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Cybernetic Big Five Theory

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ABSTRACT

Cybernetics, the study of goal-directed, adaptive systems, is the best framework for an integrative theory of personality. Cybernetic Big Five Theory attempts to provide a comprehensive, synthetic, and mechanistic explanatory model. Constructs that describe psychological individual differences are divided into *personality traits*, reflecting variation in the parameters of evolved cybernetic mechanisms, and *characteristic adaptations*, representing goals, interpretations, and strategies defined in relation to an individual's particular life circumstances. The theory identifies mechanisms in which variation is responsible for traits in the top three levels of a hierarchical trait taxonomy based on the Big Five and describes the causal dynamics between traits and characteristic adaptations. Lastly, the theory links function and dysfunction in traits and characteristic adaptations to psychopathology and well-being.

1. Introduction: Cybernetic Big Five Theory

The mission of personality psychology is "to provide an integrative framework for understanding the whole person" (McAdams & Pals, 2006, p. 204), but such grand theoretical frameworks are in short supply in modern research. An adequate theory of personality must explain not only *how* individuals differ from each other in their persisting patterns of emotion, motivation, cognition, and behavior, but also *why*. In other words, it must be an explanatory, causal theory. Further, to have any claim to being a "grand" theory, it must be comprehensive, synthetic, and mechanistic. To be comprehensive, it should encompass everything that psychologists mean by "personality." To be synthetic it should integrate what is known about the various components of personality within a single coherent framework. And to be mechanistic, it should explain what causes the components of personality to be what they are and to function as they do. Cybernetic Big Five Theory (CB5T) is designed to provide a framework capable of meeting these criteria.

A complete mechanistic theory of personality should encompass the biological basis of the mechanisms responsible for personality, and CB5T is designed to be fully compatible with the current state of personality neuroscience (DeYoung, 2010b, 2013; DeYoung & Gray, 2009). Biological constructs are not necessary for use of CB5T, however, because the theory is designed to offer a reasonably complete description of personality in psychological terms. The present article will not focus on the biological component of CB5T, referring to biological research only when it provides particularly useful evidence for a given psychological argument. This is not to say that psychological processes are in any way independent from biological processes; rather, psychological processes supervene on biological processes, meaning that any change in psychological function must involve a change in biological function, but not vice versa because biological constructs are at a higher (more fine-grained) level of resolution than psychological constructs (Kim, 2009). Nonetheless, an adequate theory of psychological mechanisms does not depend on complete or immediate translation into biological mechanisms for its utility.

The fundamental premise of CB5T is that any adequate theory of personality must be based in cybernetics, the study of goal-directed, self-regulating systems (Austin & Vancouver, 1996; Carver & Scheier, 1998; DeYoung, 2010c; Peterson & Flanders, 2002; Van Egeren, 2009; Wiener, 1961). Cybernetic systems are characterized by their inclusion of one or more goals or reference values, which guide the work carried out by the system. (In psychology, the term "goal" is sometimes reserved for conscious representations of goals, but the term is more general in cybernetics, and many goals are not conscious.) Further, all cybernetic systems receive feedback, through some kind of sensory mechanism, indicating the degree to which they are moving toward their goals. Finally, they are adaptive and adjust their behavior, based on feedback, to pursue their goals. Cybernetics is a useful, and perhaps even necessary, approach to understanding living things (Gray, 2004, chap. 3).

In psychology, "personality" is often used to describe the array of constructs that identify variables in which individuals differ, but "personality" also refers to the specific mental organization and processes that produce an individual's characteristic patterns of behavior and experience. These are the between-person, or

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interpersonal, and within-person, or *intrapersonal*, senses of "personality," respectively. Most intrapersonal personality constructs are causally interacting psychological elements that generate the ongoing flux of behavior and experience. These elements constitute a cybernetic system that, when functioning well, allows the organism to fulfill its needs (Block, 2002; DeYoung, 2010c). CB5T is an attempt to create a theory bridging the two senses of "personality," explaining interpersonal personality differences in terms of variation in the intrapersonal elements of personality.

The cybernetic component of CB5T renders it mechanistic, but a central aim is also to provide an explanatory framework capable of synthesizing the full range of phenomena that psychologists signify by the term "personality." McAdams and Pals (2006) provided an elegant delineation of the scope of personality, and the words "Big Five" in "Cybernetic Big Five Theory" serve as a reference not only to the well-known Big Five personality traits but also to their "New Big Five"—a set of five "principles for an integrative science of personality." These principles serve as a guide for the development of any personality theory and are themselves integrated within a definition of personality that is a useful starting point for CB5T: "Personality is conceived as (a) an individual's unique variation on the general evolutionary design for human nature, expressed as a developing pattern of (b) dispositional traits, (c) characteristic adaptations, and (d) self-defining life narratives, complexly and differentially situated (e) in culture and social context" (McAdams & Pals, 2006, p. 204). Each principle will be discussed at the appropriate point in what follows.

2. Personality as an evolved cybernetic system

The first of the five principles is that personalities are "individual variations on a general evolutionary design" (McAdams & Pals, 2006, p. 205). In many ways, all people are fundamentally similar, reflecting the species-typical, evolved design of the human organism. Understanding this design is a crucial step toward understanding the variations that constitute personality. In characterizing human nature, McAdams and Pals (and many evolutionary psychologists; e.g., Cosmides & Tooby, 1992) emphasize adaptations specific to *Homo sapiens*, those that occurred in the Pleistocene and more recently. Although specifically human adaptations are certainly of interest in understanding human nature, equally important are adaptations that occurred prior to the appearance of hominids. Human beings share the basic mammalian brain plan, and many features of the brain, as a cybernetic system, are shared with nearly all vertebrates. Comparing the human brain with those of other mammals reveals that our cerebral cortex has been greatly expanded by evolution, but the proportions of subcortical structures are strikingly similar (Deacon, 1997; Gray, 2004). Gray (1995, p. 1165) referred to subcortical structures known as the limbic system and basal ganglia as "a mechanism for the attainment of goals." This cybernetic architecture has been extremely well preserved by evolution because it provides the general behavioral control system that allows organisms to adjust their behaviors to their situation from moment to moment to accomplish their goals and, hence, to survive and reproduce. The foundation of the mechanistic component in CB5T is a description of the major functional elements of the human cybernetic system.

The operation of cybernetic systems can be characterized by a cycle with five stages: (1) *goal activation*, (2) *action selection*, (3) *action*, (4) *outcome interpretation*, (5) *goal comparison*. In the first stage, one of the person's goals is activated and guides the rest of the upcoming cycle. In the second, decision making takes place to select an appropriate action to move toward the goal. In the third, that action is carried out. In the fourth, the consequences of that action are interpreted; feedback processes provide information about the state of the world after the action, and that information is analyzed and structured using remembered knowledge (again, not necessarily conscious knowledge). Finally, the current state is compared to the goal to detect any mismatch. If the current state and the goal match, then that goal has been accomplished and a new goal will emerge to guide the next iteration of the cycle. If a mismatch is detected, however, the cycle will begin again with the same goal in place, and another action will be selected in order to attempt to move toward the goal (or, as discussed in Section 4.2, the goal may be abandoned).

This cycle is a useful schematic, but it is misleading in one crucial way (Austin & Vancouver, 1996; DeYoung, 2010c): Most of the five stages describe processes that are carried out simultaneously, in parallel rather than serially. For example, people are almost constantly interpreting feedback about the world from their sensory systems, and they are almost constantly comparing what is perceived to what is predicted or desired in order to detect mismatches, before and during action, as well as afterward. They are often engaged in selecting an upcoming action, even while carrying out the current action or interpreting their situation. Why, then, is it useful to model the cybernetic process as a linear cycle? Primarily because a bottleneck exists at stage 3 (action), which renders motor action mainly serial despite the fact that most psychological functioning is massively parallel. It is very difficult for people to carry out more than one action at once. Occasionally, someone will manage two actions at once (i.e., actions aimed at two different goals, not subcomponents of a single goal-directed action such as moving the head and arm simultaneously), usually when one of them is very well-practiced or habitual, but these are the exceptions to the rule. Given that actions are mainly serial, we can conveniently delineate the necessary elements of the cybernetic system in relation to a cycle built around action.

These elements can be divided into two basic categories. First, there is a collection of mechanisms that evolved to carry out the different processes associated with each stage of the cycle. Some mechanism must activate a particular goal, so that it is sufficiently influential on psychological functioning to cause relevant actions to be carried out; some mechanism must carry out comparisons between current state and goal state and output a signal of match or mismatch; etc. Second, stored in memory is a collection of goals, actions, and knowledge about the world. Human beings adopt many different goals, possess a huge behavioral repertoire, and understand a great many patterns that exist in the world, and most of these are learned through experience rather than innately preprogrammed. These learned, updateable memory contents of the cybernetic system are deployed by the mechanisms (in the first category) that are necessary to carry out the cybernetic cycle regardless of what goal is being pursued, what action selected, and what specific situation perceived. In the following section, I will argue that these two different categories of cybernetic elements, the general functional mechanisms and the specific contents of memory, account for the distinction between dispositional personality traits and characteristic adaptations, which constitute the second and third of McAdams and Pals' (2006) five principles. Following definition and explanation of traits and characteristic adaptations in Section 3, I will return, in Section 4, to describing in more detail the mechanisms that carry out the cybernetic cycle.

3. Defining personality traits and characteristic adaptations

A basic premise of CB5T is that *personality traits* and *characteristic adaptations* provide a complete description of everything that psychologists consider as psychological individual differences. McAdams and Pals (2006) listed these as only two of three types

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of variable within personality, with the third being "self-defining life narratives," but CB5T follows McCrae and Costa's (2008) Five Factor Theory (FFT) in describing self-defining life narratives and most other contents of the self-concept as a particular kind of characteristic adaptation (though a special and important kind, to be sure). In other regards, CB5T diverges substantially from FFT (and to a lesser extent from McAdams and Pals), particularly in the way it defines personality traits and characteristic adaptations.

3.1. Personality traits

Personality traits are probabilistic descriptions of relatively stable patterns of emotion, motivation, cognition, and behavior, in response to classes of stimuli that have been present in human cultures over evolutionary time. This definition has at least three important features. First, it equates traits with the tendency to be in certain emotional, motivational, cognitive, and behavioral states.[1] This equation is consistent with the work of Fleeson (2001), who has described traits as "density distributions of states" and has used experience sampling to show that people's average levels of states associated with a given trait are highly stable from week to week and correspond well to trait scores on standard questionnaire assessments of personality (Fleeson & Gallagher, 2009). Regardless of their level of a given trait (corresponding to their stable average), people display behavior corresponding to various different levels of that trait over the course of a day.[2] Thus, traits are probabilistic, and even an error-free measure of them could not perfectly predict behavior at any particular moment. Nonetheless, they may provide substantial predictive power for behavior in aggregate and are better than nothing for predicting even single instances of behavior (as long as the appropriate trait is measured for a given criterion). From a dynamical systems perspective, traits are equivalent to persistent attractor states of the cybernetic system; they indicate states toward which the person will tend to gravitate but do not preclude that person from being in other states (Lewis, 2005; Nowak et al., 2005).

The second important feature of the CB5T trait definition is that traits are situationally specific; they describe responses to specific classes of stimuli. Some of the moment-to-moment variation in states that renders traits probabilistic is systematically linked to the stimuli present in the situations where traits are expressed. Some authors, including McAdams and Pals (2006, p. 207), have referred to traits as "nonconditional" or "decontextualized," implying that the situation is irrelevant for understanding traits. This is not the case. Traits *are* contextualized and require appropriate eliciting stimuli before they are manifested in behavior and experience. This has long been recognized by trait theorists such as Allport (1937), Gray (1982), and Tellegen (1981, p. 219), the last of whom described traits as "the disposition to exhibit reaction R under condition S." One reason people may be inclined to believe that traits are decontextualized is that the context or "condition S" for most traits of interest is quite broad. The relevant eliciting stimuli tend to be broad classes, such as rewards, punishments, distractions, uncertainties, or conspecifics. Most situations involve many of these classes, which means that broad traits will be relevant to many, though not all, situations (Funder, 1991). Additionally, situations vary in the degree to which they involve each class of stimuli. Traits, therefore, vary in their relevance across situations, and, in situations where people are minimally exposed to some trait-relevant class of stimuli, individual differences in the corresponding trait will not be apparent (Corr, DeYoung, & McNaughton, 2013). The dependance of traits on situational features is formally demonstrated whenever an experiment reveals a trait-by-treatment interaction, such that a trait predicts an outcome in one condition but not another (Tellegen, 1981).

The third important feature is the stipulation that trait-relevant classes of stimuli have been present in human cultures over evolutionary time (which means that not every "condition S" counts as trait-relevant). This restriction entails that these classes of stimuli have had the opportunity to exert selection pressure during evolution, leading to the existence of evolved cybernetic mechanisms for reacting to them. (Indeed, as noted in Section 2, many of them have been exerting selection pressure since long before the emergence of hominids.) The continual presence of trait-relevant classes of stimuli in human history (and pre-history) accounts for the universality of traits. Providing some evidence for this universality, the genetic five-factor covariance structure of 30 traits has been shown to be equivalent in Canadian, German, and Japanese samples (Yamagata et al., 2006). McAdams and Pals (2006, p. 207) made a similar point regarding the cultural universality and evolutionary relevance of traits, describing them as "implicated in social life (both in the EEA [environment of evolutionary adaptedness] and today)." Here one can substitute "human life" for "social life." All traits have social implications because human beings are an intensely social species, but traits describe patterns of behavior and experience even in situations involving single individuals who are not currently dwelling on social concerns. The cybernetic context is even more fundamental than the social context, and traits are produced by variation in the parameters of universal human cybernetic mechanisms. The universality of traits is useful for distinguishing traits from characteristic adaptations, which are defined in relation to particular cultural and individual contexts (Section 3.2).

3.1.1. The trait hierarchy

A crucial observation regarding traits and their covariance structure is that they form a hierarchy. Correlated groups of very specific traits can be grouped together into broader traits, and these broader traits also form correlated groups indicating the existence of even broader traits. At each level of the hierarchy (below the highest), some set of forces causes groups of traits to vary together in patterns described by the next higher level of the hierarchy, and some other set of forces causes each trait to vary independently of the others. In other words, all traits below the highest level of the hierarchy have both shared and unique valid variance. Some evidence for this assertion is that unique genetic variance is associated with traits at each level of the hierarchy (Jang, McCrae, Angleitner, Riemann, & Livesley, 1998; Jang et al., 2002; McCrae et al., 2008). The hierarchical structure of traits highlights another way in which they are probabilistic: Although the lower-level traits grouped within a higher-level trait are correlated, they are not perfectly correlated. A high score on a higher-level trait, therefore, indicates high scores on some, but not necessarily all, of the lower-level traits to which it is related. Thus, the same score on a given trait can be achieved in substantively different ways, relying on different combinations of subtraits.

Much personality research in the second half of the 20th century was focused on organizing traits into a hierarchy based on empirical data. By the 1990s, a remarkable degree of consensus had arisen that five broad factors account for most of the covariance among more specific traits (John, Naumann, & Soto, 2008). CB5T involves a hierarchy of traits built around these Big Five personality dimensions, Extraversion, Neuroticism, Agreeableness, Conscientiousness, and Openness/Intellect (Fig. 1). The Big Five emerge from factor analyses of ratings of adjectives in many

[1] Throughout this article, the word "traits," used alone, refers to psychological traits only, not to physical traits. Additionally, the word "trait" is used to refer both to psychological dimensions along which individuals vary and to any particular value of one of those dimensions (in the sense that an individual has a particular set of traits).

[2] Indices of the variability of behavior—for example, the standard deviation or skew of density distributions of states—can also be considered traits, as long as they have a stable average, or even a stable pattern of oscillation (cf. Moskowitz & Zuroff, 2005; Nowak, Vallacher, & Zochowski, 2005).

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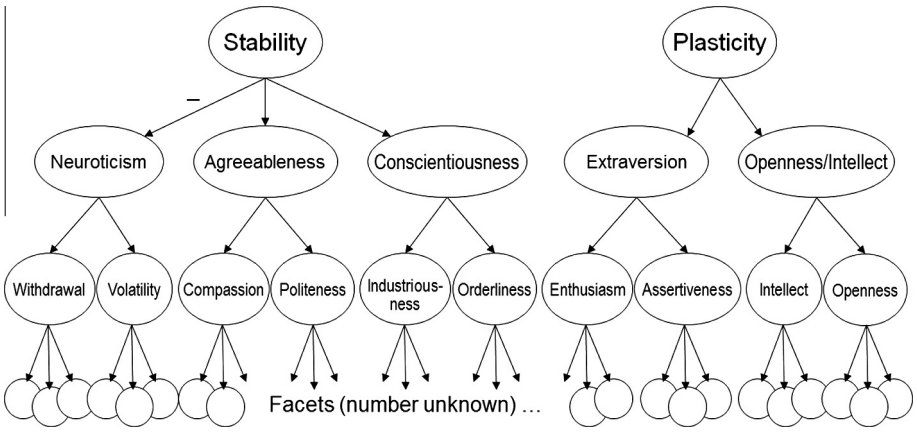

Fig. 1. The personality trait hierarchy. First (top) level: metatraits. Second level: Big Five domains. Third level: aspects. Fourth level: facets. The minus sign indicates that Neuroticism is negatively related to Stability.

languages as well as from existing personality questionnaires not designed to measure the Big Five (John et al., 2008; Markon, Krueger, & Watson, 2005).[3] Further, they appear to be applicable across the lifespan, even in childhood (Shiner & DeYoung, 2013).

