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# SEMANTICALLY MEDIATED INTEGRATION OF COGNITION IN *HOMO SAPIENS*: EVOLUTION, GRAMMAR, UNCERTAINTY, AND COGNITIVE ACCURACY

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## ABSTRACT

This article reviews research on human brain, cognition, language, behavior, and evolution to posit the value of operating with a stable reference point based on cognitive accuracy and a rational bias. Drawing on rational emotive, cognitive behavioral and cognitive neuroscience on the one hand and a general brain model of frontal lobe executive function and working memory on the other, along with proposed language mediation of cognitive processes, this review yields potential implications for maximizing brain functioning of *Homo sapiens*. Cognitive thought processes depend on the operations and interactions of specific brain structures and networks, functioning more effectively under conditions of cognitive accuracy (including accurate information, thought process accuracy, and event-level accuracy). However, typical cognitive processes appear to promote the adoption and use of subjective cultural beliefs, mediated by language and grammatical habits mostly learned during early development. In turn, these grammatical habits tend to bias humans toward cognitive inaccuracies. On the other hand, a process that applies informed frontal lobe executive functioning to the mediation of cognition, emotion, and behavior may help to minimize the negative effects of indiscriminately applied cultural belief systems, provide a naturalistic framework for future research and ultimately enhance cognitive accuracy as a reference point for evaluating humans while offering improved relative environmental homeostasis.

**Keywords**: Neuroscience, Rational, Evolution, Grammar, Cognition, Cultural belief systems.

## INTRODUCTION

As an evolving species, *Homo sapiens* tend to use more primitive, inherently inadequate tools to measure the results of thought and behavior. Lacking awareness of how we use words to think and speak, and measuring our success by unquestioned cultural belief systems that we have accepted uncritically, we frequently fall prey to confusion, misunderstanding, and emotional turmoil (Browne & Keeley, 2007, pp. 182-5). Human cognition and behavior developed as a product of evolution, socialization, development, and language mediation, as proposed by Luria, influenced by Vygotsky (Luria, 1981, pp. 1-13) This article contends that application of components of accurate human mental functioning and evaluations, mediated by language, will enhance the probability of more successful, rational outcomes (Bailey, 2006). "Rational" as used here derives from cognitive accuracy and refers to purposeful cognition, evaluation, behavior, learning, and informed deliberation. Rational cognition promotes adaptive, pragmatic, practical, flexible decision-making matched as closely as possible with the present instead of the past. In this view, rationality does not imply finding or knowing a supposed single right answer, but rather recognizes that, lacking omniscience, we do best to prepare for a variety of possible outcomes and adapt readily when things do not happen as we would prefer. "In forming opinion about future events, [rational expectations imply] the use of all available information to assess the probabilities of the possible states of the world. More simply, [rational] expectations [are those] that are as correct as is possible with available information" (Deardorff, 2006). Such flexibility is preferable to "irrationality," used here to refer to behavior that is rigid and reactive, especially cognition oriented towards learned rather than learning behavior, and based on belief rather than evidence, i.e., operating with outdated non-contextual information containing unexamined cognitive inaccuracies that promote incongruent stimulus-bound event-level reactions and primitive objectification.

## BRAIN, BONDING, LANGUAGE, CULTURE, AND EVOLUTION

To understand normal human brain functioning and cognition, it may be helpful to distinguish independent variables among organisms, especially between mammals, higher primates, and human primates. What are the variables and how do they affect the species? What does this mean to us as *Homo sapiens*? The largest obvious difference between humans and other primates is the unique prefrontal cortex (PFC) that supports language (Broca, 1877). Subsequent to this distinction, as far as we know, we have more words than any other species (LeDoux, 2002, p. 198). Likewise, words and language make up the largest differences among human populations, forming the basis for relationships and individual cultural belief system values (Luria, 1981, p. 6-7). Humans innately seem to express social attributes for relationships at many levels (Panksepp, 1998, 221-99). Relationships depend on interactions between individuals including cooperation and coordination. These interactions in turn usually depend largely on communication (Cacioppo & Berntson, 2004, p. 978). Faulty, or inaccurate, communication tends to have an adverse effect on relationships at all levels.

**Bonding and the Limbic System**

We share many of our brain attributes with other primates, particularly our limbic system, which contributes to our lower-level emotional cognition. We can trace the large variation in socialization among species to the differential distribution of oxytocin and arginine-vasopressin (avp) receptors and the pathways that enable bonding, attachment, affiliative behavior, and creation of cohesive groups (Insel, 1997; Bartels & Zeki, 2004; Young & Wang, 2004; Fisher et al, 2002; Cho et al, 1999; Lim et al, 2004). These oxytocin and avp attachment receptors support the bonding cascade that mediates reward pathways in the ventral tegmental area (VTA), demonstrating associations with the nucleus accumbens, bed nucleus of the stria terminalis (BNST), and interstitial nucleus of the posterior limb of the anterior commissure (IPAC) (Heimer et al, 2005, pp. 61-65). These reward pathways add a positive emotional valence, or value, to bonding and affiliative behavior, mediated (at least in part) by a positive shift in VTA dopamine and probably endogenous opioids (Panksepp 1998, p. 263). These pathways appear to overlay lower-level limbic reinforcement and pain pathways identified in mammals and other primates (Tranel, 2000, p. 218). This suggests an evolutionary adaptation of social behavior to preexisting limbic and somatic pain-reward pathways. (See Caldwell & Young, 2006, for a review of oxytocin and vasopressin.)

Unbonding, rejection, social disapproval, or exclusion from social groups (Cacioppo & Berntson, 2004, p. 983) can induce a negative limbic valence, or value. Threats to attachment or approval may produce emotional pain, jealousy, anger, aggression and violence (Insel, 1997). This negative valence appears to correlate with increased amygdala activity. Studies show that the stress induced by detachment or disapproval triggers bereavement-related syndromes, correlated with an increase in stress hormones, corticotrophin releasing factor (CRF), and a decrease in brain-derived neuronal growth factor (BDNF). Other mammals also express increased CRF associated with social defeat and subordination (Ferris, 2006, p. 167-8). This increased CRF in turn correlates with increased amygdala activity and possibly with the downshifting of cognition to implicit limbic and automatic striatal pathways, with decreased PFC and hippocampal volume coupled with diminished executive cognition and attenuated memory. These symptoms echo those of anxiety and depression, sometimes leading to anger and aggression (Panksepp, 1998, p. 205). Shifts in the limbic bonding axis have a dramatic impact on emotional homeostasis, rewarding bonding, affiliation, and approval, while punishing detachment and disapproval. In social animals like human primates, this fundamentally influences cognition, emotion, and behavior (Nair & Young, 2006).

**Differentiation, Language, and Socialization**

While inter-species social behavior in non-primates and primates may range from very similar to very different, among primates the habit of language distinguishes human primates from our close primate relatives. “Human language offers replication machinery for unlimited cultural evolution”, possibly, “representing the biggest invention of the last 600 million years” (Nowak, 2006, p. 249-50). Similar to many social species, humans normally appear to share a genetic predisposition for relationships. For us, however, the innate tendency to bond and affiliate is intimately associated with cultural belief systems, mediated by language (Panksepp, 1998, p. 245). This underscores the importance and impact of language and communication on relationships, thought, emotion, and behavior (Damasio, 2000, p. 17).

**Cultural Belief Systems**

The human ability for complex language, formulations, thought, and verbal communication helps define our social interactions (Grafman, 2002, p. 298; Mitchell et al, 2006, p. 63; Risberg, 2006, p. 8-7). Words, grammar, and language support cultural belief systems, which form the major independent variable among normal humans (Luria, 1981, pp. 205-9). Normal human brains exhibit relatively consistent form and function across cultures (LeDoux, 2002, p. 231), but cultural belief systems differ, sometimes dramatically (Whorf, 1956, p. 221). We implicitly learn the structure and rules of what we think and how we think from the culture that we grow up in (Nowak, 2006, p. 263). In other words, communication of cultural belief systems depends on hand-me-down semantics and grammar, which vary from culture to culture (Sapir, 1949, p. 162). Language identifies and defines cultural belief systems and represents a distinguishing group characteristic, directly affecting the thoughts, emotions, and behavior of the group (Adolphs, 2006, p. 269-74).

Cultural belief systems and groups frequently overlap or contain subgroups, but a prerequisite set of beliefs usually determines membership. These systems form within social groups due to our inherited propensity for bonding and affiliations. We find unique belief systems at all scales: individuals, small groups such as families or affiliations, and large groups such as entire societies or states. The rules they embody for the group, regarding thought and behavior, usually pass down from elder members and define the particular belief system. Because the rules and beliefs have direct impact on thought and behavior, they also have a dramatic effect on emotions.

**Language, Semantics, grammar, and Cultural Variance**

We may assume that a person born and raised in a particular cultural belief system would think, feel, and behave differently than one born elsewhere, not because their brains differ but because they internalize different cultural beliefs (Benjafield, 2007, p. 237; Thompson-Schill et al, 2006, pp. 178-9; Vygotsky & Luria, 1993, pp. 230-31). Even though they share basic human emotions, they will react differently to stimuli based on culturally defined values (Browne & Keeley, 2007, p. 53-69). Words culturally bind our thoughts, our beliefs, and subsequently our behaviors and emotions in a wide range of circumstances (Phelps, 2004, p.1008). Since cultural belief systems rely heavily on semantics—the use and meaning of language—one might also conclude that the use of semantics and grammar figure as the largest independent variables in understanding human cognition and interactions.

These insights highlight the tremendous impact grammar has on emotions, behaviors, and perceptions across cultures as well as between individuals (Boyd & Richerson, 2005, p. 206). Semantics directly affects most aspects of human experience, including cultural belief systems, cognition, emotions, behaviors, evaluations, perceptions, affiliations, pair bonding, bonding mechanisms, social interactions, and even aggressive behavior. It seems reasonable and appropriate to account for this by constructing more *naturalistic* research designs for investigation of human brain function and behavior (Benjafield, 2007, p. 32; Grafman, 2002, p. 293; Delgado, 2007, p. 64; Giesbrecht et al, 2006, p. 104). This will require integration among many fields of science (Roepstorff, 2004, p. 1115; Norris & Cacioppo, 2007, p. 85; Edelman, 1992, p. 252).

**Integration of Semantics and Grammar, Biases, and Cognition**

Naturalistic approaches seem especially suited to studies assessing complex influences such as the role of higher-order brain functioning on beliefs (O'Doherty et al, 2007, p. 46) and ultimately, on accurate cognition and behavior. Humans have a highly developed frontal lobe system that, along with semantics and grammar, allows for higher-level executive functioning (LeDoux, 2002, p. 197). Even though cognition relies on measured integration of lower-level limbic and automatic cognition (Tranel, 2002, p. 351), the higher-level executive function and higher-order working memory are in a position to have the *last word*. Higher level and higher order as used here refer to executive functioning (DLPFC) with capacity for flexibility, explicit *objective* evaluations and abstractions, as well as considered thought and decision making. We can describe many higher cognitive processes as symbolic processes, including memory, attention, imagery, ideation, concept formation, generalization, abstraction, problem solving, thinking, reasoning, and planning (Logothetis, 2004, p. 849). Lower level and lower order as used here denote more rigid, automatic, stimulus-driven, or subjective emotional limbic appraisals and *subjective* implicit automatic cognition (Benjafield, 2007, p. 44-5, 51, 264-7, 307-9; Frith, et al., 2004, p. 265). This nomenclature allows for parsing of higher level and lower level brain function relative to grammar and cognitive accuracy (see Table 1). In human primates, language supports the option of making decisions based on reason rather than emotions. The last—and possibly the most influential—step in cognitive processing uses information abstracted from our personal history (Stuss et al, 2001, p. 102). This information embodies the relative values of our personal cultural belief system that ultimately biases our choices and their consequences.

