Efficiency and Inefficiency Arguments in Evolutionary Neurobiology: *The Sensory Order,* Social Conformity, and Adaptation

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Abstract: A vast body of literature on evolutionary neurobiology typically argues that the brain evolves through adaptations which improve the organization of information-processing capacity, thus freeing available capacity for alternative uses. This strand of research often emphasizes social conformity and the benefits of an expectation of uniform behavior within the community group, e.g., enhanced group cohesion, facilitation of minimally counterintuitive narratives, and minimizing cognitive burdens. Contrasting arguments have also arisen in the same literature based on the greater information-processing burden, either imposed by interaction in larger social groups, or created by inefficiencies which arise as byproducts of path-dependent development. The cognitive burden imposed by simultaneous navigation of social and natural environments, sometimes with conflicting incentives, imposed short-run disadvantages but better enabled us to survive in the long run by supporting evolution of a more sophisticated and powerful brain. Distinguishing between short-run and long-run costs and benefits suggests a possible resolution of this apparent conflict. High social conformity saves energy, time, and uncertainty in the short run, facilitating more immediate responses and social consensus, and allowing efficient utilization of currently available information-processing capacity. When conflicts between behavior and reality have to be resolved in the longer run, the information processing burden imposed by abstract reasoning, and perhaps more importantly by discussion, argument, and debate within the social group, may well contribute to enlargement of the neocortex.

Keywords: sensory order, neocortex weight, minimally-counterintuitive narrative, self-organizing systems, spandrel.

1. INTRODUCTION

This paper examines the manner in which the emergence of cultural traditions and social norms among our distant ancestors contributed to enhancing their sociability and improved their reproductive and survival opportunities. In Hayek's (1952) construction of the sensory order, the mind constructs, evaluates, and maintains networks of interconnections which evolve over the individual's lifetime. Social interaction relies on common areas of belief and overlapping congruencies among potentially varying subjective beliefs held by individuals. Individuals measure their own belief systems against those of others, as well as against external reality.

Behavioral regularities arise to exploit the available structure of cortical connectivity, which evolves further in accordance with the extent we take advantage of the available level of organization and complexity. Subtle and apparently random local variations in brain structure occur naturally, facilitating particular behavioral rules and institutional arrangements. If a behavior turns out to be advantageous, then the structural adaptations it exploits are passed on throughout the species. For rules and other behavioral regularities to survive, they must first be experimentally adopted by entrepreneurial carriers, and then must enhance their survival and reproductive opportunities.

Hayek suggests the human mind evolved to construct tentative models of external reality. Continual revision of these provisional models constitutes the sensory order and provides a sophisticated, flexible, and yet effectively simple set of classifications for the otherwise unintelligible mass of experience and memory. In Hayek's view, the mind works by organizing sensory impressions into manageable summaries. It does this through categorizing new impressions according to classifications already in place, but also subject to partial reorganization to accommodate new experience. Thus, the sensory order is a naturally occurring, naturally evolved, spontaneous order, which emerged through natural selection to enhance the survival and reproductive opportunities of the organism.

Hayek's insight was that learning implies something beyond the passive recording of information received from the external reality. The brain organizes sensory impulses according to evolving abstract categories learned through experience, and continually reorganizes them. We are thus free to make mistakes, and our recollections can also be mistaken, however since we cannot avoid the consequences of errors, there is always an incentive to correct them. This contrasts sharply with behavioral psychology's atomistic-positivistic conception of the mind, which views memory as a passive tape recorder that unselectively perceives everything, though our access to these memories is flawed and limited, and even more sharply with the radical empirical behaviorism of B. F. Skinner (1953, 1968; Ferster & Skinner 1957), which subordinates the role of the organism to that of the environment (Skinner 1957).