Although the Big Five traits were initially assumed to be independent and, thus, the highest level of the hierarchy, they are, in fact, regularly intercorrelated such that there exist two higher-order traits, or *metatraits*, which we have labeled *Stability* and *Plasticity* (DeYoung, 2006; DeYoung, Peterson, & Higgins, 2002; Digman, 1997; see Section 5 for explanation of these labels). Although Stability and Plasticity are positively correlated in ratings by single informants, this correlation appears to result from rater bias, as they are typically uncorrelated in multi-informant studies (Anusic, Schimmack, Pinkus, & Lockwood, 2009; Chang, Connelly, & Geeza, 2012; DeYoung, 2006; McCrae et al., 2008). The metatraits, therefore, appear to be the highest level of the personality hierarchy, with no "general factor of personality" above them (Revelle & Wilt, 2013).

The facet level of the hierarchy has typically been considered to be the level immediately below the Big Five. Recently, however, the existence of an intermediate level was demonstrated, first in twin research that showed two genetic factors were necessary to explain the covariance among the six facets in each Big Five domain as measured by the NEO Personality Inventory-Revised (NEO PI-R; Costa & McCrae, 1992; Jang et al., 2002). If the Big Five were the next level of the personality hierarchy above the facets, only one genetic factor would have been necessary for each domain. The nature of these 10 intermediate factors, or *aspects* of the Big Five, was then clarified in factor analysis of a larger number of facets for each domain (DeYoung et al., 2007). Although less research exists to support the specific identities of the aspect-level traits than of the Big Five or metatraits, the aspects are important because they form an empirically derived substructure for the Big Five that is lacking at the facet level. Lists of facets have typically been rationally or intuitively derived, and no consensus exists regarding the number and identity of the facets. In principle, the number of facets might be limited only by the number of narrow trait constructs one can measure with discriminant validity. In practice, there are probably not more than a few importantly distinct facets below each aspect. The existence of the aspects is reflected in some details of CB5T, as described in Section 4, and the two aspects in each domain are likely to reflect the most important distinction for discriminant validity within each of the Big Five (e.g., DeYoung, Grazioplene, & Peterson, 2012; DeYoung, Weisberg, Quilty, & Peterson, 2013).[4] The 10 aspects can be measured directly by the Big Five Aspect Scales (BFAS; DeYoung et al., 2007).

Much research on personality today is organized around the Big Five. Importantly, however, the term "personality traits" is not synonymous with "the Big Five." There are a great many personality traits, and the Big Five merely represent the major dimensions of covariation among them. A pet peeve of mine is the tendency of researchers to claim to have "measured personality" or "controlled for personality" by collecting ratings on a brief Big Five instrument, treating this assessment as if it captured all variance in personality and implying that any other measures of individual differences in their study were somehow not measures of personality. CB5T asserts that all reasonably stable psychological individual differences are part of personality, and that all of them encompassed by the definition of traits that begins Section 3.1 are properly called traits. Nonetheless, CB5T recognizes (1) that most traits can be categorized either as a facet of one of the Big Five or as a compound trait reflecting a blend of two or more of the various traits at all levels of Fig. 1, and (2) that any successful explanatory theory of personality must account for the existence of the Big Five as the major dimensions of covariation in personality.

A final note on the hierarchy shown in Fig. 1: It is necessarily an oversimplification at the levels below the Big Five, because personality does not have simple structure (Costa & McCrae, 1992; Hofstee, de Raad, & Goldberg, 1992). Some facets and aspects have associations, not depicted in the figure, with factors in other domains. This is true even between some traits located under different metatraits, which could not be related if the diagram in Fig. 1 were complete. For example, Compassion is positively related to Enthusiasm, and Politeness is negatively related to Assertiveness (DeYoung et al., 2007, 2013). Although most deviations from simple structure are not addressed here, CB5T is compatible with the existence of these additional associations,

[3] Although a six factor solution may be more replicable than the Big Five across languages (Ashton et al., 2004), this solution is not very different from the Big Five because the major change is merely to split Agreeableness into two factors, one blended with elements of Neuroticism (De Raad et al., 2010; DeYoung, Quilty, & Peterson, 2007; Saucier, 2009). Questionnaire rather than lexical studies do not support the six factor solution (Markon et al., 2005). Further, within the Big Five hierarchy, the content of the Honesty/Humility factor (the sixth factor) can be encompassed by the Politeness aspect of Agreeableness (DeYoung et al., 2007; McCrae & Costa, 2008). Finally, replicability across languages is not adequate as a sole criterion for choosing a factor solution to use in personality theory (DeYoung, 2010b).

[4] CB5T currently offers no explanation for why there should be two, and only two, major subfactors in each of the Big Five; however, this pattern did not appear to result from any obvious artifact or methodological limitation (DeYoung et al., 2007).

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especially when combined with a biological perspective on personality traits. The brain includes many different mechanisms. The most central cybernetic mechanisms can explain the Big Five (see Section 4), but other mechanisms can be identified to explain trait associations not illustrated in Fig. 1 (DeYoung, 2010b, 2013; DeYoung et al., 2013).

3.1.2. The causal role of personality traits

CB5T's primary definition of personality traits (Section 3.1) should be widely suitable for personality theories, even if they differ in other ways from CB5T. However, the term "personality trait" is used in multiple ways in psychology, and another of these is particularly important here. In this secondary meaning, a personality trait describes *the typical functional level of the underlying psychological processes responsible for generating the emotional, motivational, cognitive, and behavioral states associated with that trait*. Something like this sense of "trait" appears to be what lay people often mean when they refer to a trait in conversation; they are attempting to identify the cause of someone's behavior (Kressel & Uleman, 2010). Note that one may make valid (though non-causal) inferences about behavior even when relying only on the primary definition of traits. If one guesses that someone will decide to go to a party "because he is extraverted," one may simply mean that, because one knows he is likely, in general, to engage in the class of behaviors described by Extraversion, one can infer that he is likely, in this particular situation, to engage in a specific behavior in that class. This inference from the general to the particular is not merely circular (it could be made even if one did not know whether the person in question had ever gone to a party previously) and follows validly from the primary definition of traits (Funder, 1991). Nonetheless, one might wish to infer something more interesting—namely, that some psychological mechanism associated with Extraversion is likely to contribute causally to his decision to go to a party. This latter inference relies on the secondary meaning of "trait."

In his Whole Trait Theory, Fleeson (2012) describes these two meanings of "trait" as necessary complements to each other, the first providing the descriptive part of the trait construct and the second providing the explanatory part. CB5T considers the explanatory usage of "trait" to be a valid and convenient shorthand for talking about the causal mechanisms underlying traits, but one to be used with caution by psychologists because the mechanisms underlying the Big Five and other traits are currently described by theories that need further testing; they are much less well established than the descriptive entities identified by the primary definition of traits. Thus, when one says "Extraversion," the referent is well specified in relation to patterns of behavior and experience but relatively poorly specified in relation to causal processes. From the CB5T perspective, it is precisely these underlying processes that need to be explained, and it would be unwise to treat a score on a questionnaire asking about patterns of behavior and experience (our typical measure of traits) as if it were an adequately validated measure of any of the particular underlying processes that generate those patterns. Throughout this article, therefore, the word "trait," as well as various trait labels, are used in the primary sense from Section 3.1.

Fig. 2 depicts both causal antecedents and effects of traits. Traits are directly caused by relatively stable parameters of psychobiological cybernetic mechanisms. The "mechanisms" box encompasses the secondary meaning of "traits." Biological mechanisms are combined in this box with psychological mechanisms because biological and psychological function are not considered to be causally sequential. Rather, as noted in Section 1, their relation is one of supervenience; biological mechanisms simply provide a fine-grained description of the instantiation of the psychological mechanisms. The values of these relatively stable parameters are

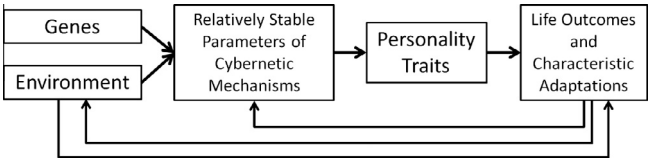

Fig. 2. The causal role of personality traits. Personality traits are relatively stable patterns of emotion, motivation, cognition, and behavior caused by relatively stable parameters of evolved psychobiological cybernetic mechanisms. These parameters are calibrated by interacting genetic and environmental forces. Traits causally influence life outcomes and characteristic adaptations, which can influence personality traits by influencing either cybernetic parameters directly or environmental factors that influence those parameters. Environmental forces also influence life outcomes and characteristic adaptations. Not depicted in the figure but acknowledged by CB5T are (1) causal interactions between characteristic adaptations and other life outcomes, and (2) other psychobiological processes that contribute causally to characteristic adaptations but are not stable parameters.

shaped by both genetic and environmental forces, which interact to influence the development of personality traits over the lifespan by altering brain function (DeYoung, 2010b; Roberts & Jackson, 2008). At any given moment, the mechanisms associated with a given trait may be operating anywhere across a wide range of function, conditional on their interactions with other mechanisms in the system, including sensory input from the current situation. This is why the states associated with each trait display a density distribution over time and are not always at the same level in a given individual (Fleeson, 2001, 2012). Nonetheless, some relatively stable parameters of the system incline the mechanisms of each trait toward a particular level of function, producing a stable average state over time. In the language of dynamical systems, these parameters describe persistent attractor states shaped by genetics and by dynamic interactions of elements of the system both with each other and with features of the environment (especially interpersonal relationships) that lead over time to relatively stable patterns of function (Lewis, 2005; Nowak et al., 2005).

Finally, Fig. 2 shows that traits have causal effects on life outcomes, such as health, occupation, access to resources, and personal relationships, because consistent patterns of behavior have consequences (Ozer & Benet-Martinez, 2006). These outcomes can in turn have influences on traits, either by directly influencing the functioning of the brain's cybernetic mechanisms or by influencing the environment that contributes to shaping personality. Of course, the genetic sequence cannot be changed by these effects, but the epigenome, the pattern of molecules binding to DNA that regulate gene expression, can be (Morgan, Santos, Green, Dean, & Reik, 2005); such epigenetic effects are captured in Fig. 2 as effects on cybernetic mechanisms in the brain, which are built, maintained, and modified through the transcription of genes. Some of the outcomes influenced by personality traits constitute characteristic adaptations, as discussed in Sections 3.2 and 5. Additionally, characteristic adaptations and life outcomes often affect other characteristic adaptations and life outcomes, so there are causal interactions among the elements in this box that are not depicted in the figure.

Fig. 2 suggests two additional potential meanings of the word "trait" that are worth discussing briefly. First, one might use "trait," to refer not only to an underlying psychological function, but also to the neurobiological processes that instantiate that psychological function. This would be reminiscent of Allport's (1937, p. 295) definition of traits as "neuropsychic structures." This usage, though not strictly wrong if one is willing to use the word "trait" in the explanatory sense, is even riskier than the secondary meaning described above; if we know relatively little about the psychological causes of traits, we know even less about the biological causes. Second, some researchers have used "trait" to describe the genetic component of the distal causes of personality, excluding

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environmental causes. This appears to be the meaning preferred by FFT, for example, which asserts that "the course of personality [trait] development is determined by biological maturation, not by life experience" (McCrae & Costa, 2008, p. 167).[5] In CB5T, equating traits exclusively with the genetic predisposition to develop particular patterns of function is deemed incorrect because it confuses the genotype with the phenotype. Traits are phenotypic constructs, and genetically informative research indicates that all traits are subject to environmental influence. All traits are heritable, meaning that their variance is due in part to variation in the genome, but none are perfectly heritable, meaning that variation in the environment additionally contributes to their variance (Turkheimer, 2000). Though typically estimated at around 40–60% in self-ratings of adults, the heritability of the Big Five is in the range of 60–80% when assessed with multiple raters (Riemann, Angleitner, & Strelau, 1997; Riemann & Kandler, 2010). This is consistent with adult heritability estimates for intelligence (IQ), which CB5T considers a personality trait (Deary, 2012; DeYoung, 2011). Despite common misconceptions, such high levels of heritability in adulthood are perfectly compatible with the existence of substantial environmental influences on traits (Johnson, 2010). One must also remember that heritability is not uniform in the population and can be moderated by a wide variety of factors, meaning that the balance between genetic and environmental contributions to trait variance shifts across different environments (Krueger & Johnson, 2008).

FFT claims that the relative stability of the Big Five over the lifespan and their existence in diverse human cultures "make sense only if personality traits are insulated from the direct effects of the environment" (McCrae & Costa, 2008, p. 164). One problem with this claim is that the lifespan stability of the Big Five (and other traits), though impressive, is far from perfect (Roberts, Wood, & Caspi, 2008), so the stability of the Big Five is compatible with environmental influence throughout life (and longitudinal research is beginning to identify specific life events that influence the Big Five; Ludtke, Roberts, Trautwein, & Nagy, 2011; Specht, Egloff, & Schmukle, 2011). Regarding the universality of the Big Five, CB5T ascribes it to the fact that these traits reflect individual variation in the parameters of a set of cybernetic mechanisms that is present in every intact human brain. The specific values of these parameters for a given individual at a given time are influenced by experience as well as by genetic endowment, but this does not contradict the universality of the mechanisms themselves (cf. MacDonald, 2006).

3.2. Characteristic adaptations

Characteristic adaptations are relatively stable goals, interpretations, and strategies, specified in relation to an individual's particular life circumstances. In contrast to traits, relatively few researchers have worked to define characteristic adaptations, and my succinct definition will need to be unpacked extensively to reveal its full implications.[6] CB5T's definition differs from both McAdams and Pals' and FFT's definitions in ways that stem from differences in how the three systems define traits. McAdams and Pals (2006, p. 208) defined characteristic adaptations as "motivational, social-cognitive, and developmental adaptations, contextualized in time, place, and/or social role," and, later in the same article, they described them as contextualized in "situations" as well (p. 213). Because they defined traits as nonconditional and decontextualized, they were free to identify any conditional or contextualized personality variable as a characteristic adaptation. In contrast, CB5T recognizes that traits are contextualized in situations, in that they are conditional on the presence of specific classes of stimuli. A more specific criterion is necessary, therefore, to distinguish characteristic adaptations from traits, and the most useful criterion is cultural universality. Individual-difference constructs are traits if they reflect reactions to classes of stimuli that have been present in every human culture. (This criterion works even if members of different cultures differ in their typical reactions to some universal classes of stimuli; such differences simply constitute differences in average trait levels across cultures.) Individual-difference constructs reflecting reactions to the specific, non-universal circumstances of a given culture or individual life are characteristic adaptations. This cultural specificity accounts for McAdams and Pals' (2006, p. 211) fifth principle, "the differential role of culture," which asserts that culture has a stronger effect on characteristic adaptations than on traits.

Whereas McAdams and Pals' definition of characteristic adaptations is less constrained than CB5T's, FFT's definition is, in one way, more constrained, limiting them to mere intermediaries between traits and specific behaviors. For FFT, characteristic adaptations are the "intrapsychic and interpersonal features that develop over time as expressions of [traits]," and the "concrete manifestations [of traits] in the personality system" (McCrae & Costa, 2008, p. 163). They develop as "individuals react to their environments by evolving patterns of thoughts, feelings, and behaviors that are consistent with their personality traits and earlier adaptations" (McCrae & Costa, 2008, p. 165). Because FFT defines traits as unobservable genetic tendencies, untouched by experience, it must consider all relatively stable patterns of behavior that have been shaped by environment to be characteristic adaptations. Once traits are recognized as phenotypic rather than genotypic constructs, shaped by both genes and environment, this criterion becomes untenable. In CB5T, characteristic adaptations are influenced by traits, but they are separate entities in their own right, generated by the cybernetic processes of exploration and adaptation discussed in Section 5, and they may influence traits in return (as shown in Fig. 2). For this reason, characteristic adaptations are not always consistent with traits (although many of them are, due to the influence of traits on the process of adaptation).

Lists of personality constructs that constitute characteristic adaptations tend to resemble laundry lists and are acknowledged to be incomplete sets of examples. McCrae and Costa (2008) first listed "habits, attitudes, skills, roles, relationships" (p. 163) and then added another, mostly non-overlapping list: "interests, roles, skills, self-image, psychiatric symptoms" (p. 172). McAdams and Pals (2006, p. 208) provided a longer, but almost entirely non-overlapping, list: "motives, goals, plans, strivings, strategies, values, virtues, schemas, self-images, mental representations of significant others, developmental tasks." McCrae and Costa (2008, p. 176) acknowledged that the field needs "subtheories that catalogue the contents of characteristic adaptations and systematize dynamic processes." CB5T begins to fill that need and is dramatically different from these other two models in that it provides a list of just three categories that are asserted to cover every characteristic adaptation: goals, interpretations, and strategies.

