence, but they rationalized their decision not to observe behavior directly by arguing that "a large scale study such as the current one would be more difficult to set up using observational methods" (Alink et al., 2006, p. 964). This is not a reasonable defense. A chemist who asked three expert informants to estimate the chemical composition of a white powder, rather than perform the time-consuming analysis necessary to determine the ingredients, would be a target of satire or serious criticism.

Because most of the correlations between self descriptions and observed behaviors hover around 0.2 when they are statistically significant (corresponding to an $F$ of 4.0 for a sample of 100 participants), the modest magnitudes of these coefficients mean that investigators trying to predict behavior from verbal reports will be correct for about 30% of the sample, most of whom had extreme values on the two variables. It is usually impossible to predict behaviors from verbal reports for participants whose scores are between the 20th and 80th percentiles on the two variables. An $F$ of 36.0 with a sample of 100 participants, which has never been reported, is required for a correlation of 0.50 between a variable based on verbal report and a related class of behavior.

These data motivated the author of an extensive review on personality to remark, "Psychologists want and need to know what people actually do think and feel in the various contexts of their lives" (Funder, 2001, p. 213). Those who have read Jonathan Swift's *Gulliver's Travels* may remember that the writer satirized those who argued that language was capable of describing nature accurately. Swift described two philosophers scheduled for a debate who arrived in the hall with large sacks filled with the objects they planned to pull out in order to make each of their communications unambiguous. This cumbersome strategy may work for conveying the meanings of bricks, broccoli, and balloons, but it fails for most personality traits.

An important reason for the poor relation between questionnaire replies and direct observations is that the answers to questionnaires probing personality are always influenced by the unique organization each respondent's semantic networks impose on the replies. In addition, the replies are influenced by the person's ego ideal, the motive to be semantically consistent across questions, and the perceptual representations of specific life experiences that informants might retrieve when answering a question. Hence, investigators would profit from gathering information on the person's ego ideal for the traits being assessed and determining how each person interpreted the questions. This extra information would aid an understanding of the meaning of each individual's replies. For example, a woman who reported that she did not like parties might feel this way because she would prefer to be working, whereas another may feel this way because she becomes anxious in crowds. And some who affirmed the above statement might regard an introverted personality as a desirable quality, whereas others might regard the same trait as undesirable.

Finally, most, but not all, items on questionnaires allow the respondent to choose one of two different nodes for comparison (either the predicate naming the trait or the context in which the trait is actualized). Consider a sample of college students judging the degree to which the sentence, "I enjoy going to parties" applied to the self. An informant who selected the verb *enjoy* as the node for comparison would compare the pleasure experienced at parties with the level of uncertainty felt at such gatherings. However, the informant who selected *parties* as the node would compare the degree of pleasure at parties with the enjoyment that came from listening to music, reading, or athletic activity. These two informants might give exactly the same answer to the question but would do so for different reasons. A description of self as "happy most of the time," given by adolescents who had been high-reactive infants at 4 months and fearful to unfamiliarity at 2 years, meant that they believed they were meeting their personal ethical standards for achievement and loyalty. The same self-description offered by adolescents who had been low-reactive infants and fearless toddlers meant that they usually experienced a relaxed bodily feeling and were free of tension and excessive worry (Kagan & Snidman, 2004; Kagan, Snidman, Kahn, & Towsley, 2007).

Moreover, different answers to the same item can be misinterpreted as implying different behaviors in the natural setting the question described. Imagine two 1-year-old infants who were both determined to be in the 75th percentile of a large representative sample with respect to the frequency and intensity of the behavioral signs of fear to strangers, as based on reliable behavioral observations. The mothers of these infants are asked to respond "yes" or "no" to the statement: "My infant is afraid of strangers." If one mother observed that her infant more often smiled than cried around strangers, she might reply "no." If a second mother compared her infant's distress to strangers with the distress shown to dogs, and her infant had no fear of dogs, she might answer "yes," even though both infants were observed to be equally fearful of strangers.