From culture to culture, semantic structure, grammar, and the use of language vary. The potential for higher-order abstractions appears enhanced in sophisticated cultures, and this potential seems associated with more highly developed language and advanced education. The processing of complex information gives rise to abstractions mediated by language (Luria, 1981, pp. 26-30). Abstractions range along a cognitive gradient from subjective to objective, depending on the degree of rationality of the grammar and processing. Across cultures, semantic, grammatical, and linguistic structural gradients range from dichotomous to multivariate, concrete to abstract, simple to complex, and few words and concepts to many. Language that supports more complex and abstract thought, at least in theory, seems to impart a cognitive advantage to *Homo sapiens*, “the human that knows they know” (Risberg, 2006, p. 3). By supporting higher-level abstract abilities, language provides the tools with which to think about how we think. Increased use of these higher-level abstract expressions of “thinking about thinking” apparently evolved fairly recently, around the sixteenth century or after (Benjafield, 2007, p. 235). This in turn allows us to discover the more objective, abstract principles of science that can lead to a more accurate understanding of the natural environment, human thought, emotions, and behavior (LeDoux, 2002, p. 176). This scientific understanding then forms the basis for the generation of a cascade of more accurate information for logical problem solving and appropriate objective decision making. Science offers a system for locating knowledge along a subjective-objective spectrum of classification. This distinguishes the subjective knowledge of cultural beliefs, what we *assume* we know, from objective scientific knowledge, what we can *demonstrate* we know.

When it comes to understanding humans and the human brain, it also seems important to consider the significance that semantics, grammar, and the resulting *beliefs* and biases have for human evaluations and interactions (Jones, 1998, p.14-23). Brain research lags in consideration of the subjective cultural bias of semantics and language, and it rarely accounts for the relative semantic and grammatical accuracy of cultural belief systems and their relationship to thought, emotion, and behavior. Perhaps the relationship often goes unnoticed because we implicitly take our own belief systems so much for granted. The automatic semantics and grammar of our cultural belief systems lie at the center of our oldest and most strongly registered memory traces. They mostly operate implicitly—their day-to-day causal effects generally invisible to us—and we often take them at face value, without notice or challenge. Indeed, we simply and spontaneously tend to accept the grammar and beliefs of our culture as *factual*

Table 1. Inaccurate versus Accurate Bias

| Lower Level Inaccurate Irrational Bias | Higher Level Accurate Rational Bias |
|---|---|
| Faulty rigid assumptions; dogmatic beliefs, unsupported by facts, but stated as unquestionable “truths of the Universe” with questioning prohibited, “superstitious” ritualistic thought and behavior that promotes mind-brain dualism, subjective abstractions | Rational flexible assumptions stated as theories; hypotheses and conclusions supported by evidence, scientific testing, and mandatory questioning, “scientific” adaptable thought and behavior, mind = brain = mind/brain, objective abstractions |
| Rigid, maladaptive, with lower-level subjective | Flexible, adaptive, with higher-level objective |

| | |
|---|---|
| bias, vertical subordinate communication | bias, collateral communication |
| Absolute, static bias: certain, *"determinate,"* guaranteed | Variable, dynamic bias: uncertain, *"probability,"* not guaranteed |
| Cognition using dichotomous grammar limits freedom of executive function | Cognition using multivariate grammar expands freedom of executive function |
| Veridical bias: true and false, either-or, absolute, concrete, black and white; constrictive and restrictive, *not contextual* | Associative bias: abstract, gray, gradated; expansive and extensive, *contextual* |
| Predetermined certainty, all knowing, resulting in decreased frontal lobe requirements: *"afrontal"* | Relative uncertainty, inquisitive, resulting in increased frontal lobe requirements: *"frontal"* |
| Parental, demanding; adversarial | Adult, requesting; cooperative |
| Semantic inaccuracy: vague, poorly defined, with overgeneralizations: always, never, every, all, none, etc. | Semantic accuracy: specific, best definition and word use: frequently, infrequently, many, some, few, etc. |
| Rigid, implies no other choices: I should, I must, I have to, I need to, and I have got to. *"I am obligated"* | Flexible, implies choices; preferential: I prefer, I would rather, I would like to, I choose to. *"It is a choice"* |
| Tends to ignore inaccuracies of information, of thought process, and of event-level orientation; retroactive, "reactive" | Tends to promote accuracies of information, of thought process, and of event-level orientation; forward-thinking, proactive, "considerate" |
| Inaccuracies and faulty assumptions promote faulty and inaccurate cause-and-effect conclusions | Accuracies and rational assumptions promote more plausible and more accurate cause-and-effect conclusions |
| General unawareness of irrational cognitive process "Cultural belief system anosognosia" | General awareness of rational cognitive process and "Cultural belief system awareness" |

(Benjafield, 2007, p. 400). Unexamined inaccurate cultural beliefs, however, directly contribute to the mechanical use of inaccurate information along with rigid, dichotomous inaccurate cognition (Hooker & Knight, 2006, p. 317).

**Evolution of Grammar**

Human grammar contains many hidden, habitual attributes that directly affect our cognition, but we use them on a daily basis without inspection or consideration of reliability or accuracy. These hidden features include primitive, unscientific, subjective, and over-generalized object classifications, categorizations, groupings, and labeling. A relative comparison of language "grammar" equivalents between mammals, other primates, and human primates shows many similarities in basic object-action cognitive processing, demonstrating the high level of evolutionary conservation in mammalian brains. Brain areas for object-action cognition tend to function similarly in mammals and other primates, providing representations of stimulus pattern characteristics including object identification, object spatial location, and limbic mediated object risk-reward contingency value including evaluating intention of animate objects. However, human primates possess large visual and auditory association areas that represent recent evolutionary development for specialized vision and language processing networks. Theories of innate universal grammar postulated in linguistics may have derived from observed pattern recognition functions in the object-action-intention predisposition in mammals, primates, and human primates to the relative evolutionary conservation of brain function (Hauser, Chomsky & Fitch, 2002). However, a usage-based approach used here seems to offer a simpler model with more ecological validity for cross-cultural grammatical appraisals (Tomasello, 2004, pp. 642-5; Luria, 1981, p. 6), especially relative to evaluating the functional differences between multivariate and dichotomous grammar.

Language incorporates the skills of speech and grammar to provide a basic substrate for higher-level object and action description and identification, cognitive and emotional processing, and communication. Grammar also incorporates other sensory components, adding further descriptive value to stimulus object-action perception. Other primates have rudimentary language components but lack the sophistication of human syntax and grammar leaving their communication literal and mostly inflexible by comparison (Mesulam, 2002, p. 19). Mammals including other primates rely on sensory information to regulate environmental homeostasis, while limbic components provide valuable subjective risk reward contingency, information for actions. Homeostasis relies on feedback to maximize adaptation over time. This feedback may largely depend on semantics and grammar in humans. We have the benefit of words and grammar to assist in evaluating object salience and intention, contingency value, as well as action choice and planning. Contingency implies prediction. Prediction of causality requires awareness of the contingency between the intention and the action and between the action and its consequences (Portas et al., 2004, p.288). The accuracy of this awareness would seem pertinent for obtaining the most objective evaluations. Rigid limbic-driven imperatives dominate most other animals (Mesulam, 2002, p. 19). It seems that in humans, even though we have the added flexibility of our more sophisticated brain, we often simply augment or replace the limbic imperatives with rigid subjective semantic imperatives, especially regarding our subjective inferences and perception of the intentions of others. Humans have the option of lower level subjective limbic evaluations and higher-level objective evaluations not afforded to other mammals.

Vision and visual processing occupies a large part of the human brain. The addition of grammar creates value by providing a mechanism for parsing the categorization of environmental stimuli into discrete categories of objects, groups of objects, intentions, and actions (Nowak, 2006, p. 251-2. Vision plus grammar maximizes environmental object detection, subsequent labeling, and identification. Auditory detection and processing provides value, especially regarding the listening component of communication. The addition of grammar to motor function, the evolution of speech, and later writing, provided important components of communication. Symbol use and speech probably evolved around 50,000 to 100,000 years ago, while writing most likely evolved within the past 4,000 years (Striedter, 2005, p. 312-13). It seems to follow that early in language evolution, oral communication provided the major component of cultural transmission of information. Since this predates writing, story telling by narratives, influenced by implicit and explicit recollections and emotions, most likely provided the medium for informing each new cultural generation (Siegel, 1999, p. 333). In many cases, cultural belief systems, anecdotes, magical interpretations, myths, and story telling continue to trump scientific facts and statistical probability. This might also explain the prevalent human propensity to rely on primitive dichotomous grammar constructs and imprecise pattern recognition principles supported by superstitions, primitive rituals, over-generalizations, faulty subjective information, and faulty cause-effect conclusions (Vygotsky & Luria, 1993, pp. 138-9).

Cognition, an important piece of the human brain function puzzle, in large part relies on grammar. Evolutionary theory suggests that we benefit most as a species by achieving and maintaining consistent homeostasis with our dynamic environment. Furthermore, we can assume that we achieve the most effective object categorization and recognition, which guides our subsequent actions, by integrating and processing information pertinent to our event-level relationship with our environment. From this, we can conjecture that human long-term overall survival and success might depend on our ability to obtain the most accurate identification of objects and stimuli and the most accurate internal information about object relationships, and to process this information with the most accurate processing rules we can develop. To the extent that we can do this, we learn to make the most accurate assessments and devise the most reasonable methods for integrating variables involved in problem solving, for developing reasonable strategies, and for choosing the best actions to achieve a desired goal.

### Evolution of Subjective Cultural Classifications

We might assume that language and grammar have evolved over evolutionary history as an adaptation for maximizing homeostasis of *Homo sapiens* with its environment, which includes other *Homo sapiens*. The phylogeny and ontogeny of words and grammars across cultures and history appear to offer some clues to the evolution of this adaptation. Words as linguistic symbols adapted by humans have evolved along side the social culture, as the defining language of the culture and the concomitant cultural belief system. The conventional usage learned by children includes the words and formulation forebears found useful in the past. Grammars evolve over many generations as our ancestors developed words, meanings, and grammar structure in response to changing environmental factors over time. This evolution developed from concrete utterances and symbols operating through cultural historical processes, rather than biological ones. Grammars passed along to subsequent generations, succeed as a product of familiarity, exposure, and the potential practical value they afford each new generation (Tomasello, 2005, p.13).

We might expect that the higher-level skills of more accurately identifying, manipulating, and interfacing with objects and other *Homo sapiens* in our environment would provide humans with survival benefit. Language offers a socialization advantage unique to humans, enhancing our ability to communicate, share information, plan actions, and understand the intentions of others (Risberg, 2006, p. 10). Nearly all language provides nouns for referentially labeling objects, and verbs for predicatively labeling actions or behaviors. It seems to follow that the more accurately we describe objects and predict their likely actions, the greater our ability for conceptualization of abstract representations. This improves our decision–making abilities, which in turn confers a greater adaptive advantage. Complex languages that enable much more objective higher-level abstract formulations would seem to offer an even greater adaptive value. However, as grammars become more complex and abstract, they can become less precise, with a potential for increased variance and errors. The importance of error monitoring, detection, and correction then increases. This suggests that assessments of abstractions based on accuracy might offer more precision and fewer errors, i.e., more objective, scientific abstractions versus more subjective abstractions.

Language evolved from primitive nonliterate cultures dominated by uninformed abstractions and subjective ways of knowing, and language still appears to convey some of that imprecision in cultures that continue to cling to subjective beliefs as facts. Science represents the other end of the knowledge spectrum, as demonstrated by the acceleration of more objective knowledge, i.e. scientific facts and technological advancements. The continuing dynamic seems to highlight the opportunity for rational intervention and the establishment of a more accurate reference point for measuring the objective descriptive precision of grammar, semantics, and abstract conceptualizations. Many of the abstractions humans use on a day-to-day basis fall into the category of *subjective abstractions* with inherent inaccuracies and irrational biases. *Objective abstractions*, on the other hand, use scientific principles and critical thinking skills to maximize accuracy, resulting in a more rational bias. This distinction, between cultural subjective categories and processing versus scientific objective categories and processing, offers a potentially beneficial reference point for human evaluations.