As noted in Section 2 (cf. DeYoung, 2010c; Peterson, 1999), these categories describe the updateable memory contents of the human cybernetic system. All three can be conscious or unconscious. *Goals* are defined broadly as representations of a desired

[5] The FFT understanding of traits is incoherent because, although traits are claimed to be immune from environmental influence, an exception is made for interventions that change the brain, such that brain damage, psychotropic drugs, and even psychotherapy are acknowledged to be capable of changing traits (McCrae & Costa, 2008). Unfortunately for FFT, once pharmacological manipulation or psychotherapy are allowed to change traits, other environmental influences must be allowed as well, because many experiences cause analogous neurobiological changes that could lead to lasting changes in traits.

[6] One important distinction is between *characteristic adaptations*, which emerge through changes in brain function within the span of a single lifetime, and *evolutionary adaptations*, which emerge through changes in genetic structure due to differential fitness of individuals from generation to generation. In this article, "adaptation" refers to the process within a single lifetime, unless otherwise noted.

future state and, more formally, as cybernetic reference values (Austin & Vancouver, 1996). Researchers may wish to identify different types of goals using multiple terms (e.g., goals, motives, strivings), and this is legitimate from the perspective of CB5T as long as one recognizes these types as members of the larger cybernetic category in which they are functionally unified (for which CB5T uses the term "goals"). Like traits, many goals and other characteristic adaptations can be considered attractor states within a dynamical system (Carver & Scheier, 1998; Nowak et al., 2005). Different goals are active at different times, as the cybernetic system shifts among multiple attractor states, prompted by both external stimuli and internal dynamics. Some goals are strong attractors and are capable of organizing and governing motivation for extended periods of time, despite potential disruptions, whereas others are relatively weak attractors, readily disrupted and displaced by other goals, even if they are characteristic in the sense that they are held in memory over long periods of time.

Interpretations are representations of the current state of the world (including the self), involving both factual and evaluative information. All interpretations are inherently representations of the past as well as the present because the present is always understood in relation to past experience. Further, many interpretations of the current state of the world include expectancies about what is likely in the future, given the current state. The evaluative or affective component of interpretation is necessarily framed in relation to goals (phenomena can be deemed good or bad only in relation to some desired state), and these goals range from the innate and concrete, like obtaining food or sex, to the learned and highly abstract, like developing a theory of personality or supporting a religious ideology. Our brains interpret the world primarily as a forum for action and only secondarily as a realm of facts, and our interpretations are shaped, more than most people are likely to realize, by relevance to our goals (Harkness, Reynolds, & Lilienfeld, 2014; Peterson, 1999). Nonetheless, we have evolved to detect and remember a great many facts (with "facts" meant broadly as any kind of nonevaluative information about the state of the world) that may be irrelevant to our goals, presumably because our goals and strategies are so complex and changeable that phenomena that seem irrelevant at present may well prove relevant to one of our goals in future (DeYoung, 2013; Schwartenbeck, FitzGerald, Dolan, & Friston, 2013).

Strategies are plans, actions, skills, and automatized routines that are used to attempt to transform the current state into the desired future state. Note that strategies can be either behavioral or cognitive; psychological research on problem solving has referred to the strategies that allow progress from a problem state (i.e., an interpretation of the current state) to a goal state as "operators," and the available operators for solving problems can range from simple motor output to complex cognitive operations like algebra (Newell & Simon, 1972). Of the three categories, strategies are most complicated to define, due to the hierarchical structure of goals (Carver & Scheier, 1998; Peterson, 1999). Most goals must be achieved through the accomplishment of various subgoals. All strategies other than the most simple actions, therefore, involve nested sequences of goals. One might argue, then, that simple actions should take the place of strategies as one of the three basic categories of characteristic adaptation, but a good reason exists to decline this option: Collections of actions and subgoals that form coherent strategies for particular larger goals are chunked into representations in memory that can be retrieved and utilized as functional units (Graybiel, 1998). To analyze people's strategies in units of coordinated sequences of actions with multiple subgoals is typically more natural and useful than to think about the individual actions (move the legs, move the arms, etc.) that make up those functional units. Nonetheless, one must remember that these functionally chunked representations often can be decomposed by the individual in order to make adjustments to substrategies or subgoals. A characteristic adaptation categorized as a strategy in one context might be analyzed in terms of its constituent goals in another.

This flexibility in what is considered a strategy versus a goal raises the issue that several of the terms in the lists of characteristic adaptations quoted above refer to concatenations of elements from more than one of the three basic categories of characteristic adaptation. Roles and relationships, for example, are likely to involve multiple interpretations, strategies, and goals. This is not a problem for discussion of characteristic adaptations, as long as one recognizes that broad characteristic adaptations can be decomposed into more narrow ones. Having a career as a lawyer, for example, is a characteristic adaptation that entails many more specific characteristic adaptations, and the latter can be categorized as goals, interpretations, or strategies.

Goals, interpretations, and strategies represent the information used by the cybernetic system to function in any situation, and they always reflect the manner in which the individual has adapted to that situation, even if they are one-off, never repeated. This means that not all adaptations are characteristic. To be considered "characteristic," the adaptation must have enough stability to be a useful descriptor of the person for some reasonable length of time. Unfortunately, this duration is poorly specified, and it seems unlikely that psychology will ever arrive at an exact length of time required for a goal, interpretation, or strategy to be considered part of someone's personality, rather than merely a transient, uncharacteristic state. (Perhaps the degree to which an adaptation is characteristic could most accurately be viewed as a continuum based on how long it persists.) For traits, we have standards based on test–retest reliability, and we expect traits to be reasonably stable even over multiple years, but characteristic adaptations need not have the longevity of traits. CB5T does not take any strong position on the duration required of a characteristic adaptation, although, as a rough guideline, it seems unlikely that one would want to identify a characteristic adaptation that was not present for multiple weeks at least. (Note that this does not prevent very short-term goals—such as acquiring a cup of coffee—from being characteristic adaptations, because the same immediate goal may be adopted repeatedly over a period of weeks or more. When not active, it remains in memory as a characteristic adaptation.)

3.3. Distinguishing and measuring traits and characteristic adaptations

Having defined both traits and characteristic adaptations, we can now consider the implications of these definitions for the field. First, CB5T helps to clarify the role of motivation in personality, which has been particularly confused in relation to the distinction between traits and characteristic adaptations. Some researchers have asserted that motivation is unrelated or peripheral to personality traits (e.g., McAdams & Pals, 2006; Pervin, 1994), whereas many others have argued that motivation is central to personality traits (e.g., Austin & Vancouver, 1996; Corr et al., 2013; Funder, 1991; Ortony, Norman, & Revelle, 2005; Pickering & Gray, 1999; Read et al., 2010; Sheldon, 2004). CB5T's distinction between traits as reflections of parameters of universal cybernetic mechanisms and characteristic adaptations as goals, interpretations, and strategies defined in relation to an individual's particular life circumstances allows motivation to be central to both types of construct without muddying the distinction between them. Many traits are associated with motivations (e.g., to pursue rewards, avoid punishments, complete tasks, etc.) that are present in all normally functioning human beings, but to varying degrees. The motivations associated with an individual's characteristic adaptations, in contrast, may be present in many people (e.g., the motivation

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to write an article or to get a promotion at work), but are certainly not present in all of them, and may be present in just one person (e.g., the motivation to write this particular article).

Characteristic adaptations are, by definition, reactions to particular life circumstances, whereas traits need not be. Nonetheless, traits do show some degree of adaptation to life circumstances, such that environmental influences can shift trait levels, despite their substantial genetic basis. Whereas changes to traits are changes to parameters of already existing evolved mechanisms, changes in characteristic adaptations are novel additions to memory or reconfigurations of previous additions to memory. In CB5T, as implied by Fig. 2, all of the genetic variance in any characteristic adaptation is a function of related traits, so traits should mediate genetic effects on characteristic adaptations, and one might expect heritabilities to be lower for characteristic adaptations than for traits. In practice, however, it may be exceedingly difficult to identify (and to measure with sufficient accuracy) exactly the relevant set of traits that would account for the genetic variance of any given characteristic adaptation. Heritability studies, therefore, are unlikely to offer any guidance as to what is a trait versus a characteristic adaptation.

Neither the involvement of motivation nor patterns of heritability are adequate for distinguishing traits from characteristic adaptations. Traits have been studied extensively as such, whereas characteristic adaptations have been studied under many different names. So what exactly counts as a characteristic adaptation? The easy answer is that any psychological individual-difference variable that is not a trait is a characteristic adaptation (including categorical variables such as "being a lawyer"), as long as it is of sufficient duration. In reality, the distinction is not always straightforward, and it is worth exploring instances in which CB5T contradicts or complicates the identification of constructs as characteristic adaptations by other frameworks.

For example, McAdams and Pals (2006) identified regulatory focus as a characteristic adaptation, whereas CB5T identifies it as a trait. As a personality construct, regulatory focus refers to the orientation that people chronically take toward selecting strategies when pursuing goals (Higgins et al., 2001). Promotion focus reflects the degree to which people tend to focus on achieving positive outcomes, whereas prevention focus reflects the degree to which people tend to focus on preventing negative outcomes. Because positive and negative outcomes are broad classes of stimuli present in all human cultures, CB5T recognizes chronic promotion and prevention focus as traits and asserts that they can be explained in terms of relatively stable parameters of universal cybernetic mechanisms. McAdams and Pals' (2006, p. 214) identification of regulatory focus as a characteristic adaptation stemmed in part from their observation that regulatory focus "can be primed by situational influences." However, given that traits reflect the probability of being in particular states given appropriate eliciting stimuli, the fact that the states associated with some trait can be manipulated does not disqualify that construct as a trait. People (including introverts) can be put into an extraverted state experimentally, for example, with measurable consequences, but this fact does not detract from Extraversion's status as a trait (Fleeson, Malanos, & Achille, 2002).

Other constructs likely to cause confusion about the distinction between traits and characteristic adaptations include self-concepts, coping styles, defense mechanisms, virtues, and values. Depending on how these constructs are conceived and measured, each may describe both traits and characteristic adaptations. Most aspects of the self-concept, including the self-defining life narratives that constitute McAdams and Pals' (2006) fourth principle, are clearly characteristic adaptations because they reflect the individual's reaction to particular cultural and individual life circumstances. Self-defining life narratives, for example, are a type of interpretation that provides a conscious meta-representation of many of the individual's goals, interpretations, strategies. Self-esteem, in contrast, should be considered a trait because it reflects global evaluations of the goodness or badness of the self that are made by individuals in every human culture. Although environmental influences on self-esteem are likely to differ from culture to culture (just as environmental influences on any trait may vary across cultures), global self-esteem fits empirically into the trait hierarchy as a facet of Neuroticism (Goldberg & Rosolack, 1994; Judge, Erez, Bono, & Thoresen, 2002), suggesting that proneness to experiencing negative emotion is one of the strongest influences on self-evaluation in any culture. Nonetheless, culturally specific criteria by which individuals habitually judge themselves (e.g., culturally specific standards of beauty) should typically be considered characteristic adaptations. Thus, characteristic adaptations may influence the trait of self-esteem, as well as vice versa.

A similar distinction can be made in relation to defense mechanisms and coping styles. If the mechanism or style in question appears in all cultures (though not necessarily to equal degree), then it should be considered a trait, stemming from the operation of mechanisms shared by all people. The degree to which people are generally prone to problem-focused coping should be considered a trait, for example, as should general tendencies toward emotion-focused, meaning-focused, engagement-focused, and disengagement-focused coping. In contrast, when considering how a person habitually copes with a particular stressor (e.g., a demanding boss), the specific strategy (e.g., often calling in sick) is a characteristic adaptation, because its description requires reference to the individual's particular cultural circumstances.

Many virtues—honesty, patience, diligence, compassion, courage, etc.—describe patterns of behavior that can be found in all cultures, are obviously traits, and can easily be assimilated into the trait hierarchy shown in Fig. 1. Nonetheless, different cultures may disagree about which traits constitute virtues. Open-mindedness might be considered a virtue in one culture but not another, for example. Further, one might be able to identify some culturally specific virtues—for example, having the skill or motivation to carry out some particular culinary or performative tradition—that are clearly characteristic adaptations. Exactly which traits and characteristic adaptations are evaluated as virtues differs not only across cultures but also across individuals, and these evaluations can be described as values. As with virtues, values may be traits if they refer to culturally universal phenomena (Schwartz et al., 2012) or characteristic adaptations if they refer to culturally or individually idiosyncratic phenomena. Further, an individual's explicit ranking of values would constitute a characteristic adaptation even if many of the values in the ranking referred to culturally universal phenomena, because which values were included in the list and in what order would be somewhat idiosyncratic. Such a ranking could be considered part of the individual's self-concept. The fact that many virtues and values must be considered traits does not mean researchers should stop studying values and focus on the Big Five. As noted in Section 3.1.1, the term "personality traits" is not equivalent to "the Big Five." It does mean, however, that many values can be categorized as facets of the Big Five, and these categorizations should be mapped to aid in integrating theories of values with other theories of personality.

Some examples may help to illustrate the difference between traits and characteristic adaptations: Being argumentative is a trait; being a trial lawyer is a characteristic adaptation. Liking to frolic with friends is a trait; belonging to a fraternity is a characteristic adaptation. Being typically prevention focused is a trait; checking the stove every time one leaves the house is a characteristic adaptation. Having an avoidant coping style in general is a trait; habitually avoiding a particular acquaintance is a characteristic adaptation. Having an insecure attachment style in general

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is a trait; being insecurely attached to one's current romantic partner is a characteristic adaptation. Valuing honesty is a trait; explicitly claiming honesty as one's highest value is a characteristic adaptation.

Some of the reasons it can be complicated to decide whether a construct is a trait or a characteristic adaptation have to do with measurement. Due to the difficulty of acquiring sufficiently broad samples of individuals' behavior to identify the relatively stable patterns that constitute traits, we typically assess traits through questionnaires that ask people to report on themselves or others. These questionnaires rely on the fact that people's conscious concepts of self and others include concepts of their traits as such, or at least of the behaviors they are most likely to exhibit. This is convenient, but it means that we assess traits using characteristic adaptations in the form of interpretations of self and others (McCrae & Costa, 2008). Discrepancies between these interpretations and actual patterns of emotion, motivation, cognition, and behavior are one source of error in trait questionnaires. Other methods of assessing traits, such as performance or decision-making tasks, do not rely as heavily on subjective interpretation, but, with a few exceptions (e.g., traits related to cognitive ability), they have been much less well developed than questionnaire measures (DeYoung, 2011). The psychometrics of task-based trait assessment is a promising growth area in personality psychology (Robinson, 2007).

Another complication in questionnaire assessment is that some items in trait questionnaires describe characteristic adaptations. Although many personality items simply describe culturally universal traits (for example, most of the brief items in the International Personality Item Pool; Goldberg, 1999), some items refer to culturally specific patterns of behavior and experience. Even if all the items in a trait scale described different characteristic adaptations, however, it would be possible for the total score on the scale to be a valid trait measure, if all of the characteristic adaptations described by the items were primarily associated with the same trait (e.g., an Extraversion scale could include items like, "I enjoy meeting people in bars," "I spend a lot of time talking on the phone," etc.). This reflects the principle of aggregation (Epstein, 1979); the total score would reflect not any particular characteristic adaptation, but rather the trait to which all those adaptations were related.

Given the possibility of assessing traits using characteristic adaptations, one might wonder whether it is ever possible to assess characteristic adaptations by questionnaire. The answer is decidedly yes. What must be done is to focus the items on a particular adaptation, in all its cultural and personal specificity. An example used above was the quality of one's attachment to one's current partner. Attachment questionnaires that frame all of their items in relation to a single relationship with a particular individual are validly assessing a characteristic adaptation, regardless of whether that characteristic adaptation has been influenced by a trait reflecting typical attachment style.

Whereas some surveys require respondents to focus on particular characteristic adaptations selected by the researcher, others allow respondents to identify their own. One of the most thorough methods for assessing characteristic adaptations is Little's (1983, 2006) personal projects analysis, which asks people to generate their own list of personal projects—"activities and concerns ... that we think about, plan for, carry out, and sometimes (though not always) complete" (McGregor, MacAdams, & Little, 2006, ellipsis in original)—and then to identify key elements of those projects and rate them on a set of standard dimensions that allow quantitative analysis and comparison. Similar methods can be used to study goals rigorously over time—for example, by asking people to specify possible positive and negative outcomes for their own goals at time 1, so as to avoid *post hoc* biases when assessing goal attainment at time 2 (Sheldon, 2004; Sheldon & Elliot, 1999). Little (2006) describes personal projects as one type of *personal action construct*. Personal action constructs may be categorized as goals, interpretations, strategies, or some combination thereof, and when they are sufficiently stable to be useful in characterizing an individual over time, they are equivalent to characteristic adaptations. A personal project typically encompasses a goal and a related set of interpretations and strategies, complete with subgoals (Little, 2008).