Hayek (1952, pp. 70-73 [3.54-3.62]) describes the emergence of higher-order classificatory schemata or mappings as being limited by the possible permutations of the primary impulses, but efficiency imposes the much lower threshold of physical feasibility, where classification strategies emerge to address the individual's most immediate needs. Conformity, such as that imposed by social norming, lessens the need for higher-order schemata. Experience potentially forces continual revision of the complex of classificatory linkages. These complexes of hypothesized causal linkages constitute the sensory order, a working model of reality which supports our perception, conceptualization, and logical reasoning (Hayek 1952, p. 143).

The remainder of this paper is organized as follows: Section 2. "The Sensory Order," reviews Hayek's theory of the psychology of perception; Section 3. "Efficiency and Inefficiency Arguments in Sociobiological Adaptation," introduces the debate over whether efficiency necessarily confers evolutionary advantages; Section 4. "Efficiency Arguments," discusses why adaptations improving information processing efficiency are generally seen as conferring evolutionary advantage; Section 5. "Inefficiency Arguments," presents the more subtle dissenting view, that less efficient information processing may also be adaptive; Section 6. "Time Horizon and Efficiency Arguments," develops the view that both adaptations may work in parallel over different time scales; and finally, Section 7. "Conclusion," presents concluding comments.

2. THE SENSORY ORDER

Perhaps it is too bold a venture for the human mind to speculate about its own nature and origin.
—Ludwig von Mises (1957, p. 97).

In 1919-1920, Hayek produced an outline for a doctoral dissertation in psychology, "Contributions to a Theory of How Consciousness Develops," taking as his subject a speculative theory of perception (D'Amico & Boettke 2010). He set his outline aside for nearly thirty years when he decided to study economics. In returning to his original ideas in the late 1940s, he updated and expanded his theory with extensive references to contemporary and intervening developments in psychology. In *The Sensory Order*, Hayek synthesized those schools of contemporary psychological thought he felt could be applied most fruitfully to explaining human behavior, especially economizing behavior. Nevertheless, Hayek recognized the spontaneous character of markets and the price mechanism, not to mention market organization. The economic significance of the theory of knowledge can be appreciated by contrasting papers strewn at random around a room, a state of noise or chaos, and the same papers organized neatly in filing cabinets (or on computers) and retrievable through a particular, though non-unique, system of organization. Butos (2003) and McQuade and Butos (2005) see the sensory order as an archetypal model of such knowledge-generating orders, including the entrepreneurial activity of generating the market-based knowledge of prices. One key ingredient of knowledge-generating orders including the sensory order, is a necessary reduction in entropy or disorder.

Hayek appreciated the ambition of his research program, and perhaps influenced by the notable lack of critical approval during his lifetime, remained both modest about the extent of his accomplishment and cautious about extending his work on the sensory order. Hayek's subsequent work on spontaneous evolution of the liberal order (Hayek 1960, 1973, 1976, 1979) displays a notable thematic consistency with this seminal early work, in that both address spontaneous order. *The Sensory Order* presents an even more ambitious and original application of spontaneous order doctrine to the field of psychology. In some way this new application was intermediate between traditional applications of spontaneous order to legal, political, and economic theory (by, e.g., such figures of the Scottish enlightenment as David Hume, Adam Ferguson, and Adam Smith, and related thinkers Sir Matthew Hale and Bernard de Mandeville (Ratnapala 2001)), on the one hand, and to biological evolution on the other.

Hayek (1952, p. 77 [3.74]) followed the gestalt school of psychology in rejecting the atomistic conception of sensory qualities. According to gestalt psychology, the importance of sensory data lays less in those purely physical aspects which lend themselves to atomistic thinking, than to the way the organism uses, integrates, and acts on sensory data (Ehrenfels 1890; Wertheimer 1912). The gestalt school called this integrative facility "organization of the field" (Braly 1933; Leeper 1935; Duncker 1939). Hayek reinterpreted this rather vague concept in terms of subjective "causal connections between physiological impulses" (Hayek 1952, p. 77 [3.74]). The impulses might be atomistic in some sense, but our subjective and opportunistic organization of the impulses as a whole, interpreting them in terms of causal connections cannot be. More importantly, this organization must also be tentative—the sensory order is always subject to revision as we experience and integrate new data.