**Ontogeny and Phylogeny of Grammar**

How could humans evolve such a powerful dynamic evaluative capability as the human modern brain and continue to operate largely on primitive subjective evaluations? Infants begin their interactions with the world with generalized expressions, gestures, and utterances including cries, grunts, and coos. These and the concomitant facial expressions represent the primary form of communication with caregivers. Over time, infants begin to add single words and abbreviated short word phrases, as they master the naming of objects and actions, leading eventually to predication.

Verb development usually follows noun development. Labeling objects with names appears to help the child master the environment, and children seem biased toward using any new word as an object name (Bloom, 2002, pp. 92-9). After the child learns to use verbs and later to construct whole phrases, this functional vocabulary provides the foundation for the exponential growth for grammar development. Even in nonliterate cultures, the selection of objects to label reflects the linguistic ideology of the culture. Children apparently learn most of their early vocabulary simply by listening to the conversations around them. This applies particularly to preliterate children and to older children and adults in nonliterate societies (Bloom, 2002, pp. 118-9, 192). Much of this early vocabulary represents the building blocks of the background cultural knowledge and categories that structure and determine word meanings for abstractions related to space, time, causality, objects, intention, and possession (Tomasello, 2006, p. 54). This cultural knowledge also appears to bias the cultural frame of reference used in various other representations (Bloom, 2002, p. 247).

Children deduce early in language development that when adults refer to objects, they do so in terms of whole objects (Bloom, 2002, p. 92), i.e. they tend to over-generalize. A major part of human linguistic competence involves mastering by rote many routine formulas, fixed and semi-fixed expressions, idioms, and frozen collocations that objectively have somewhat unpredictable or inconsistent meanings (Tomasello, 2006, pp. 101-2). In many languages, including English, these expressions represent templates that, when used in conjunction with a coupler, can generate an almost infinite number of culturally *subjective* abstractions. A common grammar component across many languages is the copula, or coupler. In English, the verb “to be” represents the primary copula, and its use appears early in development (Tomasello, 2006, p. 255). Unfortunately, despite its ubiquity, “to be” is generally insensitive to pattern specificity, time specificity, and context specificity, which makes it very useful for subjectively over-generalizing labels but at the cost of reduced precision and distorted perceptions.

The utility value of the predicate form of “to be” encourages subjective generalization of behaviors (actions) to objects. This allows indiscriminant objectification of dynamic processes by semantically converting any subjective condition into a seemingly objective noun (i.e., we can say, “He *is* a *failure*,” instead of saying, “He *failed* at this particular effort” or “She *is bad*,” rather than “She acted *badly* last night”). The verb “to be” represents great utility as a very handy general label-making tool. In light of this generalization utility, “to be” might represent the basis for primitive verb evolution. Cultural labels often represent subjective, discriminatory, rigidly held prejudices, biases, and habitually defended beliefs, supported in lieu of objective scientifically derived classifications or alternatives. Objectification, or subjective labeling of humans or groups of humans as objects, presents a biased, usually derogatory “image” of those humans. Human adults and infants reflect this bias (Bloom, 2002, pp. 93-4). Other evidence suggests that the mere presence of labels may encourage people to exaggerate differences between groups (Bloom, 2002, p. 254).

Cultural belief systems also rely on prescriptive, imperative, rigid, authoritarian, and sometimes intimidating auxiliary verbs, or “helping” verbs (should, must, have to, need to, ought to, got to, etc.) that do not convey contextual specificity. Descriptive verbs describe the reality of the world, while prescriptive verbs describe how the world *should be*, usually based on unspoken assumptions. Unfortunately, prescriptive verbs usually express a subordinate frame of reference bias held by the *should-er*, but not necessarily known or accepted by the *should-ee*. “Need” is often overused subjectively. Humans need food, water, shelter, and air to survive. We may want or desire other things but they hardly meet objective criteria as needs. Many of these prescriptive and imperative verbs represent arbitrary cultural artifacts that deftly sustain the cultural belief system and exclude rational choice or consideration of reasonable choice-outcome paradigms. Each decision has many choices and variable consequences. Prescriptive and imperative statements demand a predetermined *choice*, with insensitivity to awareness or consideration of the *context* or the nature of the decisions and the probable outcomes involved (Capaldi, 1987, p. 17). Prescriptivism supports dominance grammar and consequently supports and sustains cultural belief systems.

Factitive and causative verbs combine a direct object and a phrase to apply a certain characteristic or a change in status to an objective complement. One such verb, "to make," works hand in hand with prescriptive statements. "You *make* me sad, you *made* your father angry, you *made* me act that way." These subjective verbs enable an individual or group to transfer to others the responsibility for their own thoughts, emotions, behaviors and choice-consequence outcomes. Factitive and causative verbs probably made sense historically in the primitive evolution of grammar, language, culture, and learning. Perhaps due to their social utility, they survive even in well-educated cultures by providing a vehicle for maintaining cultural belief systems and superstitions, transferring responsibility, and blaming of others.

Humans also often apply faulty knowledge and confuse coincidence or correlation with cause and effect (Skinner, 1953, p.84-5). We learn these habits as children, by listening to the conversations of adults. Unfortunately, "children aren't like scientist who have theories; they are like scientist before they have theories, trying to make sense of some domain they know little about" (Bloom, 2002, pp. 168-9). Children physically grow into adult humans but generally retain their subjective cultural belief system biases. Science requires inferences based on scientific inquiry with objective observation, and correlations with statistical probability. "Science attempts to find out how things really are, not just how they appear to be." (Bloom, 2002, p. 169) Subjective cultural belief systems often result in this true or false, dichotomous grammatical underpinning to human cognition.

Dichotomous grammar, consisting of veridical, either-or, black or white structures, continues this pattern of culturally learned conventions. Culturally derived dichotomous cognition automatically preempts objective, multivariate cognitive strategies for evaluation, even in adult humans. The verb *to be*, imperative prescriptivism, and either-or cognition represent complementary candidates for the primary source of primitive dichotomous grammar evolution. Even though these habits become automatic and implicit in a sense, they can become apparent with ongoing effort and inspection. However, we have little chance of noticing them, finding them, or correcting them if we do not even think to look in the first place (Jones, 1998, p.33).

## Evolution and Dominance Hierarchies

An evolutionary model seems to offer some plausible explanations for the relationships between culture and language. If we start with the assumptions that dominance hierarchies have historically supported the evolution of adaptability in human social systems, and that survival depends on group functioning, then it seems to follow that hierarchies controlled through reinforcement and punishment by dominant individuals or groups of individuals have historically conferred an adaptation for survival and reproduction. This applies to many other species as well as to humans. Indeed, in modern human interactions and language, we may still observe the slow evolution of these fundamental dominance features. If language and grammar have evolutionary characteristics, we might benefit from considering how these adaptations evolved.

A language, in some ways, resembles a species, as it defines social groups. Within most species of languages, there is variety, and most large groups exhibit significant differences in dialects and colloquialisms. Greater descriptive variety and complexity in language and grammar can enhance higher-level abstractions and flexibility; in contrast, constricted or subjective dichotomous homogeneity shifts the speaker towards concreteness and rigidity. If descriptive complexity enhances the potential of language features, including higher-level abstraction, and offers an adaptive value, we would expect to see languages with these features proliferating over time and becoming more dominant; indeed, this seems to be the case. Descriptive variety appears to endow language with this adaptive evolutionary trait of diversity, in much the same way that variety and diversity supports the natural selection processes described by Darwin in *The Origin of the Species*.

This spectrum of linguistic and grammatical variety, ranging from concreteness to abstraction, represents various gradients used for cognition: from static thinking to plastic, rigidity to flexibility, dichotomous to multivariate, resistance to diversity and change to enhancement of diversity and change. We observe a similar evolution in organisms from single-cell simple systems to multi-celled complex systems, with each level of complexity usually enabling enhanced flexibility and adaptive value. Cultures tend to parallel this progression from simple to complex, brought about and supported in large part by complex language and grammar. If we apply evolution theory to grammar and social development, we may assume that the *beliefs* that helped our ancestors and parents reach the age of reproduction and produce offspring may, in a sense, pass on to their children as a inherited adaptive value, however rigid or inaccurate. When contemplating how languages and cultural belief systems could possibly demonstrate such rigid resilience over time, it helps to remember the span of human evolution represents a very brief time evolutionarily. In our earliest stages as humans, we most likely benefited from a strong sense of confidence in the historical success and survival of the group. In this brief window of social evolution, in some ways we see relatively small transmutations from rigidity to flexibility, while our brains have progressed biologically to the point where they can support abundant flexibility. The firmly ingrained language of social rules and beliefs, supported by rigid grammar structure, seems to impose impediments to change.

Indeed, dominance hierarchies in humans—characteristic of our genetic inheritance and conditioned by our environment—have a large influence on this stodgy rigidity. Our brains contain hard-wired circuits for aggression, territoriality and competition for resources, dominance status, parental-familial-affiliation, defensiveness, and irritability (Wingfield et al, 2006, p. 180). These circuits represent a significant inertia and resistance to the evolution of more objective and rational language use that can replace our typical irrational, dominance-related expressions of aggression. From individuals to whole cultures, we see dominance and rigidity perpetuated by the grammatical language habits acquired in early development. Our learning mechanisms (including *modeling*, instrumental learning, and associative conditioning) largely depend on implicitly embedded language and grammar, which makes it difficult for us to discover and overcome the inertia of our belief systems. This learning, supported by semantics, forms the basic template of *what we believe* and *how we think* for most of our lives. Our language and grammatical processes provide the vehicle for culture, social structure, and adaptation that, theoretically and potentially, enable us to operate on a gradient from a subjective irrational bias to a more objective rational bias. Culturally, we tend toward the former, while cognitive accuracy offers a way to move closer to the latter.

**Cultural Social Inheritance**

Through the mechanisms of genetics and learned belief systems, our thought and behavioral patterns reflect our personal, social, and cultural histories. Genetically, we inherit a basic blueprint for how our brains operate. Culturally, we acquire a blueprint for what we think, how we think, and for expected behaviors. Inevitably, as humans we inherit cultural beliefs representing a long line of learned and rigidly held subjective inaccuracies that bias our perception. Becoming aware of the potential inaccuracy of what we know, *or think we know*, allows us to make corrections and to think more critically. We measure cognitive accuracy by the relative distance or gradient between the unexamined, inconsistent, and irrational yardsticks we have inherited and the validated, external, more reliable, rational reference points we have identified through science. The shorter this distance, the more objectively, rationally, and accurately we think.

Most people contend they think accurately, rationally, and logically. However, they generally base their contentions on their own usually unexamined, inaccurate, and irrational frame of reference. For the most part, our individually inherited grammar and cultural belief systems subjectively bias our thoughts and perceptions, even of ourselves. This bias becomes apparent when compared with a rational reference point or standard (see Table 1). Awareness of this irrational bias opens the door to the adoption of standards with more objective accuracy and reliability, resulting in the potential for a more objective rational bias.

## HUMAN BRAIN MODEL

Neuroscientists sometimes describe normal human brain functioning in terms of a computer model (Avrutin, 2006, p. 49; Benjafield, 2007, p. 14-18; Braver & Ruge, 2006, p. 338-9; Neisser, 1967; Panksepp, 1998, p. 20; Shiffrin & Atkinson, 1969; Toates, 2007, p. 17; Baum, 2004, p. 7). Our brain (*hardware*) comes initially from our inherited genetic blueprint; environmental learning makes the major contribution to our stored memory information (data), and grammatical process information (*software*) (Schmalhofer & Perfetti, 2007, pp. 180-81). The brain stores memories as information in various storage areas, similar to a computer's hard drive. A portion of this storage contains grammatical templates for *processing* information—the rules of how we think, similar to computer software that determines how information is processed (Fuster, 2003, p. 55). Like computers, humans may acquire or develop faulty or pathological hardware, software, or data. Both computers and humans get the most accurate results with the most appropriate hardware, most up-to-date adaptive software, and as accurate and timely data as possible. This enables the most reliable choice-outcome conclusions at a desired point in time. Neither computers nor humans can produce satisfactory results with inaccurate, out-of-date data or faulty, inflexible software.