4. The Big Five as cybernetic parameters

One reason it is important to determine whether any given individual-difference construct should be considered a trait or a characteristic adaptation is that CB5T provides different causal accounts of the genesis of traits versus characteristic adaptations. Crucially, however, these two causal accounts are joined within a unified mechanistic theory of personality, rather than merely being considered two different levels of analysis. Characteristic adaptations are seen to be updateable memory contents of the same cybernetic system in which variation in basic mechanisms produces traits. Both traits and characteristic adaptations play out at the same level of analysis.

At the center of CB5T is an explanation of why the Big Five are the major dimensions of covariation among personality traits. Specifically, each of the five traits corresponds to interpersonal variation in one of the major functional categories of intrapersonal mechanism involved in the operation of the human cybernetic system, as schematized by the cybernetic cycle: goal activation, action (or strategy) selection, action, outcome interpretation, goal comparison. Table 1 contains a summary of the cybernetic function of each of the traits labeled in Fig. 1, as well as an adjective describing the negative pole of the trait and thus a low level of the relevant function. CB5T is, in part, a refinement and extension of a theory by Van Egeren (2009), which attempted to characterize each of the Big Five in terms of the functioning of cybernetic systems. For reasons articulated previously (DeYoung, 2010c), Van Egeren's model is overly simplistic. A one-to-one mapping of each of the Big Five to one step of the cybernetic cycle will not work because most of the mechanisms that carry out the cycle operate in parallel and influence multiple steps of the cycle. Nonetheless, Van Egeren's model largely agrees with CB5T in its characterization of the basic psychological function that unifies each of the Big Five. This agreement is unsurprising because a number of researchers have proposed roughly similar theories regarding these functions, based on decades of relevant empirical data from questionnaire, cognitive, behavioral, and biological studies of personality (e.g., Denissen & Penke, 2008; DeYoung, 2010b, 2010c; MacDonald, 2006; Nettle, 2006, 2007).

4.1. Extraversion

Extraversion makes a good starting point because it is the trait most obviously related to the first stage of the cybernetic cycle, goal activation, in which a goal becomes sufficiently motivating to govern subsequent information processing and behavior. The degree to which the current situation affords possibilities for pursuing or attaining desired goals is the degree to which it contains cues for reward. From the cybernetic perspective, rewards are any stimuli that indicate progress toward or attainment of a goal, and every cybernetic system must have the ability to respond to such stimuli. Although some rewards—like food, sex, social affiliation, and social status—are strongly conditioned by innate predispositions, human beings are remarkably flexible in the goals they adopt, which clarifies why it is that a relatively abstract or

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Table 1
Personality traits and their cybernetic functions. Adjectives in the third column describe people with low levels of each trait.

Trait	Cybernetic function	Negative pole
Metatraits		
Stability	Protection of goals, interpretations, and strategies from disruption by impulses.	Unstable
Plasticity	Exploration: creation of new goals, interpretations, and strategies.	Rigid
Big Five		
Extraversion	Behavioral exploration and engagement with specific rewards (i.e., goals to approach).	Reserved
Neuroticism	Defensive responses to uncertainty, threat, and punishment.	Unflappable
Openness/Intellect	Cognitive exploration and engagement with information.	Unimaginative
Conscientiousness	Protection of non-immediate or abstract goals and strategies from disruption.	Unreliable
Agreeableness	Altruism and cooperation; coordination of goals, interpretations, and strategies with those of others.	Selfish
Aspects		
Assertiveness	Incentive reward sensitivity: drive toward goals.	Submissive
Enthusiasm	Consummatory reward sensitivity: enjoyment of actual or imagined goal attainment.	Unenthusiastic
Volatility	Active defense to avoid or eliminate threats.	Even-tempered
Withdrawal (anxiety, depression)	Passive avoidance: Inhibition of goals, interpretations, and strategies, in response to uncertainty or error.	Self-assured
Intellect	Detection of logical or causal patterns in abstract and semantic information.	Unintellectual
Openness to Experience	Detection of spatial and temporal correlational patterns in sensory and perceptual information.	Imperceptive
Industriousness	Prioritization of non-immediate goals.	Undisciplined
Orderliness	Avoidance of entropy by following rules set by self or others.	Disorganized
Compassion	Emotional attachment to and concern for others.	Callous
Politeness	Suppression and avoidance of aggressive or norm-violating impulses and strategies.	Belligerent

arbitrary accomplishment, or even pain, can be experienced as rewarding if it has been selected as a goal. The brain contains a complex system for keeping track of the reward value of stimuli and for motivating behavior designed to move toward goals, and some parts of this system are involved in response to every reward. Variations in this system, therefore, are likely to influence a wide range of behaviors in response to reward.

CB5T posits that Extraversion stems from variation in parameters of the mechanisms designed to respond to rewards. All other things being equal, Extraversion will predict who is more motivated by the possibility of attaining a given reward and who gets more enjoyment out of a reward when attained. The theory that Extraversion reflects reward sensitivity is reasonably well supported (Depue & Collins, 1999; Smillie, 2013). A number of the traits that fall within Extraversion, including drive, the tendency to experience positive emotions like joy, and excitement seeking, are clearly conceptually linked to reward sensitivity. Extraversion has been shown to predict better learning under conditions of reward in reinforcement learning paradigms, as well as facilitation of reaction times and accuracy following rewarding stimuli (Pickering, 2004; Robinson, Moeller, & Ode, 2010; Smillie, 2008). A variety of neurobiological evidence supports the link between Extraversion and the brain's reward systems. Several studies have found Extraversion to moderate the effects of pharmacological manipulation of dopamine, and dopamine is strongly implicated in reward sensitivity in both human and non-human research (DeYoung, 2013). Further, Extraversion has been found in several studies to be associated with volume of ventromedial prefrontal cortex, a brain region crucial for representation of the reward value of stimuli (DeYoung et al., 2010; Omura, Constable, & Canli, 2005; Rauch et al., 2005). Several fMRI and EEG studies have shown that brain activity in response to monetary rewards or pleasant emotional stimuli is associated with Extraversion, but their sample sizes have generally been small, rendering these findings less than conclusive (Canli, Sivers, Whitfield, Gotlib, & Gabrieli, 2002; Cohen, Young, Baek, Kessler, & Ranganath, 2005; Mobbs, Hagan, Azim, Menon, & Reiss, 2005; Schaefer, Knuth, & Rumpel, 2011; Smillie, Cooper, & Pickering, 2011). Still, the evidence supporting the fundamental link between Extraversion and reward sensitivity is considerable.

What has been less well studied is the relation of Extraversion to two distinct classes of reward: (1) incentive or appetitive rewards, also called cues of reward or promises, which indicate an increase in the probability of achieving a goal, and (2) consummatory or hedonic rewards, which represent the actual attainment of a goal. Berridge (2007) has described the responses to these two classes of reward as *wanting* and *liking* respectively, and CB5T hypothesizes that the two major subfactors or aspects of Extraversion, Assertiveness and Enthusiasm, derive from this distinction (DeYoung, 2010b, 2013). Assertiveness, reflecting the tendency toward drive, social status, and leadership, is a reflection of wanting—that is, motivation to attain desired goals. Enthusiasm, reflecting the tendency toward gregarious social interaction and positive emotions, reflects wanting to some extent but is primarily a reflection of liking, the enjoyment experienced on receiving or imagining a reward. Some evidence for this distinction comes from personality neuroscience, in which Assertiveness (also called Agentic Extraversion) is more closely related than Enthusiasm to dopamine, the major neurotransmitter for incentive reward, whereas an excellent marker of Enthusiasm (Social Closeness) has been linked to endogenous opiates, the major neurotransmitters for hedonic reward (Depue & Collins, 1999; Depue & Morrone-Strupinsky, 2005; DeYoung, 2013; Wacker, Mueller, Hennig, & Stemmler, 2012).

It would be tidy if Assertiveness purely reflected wanting and Enthusiasm purely reflected liking, but this does not seem to be the case. Emotions like excitement and enthusiasm, which characterize Enthusiasm as a trait, have a clear incentive component. Further, both Assertiveness and Enthusiasm predicted high levels of aroused positive affect (e.g., feeling "energetic" and "active") in response to an appetitive film clip depicting vigorous goal-directed behavior (Smillie, Geaney, Wilt, Cooper, & Revelle, 2013). The cybernetic perspective provides an elegant explanation for the fact that the distinction between wanting and liking is not complete at the trait level. Because of the nested nature of goals, in which superordinate goals are achieved through the accomplishment of subgoals, a single stimulus can be simultaneously a consummatory reward (attainment of a subgoal) and an incentive reward (cuing increased likelihood of attaining the superordinate goal). Thus, Enthusiasm, which reflects individual differences in response to attaining reward, encompasses individual differences in desire as well as enjoyment. This blending is additionally sensible cybernetically because a crucial function of enjoyment of any reward is to make it memorable and motivate desire and pursuit of similar rewards in future. The functional interdependence of liking and wanting helps to explain the coherence of Assertiveness and Enthusiasm within the broader trait of Extraversion. People who

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like things more intensely are more likely to want them intensely and to pursue them assertively.

The association of one aspect of Extraversion with goal attainment highlights the fact that Extraversion is relevant to more than just the first stage of the cybernetic cycle. The final stage, goal comparison, is the stage at which the current state is compared to the goal state and goal attainment is determined. The degree to which goal attainment triggers positive affect is posited to be the major contributor to Enthusiasm. Subgoal attainment is often an indicator of the speed of progress toward a superordinate goal; thus, the positive affect experienced after achieving a subgoal tracks progress toward the relevant superordinate goal (Carver & Scheier, 1998). People who are particularly prone to enjoy subgoal attainment may be more likely to reduce their effort or "coast" for a while, before being motivated to continue toward the next subgoal and the superordinate goal (Carver, 2003; Fulford, Johnson, Llabre, & Carver, 2010). This possibility suggests a testable hypothesis: when used as simultaneous predictors Assertiveness and Enthusiasm should make opposite predictions of motivation for further goal pursuit immediately following attainment of a subgoal.

Reward sensitivity, and hence Extraversion, is undoubtedly related not only to the first and last stages of the cybernetic cycle, but also to stages in between. Extraversion is likely to predict the strategies chosen for goal pursuit in the second stage (for example social versus non-social strategies) and the vigor with which actions are carried out in the third stage. In this context, it is notable that activity level is a facet of Extraversion, falling primarily under Assertiveness (DeYoung et al., 2007). Part of the general cybernetic response to most cues of reward is to increase motivation for action, and the incentive reward system related to Extraversion has been described as the behavioral activation or approach system (BAS; Gray & McNaughton, 2000; Quilty, DeYoung, Oakman, & Bagby, 2014; Smillie, 2013).

The CB5T perspective on Extraversion is largely congruent with existing modern (i.e., non-Jungian) perspectives. It posits that Extraversion is a strongly social trait because many human rewards are social (and the human reward system has undoubtedly evolved to be particularly responsive to social rewards), but also that Extraversion is not exclusively social and applies to all rewards (with the possible exception of the reward value of information, which is posited to be associated with Openness/Intellect; see Section 4.3 and DeYoung, 2013). CB5T does suggest, however, that the label "Detachment" may be more accurately descriptive of low Extraversion than is "Introversion" (Krueger & Markon, 2014). People who score low in Extraversion are not necessarily turned inward; rather, they are less engaged, motivated, and energized by the possibilities for reward that surround them. Hence, they talk less, are less driven, and experience less enthusiasm. They may also find levels of stimulation that are rewarding and energizing for someone high in Extraversion merely annoying or tiring (or even overwhelming, depending on their level of Neuroticism). Their reserved demeanor is not likely to indicate an intense engagement with the world of imagination and ideas, however, unless they are also high in Openness/Intellect.

4.2. Neuroticism

Whereas Extraversion is most obviously related to the beginning of the cybernetic cycle, Neuroticism is most obviously related to its end, goal comparison, when the current state is compared to the desired state. This comparison process leads either to a match, indicating goal attainment, or a mismatch, indicating that the goal is not yet attained. One possibility in the case of mismatch is simply to attempt a different strategy (or even the same strategy again) to continue movement toward the goal. However, mismatch may mean that a serious problem exists, or even that one is in danger, because the failure to predict an outcome may indicate that the present situation is not sufficiently well understood to be confident in its safety (Peterson, 1999). One innate response to mismatch, therefore, is the activation of defensive systems. Neuroticism, describing individual differences in the tendency to experience negative emotions—anxiety, depression, irritability, anger, shame, etc.—appears to reflect individual differences in the sensitivity and reactivity of those defensive systems.

Neuroticism is commonly linked to emotional responses to punishment and threat. It has been found to predict reactivity to error feedback in cognitive tasks and neural responses to emotionally negative, threatening, or punishing stimuli (Amodio, Master, Yee, & Taylor, 2008; Cremers et al., 2010; Etkin et al., 2004; Haas, Omura, Constable, & Canli, 2007a; Hirsh & Inzlicht, 2008; Moeller & Robinson, 2010; Robinson, Moeller, & Fetterman, 2010). From the cybernetic perspective, punishments are any stimuli that signal definite inability to attain a goal, whereas threats, or cues of punishment, signal a decrease in the probability of attaining a goal. Punishments cover a wide range of complexity, from stimuli as basic as undesired pain, to social or romantic rejection, to loss of a chess match, failure to achieve promotion, or invalidation of a cherished belief. A punishment is often simultaneously a threat—either a threat of immediate further punishment or, if it represents the thwarting of a subgoal, a threat of inability to reach the superordinate goal. Threats inherently increase uncertainty regarding the completion of a goal. In the cybernetic framework, uncertainty can be described in terms of psychological entropy (DeYoung, 2013; Hirsh, Mar, & Peterson, 2012).

Entropy is a measure of disorder that describes the amount of uncertainty or unpredictability in any information system (Shannon, 1948). In a cybernetic system, entropy reflects uncertainty regarding the system's capacity to move toward its goals (Wiener, 1961). Psychological entropy reflects the number of plausible options or affordances available to the individual for interpretation and for action, at any given time (Hirsh et al., 2012). In other words, the harder it is to answer the questions, "What is happening?" and "What should I do?" the higher the level of psychological entropy. (These are not necessarily conscious questions, but rather assessments carried out by the brain unconsciously as well as consciously.) This account implies that the human cybernetic system continually makes comparisons of the current state not only to a desired state but also to a predicted state, including aspects of the current state that are not obviously relevant to a currently operative goal. In other words, violation of our expectations about the world we perceive increases psychological entropy and is potentially threatening, just like failure of an action to reach its goal (Peterson & Flanders, 2002; Proulx, Inzlicht, & Harmon-Jones, 2012). CB5T specifies that Neuroticism is a function of the parameters that determine whether any increase in psychological entropy triggers a defensive response. People high in Neuroticism tend to experience negative emotion in response to frequent perceptions that they are not in the state they would like to be in.

Defensive responses are of two distinct kinds, which can be described as active defense and passive avoidance. Gray and McNaughton (2000) referred to the brain systems that govern active defense and passive avoidance as the fight-flight-freeze system (FFFS) and the behavioral inhibition system (BIS), respectively. CB5T posits that the two aspects of Neuroticism, Volatility and Withdrawal, correspond to these two forms of defensive response (Corr et al., 2013; DeYoung et al., 2007). Active defense involves emotional and behavioral responses to immediate threats or punishments where the only motivation is to escape or eliminate

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them. These responses include panicked flight and reactive anger. Volatility describes the tendency to be emotionally labile and to get upset, irritated, or angry easily and, thus, appears to reflect individual differences in the tendency toward active defense.

Passive avoidance involves involuntary inhibition of approach toward a goal in response to increases in psychological entropy. It occurs not when there is an uncomplicated motivation to avoid a punishment, but rather when motivation is conflicted (Gray & McNaughton, 2000). The most common cause of passive avoidance is approach-avoidance conflict, in which an approach goal (e.g., acquiring a romantic partner) conflicts with an avoidance goal (e.g., avoiding rejection), creating uncertainty about the best course of action, but one should remember that any uncertainty may cause passive avoidance (Hirsh et al., 2012).

Passive avoidance states can be subdivided into anxiety and depression (Gray & McNaughton, 2000). In anxiety, the possibility of punishment has not entirely overcome the possibility of reward, such that the goal in question is still perceived to be potentially attainable. Anxious passive avoidance is associated with increased attention to both sensory input and information in memory, in order to scan for further threat (Gray & McNaughton, 2000; Hirsh et al., 2012). Additionally, during anxiety, arousal increases to prepare for a possible switch to active defense, if danger becomes too great. The inhibition or slowing of action that characterizes passive avoidance evolved to prevent encountering any danger that might be associated with the current goal. It may also lead to abandoning the goal entirely and switching to some other goal. In depression, the goal is perceived to be unattainable and approach motivation is extinguished (Carver & Scheier, 1998). (Clinical depression represents a state in which this extinction of behavior has been overgeneralized, extinguishing a maladaptively large range of behaviors.)