By the early twentieth century, the traditional introspective approach to psychology typified by William James (1890) and Wilhelm Wundt (1910) was being criticized as subjective and non-rigorous by such founders of behaviorism as John B. Watson (1913, 1919). Some behaviorists viewed the stimulus-response as an automatic causal relation (Watson & Rayner 1920; Pavlov 1927), while others emphasized its volitional character (Skinner 1938). Behaviorism imitated the empirical approach of the physical sciences to focus almost exclusively on atomistic-deterministic aspects of psychology which lent themselves to that approach. In contrast, gestalt psychology recognized that insight and intuition could enhance the efficacy and efficiency of the learning process far beyond mere trial-and-error. Tolman and Honzik (1930) were able to demonstrate that rats' ability to learn mazes was enhanced through recollection over time, and this enhanced learning could be demonstrated long after their most recent experience with a particular maze configuration. Their study contributed to the belief that recall enhances learning because it reinforces or corrects existing knowledge. It was suggested that the rats constructed an internal conceptual model of the maze, but would not necessarily demonstrate that knowledge objectively until reinforcement was offered. Tolman (1948) later demonstrated that humans construct comparable conceptual mappings, along with Adrian's (1947, pp. 16-18) use of conceptual mappings, results Hayek (1952, pp. 107-118 [517-549]) relied on to build his theory of revisable mappings onto reality. Hayek (1952, pp. 61-64 [3.25-3.34]) starts with the observation that within the brain, neurons serving adjacent sensory receptors are necessarily organized spatially in juxtaposition with the receptors they serve, and therefore with each other. Even viewing the central nervous system as an inactive physical object, Hayek observes its connections are organized for the efficient processing and coordination of information from the receptors, enabling us to form consistent perceptions of experience, coordinating the senses of taste, touch, smell, etc. This explains why we would be confused if we were shown one kind of food, but exposed to the odor or taste which experience has taught us to associate with another. Hayek considers further that an additional level of categorization is imposed by the gross physical need to process the different sensory qualities of sight, taste, hearing, smell, touch, and distinguish among them (Hayek 1952, p. 66 [3.43]). As infants we learn first to distinguish between light and dark, then to identify shapes and colors, then distinguish objects, and finally to understand and distinguish among an unlimited variety of abstract qualities which are properties of the objects we perceive, including size, proximity, temperature, vibration, texture, etc. Depth perception rests on such abstract qualities. Sufficient experience is required before we can imagine, for example, fictional objects which may or may not exist, but at this early stage, cognitive development limits our ability to coordinate sensory inputs and conceptualize actual objects.

The vast majority of sensory impulses are set aside and largely ignored, unless subsequent events focus our attention on particular qualities, or cognitive dissonance triggers recall of something which previously failed to capture our attention (Mayer 1992). Implicitly, the most important category we create is the default one of inessential impulses which fail to merit our attention. Impulses which do receive the attention of the brain's classificatory apparatus are first implicitly classified by timing of reception, the sense engaged (e.g., sight or touch, etc.), and location (fingertip v. toe, near v. far, etc.) Because of the structural organization of the central nervous system, this initial classification is a spatial one, where impulses related through qualities, senses, proximity, etc., are organized spatially through temporary storage on neurons near those receiving the initial inputs, i.e., neurons immediately juxtaposed within the brain to those connected to the sensory receptors. However, this is only the beginning of the classification process. At each stage, the majority of information is judged useless and is discarded, serving to further focus attention on memories which are retained for further processing. Those categorizations of primary impulses are combined and aggregated to form more sophisticated and intricate classification systems, which now apply not to primary impulses, but to broader classes now identified as having some perceptible concrete, or some synthetic, imperceptible abstract characteristics in common. Since Hayek, numerous cognitive psychologists have described similar classificatory structures: e.g., frames (Minsky 1975), schemata (Rumelhart 1975, 1991), and scripts (Schank & Abelson 1975; Abelson 1981).