We tend to build error detection into our computers, and to upgrade and install new versions of software as new information and technologies become available — it seems logical to look for ways to do the same with our own human brain computers. If instead we approach the brain as a black box with only input and output, we would most certainly have very much interest in the unknown processing going on inside the black box. Fortunately, we do have a growing knowledge of this processing in the human brain. The quality and precision of the output seems to correlate with the quality of our information and quality of its processing. With direct evidence of the adverse affects of irrational grammar usage on cognition, emotions, and behavior, we can abandon the ancient perception of the brain as a mysterious black box, and scientifically apply what we have learned about it to improve the way we make use of it.

**Frontal Lobe Integration: Executive Functioning and Working Memory**

The higher-level executive working memory (Baddeley, 2002, p. 246) of the brain's frontal lobes (specifically, the integrated functioning of the dorsolateral prefrontal cortex (DLPFC), along with frontopolar cortex (FPC), Broca's area, temporal, temporoparietal and association areas, etc.) compares to a computer's random access memory (Mesulam, 2002, p. 26). The information the brain uses to make decisions with compares to the data stored in the computer. The DLPFC and FPC appear to play an important role in the integration of internal and external appraisals to adapt to changing conditions (Gazzaley & D'Esposito, 2007, p. 188; Risberg, 2006, p. 6; Wagner et al. 2004, p. 714) and with explicit empathy with others (Decety, 2007, p. 258-60; Ferstl, 2007, pp. 87-90). This dynamic integration of information enables critical error monitoring, error detection, and error correction. The left DLPFC plays a large role regulating language function and sequencing while the right DLPFC has more involvement with the processing of interpretations, inferences, and concepts, awareness of novelty, situational and emotional appraisals, as well as autobiographical memory (Schmalhofer & Perfetti, 2007, p. 184; Long et al, 2007, p.330; Tapiero & Fillon, 2007, p. 365; Siegel, 1999, p. 331). The OFC assists with a parallel role in mediation of emotion and object-affect associations (Mega et al, 2001, p. 23).

The anterior cingulate cortex (ACC) appears to play a pivotal role in motivation-related error detection (Niv, 2007, p. 369), novelty/complexity detection and performance monitoring (Braver & Ruge, 2006, p. 322-24) by interfacing with the DLPFC and limbic, temporal lobe, parahippocampal gyrus, and automatic subcortical association pathways (Kaufer, 2007, p. 49-52). When automatic pathways offer incongruent motivational resolutions to homeostasis, the

DLPFC generates congruency. Over time, “congruence strategy” efficiency will benefit from up-to-date information, continual monitoring and improvement of error detection strategies and increased error resolution precision. Error correction may be enhanced deliberately and rationally, by updating the accuracy of perception i.e. information, process, and event-level accuracy, or reflexively and irrationally, by explaining away discrepancies and preserving subjective beliefs and perceptions despite their inherent inaccuracies. Without frequent evaluation of the relationship between our behavior and the environment relative to reality, we can easily fall prey to stimulus bound reactive behaviors (Luria, 1966/1980). As a part of the broader network involved in adaptive decision-making (Lee & Seo, 2007, p. 108), the DLPFC can conduct more objective, considered, and deliberate routine monitoring (Goldman-Rakic, 1995) of appropriate cognition, emotion, and behavior (Braver & Ruge, 2006, p. 321), perhaps enhanced by operating with a perspective biased toward accuracy and objectivity. This objective accuracy bias potentially offers improved error detection and correction with enhanced risk prediction (Preuschoff & Bossaerts, 2007, pp. 142-45).

Even though the orbitofrontal cortex (OFC), limbic system, hippocampus, striatum, etc., play a critical and often parallel role in working memory and decisions (Wagner et al, 2004, p. 709), “there is a hierarchy” (D’Esposito & Postle, 2002, p. 177; Curtis & D’Esposito, 2006, p. 295, fig. 9.8). “Executive functioning requires the integration of prefrontal and subcortical activity”, (Mega & Cummings, 2005, p. 18). Semantics, grammar, and language seem to contribute, directly or indirectly, to accurate cognition at each level. A series of parallel networks, including the subcortical cognitive pathways, provide information for executive decisions and explicit and implicit automatic cognition, allowing for adaptive interactions with environment (Chow & Cummings, 2007; Salloway & Blitz, 2002; Lichter & Cummings, 2001, Middleton & Strick, 2001). This hierarchy allows for top-down use and regulation of subcortical systems to enhance monitoring, and correction of contingent input-output incongruence (Stuss, et al, 2001, p. 101). An anatomical and functional viewpoint of these networks seems to offer some relevance for understanding this hierarchy.

The frontal lobes comprise two basic anatomical and functional systems (Pandya & Barnes 1987), the dorsal system consisting of dorsolateral and medial portions of the frontal lobes, and a ventral system consisting of the orbital portions of the frontal lobes. The dorsal system has interconnections with the posterior parietal lobes and cingulate gyrus, and deals with sequential processing of sensory, spatial, and motivational appraisals of external environmental objects and stimuli (the *where* of the event). The ventral system has interconnections with limbic networks involved in regulation of internal homeostasis and emotional conjectures about perceived external objects (the *what* and *why*, or intention), as well as appraisals of stimuli salience, valence, and motivational relevance (Ogar & Gorno-Tempini, 2007, p. 59). The two basic divisions along with their two primary subdivisions are:

1) DLPFC, providing executive functions of deliberate, explicit executive cognition/explicit working memory involved in processing higher-level cognition. The superior medial prefrontal cortex (a.k.a. ACC) functions as an automatic explicit/implicit integrative center for cognitive-behavioral (attention-motivation and possibly error monitoring) and emotional-autonomic-motor neural networks (Chow & Cummings, 2007, p. 25; Kaufer, 2007, p. 49).

2) OFC, providing limbic regulation and ACC interaction involved in emotional integration of automatic, explicit?/implicit, emotional working memory (medial OFC), including ventral striatal, medial temporal lobe (MTL), amygdala, hippocampus, and hypothalamus. In addition, the lateral OFC is involved in social working memory processing for emotional components of social motivation and cognition (Chow & Cummings, 2007, p. 30-1; Salloway & Blitz, 2002, p.10; Mesulam, 1985).

Each of these systems may contain subsystems along with accessory parallel frontal-subcortical circuits (FSC), consisting of cortico-striato-pallido-thalamic-cortical loops. There have been at least five to seven proposed general loops including skeletomotor, oculomotor, dorsolateral prefrontal, anterior cingulate, lateral orbitofrontal, medial orbitofrontal, and possibly inferotemporal/posterior parietal (Alexander et al., 1986; Middleton & Strick, 2001). Each of these loops appears to be comprised of multiple parallel segregated circuits. These pathways offer multiple levels of parallel processing of information for cognition, emotions, and behavior, including extrapyramidal, motor, and speech systems probably including rule-based cognitive processing (Poldrack & Willingham, 2006, p. 130-1). The basal ganglia have direct input from the large association cortex in the parietal, temporal, medial, and frontal areas, as well as the hippocampal formation and the amygdala. There is also large outflow directed towards the frontal cortex via synaptic links in the thalamus, outflow to temporal and parietal lobes linked to executive functioning (Graybiel & Saka, 2004, p. 495-7) and open pathways to inferotemporal and posterior parietal areas.

In addition, other pathways provide integrated reflexive, or innate, lower-level automatic, stimulus-response pathways, responding to potentially threatening stimuli, i.e. loud noise, fast movement, gestures, as well as to threatening facial expressions and involvement in reflexive empathy. The frontal lobes evolved to manage the pyramidal pathway and to implement cognitive decisions in adaptation to a dynamic environment by incorporating a wealth of sensory input, using higher cognitive function to prioritize that input, and choosing the most effective response, by ongoing evaluation of shifting priorities, initiating action, and monitoring its execution (Chow & Cummings, 2007, p. 38).

The separate but parallel dorsal and ventral anatomical systems appear to represent two functionally distinct hierarchal networks relative to objective higher level DLPFC and subjective lower level OFC cognition respectively. "'Executive cognitive functions' are defined as (and the term is limited to) high-level cognitive functions, believed to be mediated primarily by the LPFC (lateral prefrontal cortex), that are involved in the control and direction (e.g., planning, monitoring, energizing, switching, inhibiting) of lower level, more automatic functions" (Stuss, 2007, p. 293). Executive functions include the ability to solve a complex problem and organize a volitional behavioral response in a temporally informed manner. They also encompass the learning of new information, the systematic searching of memory, activation of remote memories, appropriate prioritization of external stimuli, attention, generation of motor programs, metacognition, and probably the use of verbal skills to guide behavior (Chow & Cummings, 2007, p. 29; Cummings & Miller, 2007, p. 15). Language, semantics, and grammar usage associated with these distributed neural networks may explain the integration of orbitofrontal/emotional and dorsolateral/cognitive processes and resolve the long-standing difficulties in the reconciliation of internal integration and processing of cognition and emotions, especially for higher order processes such as decision making and social perception (Gazzaley & D'Esposito, 2007, p. 190-1).

The DLPFC modulates cognition and human environmental interaction from the top down via integration of externally driven information with internally represented information. The relative effectiveness of cognition seems to depend on the quality of external information received or perceived, and on the perceptual quality of information stored in long-term memory, including "beliefs" related directly to information, information processing, emotions, responsibility, and intentional perceptions of others (Gazzaley & D'Esposito, 2007, p. 192-7). Language may directly mediate the quality of cognitive integration as measured by objective accuracy. Executive functioning depends on the integrity of instrumental functions such as language (Cummings & Miller, 2007, p. 16). Semantics and grammar appear to act as the common denominator between higher-level executive functional networks and lower-level limbic system functional networks, supporting appraisals for the identification and perception of object/stimulus salience, emotional valence, actions, and reactions.

Human evolution seems to have "thoughtfully" overlaid semantic representations onto our cognition. Words and concepts bind to sensory information, creating a kind of a sixth sense—specifically, a semantic sense (LeDoux, 2002, p. 203). This allows language and grammar to provide a substrate for human cognition using words to assign values to stimuli, emotions, behaviors, perceptions, belief systems, etc. Culture provides the foundation for the development of values by grounding specific cultural beliefs in grammatical semantic usage, coupling words and beliefs with historically learned reward contingencies during development. Words have become a sense for detecting and coding predictive relationships among stimuli, objects, responses, and rewards. As such, words assign the relative emotional and motivational significance for the value of rewards and the anticipation of rewards (Phelps & LaBar, 2006, p. 432). These evaluations are automatically mediated by the OFC (Petrides & Pandya, 2002, p.45-46) and depending on task demands, will often default to lower level automatic grammar habits managed by the striatal complex (Poldrack & Willingham, 2006, p. 134-40). Cultural beliefs thus underpin the fabric of human social interaction, by relying on learned, automatic implicit grammars that allow speech to flow effortlessly. Mostly learned by implicit inductive inference in childhood (Nowak, 2006, p. 263), habitual grammar forms a silent, "ritualized" soundtrack for our adult cognition.

Words and grammar give us a unique descriptive ability to encode environmental cues with the potential to maximize efficient usage of neocortical associations. Depending on task demands and stimuli, association mechanisms generally run implicitly and almost continuously in the background, evaluating object features and place associations, risk-reward associations, and past related choice-outcome associations. As complexity, novelty and unfamiliarity increase (Anderson et al, 2002, p. 505), and when higher-level abstract demands increase, the brain typically achieves more preferred outcomes by using the executive functions of the DLPFC and FPC (Curtis & D'Esposito, 2006, p. 293-95; Braver & Ruge, 2006, p. 330). However, in routine situations, lower level limbic and habitual cognition often suffices.