## IMPLICATIONS

These comments have implications for research in personality, pathology, development, and social psychology. The investigators in these domains who rely on questionnaires as the sole or the major source of evidence assume that the meanings of the questions are transparent, that they will be interpreted in the same way by most informants, and that they are valid descriptions of the feelings and behaviors that individuals would experience or display in life settings. These assumptions are ingenuous (Ghuman, Lee, & Smith, 2006).

This criticism of questionnaires does not imply that verbal self-reports are without value. Rather, it means that conclusions based on verbal reports do not necessarily apply to objective measures of related behaviors or biological states. Furthermore, the meaning of a relation between two concepts that are measured with the same source of evidence is limited to that information. That is, a positive relation between a report of parental warmth during childhood and a feeling of satisfaction in adulthood does not mean that this relation would be found if investigators had actually observed the interaction between individuals and their families during the childhood years and observed their adult behaviors in varied life settings. Questionnaires provide useful sources of information on individuals' personal constructions of their actions, motives, feelings, and moods. The critical phrase in this claim is "personal constructions" (Schwarz, 1999). The answers to questionnaires reflect a balance among the individual's ego ideal, private constructions of experience, and desire to present oneself in a favorable light for the select characteristics that can be probed because the questions are not offensive and are phrased with a vocabulary familiar to the community. These are not unimportant limitations on what can be discovered.

Of course, behaviors also have serious limitations, as they can only provide evidence on the probability of actions in a particular setting. Because many significant settings cannot be created in the laboratory or even observed outside the laboratory, the range of behaviors that can be quantified is limited. Brain states, evaluated with magnetic resonance scanners, EEGs, or MEGs, usually reflect a balance among the sensory modality, unexpectedness or unfamiliarity of the incentive, the amount of cognitive work required, the necessity of a motor response, the resting brain profile before any intervention occurred (which is influenced, in part, by the person's genome), and the psychological meaning of the incentive (Smolka et al., 2007). This evidence has not proven to be a sensitive predictor of behaviors in specified settings or ego ideals.

I believe that a theoretically richer conception of personality should contain information on the person's self-reported ego ideal and personal constructions of experience, together with observations of behaviors in varied settings and typical brain profiles to varied classes of incentives. It should prove fruitful to gather all of these sources of evidence. An investigator has to gather self-reports, behaviors, and biology to determine which individuals from a large sample would behave in a sociable, affectively spontaneous manner with strangers because of a temperamental bias to experience minimal anxiety in unfamiliar settings and which individuals were equally sociable but did not inherit a temperamental bias.

Among a large group of adolescents who described themselves as sociable, relaxed, and sanguine, only some behaved that way during a long interview with an unfamiliar examiner, and an even smaller number showed both sociable behavior along with high vagal tone and left frontal activation in the EEG (Kagan et al., 2007). The extraversion a psychologist might ascribe to this small group who showed concordance among self-reports, behaviors, and biology should be distinguished from the extraversion defined only by self-reports. Although patients with early or late onset depressive disorder reported similar symptoms, only the former failed to show left frontal activation in the EEG to an approach task, and this group was more resistant to standard treatment (Shankman, Klein, Tenke, & Bruder, 2007). Physicians appreciate the wisdom of combining patients' descriptions of their symptoms with their physical appearance and behavior in the office, blood tests, X-rays, and tests of cardiovascular function in order to arrive at the most accurate diagnosis and, therefore, the best therapy.

Stated more formally, if each of three measures has more than one origin (which is true for verbal reports, behaviors, and biological data), and the origins are independent, then the correlations among them will be low. However, there is often a small group for whom a single origin lies behind all three measures. These individuals belong to a special category that is not equivalent in meaning to the average standardized score on all the measures.

## SUMMARY

Psychologists have made less progress over the last century than biologists have because the latter have enjoyed the advantage of technologies that have uncovered new phenomena and permitted the posing of novel questions. Biologists also share greater consensus on the questions that have priority (for example, evolution, genetic mechanisms, embryological development, and cell function), expect extreme specificity in the relations between variables, and are willing to spend entire careers trying to illuminate one question. Max Perutz spent almost 30 years before he established the structure of hemoglobin (Lightman, 2005). With the exception of amplifiers, brain scanners, computers, movie cameras, and VCR recorders, which are general purpose machines, psychologists have not had the advantage of new technologies appropriate to specific questions, agree less than biologists do on the concepts that should have priority, prefer abstract constructs with a broad application, and too often abandon a problem after a few years of effort before they arrive at a solution. This is not a recipe for progress.