Bartlett (1932) found memory recall to be a reconstructive activity—we construct selective recreations of the original constellations of sensory impulses. These selectively retained internal models of primary sensory impulses and their complex combinations, both map onto objective reality, and guide our subsequent experience and expectations. Classification is always experimental, tentative, and subject to revision. Rather than dramatic paradigm shifts, a classification schema tends most often to be subsumed into more intricate schemata, rather than discarded entirely. Often, a more effective classification will evolve out of an older, more primitive one, which served the organism's needs well enough at one point, but eventually sufficient new experience emerges to support a more subtle and effective appreciation of reality (Hayek 1952, p. 145 [6.45]). Rizzello (2004) concludes that the sensory order so conditions the learning of new information, that path dependency dominates cognition, decision-making, and institutional change. Clearly, Hayek emphasizes the extent to which the sensory order is developed through building on previously-established associations, but it is also clear that the sensory order can be superseded when sufficient disconfirming sensory evidence or logical dissonance is encountered. Institutional change may be more narrowly bounded by path dependency than an individual's sensory order, due to the complexity imposed by interaction among many cooperative individuals, compared with the organization of one individual's perceptual impulses or even their higher and more abstract classificatory schemata. Some degree of revision and reorganization of the sensory order can occur even in the absence of new experience, through sudden insight, but this always seems to depend on relating past experiences in a new way.

Damasio (1995, 1999, 2003) emphasizes that the central nervous system evolved to be aware of the human body, the external reality, and their interrelationships. Thus, we can imagine responses to an external stimulus before it is applied. In extreme cases, merely thinking about stimuli which can trigger anxiety, can trigger an anxiety response even in the absence of the actual stimuli. For example, imagining a rapid pulse can elevate one's pulse and blood pressure, as can recalling or imagining an embarrassing or dangerous experience. Hayek notes that expectations require some vision or model of causal relationships, that is, a mapping of temporally-ordered impulses onto external reality. The act of revising a course of action to better realize disappointed expectations clearly calls for an ability to model reality and to revise those models in response to new data (Hayek 1952, p. 95 [4.54]). Revising expectations in light of current perceptions constitutes a feedback loop. Educated by experience, the mind forms linkages among both simple sensory data, and complex aggregates of sensory information summarized in concepts used to categorize sensory impulses (Hayek 1952, p. 143 [6.37-6.38]).

Cognitive psychology emerged subsequently (Broadbent 1958; Neisser 1967) in further reaction to the atomistic-reductionist approaches of the dominant behaviorist school of psychology, against which the gestalt school which originally inspired Hayek had been the only major alternative. Along with Hayek, cognitive psychology recognizes that prior belief and understanding are critical for determining behavior in general, as well as determining our approaches to learning in a particular context, and even for how we frame problems for possible solution (Eysenck & Keane 1990; Schallert 1991; Mayer 1992). We adopt patterns of behavior, problem-solving algorithms, and heuristics. Given our level of cognitive development, these are constructed to address the problems we define, which also help determine our approach to defining problems (Piaget 1951, 1953). Cognitive psychologists identify schemata, "hypothesized mental frameworks that give organization to incoming information" (Bruning 1994, p. 8), as the context we use to interpret subsequent experience. As Hayek suggests, the classificatory schema organizing sensory data accommodates the simplest, unassociated, concrete impulses as well as the most abstract, higher-order generalizations. Rumelhart (1991) proposes several features of these classificatory schemata:

1) they accommodate a range of information from simple to highly complex;
2) they organize information into one or more non-exclusive hierarchical structures;
3) they drive our interpretations of experience, and influence how we integrate current experience with memories of past experience; and
4) they contain slots or place-holders for the reception of fixed or variable values, which may be qualitative or quantitative, and which may be empty at any point in time.

Each of these features can be found in various forms throughout *The Sensory Order*.