Withdrawal describes the tendency toward both anxiety and depression. "Withdrawal" is a potentially misleading label because it does not refer to social withdrawal specifically, but rather to the automatic withdrawal of motivation, either partially or completely, from particular strategies or goals, in response to uncertainty. It is not a specifically social trait. Not surprisingly, however, given that passive avoidance involves inhibition of approach behavior, Withdrawal, and especially its depression facet, are negatively associated with Extraversion (DeYoung, 2013; Watson, Gamez, & Simms, 2005).

Although threat and punishment sensitivity, and hence Neuroticism, are most obviously related to the last stage of the cybernetic cycle, when goal comparison may indicate that the current state is not as one would like it to be, they have implications for other stages of the cybernetic cycle as well. At the initial stage of goal activation, high Neuroticism should be associated with activation of avoidance goals, or repulsors. Whereas approach goals, or attractors, involve reducing the discrepancy between the current state and the desired state, avoidance goals involve increasing or maintaining the discrepancy between the current state and some undesired state (Carver & Scheier, 1998). The problem with avoidance goals, from a cybernetic perspective, is that they do not inherently specify a concurrent approach goal that could guide behavior—that is, knowing what one wants to avoid does not specify exactly what to do instead. Approach goals must subsequently be specified, therefore (potentially as subgoals within avoidance strategies), following activation of an avoidance goal. Clearly, then, Neuroticism should also be associated with individual differences in action selection, and it is also likely to interrupt or slow actions as they are carried out (Robinson, Moeller, & Fetterman, 2010; Robinson, Moeller, & Ode, 2010) and to influence the way that the world is interpreted. People high in Neuroticism show biases toward negative information during processes of categorization and memory (Chan, Goodwin, & Harmer, 2007).

4.3. Openness/Intellect

Openness/Intellect describes individual differences in cognitive exploration, the tendency to seek, detect, appreciate, understand, and utilize both sensory and abstract information (DeYoung, 2014; DeYoung et al., 2012). In cybernetic terms, this trait corresponds to individual differences in the processes of interpretation that allow sensory feedback to be transformed into a model of the world, which can then be used to detect discrepancies between the current state of the world and the desired state, as well as to identify potentially goal-relevant stimuli in the environment and to predict what strategies might be most effective in pursuing any given goal. Our schematic representation of the cybernetic cycle emphasizes interpretation only at the moment after an action has been carried out, when the state of the world has been altered by the action just completed and must be updated before it can be compared to the desired state. As noted in Section 2, however, this process of interpretation is actually nearly constant during waking states. Further, recall that interpretations form one of the basic categories of characteristic adaptation. Whenever any interpretation becomes a stable component of memory for some reasonable length of time, a new characteristic adaptation has been created. People high in Openness/Intellect have more complex and extensive interpretations of the world than people low in the trait, and they are therefore likely to use more creative and innovative strategies to pursue their goals (DeYoung, 2010c).

At the core of Openness/Intellect are curiosity, imagination, creativity, and innovation (DeYoung, 2014; Saucier, 1992); these traits involve both the motivation and the ability to create new interpretations of the world. This raises the point that most traits have both motivational and ability components, with the former reflecting how likely the system is to attempt to carry out a particular function, and the latter how likely is it to succeed. This point is particularly salient in relation to Openness/Intellect because it is the only Big Five trait to show a consistent and substantial positive association with IQ, and CB5T considers intelligence to be a facet of Openness/Intellect (DeYoung, 2011; DeYoung et al., 2012). (Note that positioning intelligence as a facet in no way downplays its great importance for the human species. Human intellectual functioning is incredibly complex, and intelligence itself may be broken down into various subcomponents. Nonetheless, many important human traits are not correlated with intelligence.) Although some theorists have attempted to separate ability from personality, abilities are included in the Big Five and are apparent in multiple domains (e.g., Conscientiousness encompasses the ability to resist distraction; Agreeableness the ability to empathize; and Neuroticism the ability to remain calm under stress). Measures of motivation and ability may be difficult to separate cleanly because (1) high ability is likely to lead to increased motivation and low ability to decreased motivation, and (2) strong motivation may lead to the development of greater ability through practice and learning. Because the cybernetic functions that underlie the Big Five are applicable or necessary in many or even most situations, their ability components influence typical behavior extensively.

Human beings are remarkable as a species for their ability to create complex interpretations not only of the present but also of the past and future. Evidence is accumulating that imagining (remembering) the past and imagining the future or any other hypothetical scene require fundamentally similar processes, involving an extended brain system known as the *default network* because people spontaneously engage in this kind of imagining when their attention is not constrained by the demands of current action (Spreng, Mar, & Kim, 2008). Imagining possibilities appears to be a default activity for all human beings, yet striking individual differences exist in the complexity with which people engage in exploring the world perceptually, abstractly, and imaginatively,

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and these differences are captured by Openness/Intellect, which has been found to predict individual differences in the functioning of the default network (Adelstein et al., 2011). Perhaps because it reflects the ability to imagine possibilities, Openness/Intellect is strongly associated with *divergent thinking*, the ability to generate multiple unusual and creative solutions to problems, such as "What are all the uses you can think of for a brick?" (Carson, Peterson, & Higgins, 2005; McCrae, 1987).

The compound label "Openness/Intellect" reflects an old debate about whether to label this trait "Openness to Experience" or "Intellect." The debate has been resolved by the recognition (and empirical demonstration) that the two labels describe distinct but related subfactors within the broader trait (DeYoung et al., 2007; Saucier, 1992). Intellect reflects intellectual engagement with abstract and semantic information, whereas Openness to Experience reflects engagement with sensory and perceptual information and thus involves aesthetic interests and fantasy proneness (DeYoung et al., 2012). CB5T uses "Openness/Intellect" to refer to the Big Five trait, and "Openness" or "Intellect" alone to refer to one of its two aspects. Intellect is the aspect that encompasses IQ, and it has also been associated with working memory—manipulation of information in conscious attention—which appears to be the cognitive process that most contributes to intelligence (DeYoung, Quilty, Peterson, & Gray, 2014; DeYoung, Shamosh, Green, Braver, & Gray, 2009; DeYoung et al., 2012). Openness, in contrast, has been linked to implicit learning, automatic detection of patterns in sensory experience. Kaufman et al. (2010) reported a double dissociation, in which Intellect predicted working memory but not implicit learning, whereas Openness predicted implicit learning but not working memory. In terms of their cybernetic functions, the mechanisms of Intellect appear to be responsible for producing logical and causal knowledge about the world, whereas those of Openness appear to be responsible for producing correlational knowledge about spatial and temporal patterns. This is in keeping with the argument for two qualitatively distinct types of learning, propositional and associational (McLaren et al., 2013). These functions influence goal-setting and creative production as well as interpretation: Intellect predicts creative achievement in the sciences, whereas Openness predicts creative achievement in the arts (Kaufman et al., submitted for publication).

The mechanisms of interpretation associated with Openness/Intellect are primarily those that are descriptive of the world, rather than evaluative. In other words, they generate representations of facts or patterns, knowledge about correlations and causes, rather than the affective evaluations associated with those representations. This is not to say that Openness/Intellect is unrelated to emotion. Indeed, this trait has several key emotional and motivational features: First, it reflects sensitivity to the reward value of information, which involves the emotions of curiosity and aesthetic enjoyment (DeYoung, 2013, 2014). Second, Openness in particular appears to be associated with the richness of emotional experience (DeYoung et al., 2007, 2012). High Openness is associated with greater ability to perceive and differentiate the patterns of experience that constitute conscious emotions (Terracciano, McCrae, Hagemann, & Costa, 2003). Nonetheless, the evaluations of emotional significance that form a core part of our interpretations of the world are likely to be determined primarily by basic affective processes associated with Extraversion, Neuroticism, and Agreeableness and by relevance to individuals' idiosyncratic goals (i.e., characteristic adaptations), as they interact with the mechanisms of interpretation underlying Openness/Intellect.

4.4. Conscientiousness

CB5T posits that Conscientiousness reflects variation in the mechanisms that allow people to follow rules and prioritize non-immediate goals. As a species, human beings are highly unusual both in their ability to follow explicit rules and in their ability to plan for the distant future, adapting their behavior to goals that will not be obtained for weeks, months, or even years (DeYoung, 2010a). Chimpanzees are the only other species in which a factor resembling Conscientiousness has been detected in studies of the covariation of many traits (whereas factors resembling the other Big Five traits appear in many species), suggesting that the mechanisms underlying Conscientiousness evolved relatively recently (Freeman & Gosling, 2010; Gosling & John, 1999). This does not mean, however, that other species do not possess cybernetic mechanisms designed to suppress distractions and disruptive impulses. Any cybernetic system that encompasses multiple goals and strategies must involve processes that prevent distraction from the current goal before it is completed. However, CB5T posits that some basic mechanisms involved in the suppression of disruptive impulses, which are shared with many other species, are related to the metatrait Stability, rather than to Conscientiousness specifically (see Section 5). Conscientiousness appears to be relatively specific to the problem of governing behavior across long time spans or according to the relatively arbitrary explicit rules that are a function of the complexity of human cultures.

Conscientiousness has been extensively characterized in terms of its consequences for various life outcomes. It is typically the best predictor, after intelligence, of both academic and occupational success, and it is also a good predictor of health and longevity, apparently because it predicts avoidance of risky behaviors and engagement in preventive health behaviors (Noftle & Robins, 2007; Ozer & Benet-Martinez, 2006; Roberts, Lejuez, Krueger, Richards, & Hill, 2012). In contrast, however, Conscientiousness may be the least well understood, mechanistically, of any of the Big Five. The prefrontal cortex, the part of the brain most expanded in human evolution (Deacon, 1997), is undoubtedly central to understanding Conscientiousness. Two studies have found Conscientiousness to be associated with volume of the dorsolateral prefrontal cortex, a brain region crucial for maintaining the activation of abstract goals and for executing planned action based on abstract rules (DeYoung et al., 2010; Kapogiannis, Sutin, Davatzikos, Costa, & Resnick, 2013). Another study, of brain function rather than structure, found Conscientiousness to be associated with a region of medial surface of prefrontal cortex that is part of the ventral attention network (Adelstein et al., 2011; Yeo et al., 2011), suggesting that Conscientiousness may be particularly involved in reorienting attention away from distractions and back to stimuli most relevant to important goals (Fox, Corbetta, Snyder, Vincent, & Raichle, 2006).

The mechanisms of Conscientiousness are likely to have complex interactions with the reward-seeking and defensive motivational systems related to Extraversion and Neuroticism (Corr et al., 2013). In one situation, Conscientiousness might encourage suppressing an emotional reaction to a minor threat in order to pursue a non-immediate or abstract goal. In another situation, however, it might amplify attention to a very similar threat, if the latter was likely to interfere with the larger goal. Similarly, Conscientiousness should suppress reward-seeking that is a distraction from larger goals but encourage reward-seeking that furthers those goals.

The two aspects of Conscientiousness, Industriousness and Orderliness, appear to reflect the distinction between prioritizing non-immediate goals and following rules, respectively. Industriousness involves self-discipline and the tendency to work hard and effectively without being distracted before tasks are completed. Orderliness involves neatness, perfectionism, and attention to rules (DeYoung et al., 2007). Note that the rules that govern orderly people are set not only by others but also by themselves and include rules of conduct and organization that may be, but need not be, shared with other people. Both aspects of Conscientiousness

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clearly involve the regulation of motivation, but they appear to be differentially linked to Extraversion and Neuroticism, thus highlighting the importance of discriminant validity at the aspect level of the personality hierarchy. Whereas Industriousness is negatively related to Neuroticism, Orderliness is positively related to Neuroticism (especially when controlling for Industriousness), and particularly to anxiety (DeYoung, 2013; DeYoung et al., 2007). This seems likely to reflect the fact that defensive reactions to uncertainty are likely to interrupt progress toward non-immediate goals, but they may facilitate attention to rules as a protective strategy. Similarly, Industriousness but not Orderliness is associated with Extraversion, which may reflect the contribution of incentive reward sensitivity to the motivation to pursue non-immediate rewards (DeYoung, 2013).

Conscientiousness is most obviously related to the first three stages of the cybernetic cycle. Higher Industriousness should be associated with the likelihood of activating long-term rather than short-term goals, as well as selecting more effective strategies for meeting those goals, and then resisting distraction while carrying out action. Orderliness should be associated with the likelihood of activating goals and selecting strategies that conform to rules. Additionally, however, one would expect the process of goal comparison to differ with Conscientiousness such that those high in the trait should be more likely to generate an error signal based on inadequate progress toward a long-term or rule-based goal.

4.5. Agreeableness

The final Big Five trait, Agreeableness, represents the general tendency toward cooperation and altruism, as opposed to exploitation and lack of concern for others. Whereas the other four Big Five traits are posited to reflect cybernetic mechanisms involved in the pursuit of goals in general, Agreeableness reflects variation in a set of mechanisms that exist because human beings are social animals whose survival depends on coordinating their goals, strategies, and interpretations with those of others (Graziano & Tobin, 2013; Van Egeren, 2009). This means that the mechanisms responsible for Agreeableness are not strictly necessary for the completion of the basic cybernetic cycle (though, of course, they are inseparable components of the human cybernetic system). In principle, some goals might be pursued successfully without consideration of the needs and desires of others, and there is certainly variation in the extent to which people need to be cooperative and altruistic while successfully achieving their own goals. Nonetheless, given the social nature of human existence, some degree of cooperation is necessary, both in development and in most of adult life, and CB5T asserts that all normally functioning human beings have at least some capacity to cooperate with others. Hence, Agreeableness is no less functionally important for human beings than the other Big Five traits.

Cooperative and altruistic behavior requires at least some understanding of others' emotions, intentions, and mental states, and Agreeableness has been found to predict tests of empathy, theory of mind, and other forms of social information processing (Graziano, Habashi, Sheese, & Tobin, 2007; Mayer, Roberts, & Barsade, 2008; Nettle & Liddle, 2008; Wilkowski, Robinson, & Meier, 2006). It has also been found to predict the volume of several brain regions involved in social information processing (DeYoung et al., 2010). Additionally, Agreeableness is associated with the suppression of aggressive impulses and other socially disruptive emotions (Meier, Robinson, & Wilkowski, 2006), and an fMRI study found that Agreeableness predicted activity in the prefrontal cortex during emotion regulation (Haas, Omura, Constable, & Canli, 2007b).

The two aspects of Agreeableness appear to reflect variation in different systems governing the processes of coordinating one's behavior with others'. Compassion reflects relatively automatic emotional processes, including empathy, caring, and concern for others. Politeness reflects restraint of aggression and other rude behavior and seems likely to involve more voluntary top-down control than does Compassion. Together, the four aspects of Extraversion and Agreeableness correspond perfectly to the axes of the interpersonal circumplex (DeYoung et al., 2013). (In this context, "interpersonal" means "related to social interaction.") This correspondence allows integration of CB5T and interpersonal theory (Pincus & Ansell, 2003). CB5T suggests that the social behaviors associated with Assertiveness and Enthusiasm are driven by reward processes also involved in non-social reward motivation, whereas Compassion and Politeness are driven by dedicated affiliative bonding and social regulation systems.

Although the cybernetic mechanisms underlying Agreeableness may not be necessary for the basic process of goal pursuit, they nonetheless interact with those processes and are likely to affect all steps of the cybernetic cycle. Individual differences in Agreeableness should lead to differences in the degree of altruism and cooperation in goals activated and strategies selected, to differences in how the social world is interpreted, and to differences in what experiences are registered as errors or mismatches (e.g., experiencing others' dissatisfaction or distress as a mismatch). Importantly, the fact that Agreeableness is not cybernetically "necessary" in no way entails that the mechanisms involved are peripheral to human nature. All mammalian species have some capacity for social attachment because they are defined as a class by their production of milk for their offspring; all female mammals, at least, must be able to coordinate their own goals with those of another being. In truly social mammals, which live in cooperative groups, mechanisms related to affiliation, cooperation, and altruism shape most, if not all, aspects of development. (Note that mammalian social groups are not purely cooperative, as some competition between members always exists as well.) For a species as intensely social as humans, the mechanisms underlying Agreeableness are inextricably linked to the rest of personality. Further, the sophistication of human Openness/Intellect and the capacity for Conscientiousness are both likely to have evolved because of increased complexity of the social world (Deacon, 1997; DeYoung, 2014; Dunbar & Shultz, 2007). The human cybernetic system is pervasively shaped by our sociality.