The habit of abandoning a problem prematurely is the hardest to understand. I suspect that one reason is that many psychologists begin their inquiries with a favored construct, such as intelligence, executive function, positive affect, anxiety, attachment, or regulation, and invent laboratory procedures that promise to reveal its referents rather than begin with a reliable phenomenon and explore its causes and properties. Most natural scientists begin with a puzzling, but robust, phenomenon that colleagues acknowledge as important (apples fall from trees, heat dissipates, animals and humans contract diseases, related species reproducing in geographically isolated regions vary in their biological features) and probe its properties.

Because a fair number of psychologists interested in human characteristics choose to first posit abstract ideas, they become frustrated when they discover low correlations among the various empirical measurements they thought reflected the construct. Rather than probe the meaning of one or more of the empirical measurements, which is what many biologists would do, social scientists are prone to abandon the original problem because their motivation was fueled by the attractiveness of the a priori concept. Psychologists who study memory are a happy exception to this scenario. They did explore the bases for the different measures of memory and, as a result, were able to propose the fruitful concepts of declarative, episodic, implicit, and procedural memory.

Each empiricist has a choice between betting on a pretty idea or on a reliable fact before investing energy, time, and money in research. Each intellectual effort balances a tension between a centrifugal force racing toward a universal truth and a centripetal one grounded in the details of a concrete observation. The histories of the natural sciences imply that the second approach has a better record than does the first when the discipline is in an early stage of growth, as is psychology. Johannes Kepler took the reliable orbit of Mars as a puzzle to understand because he had access to the extensive observations gathered by Tycho Brahe and his army of observers. As a result, Kepler was able to infer its elliptical orbit around the sun and reject the popular belief of a circular planetary orbit. Whenever theory is weak and reliable facts are sparse, it is usually more fruitful to attend first to a robust phenomenon and to postpone a premature decision as to its explanation.

The mind is attracted to ideas that refer to effects with single causes, possess a broad application, and are concordant with contemporary ethical premises. However, most psychological phenomena are not the product of a single cause, the concepts that account for a relation between two measurements are usually limited in breadth, and the current emphasis on biological contributions to behaviors and symptoms is a pleasing idea because it promises the certainty associated with materialistic causes and is in accord with the relatively recent ethical imperative to avoid blaming the victim. An emphasis on the biological contributions to psychopathology removes responsibility from the society to alter the social conditions that placed individuals at risk and lifts some blame from patients for not showing a measure of willful control over their decisions and actions.

This article ends with three suggestions. First, all sentences about psychological processes should specify the class of agent (species, gender, social class, developmental stage), the type of incentive, the target of any response, the setting in which the measures were gathered, and (always) the source of evidence for every inference. Investigators should not write about fear, for example, without specifying the organism (snail, rat, monkey, or human), the nature of the evidence (conditioned gill retraction or freezing, potentiated startle, or a semantic interpretation of worry to a racing heart), and the setting (a laboratory or an ecologically familiar environment). All terms for psychological processes should be contextualized by writing full sentences.

Second, psychologists should acknowledge the differences between schematic and semantic representations because of their different metrics, organizations, and brain profiles (David & Cutting, 1992; Martin, Wiggs, & Weisberg, 1997). Third, psychologists should gather multiple measurements of a presumed concept that involve different sources of information, as Lang (1968) urged almost 40 years ago. Georg von Bekesy, who received a Nobel Prize for his research on the basilar membrane, advised a young investigator worried about his research career that "the method is everything." The older scientist explained that he always measured a phenomenon with at least five different methods on the assumption that the features shared among them might reveal the critical properties of the phenomenon of interest (Evans, 2003). Because verbal reports, behavioral observations, and biological evidence have different metrics and structures, conclusions based on only one of these sources of evidence are not always valid when the information comes from one of the other sources. It is likely that when behavioral observations, biological data, and verbal reports are gathered on the same individuals, the current constructs for personality, cognitive talents, emotions, and psychopathology will be replaced with more fruitful ideas.

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