While construction of the sensory order is a problem-driven scientific inquiry which normally proceeds subconsciously, it can also be applied consciously and intentionally (Hayek 1952, pp. 132-136 [6.2-6.13]), in which instance we are not merely passive recipients of problems, but exercising entrepreneurial awareness in defining new ones. Subjective human intentions focus individual approaches to learning and awareness (Newell & Simon 1972). In Hayek's view, the sensory order we construct in the mind is a spontaneously-evolving order which the organism adapts—for the most part unconsciously—to engage and make use of the experience the organism encounters or is led to seek. The external environment may change, eventually requiring revision of the sensory order, or accumulated experience may lead the organism to revise the sensory order even in the absence of external change. We cannot manage the burden of processing each new sensory impulse as if it were unrelated to others received simultaneously or in the recent past, and we cannot make sense of existence without reference to memory of past experience. Conscious thought is inadequate for receipt of all primary sensory impulses, thus most of the apparatus of perception operates automatically most of the time (Dijksterhuis et al. 2006, p. 1006; Gifford 2007, p. 270). As the organism maintains this sensory order, the order evolves spontaneously in response to the organism's past experience, unconscious choice of classification schemata, and subsequent experience. Our memory is focused by the sensory order, as are our awareness and sensitivity to new impressions.

3. EFFICIENCY AND INEFFICIENCY ARGUMENTS IN SOCIOBIOLOGICAL ADAPTATION

We shouldn't be so discontented all the time.
—Sloan Wilson (1955), *The Man in the Gray Flannel Suit*

Anthropological study of sociobiological adaptation searches for objective benefits which enhanced our ancestors' survival and reproductive opportunities (e.g., Atran 1990, 2002). The extreme contrasting view of Dawkins (2006), Harris (2004), Dennett (2006), and others, is that notable evolved features emerged only as a byproduct of other, actually desirable adaptations, and like the appendix serve no useful purpose. Byproduct theory (Boyer 1994, 2001; Barrett 2004; Bloom 2004) views many emergent features as nonfunctional and potentially inefficient "spandrels" (Gould & Lewontin 1979). Spandrels evolved as a consequence of other, actually beneficial features. A nonfunctional spandrel could potentially be useless in its own right, but also present an efficient medium for, or at least adjunct to, the emergence of an actually beneficial adaptation.

Atran and Norenzayan (2004a, 2004b; Norenzayan & Atran 2004; Norenzayan et al. 2006) present the argument that evolutionary social adaptations were passed down because they enhanced our ancestors' survival opportunities. Their argument is two-pronged: first, emergent features shared by a community allow individuals to rapidly construct "minimally counterintuitive narratives" to explain observed phenomenon and respond as a group; and second, communal activities increase the degree of group cohesion, which in turn facilitates social cooperation (Edney 1981). In addition, though not emphasized by Atran and Norenzayan, communal activities also allow for specialization and division of labor, permitting a highly sophisticated social organization while relying on simple individual tasks.

It becomes inevitable to consider cultural manifestations as evolutionary adaptations as soon as we realize that not all are equally adaptive, that is, not all offer the same increased survival and reproductive opportunities. However, the argument made by Atran and Nourenzayan is largely independent of varying cultural norms, which differed as much across social groups in primitive times as today. In the absence of cultural norming, our ancestors would have faced the far greater burden of constructing individual and holistic explanations and responses to their environment on very short notice. One requires a sophisticated knowledge of natural science before this individual strategy could even begin to work, and in primitive times the risks in the short term were too great, e.g., of being devoured by predators, killed by other humans, or merely dying of exposure. Furthermore, in many cases community acceptance of one among several competing hypotheses might be inevitable, but often could not occur rapidly. Atran-Nourenzayan "minimally counterintuitive narratives" suggested by the community's social tradition benefited individuals directly in facilitating immediate responses in a forbidding environment, and served to coordinate the community's reaction as well, while economizing on energy, time, and resources. This allowed social groups to respond quickly, and facilitated acceptance of psychologically satisfying explanations stemming from established cultural traditions.