5. Stability, plasticity, and adaptation

The cybernetic framework laid out in Section 4 to explain the Big Five is incomplete in one notable way: It describes people's ongoing cybernetic adjustments to their environments in terms of selection among existing goals and strategies, without thoroughly discussing the creation of new goals and strategies. Neglecting the process by which new goals are created is a common failing of cybernetic theories of human behavior (DeYoung, 2010c; Sheldon, 2004). CB5T, however, contains an account of adaptation, linked to the two metatraits, that allows it to explain what is arguably the most distinctive feature of the human cybernetic system, namely that its collection of characteristic adaptations can be transformed, in ways that range from prosaic to radical (Peterson, 1999).

As noted in Section 4.2, the fundamental problem for any cybernetic system is entropy, which is always spontaneously increasing and which threatens the stability of ongoing goal-directed functioning. Increases in psychological entropy occur when prediction fails and the current state is not entirely as expected, either because some interpretation has been invalidated—raising the question, "What is happening?"—or because a strategy has failed (or is anticipated to fail) to reach its goal—raising the question,

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"What should I do? (DeYoung, 2013; Hirsh et al., 2012). Every experience can be categorized based on whether it entails a match to prediction or a mismatch, and any mismatch entails at least a small encounter with the unknown, an increase in psychological entropy. Human beings are profoundly adapted to these two extremely broad classes of stimuli, match and mismatch, the known and the unknown, the predictable and the unpredictable, the expected and the anomalous, order and chaos (Peterson, 1999; Peterson & Flanders, 2002). Not only do human beings possess evolved mechanisms designed to operate when events are unfolding as anticipated and one knows what to do, they also possess evolved mechanisms designed to operate when events do not unfold as anticipated.

The mechanisms called into play by encounter with uncertainty are of two fundamental types, reflecting the unique status of the unknown as the only class of stimuli that is simultaneously innately threatening and innately promising (Gray & McNaughton, 2000; Peterson, 1999). Increases in psychological entropy are threatening for reasons described in the previous paragraph. They are also promising, however, meaning they act as incentive rewards, because they signal the possibility of reducing psychological entropy in the longer term, either by attaining some specific reward or by acquiring information (DeYoung, 2013; Schwartenbeck et al., 2013). People are ambivalent about the unknown because everything good as well as everything bad emerges initially from the unknown (Peterson, 1999). This fact explains the existence of exploration as a class of behavior designed to extract potential benefits from the unknown, to transform anomalous experience into predictable experience. The two types of mechanism that respond to the unknown evolved to meet two fundamental human needs, one reflecting the threat, and the other the promise, inherent in the unknown. The first of these needs is to maintain the stability of ongoing goal-directed functioning. The second is the need to engage in exploration that integrates novel or anomalous information with existing knowledge.

CB5T identifies the metatraits, Stability and Plasticity, as the broadest dimensions of personality that reflect variation in the mechanisms designed to meet these two needs (DeYoung, 2006, 2010c; DeYoung et al., 2002). Our labels for these traits were inspired by Grossberg's (1987, 2013) identification of the *stability-plasticity dilemma* as a fundamental challenge for information processing systems. Cybernetic systems not only must be capable of maintaining stable functioning, they must also be sufficiently plastic to adapt to changing and unpredictable environments. Without adequate plasticity, continued stability is impossible, given sufficient environmental change. Stability and plasticity may seem conceptually opposed, but they are in fact complementary and, also, in dynamic tension, as extreme plasticity may pose a challenge to stability and vice versa. The opposite of stability is not plasticity but instability, and the opposite of plasticity is not stability but rigidity. As noted in Section 3.1.1, given high-quality measurement, Stability and Plasticity appear to be nearly uncorrelated traits. Though neurobiology is not discussed in detail here, CB5T hypothesizes that the serotonergic and dopaminergic systems are the major biological substrates of Stability and Plasticity, respectively (DeYoung, 2010b, 2013; DeYoung et al., 2002). Serotonin and dopamine modulate the functions of the mechanisms associated with the Big Five traits (Section 4) in ways that facilitate cybernetic stability and plasticity, respectively.

Stability represents the shared variance of Conscientiousness, Agreeableness, and low Neuroticism. The low pole of Neuroticism has long been labeled *Emotional Stability*, but the roles of Agreeableness and Conscientiousness in Stability are also important. Conscientiousness might be described as *motivational stability*, maintaining progress toward long-term or abstract goals, and Agreeableness as *social stability*, maintaining the harmony of social interactions. Multi-informant studies suggest that low Neuroticism is the strongest indicator of metatrait Stability (Chang et al., 2012; DeYoung, 2006), which is consistent with our hypothesis that Stability reflects variation in the control mechanisms that prevent the cybernetic system from being disrupted by emotional impulses. Because Agreeableness and Conscientiousness require suppression of socially or motivationally disruptive impulses, they can be facilitated by the same restraining mechanism that modulates emotional stability. The functions underlying both Neuroticism and Stability evolved to deal with the fact that psychological entropy is threatening. Sometimes disruption of a current goal is necessary to maintain the viability of broader goals (including extremely broad goals like survival), and this defensive disruption is the function associated with Neuroticism (Section 4.2). At other times, however, maintaining broad goals requires maintaining a current goal or strategy even when it involves potential exposure to threat, and Stability reflects variation in this capacity. Not only does high Stability prevent disruption of goals by defensive impulses, however, it also prevents disruption of goals by exploratory or reward-related impulses (DeYoung, 2010a). Stability, therefore, reduces spontaneity.

Plasticity represents the shared variance of Extraversion and Openness/Intellect. Openness/Intellect has already been described, in Section 4.3, as reflecting the tendency toward cognitive exploration. Extraversion reflects the tendency toward behavioral exploration, using motor output to pursue potentially rewarding possibilities related to specific goals (for an extended explanation of the nature of exploration and its relation to personality, see DeYoung, 2013). As noted in the previous paragraph, exploration can be disruptive of goal pursuit; however, it can also be used to generate more effective strategies for pursuing existing goals. Which of these possibilities predominates is likely to be a function of Stability and Conscientiousness. CB5T defines Plasticity as the general tendency toward exploration, with exploration defined as the creation of new goals, interpretations, and strategies (DeYoung, 2013). All exploration involves learning, therefore. (Note, however, that not all learning is exploration. In defensive reactions to uncertainty—those related to Neuroticism and especially Withdrawal—interpretations, strategies, or goals that led to perceived error are deprioritized or simply abandoned. This is contractive learning, in which the individual learns what not to do or to believe, whereas exploration involves expansive learning, in which the individual creates new goals, interpretations, and strategies.)

The metatraits have been interpreted in several other ways, which are generally compatible with CB5T. Digman (1997), who discovered the metatraits in Big Five data, proposed that Stability (which he called *Alpha*) reflects the tendency to be well socialized, whereas Plasticity (*Beta*) reflects the tendency toward personal growth. Olson (2005, p. 1692) labeled Stability *Self-Control* and Plasticity *Engagement* ("the extent to which individuals actively engage their inner and outer worlds"). Additionally, the metatraits strongly resemble the two factors constituting the most replicable factor solution in lexical research, which have been labeled *Social Self-Regulation* and *Dynamism* (Saucier et al., 2014). (The major difference between Social Self-Regulation and Stability appears to be in how much emphasis is placed on social versus motivational and emotional stability. Given the fundamentally social function of language, it is not surprising that the lexicon contains a disproportionate number of descriptors of social relative to other forms of stability; DeYoung, 2010b.) These various interpretations can easily be synthesized: The self-control or self-regulation associated with Stability should make children easier to socialize and may also be strengthened by socialization. The exploratory tendency associated with Plasticity should produce the kind of active engagement with novel and interesting

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phenomena that others tend to find dynamic and that is likely to lead to personal growth.

A number of studies have identified correlates of Stability and Plasticity. To be theoretically meaningful, such correlates must be associated primarily with one of the metatraits, rather than being primarily associated with only one of its Big-Five constituents (DeYoung et al., 2002; Hirsh, DeYoung, & Peterson, 2009). This highlights the necessity of identifying the right level of the personality hierarchy when attempting to understand the relation of any variable to basic traits. Hirsh et al. (2009) developed a method for testing whether a variable's primary association was to the metatraits as opposed to the Big Five and examined the association of the metatraits with reports of the frequency of 400 specific behaviors. Their most striking finding was that Stability predicted almost all of its behavioral correlates negatively, whereas Plasticity predicted almost all of its behavioral correlates positively. Stability thus appears to depend primarily on inhibition, but this is *not* identical to the sort of inhibition usually associated with the BIS and passive avoidance (remember that Neuroticism is strongly negatively related to Stability). Rather, it resembles what has been called "nonaffective constraint" (Depue & Lenzenweger, 2005), the inhibition of emotional and motivational impulses that would disrupt goal-pursuit, regardless of whether those impulses are threat- or reward-related (cf. Carver, Johnson, & Joormann, 2008). Plasticity, in contrast, depends on activation of behavior. Additionally, the specific content of the behaviors most strongly associated with each metatrait was consistent with CB5T's definitions: Stability was negatively associated with disruptive behaviors such as losing one's temper, using drugs or alcohol, and going without sleep, whereas Plasticity was positively associated with exploratory behaviors such as attending public lectures and telling jokes. (One might not intuitively think of telling jokes as a form of exploration, but consider that telling jokes is usually designed to pursue some form of social reward, and the outcome is uncertain. Even an old strategy, such as a recycled joke, is, in an important sense, a new strategy if it is attempted in a novel and unpredictable context.)

CB5T provides a way to understand both Stability and Plasticity in terms of the dynamics of the transformation of characteristic adaptations. Peterson (1999, 2008) has depicted the process of adaptation using variants of the diagram in Fig. 3. The two ovals at the top of the figure, which Peterson has described as "maps of meaning," represent the memory contents of the cybernetic system at two different points in time. Many of these contents (divided into goals, interpretations, and strategies) are sufficiently stable to be considered characteristic adaptations, although, at any given time, some are likely to be *ad hoc* adaptations that will not be persistent. Exactly which adaptations are active, and therefore what behavior is emitted, at any given time, is a function of complex, dynamic interactions between the affordances of the situation, the available repertoire of characteristic adaptations, and the cybernetic processes carried out by the mechanisms underlying traits (which interact with each other in complex patterns of inhibition and facilitation).

Strategies are represented in Fig. 3 as arrows from interpretations to goals because they are operations designed to transform the current state into the desired future state. Multiple strategies are shown in parallel in each oval because, in the course of most human functioning, we have multiple strategies already available to pursue our goals. Suppose, for example, I am sufficiently hungry that my currently operative goal is to find something to eat. If I go to the refrigerator, expecting to solve this problem quickly, but find nothing I'm willing to eat, a mismatch has occurred (anomalous information has emerged from the unknown, in Fig. 3). Nonetheless, I do not panic. Rather, I consider other strategies already in my behavioral repertoire, such as going to a restaurant or a grocery store. Much moment-to-moment adaptation is of such a prosaic nature, switching between strategies and updating interpretations in ways that do not call our characteristic adaptations, as such, into question. Obstacles of this prosaic kind may provoke some irritation or even anxiety (perhaps taking the time to find food elsewhere will cut in to time I meant to allocate to some other plan), but they are rarely fundamentally destabilizing. One remains in the bounded domain of the known, represented by the outline of the oval (Peterson, 1999).

In many situations, only minor mismatches occur, and the questions of what is happening and what should be done may be answered with relative ease; interpretations can be adjusted and

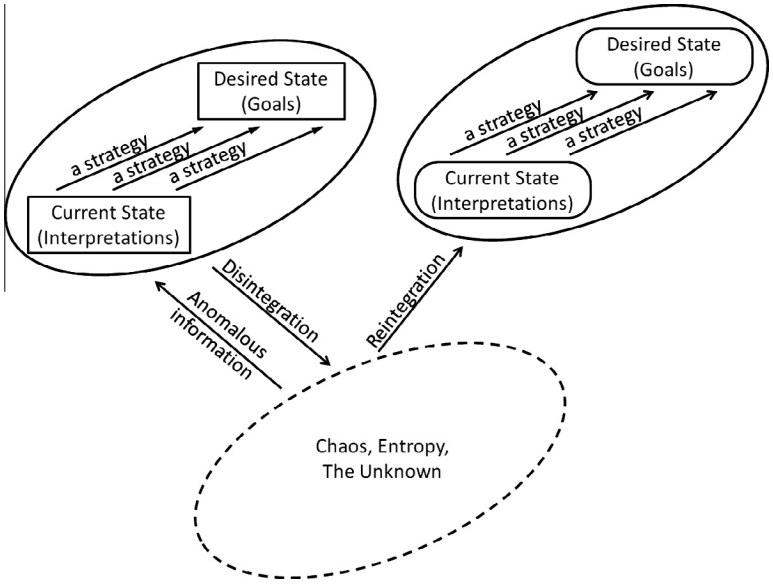

Fig. 3. The transformation of characteristic adaptations. The updateable memory contents of personality are characteristic adaptations comprising a set of persistent or recurring goals, interpretations, and strategies. Basic cybernetic adaptation in response to anomalous information can be accomplished by shifting between different known strategies to meet one's existing goals. More radical adaptation requires revision of existing characteristic adaptations and involves temporary disorganization or disintegration of personality. Reintegration requires exploration that generates new characteristic adaptations, represented by the change of shapes between the two upper ovals. (Adapted with permission from Peterson (1999).)

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alternative strategies deployed without calling major goals or interpretive structures into question. Occasionally, however, sufficiently dramatic mismatches occur that one must abandon interpretations, strategies, and goals that have been stable enough to be considered characteristic adaptations. (Consider, for example, being fired from a job or the dissolution of a romantic relationship.) The two ovals in Fig. 3 are separated by just such an episode of revolutionary adaptation, in which the individual has encountered sufficient anomaly to destabilize the cybernetic system and to invalidate one or more characteristic adaptations. Such an event can plunge the individual into chaos, which is equivalent to a sharp increase in psychological entropy and is accompanied by some amount of emotional, motivational, cognitive, and behavioral dysregulation. (The larger the span of time and the amount of cognition and behavior that a particular characteristic adaptation organizes, the more psychological entropy is released when it is invalidated, and the worse the ensuing dysregulation.) At this juncture, the personality system has, to some degree, disintegrated, in the literal sense of losing integration. Its characteristic adaptations are no longer providing coherent, non-conflicting answers to the questions of what is happening and what should be done. The secure boundary of the known has broken down, exposing the individual to the dangers of the unknown (Peterson, 1999).

From the state of chaos, a return to a regulated state in which adequate progress toward goals is again possible can be accomplished only through exploration. New characteristic adaptations must be generated—through trial and error, imitation, seeking (or at least heeding) advice from others, mental simulation of possible future states, logical analysis, divergent thinking, or some combination of these and other exploratory processes. Once exploration has led to suitable new adaptations, the personality system will be reintegrated, emotional dysregulation will subside, and the individual will have emerged from chaos with a reconfigured personality. If the episode of disintegration was particularly severe, successful adaptation may constitute *posttraumatic growth* (Jayawickreme & Blackie, in press). The changes in goals, interpretations, and strategies that accompany reintegration are represented in Fig. 3 by the change in shape of each of the three types of adaptation from the left oval to the right oval. Such changes allow people to become better adapted to their life circumstances over time. They also tend to encourage alignment between traits and characteristic adaptations, as individuals adapt not only to their external circumstances, but also to their own proclivities. Any adaptation is less likely to lead to increased psychological entropy, and thus more likely to be retained over time, if it is consistent with the general functional tendencies associated with the individual's traits.

Stability and Plasticity can be understood in this context in a way that clarifies exactly what their labels mean. The term "plasticity" is probably most often encountered in neurobiology, but Plasticity, as a personality trait, is not synonymous with "neural plasticity" (regardless of the extent to which neural plasticity plays a role in the exploratory processes associated with the trait). Similarly, Stability is not synonymous with "neural stability." Rather, the trait terms refer to the stability and plasticity of one's goals, interpretations, and strategies. As personality traits, Stability and Plasticity are descriptions of the broadest psychological properties of the cybernetic system.

Stability reflects the capacity of the cybernetic system to resist disruption. Following encounter with anomaly, people high in Stability will resist replacing their operative goal with immediate goals (like expressing anger or pursuing a distraction) that interfere with longer-term goals. In contrast, the characteristic adaptations of people low in Stability are frequently interrupted by emotions, impulses, and doubts. For people very low in Stability, even seemingly minor anomalies may plunge them into chaos, dysregulating their goal-directed functioning and leaving them distressed and at a loss. An analysis using the method of Hirsh et al. (2009) to identify items from the International Personality Item Pool (IPIP; Goldberg, 1999) specifically associated with the metatraits showed that low Stability is associated not only with disruptive impulsivity ("Get out of control," "Talk even when I know I shouldn't," "Am self-destructive"), but also with a precarious sense of identity, direction, and social role, as reflected in items like, "Am not sure where my life is going," "Have a dark outlook on the future," "Feel that others misunderstand me," and "Act or feel in a way that does not fit me" (DeYoung, 2010c). Low Stability appears to cause difficulty in developing and maintaining effective characteristic adaptations, presumably due to frequent disruption. In the language of dynamical systems, people low in Stability have trouble forming characteristic adaptations that are strong attractors (Nowak et al., 2005). High Stability, in contrast, is associated with having characteristic adaptations that are strong attractors and offer effective protection from unwilling encounters with chaos and the unpleasant dysregulation that comes with such encounters. The fact that Stability protects one from the threatening aspect of the unknown is reflected in individuals' self-defining life narratives: Stability negatively predicts the degree to which people describe threats when asked to describe memorable scenes from their adolescence and adulthood (Wilt, Olson, & McAdams, 2011).