The lower level OFC provides limbic regulation and valuable utility calculations (Glimcher et al, 2005) while monitoring somatosensory information, emotional valence, relative risk-reward contingencies, and social salience. It also contributes to inhibition of inappropriate responses (Rolls, 2002, p. 370). Except for the sophisticated language system, the human OFC somewhat resembles that of other primates. However, in humans, the OFC also automatically provides ongoing bottom-up regulation of the limbic system using the default semantics, language, and grammar from our cultural belief system, thus reinforcing the subjective social, neuroeconomic, and relative psychological values that define our cultural bias (Kahneman et al, 1982; Padoa-Schioppa & Assad, 2006). When subjective cultural belief system grammars are edited to operate more accurately (i.e. yielding a more scientific belief system), the bias shifts towards the more objective end of the value probability continuum, operating closer to the rational-cognitive end of the evaluation scale rather than the emotional-motivational end (Schultz & Tremblay, 2006, p. 195).

**Information Content and Information Processing**

The top-down executive functioning of the DLPFC likewise relies heavily on semantics, language, and grammar to perform critical integration of choice-outcome determinations and inhibition of inappropriate responses. The lateral prefrontal cortex enables greater complex abilities and flexibility in human and primate behavior (Striedter, 2005, p. 309). The newer higher level DLPFC adds the potential for more accurate rational thought onto the older lower level limbic brain by enabling humans to reason (Panksepp, 1998, p. 20). Efficient prefrontal cognition relies on the quality of information received from other cerebral regions (Anderson et al, 2002, p. 506). While rigid cognitive inaccuracies can impede the discovery and executive execution of the most logical and reasonable decisions, shifting toward an accurate and rational adaptive bias enhances objective cognition, enabling more reasonable choices and outcomes, emotions and behaviors. In terms of the somewhat simplistic computer analogy, the DLPFC executive function, probably aided by information integration involving the FPC, has the capacity for objective appraisal, reappraisal and flexible editing, while the OFC is limited to subjective emotional-based read-write operations, or subjective contingency appraisal and reappraisal. Evidence indicates that task relevant semantic knowledge develops in a relatively automatic (bottom-up) fashion or in a more controlled (top-down) manner (Wagner, et al., 2004, p. 715) probably flexibly regulated by the DLPFC. The DLPFC sits at the top of the PFC as the captain of the ship, demonstrating a higher level of competency when provided with the resources of the most accurate and the most up-to-date information.

Even though the limbic working memory can adjust responses, it does so primarily based on reward contingencies, reinforcement, and emotional valence spectra (Frith, et al, 2004, p. 265). The OFC adds some subjective flexibility, but our ability to objectively change and integrate the accuracy of *what we know* and *how we think* relative to the environment depends most heavily on the reappraisal and edit functions of the executive DLPFC working memory. The DLPFC compares internal stored memories and habits with external, objective, up-to-date information, with the rational capacity to temper our cognition, emotional responses, and automatic behavioral and grammatical responses to stimuli (Mesulam, 2000, p. 93). The DLPFC has the potential to edit our culturally inherited grammar and provide improved cognitive accuracy for error detection and correction. In addition, the FPC (BA 10) appears to have strong connections with temporal areas that support auditory working memory (Barbas, 2006, p.51; Davachi, et al., 2004, p. 670). It appears that, by holding information online during secondary task manipulation in working memory, the FPC supports DLPFC edit functions (Petrides, 2005).

The DLPFC appears to have the ability to directly select or reject individual strategies and may possibly edit grammar through direct mechanisms. However, the edit function most likely relies on explicit DLPFC-initiated reentrant "working memory" rehearsal loops for corrections (Curtis & D'Esposito, 2006, p. 283). These loops develop by practice according to Hebbian rules (Hebb, 1949), and the information at some point becomes routine and then automatically provided "preferentially" by cortical association areas (Braver & Ruge, 2006, p. 328). Corrections might also occur over time due to environmental contingencies, modeling, and instrumental and conditioned learning. Cognitive therapies take advantage of this edit function by using explicit rehearsal to teach patients more advanced, and more accurate, cognitive strategies. This provides increased cognitive accuracy for making more rational decisions and adaptations in a variety of situations. The overall efficacy of this approach probably accounts for the increasing success and acceptance of rational emotive and cognitive behavioral therapies (Ellis & Harper, 1997, pp. vii-xiv; Beck, 1976, p. 4; Wright, 2004, pp. xv-xx). The corrective effect of the edit function on cognitive accuracy greatly enhances the probability that the higher-level objective executive functioning of the DLPFC will have the most rational last word in decision-making (D'Esposito & Postle, 2002, p. 177).

The frontal lobes use stored processing rules for executive functioning, evaluating and prioritizing the available information to determine the best choices for reaching our goals. Declarative memory (i.e. information about how the world works, both *subjectively* and *objectively*) generally appears to be processed for storage by limbic system components, including the hippocampus (Duvernoy, 2005, p. 28), which has significant connectivity with the amygdala (Mesulam, 2000, pp. 2, 58-63). The hippocampus assists in encoding memories with place preference and the amygdala with the assignment of emotional valence (LeDoux, 1996). This information includes semantic and grammatical memory, episodic memory, verbal memory, and biographical memory, along with the rigid rules of our cultural belief systems. Retrieved memories tend to return with the emotions, or limbic valences, that accompanied their initial storage (Phelps & LaBar, 2006, p. 430), albeit modified to some extent by our present emotional state and by time-related decay. This allows past learning to condition present experience and explains to some extent how our cultural belief systems rule us so tenaciously and with such strong emotions. Fortunately, we can ameliorate these subjective emotional reactions by evaluating and editing inaccurate grammar and cultural beliefs, including our faulty assumptions about the cause-effect relationship between thoughts and feelings (Ochsner, 2007, p. 107; 2005, p. 253).

## Cognitive Processing

Words and grammar enable us to describe environmental cues, making maximum use of neocortical associations. The level of complexity relates to increased working memory demands. The ability of the frontal lobes to use working memory optimally depends heavily on the availability and quality of the objective process information received from other cerebral regions (Anderson et al, 2002, p. 505) as well as accurate environmental perception. The frontal lobes function best with accurate and timely up-to-date information combined with accurate thought processes i.e., accurate data and the most appropriate, flexible software (i.e. how we think). Thinking uses process information for the assessment and integration of our internal learned information with external environmental information in order to regulate our interaction with the environment and maintain a probabilistic model of anticipated events (Raichle, 2006, p. 13). The software enables the frontal lobes to process executive decisions and to help regulate our emotions appropriately and provide overall homeostasis (Malloy & Richardson, 2001, p. 128).

Grammatical process memory (i.e., acquired and developed rules of thinking) directly biases not only how we process internally stored information but also how we perceive environmental information, cues and stimuli (Decety, 2007, p. 284). Learned, rigid, *dichotomous* process rules preempt flexible thought processes and distort the accuracy of object identification and evaluation. As we might expect, *rigid*, inaccurate, irrational process information leads to inaccurate, irrational information processing, and this in turn yields inaccurately biased executive decisions. Faulty, inaccurate, rigid, dichotomous software bias tends to yield subjectively biased, inaccurate choices and outcomes, which thwart the *flexibility* offered by higher-order, multivariate executive functioning—

completing the cycle by reinforcing rigid cultural subjectivity. "No complex system can succeed without an effective executive mechanism, 'frontal lobes.' But the frontal lobes operate best as part of a highly distributed, interactive structure with much autonomy and many degrees of freedom" (Goldberg, 2002, p. 230).

## HUMAN BRAIN AND COGNITIVE DEVELOPMENT

Where do inaccurate, irrational thought processes come from? How could we have learned our culturally inherited, faulty, inaccurate, irrational thinking without realizing it? As humans evolved higher-level brain structures, they underwent biological changes that freed them from the constraints of simplistic, concrete language processes and offered the potential for complex, abstract, associative reasoning, made possible by the dramatic evolution of the neocortex and frontal lobes. The capacity for improved frontal lobe reasoning evolved in humans alongside our development of semantics, grammar, and language skills. This same evolution from concrete thinking to the potential for abstraction occurs in an individual's frontal lobe development and connectivity as they grow from childhood to adulthood. Concrete thought processes evolve into more flexible, associative, abstract cognitive capabilities. During these developmental stages—towards puberty and into young adulthood—the frontal lobes continue to mature, with increased connectivity and myelination, especially in the DLPFC (Dennis, 2006, p. 135). This development—along with language, learning, and education—increases the potential maturity of our decision-making skills (i.e. executive functioning) and heightens our ability for cognitive awareness. The frontal lobes play a critical role in this process (Stuss et al, 2001, p. 108).

An episodic increase in cortical pruning takes place in young adolescents around 11 to 14 years of age. This pruning appears to select out the least used or weakest neural connections to make room for the more focused information processing required for improved complex problem solving, social and sexual maturation. According to Hebbian principles (Hebb, 1949), the most used or strongest connections are preserved. Unfortunately, the strongest and most used connections in young humans tend represent the belief systems and associated rigid dichotomous grammatical processing information of their childhood culture, which may become even more firmly embedded in the memory storage of the young brain during this period. The timing of these changes may possibly serve to enhance the resiliency and persistence of these ingrained belief systems.

## Cultural Inheritance

As we grow into adulthood, neural efficiency and connectivity to the frontal lobes increases, along with the increasing use of acquired information and grammatical processing rules to make executive decisions. We tend to use our acquired information as if it were factual (Jones, 1998, p. 46), automatically following rigid, dichotomous processing rules that operate outside our awareness. We erroneously tend to identify the first thoughts that come to mind as "facts" and then execute heuristic (arbitrary rules of thumb) justifications and prefabrications to explain away errors based on these "facts." We implicitly assume good-bad relationships between words and reward contingencies learned during our personal developmental history. This may possibly contribute to locking in our cultural belief systems at the expense of more effective, higher-level executive functioning. We seem to favor irrational automatic rules over the acquisition and application of more accurate and up-to-date information. Our decision-making process tends toward a subjective, bottom-up frame of reference with our own personal cultural bias, driven by information filtered through our subjective personal historical matrix, and distorted by the inevitable, implicit, grammatical inaccuracies embedded there.

Our cultural bias not only reflects the ineffective cognitive habits and grammatical inaccuracies of our ancestors, it also represents the rigid, culturally biased misperceptions we inadvertently inherit from generations of unscientific, misinformed, and most often poorly educated elders. Our underlying beliefs derive in large part from their ritualized concrete thinking, faulty assumptions, coincidences imagined as cause and effect , superstitions, myths, magical thinking, etc. (Benjafield, 2007, pp. 321, 333-4). Because children have little experience with which to evaluate different concepts, they uncritically absorb whatever they encounter without regard for its rational usefulness or accuracy. They implicitly and unconditionally absorb rules and information expressed as *truths* without the full benefit of mature executive functions. They tend not to question the factual basis of information, the logic of assumptions, or the reasonableness of conclusions, nor do they have the acquired grammatical framework to do so (LeDoux, 2002, p. 96). This results in a subjective discriminatory bias. In a sense, children are "imprinted," (Lorenz, K. 1965) blind to other possibilities (Benjafield, 2007, p. 267; Shilpa et al, 2007, p. 53).

## Information and Process Bias

Concrete learning from early developmental stages tends to accumulate in memory-storage areas, along with the misinformation absorbed from cultural belief systems. The stored information usually reflects the dichotomous hierarchal processes of the parent-to-child interactions under which they formed. If their cultural belief systems remain unchallenged, adults usually exhibit parent-to-child *authoritarian* grammar characteristics in their thinking and interactions, with irrational, prescriptive and imperative demands such as *should*, *must*, *have to*, *need to*, etc. These parental, subjective, dichotomous demands typically “trump” multivariate choices and impede adults from taking responsibility for objective choice-consequence decisions. Even though the parent-to-child interaction style appears to have evolved to beneficially manage and control the child’s behavior until the frontal lobes develop, it unfortunately results in implicitly carrying irrational, dichotomous, authoritarian, parental thought and speech habits into adulthood.