Iannaccone & Makowsky (2007) conducted simulations which demonstrated beneficial clustering of homogeneous religious groups allows for faster population growth because it lowers transaction costs among individuals with similar moral standards and expectations of acceptable behavior. Interaction with different communities imposes higher transaction costs because both parties do not share a common cultural tradition, and may have drastically different ethical standards and behavioral patterns. One faces less uncertainty about the experience, behavior, and expectations of social partners from within the group, because of shared practices and norms. The information burden prevents some interactions, and makes others more costly.

However, successfully overcoming inefficiency is also adaptive. Greater diversity allows us to expand our range of activities and makes the division of labor possible. Furthermore, inefficiencies cannot be overcome if they are never permitted to arise. The underlying tension may be as simple as the observation that a level of complexity arises through a series of successful adaptations, where the complexity constitutes a non-functional spandrel, but the very existence of this newly-generated complexity or inefficiency forces the selection of a more powerful brain. Certainly toleration and diversity help select for larger, more adaptive brains, while conformity contributes to efficiency, which maximizes the adaptive advantage which can be achieved with a given level of organizational sophistication.

In certain regards, this tension may be only apparent. Efficiency and conformity allow primitive societies to grow over time and increase in sophistication, to the point where inefficiency, diversity, and toleration become both necessary and beneficial. Division of labor is very limited in social animals other than man, and tends to focus on differentiated sex roles. Among bees, wasps, and ants, workers are unspecialized and undifferentiated sterile females. The queen establishes the colony and breeding males or drones are otherwise unproductive. Among ants the males die before the colony is established, and among bees, breeding males continuously fertilize the queen, and are driven out after they become old and sterile. In lion prides, the lionesses both hunt and rear the cubs, and the male lions seemingly contribute no labor, though they will join the females in repelling outsiders. Both genders of wolves hunt in packs. Humans seem to anthropomorphize social animals—to the extent both genders are protective of the young, we admire their behavior, though we sometimes fail to emulate it.

The economic division of labor becomes increasingly beneficial as society increases in sophistication, but relies on toleration of differences. Entrepreneurial planning must be tolerated for civilization to flourish. Lowering time preference, increasing time horizon, and adopting roundabout production methods, cannot occur unless entrepreneurs are free to act on their own vision, regardless of the judgment or expectations ossified in social norms.

4. EFFICIENCY ARGUMENTS: EVOLUTIONARY BENEFITS OF MINIMALLY INCONSISTENT NARRATIVES

> *Nature makes nothing in vain.*
> —Aristotle, *Politics;* Darwin (1859), *Origin of the Species*

One of the more common arguments in evolutionary neurobiology is that the brain evolves through adaptations which improve or exploit efficient organization of information-processing capacity, freeing brain capacity for alternative uses. The more efficiently we use available processing capacity, the more capacity we have available for additional activities. Social conformity is one institutional adaptation which improves efficient processing for individuals. The expectation of uniform behavior in the community group frees individuals from having to confront the possibility of unexpected outcomes. Group cohesion and the ability to marshal common action will be high when everyone shares the same norms and expectations. When everyone thinks and acts alike, it becomes a simple matter for individuals to coordinate their activities. Even in our highly pluralistic society, we typically observe great discomfort in response to those whose values or premises differ sufficiently.

In terms of Hayek's sensory order, this kind of beneficial efficiency would require minimizing the number and complexity of mappings in the brain, frequent consolidation of existing mappings in response to additional experience, and a strong positive external benefit from social norming that lowers individuals' cognitive burden. The organism learns advantageous classifications of sensory data through experience, and it is the mapping of the simplest internal subjective model onto the external reality which is the essence of an efficient classificatory process. The sensory order enlists a highly selective, finite model, to explain, categorize, and respond to, the inexhaustible manifold of the external world.