Plasticity reflects the degree to which the cybernetic system is prone to generating new goals, interpretations, and strategies, not only when required by stressors that have caused instability and disintegration, but also voluntarily, in response to the incentive reward value of the unknown. For people very high in Plasticity, even a seemingly minor anomaly may provide motivation to explore, to put currently operative plans on hold in order to formulate some new interpretation or strategy or even a new goal. (If they are not too low in Stability, they may be able to do so without jeopardizing their existing plans.) Further, people high in Plasticity are not only prone to respond to anomaly more flexibly and eagerly when it appears unexpectedly, they also tend to seek out the unknown voluntarily, to put themselves in situations where they can predict that psychological entropy will increase (DeYoung, 2013). Because the unknown is innately promising, some people seek encounter with the unknown as an end in itself. High Plasticity is associated with exploration even when the predictability of the current state means exploration is unnecessary. Exploration transforms the unknown into the known, but it can also transform the known into the unknown (Peterson, 1999). This can be adaptive, as it may lead to unforeseen rewards and opportunities or to new characteristic adaptations that will be useful in future. It can also be disruptive. In adolescent males, at least, Plasticity has been shown to predict risk for externalizing problems like delinquency, hyperactivity, and drug use (DeYoung, Peterson, Séguin, Pihl, & Tremblay, 2008). (Note that low Stability, especially Conscientiousness and Agreeableness, is the major predictor of externalizing problems (Markon et al., 2005), and even in our adolescent sample, the association with Plasticity was not evident until we controlled for Stability and intelligence.)

IPIP items specifically associated with Plasticity reflect innovation and curiosity ("Am able to come up with new and different ideas," "Look forward to the opportunity to learn and grow"), as well as leadership, skill, and expressivity in social situations ("Have a natural talent for influencing people," "Have a colorful and dramatic way of talking about things"), all of which is consistent with the idea that a heightened exploratory tendency will cause engagement with novel and potentially rewarding possibilities (DeYoung, 2010c). Like Stability, Plasticity is reflected in self-defining life narratives: When asked to describe memorable life events, people high in Plasticity tended to describe episodes of exploration (Wilt

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et al., 2011). Because exploration can create new characteristic adaptations even in the absence of a crisis of instability (in which old characteristic adaptations are eliminated and replaced), people high in Plasticity will tend to have larger behavioral repertoires than those low in Plasticity, and they are likely to be more adaptable to a wide range of situations. People low in Plasticity, in contrast, may struggle to adapt when forced to rely on their own exploratory capacity instead of relying on cultural norms to provide their characteristic adaptations (DeYoung et al., 2002).

6. Comparisons with other theories

Having explicated the main features of CB5T, I now consider some of its advantages and limitations relative to other personality theories, in part to suggest ways it can be extended in future. Many theories exist to which CB5T might be compared; those discussed in this section are merely those most salient to the present theoretical exposition.

6.1. Social-cognitive theories

The family of personality theories known as "Social-Cognitive" invokes many constructs that can be considered characteristic adaptations (e.g., goals, beliefs, expectancies, evaluations), but they typically do not encompass explanations of traits (e.g., Cervone, 2004; Mischel & Shoda, 1995, 2008). Sometimes, in fact, they seem to deny that explanations of traits could, even in principle, be integrated with theories of intrapersonal personality processes (Cervone, 2005). Fortunately for CB5T, such an integration is not impossible in principle, but the concern that it might be is based on an important fact about the lack of necessary correspondence between three different types of personality structure: interpersonal covariance structure, intrapersonal covariance structure, and intrapersonal causal structure. It is a mathematical fact that interpersonal covariance structure (the tendency for a given level of certain traits to appear in the same people—e.g., high levels of talkativeness, sociability, and excitability—which allows the identification of factor structures like the Big Five) places no necessary constraints on intrapersonal covariance structure (the tendency for a person to be in certain states at or near the same time—e.g., talking, socializing, and being excited) (Molenaar & Campbell, 2009). Nor does the number of statistical factors present in either type of covariance structure place any necessary constraints on the number of distinct mechanisms present in intrapersonal causal structure (Bartholomew, Deary, & Lawn, 2009). Nonetheless, there must exist lawful causal relations of each type of covariance structure with the intrapersonal causal structure of the cybernetic system. Variation over time in the functioning of that system must cause intrapersonal covariance structure, and variation among people in various parameters of that system must cause interpersonal covariance structure.

CB5T is designed to explain the major mechanisms in the intrapersonal causal structure of the evolved human cybernetic system, as well as the manner in which interpersonal variation in parameters of that system produces the traits in the Big Five hierarchy. CB5T relies on a type of conceptual model (which can also be used as a measurement model in structural equation modeling) called "MIMIC," for "multiple indicators, multiple causes." The MIMIC model is consistent with current knowledge of psychological and brain function (Kievit et al., 2012). The brain is an integrated system, in which various mechanisms carry out cybernetic functions (like responding to reward), and each of these mechanisms is complex, with many parameters that may be statistically related to each other or may vary independently. Variations in these parameters are the *multiple causes* of any given trait. For example, variation in parameters of the brain systems that respond to reward corresponds to differences in reward sensitivity, which is posited to be the primary function underlying Extraversion. But Extraversion has *multiple indicators*, which means that Extraversion represents the shared variance of multiple lower-level traits. Thus, CB5T's MIMIC model for Extraversion posits that the traits encompassed by Extraversion vary together because they all, to some substantial degree, reflect reward sensitivity, which is caused by variation in a number of parameters of the reward mechanisms of the human cybernetic system.

What CB5T does not currently do very thoroughly is to explain patterns of intrapersonal covariation. What causes certain patterns of behavior and experience to group together in time for a particular person? CB5T addresses this question primarily by asserting that behaviors associated with a particular trait will be accompanied in time by some of the motivational, emotional, and cognitive states also associated with that trait, as recently demonstrated for Extraversion (McCabe & Fleeson, 2012). However, CB5T also recognizes that the same action may be a reflection of different traits at different times, as a function of the underlying motivation for selecting it (Funder, 1991). CB5T does not offer a well-elaborated theory of action selection or decision making, but it should be useful for researchers attempting to understand the influence of personality on decision making. In broad outline, CB5T indicates that action selection is always influenced by both traits and characteristic adaptations.

Future research and theory may extend CB5T to address intrapersonal covariance structure more thoroughly. In part, this structure will be different for each person, inasmuch as it depends on his or her characteristic adaptations. In part, it will depend on expanding our understanding of the causal interactions among the mechanisms that underlie different traits. A recent study of managers at work, for example, demonstrated that, when a given manager was acting more conscientiously, he or she also tended to be feeling more neurotic (Beckman, Wood, & Minbashian, 2010). At the interpersonal level, however, the sample showed the standard negative correlation between Conscientiousness and Neuroticism (an excellent demonstration of the fact that interpersonal covariance structure does not necessarily correspond to intrapersonal covariance structure). The explanation for this may be that engaging the top-down control systems associated with Conscientiousness to pursue some work-related goal leads any potential threat to that goal to become more salient, hence increasing the detection of threats and, thus, increasing state neuroticism relative to the person's typical baseline. On a longer time-scale, however, high levels of Neuroticism may tend to disrupt conscientious behavior, or successful conscientious behavior may aid in avoiding punishments, leading to reduced Neuroticism (Corr et al., 2013). These possibilities are speculative and need further testing, but they demonstrate the kind of explanation that CB5T might afford.

CB5T focuses on traits that were identified through analysis of interpersonal covariance structure, but those traits can be translated into intrapersonal causal structure through discovery of the systems in which variation produces traits. Indeed, CB5T owes its existence to the substantial body of evidence that suggests which psychological mechanisms correspond to each of the Big Five (Section 4). Characteristic adaptations are both interpersonal constructs (they can be assessed as variables across people—e.g., people can have the goal of becoming a lawyer or not) and intrapersonal constructs (they describe information in memory that plays a causal role in the functioning of the individual—the goal of becoming a lawyer will guide interpretation of situations and selection of strategies). Social-cognitive theories are typically designed to explain the kind of consistency in behavioral responses to relatively specific situations that is explained by characteristic adaptations in CB5T (Cervone, 2004; Mischel & Shoda, 1995,

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2008). One of the most useful aspects of social-cognitive theories is a focus on elucidating different kinds of interpretations (evaluations, expectancies, etc.), their varied relations to each other, and their implications for behavior. CB5T could be extended usefully by incorporating theories about the different types of characteristic adaptation within each of the three basic categories.

One of the only social-cognitive theories that attempts to integrate, within a mechanistic model, both traits and what CB5T calls characteristic adaptations is Whole Trait Theory (WTT; Fleeson, 2012; McCabe & Fleeson, 2012). WTT describes traits as density distributions of states (as discussed in Section 3.1) and "social-cognitive mechanisms" (goals, beliefs, values, etc.) as causes of the states associated with each of the Big Five. Unlike CB5T, WTT does not distinguish clearly between traits and characteristic adaptations. Rather than being distinct entities with different causal origins and functions from traits, social-cognitive mechanisms are, for WTT, merely the causal mechanisms generating traits. Although CB5T asserts that characteristic adaptations can influence traits, it ascribes traits and characteristic adaptations distinct causal roles in personality and identifies other intrapersonal constructs (basic cybernetic mechanisms) as the direct cause of traits.

The major limitation of WTT is that it does not adequately explain the existence of the Big Five as the specific major dimensions of personality. WTT describes behavior as the product of social-cognitive mechanisms that are often equivalent to characteristic adaptations, and the only reason provided for why certain types of behavior tend to covary to form the broad Big Five dimensions is "accretion," involving (1) learning about the similarities of different behaviors, and (2) causal interactions among the narrow social-cognitive mechanisms generating specific behaviors (Fleeson, 2012). This explanation does not seem adequate to account either for the substantial genetic contribution to broad traits like the Big Five or for the fact that more genetic variance is associated with the Big Five (i.e., the shared variance of their facets) than with the unique variance of their facets (Jang et al., 1998; this is also true in other trait models, e.g., Krueger et al., 2002). Nor does accretion offer a plausible explanation for the cultural universality of traits. If the Big Five emerged primarily through learning about what types of behavior were similarly effective or had similar meanings in context, surely these patterns would not be sufficiently universal to account for the replication of both phenotypic and genetic factor structure across diverse cultures (Yamagata et al., 2006). Similarly, one would not expect complex causal interactions among many narrow mechanisms always to lead to the same functional groupings.

CB5T acknowledges that some interactions between narrow mechanisms associated with low-level traits might contribute to the coherence of high-level traits (for example, in relation to Neuroticism, anxiety may cause disturbances of sleep and appetite, which may cause fatigue and disruptions of attention, which may contribute causally to depression, etc.; Cramer et al., 2012), but it also acknowledges the existence of brain systems known to have broadly acting causal influences on many different types of psychological function, and in which variation is, therefore, likely to contribute causally to the existence of broad personality traits (for example, serotonin regulates sleep, fatigue, appetite, attention, and depression; Carver et al., 2008; Spoont, 1992). By specifying the primary cause of trait covariation as evolved cybernetic mechanisms that respond to broad classes of stimuli, CB5T provides a better fit to available data than models that presume all causal forces generating traits to be highly specific.

6.2. Evolutionary theories

In one crucial sense, CB5T is an evolutionary theory. It posits that personality traits stem from variation in evolved cybernetic mechanisms that typically provide evolutionarily adaptive responses to common classes of stimuli. In this regard, it is most similar to Denissen and Penke's (2008) theory of five individual reaction norms (FIRN) underlying the Big Five. It differs from FIRN both in incorporating characteristic adaptations and in identifying stimulus classes associated with some of the Big Five that are broader than those identified by FIRN (e.g., for Neuroticism, sensitivity to punishment and threat generally versus sensitivity to social exclusion specifically). What CB5T does not provide is a set of hypotheses about what evolutionary forces have maintained variation in personality traits (Penke, Denissen, & Miller, 2007). Other evolutionary personality theories have attempted to do so, identifying the drivers of genetic variation as fluctuating and balancing selection. Different levels of each of the Big Five have been hypothesized to be associated with different trade-offs in fitness (MacDonald, 2006; Nettle, 2006). CB5T acknowledges many of these selection mechanisms as plausible, perhaps even likely, but remains uncommitted to any particular hypotheses about the phylogenetic causes of variability, acknowledging as well that much genetic variation may remain in complex traits even in the presence of strong directional selection (Johnson, 2010).

Another integrative theory of personality that relies heavily on a cybernetic perspective and includes universal evolved mechanisms is Sheldon's (2004) theory of optimal human being (later described as the Multiple Levels of Personality in Context model; MPIC; Sheldon, Cheng, & Hilpert, 2011). This theory differs from CB5T in that it does not connect these mechanisms directly to traits, focusing instead on universal basic needs—including security, relatedness, competence, autonomy, and self-esteem—and considering traits as completely separate entities. In contrast, CB5T asserts that the traits identified in Fig. 1 are intimately linked to universal basic needs because they reflect variation in cybernetic mechanisms that evolved to allow human beings to meet many of those needs. Human functioning requires the ability to respond to rewards, for example. Even someone scoring very low in Extraversion can typically find some rewards pleasurable and motivating. Someone who loses this ability entirely is likely to be diagnosed as severely depressed (see Section 7). CB5T recognizes the existence of individual differences both in the strength of universal basic needs (e.g., some people require more relatedness or autonomy than others) and in the abilities required to pursue them. Lists of psychological needs should, therefore, be investigated to determine links to specific traits. Agreeableness, for example (perhaps more specifically Compassion), should be related both to the strength of need for relatedness and to the ability to meet that need. In short, unlike MPIC, CB5T explains psychological needs and personality traits as properties of the same cybernetic mechanisms. Needs identify the goals that those mechanisms evolved to pursue (or the evolutionarily adaptive problems they solve), whereas traits reflect variation in the functional parameters of those mechanisms.

6.3. Conscious and unconscious processes

I have noted repeatedly that characteristic adaptations may be both conscious and unconscious, but otherwise I have not emphasized the distinction between conscious and unconscious processes. This should not be mistaken to mean that CB5T assumes the distinction to be unimportant. To elaborate CB5T's perspective on conscious versus unconscious processing would provide greater detail regarding McAdams and Pals' (2006) fourth principle for personality theories, the self-defining life narrative or conscious identity, but a full elaboration is beyond the scope of this article.

Nonetheless, it is worth noting that some personality theories (starting long ago with psychodynamic theorists like Freud and Jung) have made the distinction between conscious and unconscious processes their central focus (e.g., Corr, 2010; Epstein, 2003). The major individual differences considered in Epstein's

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(2003) Cognitive-Experiential Self-Theory, for example, are in two dimensions of thinking style described as *rational* (conscious) and *experiential* (unconscious). Epstein's measure of rational style is an excellent indicator of Intellect (Kaufman et al., 2010), whereas his measure of experiential style is more complex, being related to Openness, Extraversion, and Agreeableness (Kaufman, 2013; Norris & Epstein, 2011). The greater complexity of the experiential style is in keeping with Gray's (2005) observation that many human cybernetic processes can and do take place without conscious control. Most of the processes described in Section 4 as the basis of various personality traits take place unconsciously, although they have many consequences for conscious experience and can often be influenced by conscious processes. In fact, the only processes described in Section 4 that are necessarily conscious may be some of those associated with Intellect, like working memory. The conscious self-concept, and conscious awareness more generally, is created from moment to moment using a very limited subset of the information being processed by the brain unconsciously (Gray, 2004; Nørretranders, 1991). (Note that this does not make consciousness unimportant in the control of behavior; Gray's hypothesis is that conscious processes can analyze errors and adjust some cybernetic parameters based on the detection of mismatch, such that the subsequent iteration of the cybernetic cycle benefits from previous conscious experience.) The more stable components of the self-concept are incorporated into one's conscious identity, which is a remembered interpretative structure (that is, a characteristic adaptation) that encompasses a representation of many of one's characteristic adaptations and traits, and that helps to render one's experience meaningful and predictable (Hirsh, Mar, & Peterson, 2013).

One consequence of the fact that the conscious self-concept, including identity, is in part a representation of otherwise unconscious elements of one's personality is that it may be more or less accurate. In relation to Fig. 3, this means that one's personality incorporates both explicit and implicit maps of one's characteristic adaptations, and these are not likely to be perfectly aligned. Like the classic psychodynamic theories and some modern personality theories as well (e.g., Epstein, 2003; Sheldon, 2004), CB5T posits that discrepancies between conscious and unconscious mental content can be a source of dysfunction. The reason these discrepancies are often problematic is that they can increase psychological entropy. Anomalous information can originate from within as well as from without. Conflicting interpretations, goals, or strategies lead to increased difficulty in figuring out what is happening and what to do and, thus, to increased stress and even potentially to disintegration.