**Uncertainty and Deviation from the Mean**

This irrational thinking usually passes down through many generations and carries into adulthood in part because of our tendency to gravitate toward the familiar (Benjafield, 2007, p. 386) and away from the unfamiliar. Humans have a tendency to experience rewards, or gratification, for sticking with the familiar, and punishment, or anxiety, for venturing into the unfamiliar. From an evolutionary view, this makes a lot of sense, because the unfamiliar may represent a potential danger, while the familiar has at least theoretically been evaluated and found to be safe (Keller & Chasiotis, 2006, p. 277). Familiar events or those with outcomes we deem certain deviate very little from the mean, and as such, generally receive a positive valence with a higher *probability* of favorable outcome.

*Uncertain events* can deviate significantly from the mean and usually receive a negative valence and a lower favorable probability value. This tends to give certainty the upper hand over the perceived ambiguity and unfavorable probability of uncertainty. This creates a problem for humans determined to cling to illusions of certainty in an uncertain world. However, irrational thinking and heuristics, commonplace rules absorbed from the dominant culture, magically repair these deviations from reality. We use heuristics that rely on faulty grammar and faulty logic to whitewash our errors and inaccuracies and to temper the inherent increase in error variance. This allows humans to alter their perception of reality to explain away any variance by clinging to the irrational *certainty* of their faulty beliefs. Unfortunately, the erroneous irrational *perception* that variance has decreased cannot mitigate the *actual* increase in real error variance and outcome imprecision.

In a sense, the familiar represents comfort, and we human creatures favor our comfortable habits. Humans so favor the familiar that they will often tolerate a great deal of discomfort to hang on to it, sometimes enduring even catastrophe before they will consider the alternative of change, or deviation from the mean. Unfortunately, humans usually tend to err on the side of favoring the familiar and generally receive no logical framework or training to help us develop objective, reasonable, innovative methods for seeking rational alternatives. Indeed, many cultures actually punish attempts to promote cognitive accuracy, some very severely, because it challenges authority and cultural beliefs. This usually prejudices us toward choosing information based on habit, familiarity, and subordination rather than rational utility or applicability, regardless of what might represent our best interest from a more objective perspective.

**Authoritarian Communication**

Due to the parent-child environment in which they learned these concepts, most adults implicitly continue to use the familiar parental cognitive process in their adult interactions. This hierarchy of communication is authoritarian, vertical, and one-way (parent-to-child) rather than cooperative, horizontal, collaborative, and reciprocal (adult-to-adult, human-to-human). The familiar irrational habits from our past usually preempt more reasonable adult-to-adult communication and block accurate associative reasoning processes, resulting in irrational thought, decision-making, and behavior. Parent-to-child-oriented irrational thought processes generally inhibit reasonable adult-to-adult communication, and this inhibition applies internally when we evaluate our own thoughts and emotions, as well as externally when we relate to others.

The strong tendency of humans to affiliate with groups and gravitate towards the familiar appears to impede adaptive change in humans and cultures, pulling the entire group backward toward more primitive, inaccurate, concrete ways of thinking, decision making, and behaving (Goetz & Shackelford, 2007, p. 13). The cultural inaccuracies we learn often contain an accumulation of past superstitious beliefs that dictate our behavior and soothe the angst of our limbic system (i.e. our emotions). Most cultural information results from implicit grammar and accumulates without the benefit of a scientific framework. Because we grow up under its influence, we generally fail to acquire the critical skills or awareness to assess the validity of our knowledge. Our innate affiliative behavior and inherited rigid thinking, coupled with inaccurate information, unfounded assumptions and lack of awareness, hinders our progress towards maximizing accurate rational thought and behavior, and more harmonious relationships.

**Event-level Accuracy**

Furthermore, it sets us up to "automatically" use outdated, ritualistic, familiar information and processes for solving a problem at a given moment, excluding new information and shifting us toward the past. Of course, old knowledge often has benefits—but if, by using it, we exclude new and possibly pertinent objective information, our familiar solutions may fail to adequately resolve problems we face in the present or future. We operate in the *now* as if it were identical to the *past*, creating a cognitive time warp. This rigid event-level distortion contributes to our irrational bias, magnified by our rigid, irrational, grammatical software.

Conversely, by selecting the most pertinent, accurate, and current information available and then processing it with flexible, accurate software, we shift our event-level orientation to the present, facilitating the most accurate, best-choice best-outcome decisions. More specifically, we then may use our frontal lobe executive function and working memory to make the most accurate rational choices by flexibly using all available pertinent objective information. In this way, we execute decisions in the present and develop plans for the future with a higher degree of precision and rational probability. This seems preferable to making irrational choices using irrelevant imprecise subjective information from the past, and then using the frontal lobes to retroactively justify and rationalize the decision. Accurate integration of time and space remains critical for problem solving and finding the best solution at any given time (Fuster, 2003, p. 62, 109).

**Accurate Evaluations: Information and Processing**

We would generally expect to achieve the best outcomes if the frontal lobes use all of the available timely and pertinent information to make decisions, not merely relying on what we learned in the past. This applies especially when we use higher-order executive cognition (Diamond, 2002, p. 494-95; Braver & Ruge, 2006, p. 307) to evaluate and integrate the emotional components of lower-order limbic cognition to differentiate between choices that feel good but may not serve our best interest, and choices that feel bad but may serve our best interest. Without accurate information about the situation at hand, we might decide on a course of action simply because it feels good or promises familiar rewards, or because it steers us clear of unknown or imagined threats. Furthermore, thinking accurately and rationally seems more likely to yield the best results when dealing with strong emotions, such as when interacting in bonded intimate relationships and affiliations, participating in territoriality and competition for resources, or when memories come with a particular emotion from the past that may represent an irrelevant concern of the present (Heilman, 1997, p. 135). Conversely, research shows that hormones (CRF) generated under stress tend to attenuate higher-order prefrontal cortex functioning, possibly shifting our thought processes towards lower level limbic and automatic implicit cognition. Therefore, we would probably benefit from applying the knowledge that rational higher-order cognitive functioning can preempt or minimize emotional stress and make a significant difference in outcomes. Cognitive therapies focus on rationally remodeling the grammar of belief systems, including percepts, concepts, and processing, to enhance objective awareness, teach stress management and coping skills, help to prevent or relieve depression and anxiety, and improve relationships (Beck, 1976, p. 328).

### Benefits of Critical Thinking to Cognitive Accuracy

Critical thinking skills offer potential benefit for overcoming the disadvantages of normative uncritical thinking. Critical thinking encourages the adoption of more objective and scientific guiding principles useful for scrutiny of semantics, grammar, language, culture, assumptions, cause-effect conclusions, and conflict resolution. Critical thinking actually insists on questioning the totality of the argument, including the coherence of the argument process itself by emphasizing accurate, reliable and transparent evidence from a credible source, awareness of motivations and biases, clarity of observation and expression, and reliability of premises and assumptions, inferences, and conclusions. With critical thinking tools, we can evaluate the tactics used for irrational arguments by looking out for false beliefs, distractions, insults, catastrophe, perfect solutions, equivocation, appeal to popularity, authority, or emotions, distortions, false dilemmas, wishful-thinking, explaining by naming, hasty or glittering generalities, irrelevant topics, begging the question, etc.,(Kida, 2006; McInerny, 2005; Jones, 1998; Fisher, 2001; Aubyn, 1957).

### Cultural Belief System and Constraints on Accurate Thinking

Current theory of normal human brain functioning indicates that we have the capacity to choose how and what we think, and we have a capacity to adapt to new situations by making better choices (Diamond, 2002, p. 494). By choosing objective information that is more accurate, and flexibly processing it, we increase our chances for determining the most accurate, reasonable, and timely solutions. In other words, we have the potential to bias our choices and outcomes flexibly, in a more accurate, objective way, incorporating semantic and information accuracy, accurate information processing, accurate time-appropriate and context appropriate information. Given this, why would we not choose an accurate rational bias with the highest degree of flexibility? Unfortunately, the subjective characteristics of our implicit grammar, along with personal, social, and cultural biases, impede us from understanding and using the very information that could enable such a choice (Beck, 1979, p. 13). Dichotomous grammar rigidly provides a potential fail-safe mechanism for perpetuating irrational implicitly learned cultural belief systems.

Because of these inherited belief systems, many humans tend to think they *must* be perfect, unblemished and without flaws, that they *must not* be flawed and fallible. A blemish or a mistake means they *are* no good, unworthy, or deserving of punishment. This absolute rating and labeling blocks recognition of personal fallibility, causes poor acceptance of others as fallible human beings, and promotes unscientific, culturally biased, arbitrary category classifications. This leads to rigid, judgmental, and dogmatic cultural belief systems, bigotry, stereotyping, and blind trust, especially blind trust in perceived authority. It also promotes vertical hierarchies with authoritarian, parent-to-child, one-way communication.

We often state our opinions as rigid, true-or-false, absolute statements about the universe, branding them as factual and either right or wrong. We use culturally determined, rigid, dichotomous, authoritarian, imperative, either-or terms, such as *should*, *must*, *have to*, and *need to*, implying that we have no other choices or that we *are obligated* to a certain choice. This cultural binding of *shoulds* tends to reinforce simplistic true-false perceptions, rigidity, and predetermination. Rigid, inaccurate, faulty beliefs and assumptions about the cause-effect relationship between thoughts, emotions, and behaviors inaccurately absolve us of responsibility for our own individual evaluations and decisions. Inaccurate definitions and rigid word use, combined with faulty cultural classifications, assumptions, generalities and absolutes, impede reasonable thought processes, hinder personal responsibility, and undermine accurate communication.

Grammatically constraining choices by defining them with rigid words and absolute concepts limits our cognitive options, especially in a *dynamic* world with many variables in a state of frequent change. We commit both a mathematical and a practical error when we arbitrarily restrict the use of multiple, possibly pertinent, variables and rigidly subscribe to culturally determined, dichotomous, *true or* *false* values when calculating choices and their outcomes (Langer, 2000; Langer & Piper, 1987; McInerny, 2005, p. 94-5). Even though our final choice may be binary, starting with the assumption of only prescriptive, non-contextual, binary choices imposes needlessly strict constraints. Rigidly held, inaccurate cultural belief systems decrease flexibility in our thinking, and limit our ability to develop harmonious relationships both as an individual and with others. These inaccuracies also perpetuate mind-brain dualism, a worldview that artificially separates the *mind* from the *brain* and fosters dichotomous, either-or thinking. Mind-brain dualism dates back to Plato and Descartes, and persists in many subsequent theories and beliefs (Morris & Dolan, 2004, p. 365). A recent study shows this fundamentally inaccurate worldview continues to thrive in the general population, ironically even among psychiatrists, psychologists, and mental health professionals (Miresco & Kirmayer, 2006).

Dichotomous bias, and the accompanying cognitive rigidity it fosters, exhibits many of the same features as dysexecutive functioning — inability to notice, integrate, or appropriately edit internal-external discrepancies in error detection and error correction (Braver & Ruge, 2006, p. 321). Rigid bias creates and perpetuates “reflexive” responses, similar to innate instinctive behaviors, with inflexible stimulus-response paradigms impervious to modification by context or experience (Mesulam, 2002 pp. 14-15, 22-26). Frontal lobe injury often interferes with divergent thinking, perhaps similar to the results one might expect with rigid cognition. Dysexecutive disorders fundamentally limit insight and bias cognition toward the use of primitive dichotomous grammar, inflexible behavior, limited learning from experience, perseveration, and concreteness (Milner & Petrides, 1984), appearing similar to primitive, poorly educated, fundamental cultures and belief systems. Evaluation of diagnostic categories might also benefit from a consideration of objective cognitive accuracy, given the apparent prevalence of dysexecutive features associated with many diagnostic categories. Disorders attributed to personality characteristics frequently present with dysexecutive components and such patients often have a history of developmental adversity and possibly other discrete frontal lobe dysfunction as well.