Maintaining the sensory order is less an intentional activity, especially as it relates to processing concrete perceptions, than a side-effect of its own operation. Nevertheless, it allows us to adapt to reality by enhancing the individual's experience and survival opportunities. Empirical studies of learning demonstrate that the context of information and prior knowledge influence the way and extent it is learned (Pichert & Anderson 1977), and generally, the more sophisticated understanding and experience an individual possesses in a given field, the easier that individual finds it to articulate and solve problems in that area (Chi, Glaser & Farr 1988). This applies not only to the content of prior knowledge, but how it is organized by the individual. Hayek recognizes the subjective models of the sensory order are continually tested against both the external reality and the subjective beliefs of others revealed through social intercourse.

It may seem illogical to claim that the sensory order can be measured simultaneously against both the external reality and the subjective beliefs of others; however, economists and philosophers have long recognized that commonality of belief systems confers adaptational advantage by facilitating social cooperation. Horwitz (2004) suggests that monetary calculation enables and is enabled by anonymous cooperation in advanced economies. Such calculations need not imply identical values, and allow individuals with very different values and preferences to mutually benefit from voluntary exchange. Even when a shared belief turns out to have been objectively mistaken, the fact that it was shared by a group contributed to the predictability of behavior within the group, lowering transactions costs and facilitating exchange and other forms of cooperative action. Culture is present only to the extent it is shared. Although economics emphasizes the individual subjective decision, culture points to a consensus on which among the network of interconnections are most important.

Confirmation bias, first identified by Wason (1960, 1966, 1968), describes our tendency to selectively overemphasize evidence confirming preexisting beliefs and underemphasize disconfirming evidence that is more difficult to integrate with existing beliefs. Lord et al. (1979) and Evans et al. (1983) also found that prior belief generally dominates logical reasoning. Although the beliefs supported by confirmation bias may be individually held and subjective, a particularly deep-seated source of bias would likely come from communally-shared moral values. Furthermore, the benefits of Atran-Nourenzayan minimally counterintuitive narratives help explain why our behavior displays confirmation bias. The adaptiveness of confirmation bias is strengthened if many individuals within a group agree. Confirmation bias may have provided adaptive benefits in primitive times, even if it no longer does.

Socialization enables us to benefit from the experience of others, granting us not only a vastly larger and more valuable stock of experience, but also condenses this volume to a manageable digest. We rely on language, social intercourse, and literature to broaden the range and perspective of our experience far beyond what we could incorporate in the sensory order on our own. This is an essential achievement of civilization.

Wallace (1864) observed that gross anatomical evolution had largely ceased for humans, suggesting we had advanced beyond depending on purely physical development to achieve adaptive advantage, perhaps due to the physiological complexity attained by the human species, or our high level of social organization, unprecedented in the animal kingdom, had advanced to the level where further development was frustrated by path dependency. Wallace sought explanations for

1) the comparative stability in human physiology from the late Pleistocene epoch, approximately 130,000 years ago, during which lower animals had continued to evolve drastically;
2) the emergence of racial varieties among humans without reliance on a discredited theory of successive emergence; and

3) the extent to which the human brain drastically altered the prevailing rules of evolution. Wallace argued that brain evolution outpaced gross anatomical changes because that was the most efficient way to gain evolutionary advantage. This was not the case for animals with smaller brains who continued to diversify in variety over the same period.

The animal brain confronts us with a physical object behaving at least partly according to deterministic physical rules, but also seems to display a degree of behavioral indeterminacy. This flexibility or adaptability is the kind of evolutionary advantage which might contribute to heightened entrepreneurial awareness. Some primitive hominids had larger brains than homo sapiens, suggesting that improved organizational efficiency is among the adaptive advantages we possess over our ancestors and their competitors.

Minimally inconsistent narratives contribute to group survival to the extent they improve survivability better than alternative explanations. A high degree of social conformity imposes great costs on the individual. However, for social adaptations to be successful, the benefit to individuals need only outweigh the cost. Some cultural traditions do not pass this test, or in a changing environment do not continue to pass. These traditions are abandoned, or the group which persists in the tradition and associated behavior becomes extinct, outcompeted by a group with a tradition more adaptive to prevailing conditions. One plausible reason why cultural traditions evolved, especially in light of the extraordinary time and energy devoted to elaborate and sophisticated rituals, architecture, hierarchical institutions, cultural artifacts, etc., is that in primitive social groups, the time and energy devoted to these artifacts were outweighed by the incessant savings of time and energy offered by recurrent group adoption of minimally counterintuitive narratives dictated by the cultural tradition.