7. Function and dysfunction: implications for psychopathology and well-being

One of the theories most similar to CB5T, in its explanation of the mechanisms underlying personality traits, is the review of systems (ROS) approach of Harkness et al. (2014). What is particularly interesting about this similarity is that ROS is based on a five-factor model of psychopathology, rather than normal personality (Harkness, Finn, McNulty, & Shields, 2012). It has become increasingly clear that psychopathological traits or symptoms have almost the same five-factor interpersonal covariance structure as normal traits, and thus can be integrated with the Big Five (Krueger & Markon, 2014; Markon et al., 2005; Widiger & Mullins-Sweatt, 2009). This correspondence appears to apply not only to psychopathology that has been considered under the rubric of "personality disorder," but to all psychopathology (Markon, 2010). This correspondence makes sense from the perspective of CB5T because the Big Five represent variation in the major functional divisions of the cybernetic system that allows human beings to pursue their goals and to meet their basic needs. Psychopathology, including disorders like major depression and schizophrenia, must, logically, involve dysfunction of this system.

It is not entirely surprising that the major dimensions of individual differences in dysfunction are very similar to those in normal function. A breakdown in any one of the mechanisms that produces the traits identified in Fig. 1 should lead to dysfunctions located primarily (but not entirely) in the same cluster of emotion, motivation, cognition, and behavior described by the corresponding trait. "Not entirely" because the cybernetic system consists of interacting mechanisms, and dysfunction in one mechanism may cause dysfunction in others as well. Research on dysfunctional traits has noted that they tend to be more strongly correlated with each other than are normal traits because all of them are related to Neuroticism, demoralization, and subjective incompetence (Cockram, Doros, & de Figueiredo, 2009; Tackett et al., 2013; Tellegen et al., 2006). In part, this may reflect the fact that individual differences in self-esteem, depression, or morale lead people to attribute consistently desirable or undesirable qualities to themselves, regardless of content, a phenomenon known as *halo* or *evaluative consistency bias* (Anusic et al., 2009; Pettersson et al., 2014). The cybernetic perspective, however, suggests an additional, more substantive, source of this general covariance, at least when we restrict our focus to dysfunction. A breakdown anywhere in the system will cause problems specifically related to traits that reflect variation in the dysfunctional mechanism, but it will also incline the system to function poorly as a whole, creating frequent failures of goal-directed action, increased psychological entropy, episodes of disintegration, more frequent and intense emotional dysregulation, and the subjective sense that one is incapable of moving toward one's goals.

Both psychologically and biologically, the adaptive systems proposed by ROS to underlie the five major dimensions of psychopathology correspond well to CB5T for Extraversion ("resource acquisition"), Neuroticism ("short-term danger detection"), and Conscientiousness ("long-term cost-benefit projection"), but some discrepancies arise for both Agreeableness and Openness/Intellect (Harkness et al., 2014). ROS describes Aggressiveness (low Agreeableness) in terms of an "agenda protection system," the major outputs of which are "anger and rage" in response to frustration (Harkness et al., 2014, p. 134). In the Big Five, reactive anger appears as a facet of Neuroticism, rather than Agreeableness. CB5T identifies the sources of reactive anger in the low-level systems of active defense that govern Volatility. Even non-social mammals display anger when frustrated, and this does indeed serve to protect their goal-directed agendas, but social mammals appear to have evolved separate mechanisms to facilitate cooperation and altruism, for the coordination of agendas across individuals. These mechanisms interact with defensive systems and can suppress reactive anger (explaining why anger is related to Agreeableness as well as to Neuroticism), but they primarily involve systems designed for social information processing, cooperation, and affiliative bonding (cf. Graziano & Tobin, 2013). CB5T suggests that much psychopathology involving aggression or callousness is likely to involve dysfunction of these specifically social mechanisms instead of, or in addition to, those related to reactive anger.

The fifth dimension of psychopathology is Psychoticism, reflecting cognitive and perceptual aberrations that can be described as *apophenia*, the perception of patterns or causal connections where none in fact exist (or at least where the patterns or connections are highly implausible).[7] ROS ascribes variation in this dimension to a

[7] Note that this dimension is very different from the one that Eysenck labeled "Psychoticism," which consists of a combination of low Agreeableness and low Conscientiousness, and which most personality psychologists agree was mislabeled (Goldberg & Rosolack, 1994; Pickering, 2004).

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"reality monitoring for action" system, which corresponds well conceptually to the systems underlying cognitive exploration and interpretation that CB5T associates with Openness/Intellect. Unlike the other four dimensions of psychopathology, however, Psychoticism does not unambiguously correspond to one pole of its corresponding Big Five dimension. Indeed, the question of whether Psychoticism or apophenia (also called "positive schizotypy") can be integrated with models of normal personality traits has been heavily debated. We recently identified the fundamental reason for this confusion (DeYoung et al., 2012): At the aspect level, Psychoticism is positively associated with Openness (and loads on Openness if separate Openness and Intellect factors are extracted), but it is negatively associated with Intellect (and especially with intelligence). Our demonstration of this phenomenon in a healthy sample has now been replicated in clinical samples, where the opposing effects of Openness and Intellect are even stronger (Chmielewski, Bagby, Markon, Ring, & Ryder, 2014). The opposite associations of Openness and Intellect with Psychoticism mean that zero-order associations of Psychoticism with the broader Big Five dimension of Openness/Intellect are suppressed, making it harder to assign Psychoticism to that factor. Nonetheless, when normal and abnormal traits are factor analyzed together, five-factor solutions typically reveal that Psychoticism does merge into a single factor with Openness/Intellect (Ashton, Lee, de Vries, Hendrickse, & Born, 2012, footnote 6; DeYoung et al., 2012; Krueger & Markon, 2014; Markon et al., 2005).

CB5T explains the mechanisms of Psychoticism in terms of the need to balance Type I and Type II errors (false positives and false negatives, respectively). As noted in Section 4.3, Openness appears to reflect variation in systems that detect patterns automatically. The more sensitive are these mechanisms, the more likely the individual is to avoid Type II errors but to make Type I errors. Type I errors constitute apophenia. The conscious cognitive processes associated with Intellect help people to determine which patterns are likely to be coincidences or fallacies and which have a logical or causal basis. Thus, Intellect, which is on average associated with high Openness, should compensate for Openness by reducing Type I errors. When people are high in Openness but low in Intellect, therefore, they are at highest risk for Type I errors in monitoring and interpreting reality, and, in the extreme, these errors may contribute to hallucinations and delusions that lead to a breakdown in the ability to function successfully. In short, the major taxonomy of psychopathological traits and symptoms can be integrated seamlessly with CB5T, as long as one recognizes that Psychoticism must be understood at the aspect level of the personality hierarchy, rather than at the Big Five level (DeYoung et al., 2012).

CB5T is inherently a theory of disorder as well as personality because it represents psychological function and dysfunction as a continuum of variation in basic cybernetic mechanisms. Dysfunction may occur if mechanisms are either hypoactive or hyperactive (Pettersson et al., 2014; Widiger & Mullins-Sweatt, 2009). For example, loss of reward sensitivity, manifesting in anhedonia and amotivation (low Extraversion), is a key component of depression, but extremely high reward sensitivity (high Extraversion) is a key component of mania (DeYoung, 2013; Tackett, Quilty, Sellbom, Rector, & Bagby, 2008). Thus, either extreme can disrupt stable cybernetic functioning. Similarly, low Conscientiousness is associated with a variety of externalizing problems involving impulsivity and lack of forethought, but overly high Conscientiousness, especially Orderliness, is associated with compulsivity, inability to abandon goals and rules when appropriate (Krueger & Markon, 2014; Widiger & Mullins-Sweatt, 2009).

Thus far, this section has considered dysfunction only in relation to traits, but CB5T implies that dysfunction may be present in characteristic adaptations independently of traits. People with relatively normal trait profiles may nonetheless have acquired some characteristic *mal*adaptations: goals, interpretations, and strategies that hinder their ability to reach important personal goals or fulfill basic needs and that they have been unable or unwilling to change. The failure to adapt can be due to lack of awareness of the drawbacks of the maladaptations in question, or to difficulty discovering and learning adequate replacements, or to fear of the encounter with the unknown that is required for change (Peterson, 1999). Conversely, a person might not be dysfunctional even given an extreme trait profile. Clinical assessment benefits from determining whether one's characteristic adaptations are adequately functional, independently of traits—that is, whether one is able to interpret one's own specific life experiences in a sensible manner and to make adequate progress toward one's own personal goals (cf. Livesley, 1998; Wright, 2011). If one's characteristic adaptations are functional, not maladaptations, then one probably should not be considered dysfunctional even in the presence of an extreme trait profile. A possible exception here might be extremely low Agreeableness—if one is perfectly capable of maintaining a coherent interpretation of self and world and of making progress toward one's goals, but one's behavior consistently violates the welfare of others, a diagnosis of dysfunction may be possible even without signs of subjective incompetence or distress. This kind of social dysfunction without subjective dysfunction seems particularly likely in people with extremely low Compassion, because the negative pole of this trait is characterized by callousness.

7.1. Pursuing integration

A focus on characteristic adaptations is especially useful when considering well-being as opposed to psychopathology. The trait correlates of subjective well-being have been thoroughly studied—low Neuroticism and high Extraversion are the strongest correlates, which is sensible because such a profile reflects low levels of negative affect and high levels of positive affect (Lucas & Diener, 2008). CB5T suggests, however, that the highest and most enduring levels of well-being should be achieved when one's characteristic adaptations are not only well adapted to one's particular life circumstances, but also well-integrated—that is, minimally conflicting with each other, with one's traits, and with innate needs. The notion that a well integrated personality is the key to well-being has been common in psychology, from Jung's (1939/1968) concept of *individuation*, the process by which the personality becomes an undivided whole and the ultimate goal of both psychotherapy and human development, to Sheldon's (2004) theory of optimal human being, which provides an extensive examination of ways to facilitate integration, with a particular focus on satisfying basic needs.

High levels of integration may be difficult to achieve, even for people with no serious dysfunction, because the goal hierarchy is never completely unified. Goals are arranged hierarchically, with subgoals needed to achieve higher-level goals, but there is no single overarching goal of which all the others are subgoals. (One might argue that the stability of goal-directed functioning regardless of specific goals—that is, entropy reduction—could be conceived as the highest goal, but even the need for stability is in tension with the need to maintain plasticity in the system, which often involves seeking temporary increases in entropy, as discussed in Section 5.) Goals are often in competition with each other, such that strategies one might use to pursue one goal may make it more difficult to pursue others. Integration requires multiple constraint satisfaction, often leading to compromise. Further, the desired future state, as a whole, is often specified somewhat vaguely. Even worse, as noted in Section 6.3, one's conscious representation of the desired future may differ in some ways from the goals that are represented unconsciously in one's motivation systems, and this is another barrier to integration (cf. Schultheiss & Strasser, 2012).

If a high level of integration is to be achieved, it must be through the process of adaptation illustrated in Fig. 3, leading to

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a well-honed suite of characteristic adaptations. One may be able to make at least minor changes to one's traits voluntarily, but even this process of change is likely to require a change of characteristic adaptations. Little (2008) discusses the possibility of "free traits," patterns of behavior that resemble traits one lacks, which one adopts to further some personal project. If any of one's traits are problematically extreme, one may develop characteristic adaptations that allow one to behave in a manner that is inconsistent with that trait, in order to maintain adequate goal-directed functioning. Such a strategy is likely to be difficult and occasionally stressful, but may nonetheless be part of a well-functioning personality. If such strategies become habitual, they may feed back to shift the parameters of the cybernetic system and, hence, to influence traits, as illustrated in Fig. 2 (cf. Magidson, Roberts, Collado-Rodriguez, & Lejuez, 2014). For example, someone low in Conscientiousness may explicitly reorganize his or her personal goals so as to value long-term career success over what was previously a favorite hedonistic pursuit, and this may, over time, lead to an increase in Conscientiousness, as the top-down control exerted by the systems that underlie Conscientiousness is rendered more effective by having to compete less often with the hedonistic characteristic adaptation that was previously maladaptively high in the goal hierarchy.

In order to figure out what characteristic adaptations must be changed or added to produce a well-integrated personality, one must be willing to explore anomalies, as they arise (Peterson, 1999). This means avoiding self-deception, which we have defined as ignoring subjective evidence that one's current plans and beliefs might be in error (Peterson, Driver-Linn, & DeYoung, 2002; Peterson et al., 2003). The evidence in question must be subjective in order to distinguish self-deception from mere ignorance, and it consists of the innate affective responses to anomaly triggered by the mechanisms that compare ongoing experience to expected and desired outcomes. We found that a questionnaire measure of trait self-deception (specifically assessing an egoistic bias, the tendency to be overconfident in one's beliefs and abilities) predicted slower categorization of an anomalous stimulus, despite the immediate presence of affective facial expressions indicating that the anomaly had been detected by participants both high and low in self-deception (Peterson et al., 2002).

Achieving high levels of integration requires exploration of anomalous experience with sufficient caution to avoid unnecessary destabilization, but with sufficient courage to face the risk that some of one's characteristic adaptations may be invalidated, and with sufficient humility to acknowledge when a current characteristic adaptation is in error. Refusal to acknowledge error is likely to lead to perseveration and to various future costs, including heightened risk for disintegration (Chance, Norton, Gino, & Ariely, 2011; Peterson et al., 2003). Exploration of anomaly should not always lead to abandoning a characteristic adaptation (one would be disastrously unstable if it did), but one must be willing to consider the possibility that any anomaly indicates the need for change and to do enough exploration to determine whether change is necessary or desirable (though how much exploration is enough is a difficult calibration problem, pitting present expenditure of resources against future risk). Failure to adapt, due to self-deception, is likely to contribute to much psychopathology and to be a major barrier to long-term well-being in otherwise healthy individuals. In addition to avoiding self-deception, achieving a high level of integration requires paying close attention to interest, as an emotion (Peterson, 1999; Silvia, 2008), because interest indicates the potential to generate new characteristic adaptations that are well-aligned with one's traits and existing characteristic adaptations. This article cannot address all of the implications of CB5T for psychopathology and well-being, but hopefully this section begins to illuminate its applicability in that arena.

8. Conclusion

CB5T is currently the only theory of personality that provides a mechanistic explanation of traits in all of the top three levels of the personality hierarchy (Fig. 1). Further, it is the only theory that provides explanations of many specific traits in a way that is integrated with a mechanistic account of characteristic adaptations. CB5T provides more precise definitions of *personality traits* and *characteristic adaptations* than those that were previously available, allowing the two types of construct to be more clearly differentiated. CB5T provides only a broad outline of the organization and dynamics of characteristic adaptations. This is obviously a limitation, but it is also a strength because to delineate all of the processes that structure and carry out characteristic adaptations would be to summarize nearly the entire field of psychology. CB5T boils the nature of characteristic adaptations down to its cybernetic essentials. Characteristic adaptations are more complicated to measure than traits, but personality psychology will benefit from increasing its focus on these constructs and better integrating them with research on traits. Finally, the inclusion of characteristic adaptations as a separate category of elements within the cybernetic system allows CB5T to describe more clearly the referents of the metatraits, Stability and Plasticity. It is precisely one's goals, interpretations, and strategies that are stable or unstable, plastic or rigid.

CB5T affords a wealth of testable hypotheses, both psychological and biological, largely because it specifies the mechanistic functions that underlie different traits (summarized in Table 1). Hypotheses based on CB5T can be tested in a variety of ways, including incorporating them into connectionist models like that of Read et al. (2010). Their model is the most sophisticated attempt to date to create an artificial information-processing system in which personality traits are represented as parameters of specific cybernetic mechanisms. It encompasses three traits, Extraversion, Neuroticism, and Constraint, the last of which corresponds either to Conscientiousness or Stability. In future, CB5T can provide guidance for including additional traits in such models.

If CB5T is at all successful in providing "an integrative framework for understanding the whole person" (McAdams & Pals, 2006, p. 204), it should be useful for nearly every branch of psychology, though the most obvious applications outside of personality psychology may be in clinical research. CB5T interprets personality in a manner compatible with the study of development across the lifespan. A discussion of the ontogeny of the cybernetic mechanisms described by CB5T is beyond the scope of this article, but note that its mechanistic description of personality traits allows CB5T to circumvent some of the difficulties of studying the Big Five in children (DeYoung, 2010c; Shiner & DeYoung, 2013). Although the specific behaviors associated with a given trait will change during development, even very young children will show meaningful variation in most of the cybernetic mechanisms underlying the Big Five, manifested in individual differences in sensitivities to reward and punishment, curiosity and imagination, altruism and cooperation, etc. CB5T allows consideration of the developmental trajectories of the mechanisms underlying personality, which mature at different rates during early life and break down at different rates in old age. Thus, CB5T is a theory of personality for the whole person and the whole of human life.

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