In addition, substance abuse, anxiety, adjustment disorders, marital discord, obesity and eating disorders may demonstrate unacknowledged frontal lobe dysfunction, possibly due to subjective classifications and biased, subjective, culture-bound heuristic evaluations and treatments (i.e., “we have always done it this way.”) For example, consider a culturally biased definition of delusions as “false beliefs based on incorrect inference about external reality and firmly sustained in spite of the *opinion of others* or contrary evidence” (DSM). Evaluating one person’s sanity by comparing it to the average opinions of others hardly sounds objective. How would one separate a delusion from prevalent subjective cultural beliefs or widespread superstitions using this definition? A dictionary definition seems a bit more clear, “a false belief or opinion resistant to reason or confrontation with actual fact” (Random House, 1997); however, this still leaves no easy way to distinguish delusions from opinions that differ from a culturally subjective, but factually invalid, consensus opinion. It seems that what many people call *facts*, i.e., beliefs and subjective knowledge, actually serve as subjective grammatical reference points that vary from culture to culture without regard for objective accuracy. How do we distinguish the “cultural facts”, i.e., the imagined certainties of static subjective beliefs, from observed, uncertain, probabilistic, dynamic, scientific facts?

**Reference Points for Cognitive Accuracy and Rational Bias**

Life unfolds as a series of choices and outcomes. We would like to predict the outcome of a particular choice with some degree of certainty, but doing so depends on understanding the many variables in our ever-changing, *dynamic* world. It seems important in this complicated dynamic environment, to accurately assess probable outcomes using flexible, multivariate thought processing and to adequately evaluate our many choices and desired consequences, increasing our contextual response to a given situation. This enhances our overall adaptability. “Choices can be rational or they can be the outcome of irrational processes” (Benjafield, 2007, p.4). A deliberate bias towards rationality tends to enhance our overall accuracy. A rational dynamic bias favors more effective decision-making and increases the probability of more reasonable outcomes. On the other hand, an irrational static bias tends to decrease overall accuracy, leading to irrational decision-making with fewer reasonable choices and fewer objective outcomes. The standards for measuring accurate and rational cognitive bias arise in part from the following assumptions:

- *Acceptance of human imperfection enhances information and process accuracy*. We can accurately characterize humans as flawed and fallible. Accepting our own flaws and fallibilities encourages us to accept others as human beings, albeit with flaws. This acceptance promotes horizontal, human-human, adult-adult collateral communication. It also reduces inaccurate, absolute, dichotomous, or culturally biased classifications, ratings, and labeling, because we do not believe that any person is *all* bad or *all* good. It seems much more reasonable to rate the behavior rather than the person. Rational human acceptance minimizes inaccurate judgmental categories and cultural bigotry while promoting realistic scientific belief systems and healthy skepticism.

- *Flexibility enhances information and process accuracy*. Flexibility generally works better than rigidity for the most accurate planning, problem solving, and compromising in a dynamic world. Rigid, dichotomous, culturally determined terms like *should*, *must*, *have to*, *got to*, and *need to*, restrict options and diversity, while multivariate, preferential terms, such as *I would prefer*, *I would rather*, and *to me*, *this seems best*, multiply the diversity of possible choices and acceptable rational outcomes. Opinions and preferences replace absolute declarations of right and wrong. Generalities stated as assumptions or deductions represent a higher level of accuracy than generalities misrepresented as true or false *facts* when they actually represent subjective *beliefs*. Such generalizations amplify inaccuracies. Moreover, we improve the precision of our thought processes, decisions, and communications by using the most accurate word definitions, making specific rather than vague statements, using multivariate spectra or gradients for evaluations and revaluations, and avoiding faulty cause-effect conclusions (Browne & Keeley, 2007, p. 147).

- *Awareness of the relationship between thoughts and emotions enhances information, process, and event-level accuracy*. Normally, cognition has a significant causal relationship with our feelings, and realizing this enhances accurate assessment of individual responsibility for thoughts, feelings, and behaviors. Our thoughts, or the rules behind our thoughts, cause or significantly influence our feelings whether we recognize the connection or not. Awareness of this relationship enables us to choose the healthiest and most rational thoughts in order to maximize our emotional and behavioral balance at a given time. Although we might initially react to the situation itself, we largely generate and sustain our emotional reactions to events by what we think or "believe" about them (Ochsner, 2006, p. 245-50). We tend to sustain the emotion long afterwards through the action of implicit internal rules and appraisal habits that affect us almost continuously, generally without our awareness or deliberate direction. As Epictetus wrote in the *Enchiridion* in the first century, "People are disturbed not by things, but by the views which they take of them" (Ellis & Harper, 1997, p. 39).

**Cognitive Awareness**

Becoming aware of our internal narratives, rules and beliefs about the world and events gives us some understanding of the effect we have on our own individual state and, with that understanding, the ability to objectively moderate our reactions. When something unexpected happens, we often tell ourselves inaccurate, irrational, and overly negative things about the situation, needlessly upsetting and stressing ourselves about it. If instead we insightfully choose to describe the situation as accurately as possible, we can respond with the most appropriate behavior and most reasonable emotion. “Why *must* you upset your self?” (Albert Ellis, attributed). We do not *have to* upset ourselves needlessly or act irresponsibly on irrational thoughts. We improve our individual accountability when we take responsibility for our thoughts and how those thoughts affect our feelings and behaviors. We each have responsibility for managing our own cognitive accuracy, including our individual responsibility for our thoughts, emotions, and behaviors. This enhances reasonable behavior and harmony between humans (Gemba, 2002, p. 146).

> Emotional disturbance, in sum, usually stems from your Irrational Beliefs. You can uncover the basic unrealistic ideas with which you disturb yourself; see clearly how misleading these ideas are; and, on the basis of better information and clearer thinking, *change* the Beliefs behind your disturbance (Ellis & Harper, 1997, p. 69).

An orientation towards cognitive accuracy encourages active, objective thinking in the present with proactive, forward-looking, active, event-level evaluations; adaptability; continuous quality improvement; and positive reinforcement and recognition of the importance of rational thought processes. The complexity of life magnifies the importance of thinking accurately. Acceptance of human imperfection, bias towards flexibility, and individual responsibility enhance the accuracy and quality of our cognition and increase the probability of achieving the most reasonable (i.e. *best*) outcomes. This improved quality of accurate thought promotes more harmonious interactions within and between individuals. It also promotes awareness of the benefits of thinking and acting rationally, completing the circle:

> It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change (Commonly attributed to Charles Darwin, biologist).

## Correcting Irrational Biases

However, how can we learn these new skills if, throughout our development, we see few examples of critical thinking and adults fail to teach us to think more logically? How do we improve our cognitive accuracy when we receive little or no foundation for rational or logical information templates in our memory storage areas to build on? Finally, how can we use our acquired, almost "fail safe," irrational, rigid, dichotomous thought processes to learn how to think rationally and make choices that are more rational?

Fortunately, we have the capacity to replace inaccurate, irrational thinking habits with newer, more accurate, rational associative thought processes. It takes effort and practice to learn and use new concepts and retool our brain library and dictionary (Lieberman, 2006, p. 201) with new information and software. The greater the effort (i.e. the more often and harder we practice), the sooner we can replace our habitual, inaccurate, irrational thinking with the new objective skill of accurate rational thinking. This objective shift in the way we think uses higher-level, multivariate, associative reasoning instead of rigid, black-and-white, either-or cognition to evaluate choices and outcomes. Rational associative reasoning tends to maximize accurate executive cognition and decision-making. This increased accuracy contributes directly to thinking more rationally with more reasonable outcomes, because our higher-level executive functioning has the utility of the "last word."

## Implications of Irrational Bias

> "Our present problems cannot be solved at the level of thinking at which they were created" (Albert Einstein, attributed).

When applied to decision-making, rigid, irrational biases tend to employ a floating reference point; in contrast, biases that are more flexible and rational tend to operate from a stable reference point. How can we explain this seeming paradox? Understanding it depends on the perspective of the observer. An observer using the same irrational biases, grammar, terms, and definitions used to construct the irrational reference point will find this conundrum baffling. As previously stated, humans rigidly cling to their cultural belief systems, no matter how subjectively antiquated or irrelevant. These belief systems take hold during early learning, along with the related dominance characteristics of parent-child interactions and obedience to authority (Milgram, 2004, pp.114-5, 136-47). We learn, whether directly or indirectly, that *good* is rewarded and *bad* is punished, that *right* is rewarded and *wrong* is punished, and that parents know what is *right* and what is *wrong*. The problem arises when we apply these static dichotomous grammatical constructs to the complexity of the dynamic variables of the world we live in. Humans tend to perceive the rules for decision making in hierarchal, dichotomous and absolutistic terms: is, is not, black, white, should, must, have to, ought to, etc. *You must do that or you will be punished*. This creates a problem when the must of today becomes the must not of tomorrow because some variable or context has changed.

**Reference Point Drift**

This dichotomous grammar then leads to retrospective judging, faultfinding, blaming, and punishing. *You should not have done that*! This rationale might work if we had a means of predicting the future in our dynamic environment; given that we do not, we look for another mechanism to explain the unwelcome outcome. To resolve the apparent discrepancies with reality, we simply move our reference point: We redefine success or modify our recollection of errors to cast the current outcome in a better light (Schlacter, 2001, p. 151). By moving the reference point, we can always be right, always be above average, and never make a mistake. We simply move the reference point to under-value others or over-value ourselves, and this creates the irrational but comforting experience of "self-esteem." We perhaps learn this skill in childhood when governed by the multiple, subjective, and inconsistent reference points of parents, teachers, neighbors, friends, celebrities, etc.

We also learn to easily construct subjectively biased, over-generalized groups and classes and use them to denigrate and subjugate others at will. We can easily over-generalize or under-define representative classifications and prove most any point using imprecise labels. We can round up or down at will. We have our choice of measuring instruments and usually tend to choose the yardstick that casts us in the most favorable light, with little thought about accuracy. Since each individual chooses their own rules from their own frame of reference, we can use one rule to justify and a different rule to vilify any one experience to suit our own beliefs and goals (Kida, 2006, p. 78), thereby potentially artificially elevating self-esteem. This works well for confirmation bias (Kida, 2006, p. 160).

Social cognitive neuroscience has demonstrated that when humans see others as humans, they tend to moderate their prejudices (Mitchell et al, 2006) and that positive experiences with others can erase learned cultural stereotypes (Phelps & LaBar, 2006, p. 440). Milligan found that when volunteer experimenters, under commands of authority, viewed experimental subjects as “unworthy persons” rather than humans, their willingness to punish them increased (Milligan, 2004, p. 161). In another study, volunteer experimenters punished subjects less when the experimenter was in closer proximity to subjects (Milligan, 2004, pp. 37). This suggests that subjective human labeling contributes to prejudice and punishment by making others less than human. When we remove the subjective labels and see others objectively as humans, like us, we can acknowledge that we belong to the same class, *Homo sapiens*. We may not approve of certain behaviors in others but we have the option of labeling the behavior rather than the person.

Humans often blame others for their own thoughts, emotions, and behaviors. Since we fear being wrong, we simply decide that someone else *made* us think, feel, or behave a certain way. We shift the blame to a scapegoat. They are at fault. They are to blame. Simply by adjusting the reference point, we easily pass along the blame and judge ourselves not guilty. This approach may succeed in bolstering the “self-esteem” of the blamer, but usually at the expense of anger or guilt of the blamed, due to their resentment or internally demoted *self-esteem*. This can have disastrous effects on long-term relationships.

### Irrationality of Self-Esteem versus Rational Acceptance of Human Imperfection

Unfortunately, self-esteem represents an authoritative artifact of irrational cultural constructs that depend on dichotomous judgments of right and wrong, perfect and imperfect, and other culturally defined, rigid, subordinate subjective values (Milligan, 2004, p. 147). A stable reference point based on cognitive accuracy uses a consistent spectrum to gauge behavioral achievement, performance, and error, in effect giving us standards that provide a more rational reality for testing outcomes, while avoiding statements about individual worth. With a rational bias, we accept that a certain rate of failure is inevitable; this minimizes the motivation to “fix” our mistakes by justifying, rationalizing, or blaming others. This, in turn, helps us resist the temptation to float the mean or tweak the reference point to make our decisions appear more above average or always correct. We can freely admit our error and concentrate on improvement.

Acceptance of human imperfection tends to be a more objective and workable construct than self-esteem (Ellis, 2005) because it starts with reality, the rational assertion that human beings have flaws and make fallible decisions, and therefore err on occasion. If we embrace human fallibility and the uncertainty of our choices, we do not suffer an intolerable shock when we fail, and we do not find it necessary to change history or redefine our success and achievements to feel happy. However, even if we rationally accept the premise that we will rarely predict the future with 100% accuracy, we still face a potential challenge from the parts of our brain that store and apply our cultural beliefs and irrational biases. As the gatekeeper of the limbic system, in charge of safety, the amygdala appears to continue to preferentially reward the perceived certainty of familiar choices to such an extent that we still routinely choose against our own best interests. We even chisel our principles and beliefs in stone and refuse to admit to any degree of error. This mollifies the amygdala, when operating on irrational beliefs with black and white rigidity in a mostly gray world. Then, instead of rationally evaluating and predicting the future, we habitually use our exceptional frontal lobes to *rationalize the past*. We make up after-the-fact explanations and excuses to *justify* the errors of our behaviors, refute reality, or recast history according to our own wishes while magically preserving our self-esteem. Fortunately, the amygdala responds to cognitive control (Phelps, 2004, p. 1013). Cognitive and rational therapies temper the irrational anxiety of the amygdala by providing education in objectivity and competent rational strategies.

Our human tendency to rationalize and justify may come from our evolutionary roots. As our primitive semantics, grammar, and language arose from symbolic grunts, gestures, and facial expressions to form the earliest beginnings of more formal communication, we began to use words to label objects and actions (rock...not rock, bad...not bad). From this, dichotomous grammar evolved. This may have worked well in primitive cultures to improve group adaptation to the environment, using dominance, punishment, reward for accomplishments, and faulty interpretation of coincidences extrapolated to causation. The *veridical* nature of black and white, dichotomous grammar increases the probability of error in the mostly gray and ever-changing *dynamic* world we live in. Ironically, these increased errors of dichotomous cognition also increase deviation from the mean, along with increased variability in dichotomous rule adherence. These errors and deviations cause internal-external evaluation discordance. The easiest irrational corrective solution involves generating explanations for these dissonant discrepancies in the form of irrational beliefs, heuristics, and their accompanying biases.

In early primitive cultures that lacked scientific knowledge, language arose out of reasonable attempts to label objects and understand relationships between humans and the environment initially using nouns (objects) and verbs (action). Since nouns, verbs, and language predated writing, we might reasonably assume they sustained an early narrative historical record and that progress in objective knowledge made it increasingly more difficult to explain away uneducated, unscientific beliefs, faulty labeling, and transfer of fault and blame to others.

However, heuristics may have evolved as a form of mental shortcuts that were then extrapolated to justifications for irrational beliefs, thoughts, and behavior. Heuristics represent easily stated and applied “rules of thumb” that develop as a part of most cultural belief systems. While they generally purport to convey compact bits of wisdom, they more often embody cognitive and verbal tools for evading reality. They enable humans to correct errors by explaining them away, by generalizing, justifying, dignifying, signifying, rationalizing, blaming, bullying, revising, labeling, etc. We can then resort to the prefabrication of even more *preposterous* irrational rules somewhat akin to confabulation.

With irrational, dichotomous grammar, humans can create a scorecard, noting their own successes and ignoring their own errors, while tracking the errors of others and ignoring their successes. This allows us to maintain a perception of “self-esteem,” and remain above the mean, above average and perfect. Heuristics and irrational beliefs make it easier to evaluate internal-external errors and error corrections from our own frame of reference. Unfortunately, dichotomous grammar increases errors and decreases error detection, whether we can explain them away or not. Objective multivariate grammar generally makes more efficient use of the limited storage space afforded to humans (Nowak, 2006, pp. 249-86) than irrational grammar can. Rational multivariate grammar seems to offer increased accuracy without the convoluted perturbations usually required to correct for errors after the fact under subjective dichotomous grammar. It would seem plausible then that rational, multivariate grammar and acceptance of human imperfection offers a more efficient and a more reasonable construct than irrational grammar and self-esteem.

## DISCUSSION, CONCLUSIONS, AND CONSIDERATIONS

We have the resources to counter these mostly culturally determined irrational and inaccurate grammatical habits by diligent pursuit of accurate cognition, even in the face of doubt and uncertainty. We can retrain the brain to value rational, probabilistic outcomes, accept human imperfection in place of self-esteem, and use accurate information and processing to make decisions about current situations. Each of these practices can eventually enable us to use the processing capabilities of our new brain to direct the older, survival-oriented brain structures (MacLean, 1990; Milgram, 2004) toward more rational pursuits. We can then focus on achieving objective improvement and obtaining better outcomes for the future (Panksepp, 1998, p. 260). This suggests that establishing reference points for cognitive accuracy may provide a naturalistic rational framework for future research that will demonstrate an ecologically valid unifying theory for brain and behavior in *Homo sapiens*. Cognitive accuracy appears to represent an evolution-friendly *multivariate* grammar that might impart greater homeostatic benefits. Objective multivariate grammar meets requirements for simplicity (Occam's razor), and seems to offer a more efficient homeostatic mechanism, possibly minimizing the liabilities incurred by the inherent inaccuracies of subjective dichotomous grammar. Thus, cognitive accuracy may provide useful fundamental principles for establishing a scientific reference point for the evaluation of rational behaviors, choices, and consequences. A potential scientific method based on cognitive accuracy includes three fundamental principles:

- information accuracy: seeking and using objective information based on empirical observation; premise, deduction, conclusions, and testing

- thought process accuracy: making evaluations and decisions flexibly with critical thinking, multivariate terminology, and awareness of individual responsibility

- event-level accuracy: connecting and verifying both information and decisions in a time- and context-dependent manner to increase the relative probability of more accurate predictions of rational outcomes (Bailey, 2007, in press; Bailey, 2006)

Each component helps to ensure reliable cognitive functioning. Event-level accuracy is especially important for maximizing context specificity by accurately integrating cognition (information and information processing), and behavior at a given moment and place. This identifies, acknowledges, and "preserves an independent reality" (Minkowski, 1952, p. 76).

The next shift in human primate cognitive evolution could potentially consist of the implementation and integration of cognitive accuracy into all major areas of scientific study, thereby fostering individual and cultural acceptance and direct application. If so, then thinking more flexibly, accepting uncertainty, and living rationally in the present may become the norm instead of the exception. Increasing our degree of accurate, rational thinking would appear to enhance our prospects for living rationally in the present and planning for a more reasonable and likely future. As accurate, rational thoughts and behaviors increase, irrational thoughts and behaviors tend to decrease. Thinking reasonably and rationally relies on the accuracy of higher-order executive functioning, with the potential to transport humankind to a more human and humane future (Hendelman, 2006, p. 238).

Accurate, rational thinking increases flexibility and tends to maximize appropriate choices, enhancing achievement of preferred outcomes while minimizing undesirable irrational outcomes, without the liabilities of irrational cognition (Fine, 2006, p. 208). Fortunately, we have the ability to replace inaccurate, irrational, parental, absolute thinking by learning and practicing new habits of accurate, flexible, rational, and reasonable logical critical thinking, thus improving overall adaptability. We have these rational tools available, but they often go unrecognized, overlooked, or even belittled (Jones, 1998, pp. 6-7). Ideally, we will achieve this accurate, rational, cognitive evolutionary step before we trigger an irrationally induced catastrophe with our current habits of rigidity, disharmony, self-loathing, and aggression (Beck, 1999).

Science has understood the negative effects of subjective cultural beliefs on the evaluation of objective knowledge for some time. How we measure something in large part defines what we measure. “What you get from a measurement depends on what you choose to measure” (Lindley, 2007, p. 155). We tend to calibrate our personal yardsticks to the culture in which we find ourselves. Such a yardstick measures only what that culture values. Each culture’s yardstick shows normal, despite large differences between the beliefs and behaviors of various cultures. This potentially leaves us prey to the accumulated inaccuracies of our forebears.

Cognitive accuracy represents a reference point biased toward objective cognitive accuracy in order to measure human thought and behavior across cultures. This reference point does not change as you go from one culture to the next, theoretically transcending the inaccuracies of cultural belief systems. Cultures may change, but the yardstick remains the same, unless and until scientific advances using cognitive accuracy indicate beneficial objective adjustments. For accurate evaluations, we do best to calibrate our cognitive yardstick with the most accurate, timeliest information, applied consistently and rationally in the present.

This article has reviewed the intimate connection between semantics, grammar, cognition, and the functioning of various brain structures, and posited an equally intimate association between semantics, grammar, cognition, emotion, and behavior. These associations suggest an explanation for the persistence of subjective cultural belief systems and their inherent deficiencies in objectivity, accuracy, and flexibility. Can we accept the premise that objective, timely, accurate processing and accurate information usage might efficiently yield more satisfactory and reasonable results than rigid automatic responses based on inherited imprecise beliefs? If so, it would seem beneficial to society for science to orient new research to incorporate the psychological value of objective relative belief systems, using scientific insights from cognitive neuroscience, anthropology to zoology, ethology to neuropsychology, cognitive behavioral science to neuroeconomics, affective neuroscience, evolutionary dynamics etc., along with the tools of cognitive accuracy.

Cumulative prospect theories and neuroeconomics (Kahneman & Tversky, 1992; Glimcher et al, 2005) suggest that humans weigh the relative probabilities of achieving a particular outcome along an economic gradient of values that influence cognition, emotions, and behavior. Our tendency to seek reward and familiarity and generally avoid risk, uncertainty, and pain, combined with the inertia of our acquired cultural belief systems, biases our value analysis and skews choice-outcome decisions disproportionately in favor of the familiar or the presumed socially desirable outcome (Tom et al, 2007). Moreover, cultural beliefs are resistant to transformation once established (Panksepp, 1998, p. 245; Lane et al, 2000, p. 409), suggesting that whatever adult behavior (including cognition) we wish to promote in a society, we will do best to teach during childhood development and human maturation (Tse et al, 2007). For many generations, parents have raised children to hold the same rigid, unexamined beliefs they hold themselves. If we instead model humane treatment of others as humans, flexibly apply objective critical thinking, and demonstrate reasonable behavior for our children, we have some hope they will instead value cognitive accuracy as adults. Luria, many years ago, found evidence that early education can teach children the ability to use logical thought (Luria, 1981, p. 209). This suggests that exposure to and education in higher-level logical reasoning, throughout development, could enhance rational cognition and behavior.

Once a sufficient number of adults acquire the skills and habit of cognitive accuracy, their interactions with children would likely pass on fewer faulty beliefs and thought processes. Importantly, at an early age, children raised by these adults would have the opportunity to learn to develop and extend their cognitive accuracy. As adults, they would have more skills for applying cognitive accuracy to address and resolve problems with competent critical thinking, emotional balance, and reasonable behaviors. This would enable each successive generation to build on the successes of their parents, rationally living in the present (Korzybski, 1958, p. 231).

Science, by virtue of its central methodology (Browne & Keeley, 2007, p. 119), speaks for the value of accurate, rational, logical objective reasoning and critical thinking, and for advocating the teaching of objective rational cognition, which can potentially guide society towards increasingly humane thought and behavior. Future research on human behavior and neuroscience can contribute to this goal by taking into account the interdependence of biology and society. If we have the choice to conduct research that grounds our cultural belief systems in neuroscience, and it seems we do, while producing more reasonable and responsible adults who use cognitive accuracy and rational evaluations to make decisions, can we afford not to do so?

> In the final analysis, we have to depend on our rich resources of rationality to recognize and modify our irrationality…We can recognize that our own interests are best served by applying reason. In this way, we can help to provide a better life for ourselves, others, and the future children of the world, (Beck, 1999, p. 287).

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