Even when these explanatory narratives diverged from factual reality, they always had the immediate advantage that they were nearly certain to be accepted throughout the group and that they were likely to fulfill individuals' most urgent psychological needs. Thus, the community's energy was not occupied with debate, and consensus could emerge rapidly and at minimal cost. Sosis (2004) argues that specific elements of belief have to have a certain internal consistency to work together for the individual, who employs a kind of aesthetic cultural framework against which additional beliefs are evaluated. Aesthetically dissonant or culturally incompatible hypotheses are likely to be rejected, even if factually true. The evolutionary benefit comes from shielding the individual from the staggering burden of having to justify all beliefs about the external environment as they arise. Cultural traditions evolve spontaneously like property rights (Bailey 1992) and other cooperative arrangements (Benson 1991, 1999). A social group with less competitive institutions and cultural norms may adopt those of its faster-growing neighbors, may merge with them, or may be outcompeted to extinction. In each case, the less adaptive institutions are always evolutionary dead ends.

The value of emergent cultural traditions as evolutionary adaptations can be illustrated through a counterexample. In the *absence* of a spontaneously emergent cultural tradition allowing for the generation of minimally inconsistent narratives, members of the social group would have had to devote far more time and energy to constructing these narratives, and because narrative construction occurs cooperatively, further time and energy would then need to be devoted to discussion and persuasion aimed at attaining the assent of others in the social group—something we engage in extensively today. Inheriting any cultural tradition substitutes for this extraordinarily cumbersome process. Agents thus freed from the burden of constructing their own narratives and achieving consensus, would necessarily have more time and energy to devote to long-range planning and speculative foresight, giving them the adaptive advantage of lowered time preference and longer planning horizons.

In contrast, however, it will be argued below that the greater cognitive burden required to evaluate competing individual narratives better enabled us to survive in the long run by supporting evolution of a more sophisticated and powerful brain.

5. INEFFICIENCY ARGUMENTS

> *A man's reach should exceed his grasp,/Or what's a heaven for?*
> —Robert Browning (1812-1889), *Andrea del Sarto*

A contrasting set of admittedly more loosely-related arguments has also arisen based on the greater information-processing burden imposed merely by interaction larger social groups. A related argument is often made for the adaptive benefits from greater toleration of social divergence within groups of a given size. Though these two features of what will be called the inefficiency argument seem closely related, they will be analyzed separately, though keeping potential interactions in mind. Both larger social groups and weaker enforcement of conformity promote, require, and reward, development of a larger neocortex. The cognitive burden imposed by simultaneous navigation of social and natural environments, sometimes with conflicting requirements, better enabled us to survive in the long run by supporting evolution of a more sophisticated and powerful brain. In contrast to the first class of arguments—efficiency arguments—the second class—inefficiency arguments—suggests that benefits accrue from forcing relatively inefficient use at the limits of already-evolved information-processing capacity, leading through natural selection to the evolution of a more powerful and better-organized brain, though not necessarily a larger one.

In Hayekian terms, inefficient processing would be manifested through increasing the number and redundancy of cognitive mappings held by the brain, proliferation as opposed to consolidation of mappings in response to added experience, and strong external benefits to the individual (i.e., requiring here more processing rather than less) from comparison with various mappings articulated by others in the community, and communication with other individuals, or simply implicit in the behavior or inferred goals of others.

Information-processing Requirements Expand Geometrically with Group Size

The larger brain confers evolutionary advantages on the species, and is necessary to handle the volume, complexity, and sophistication of social interactions which increase geometrically with the size of the social group. The larger the social group a species evolved to interact with, the greater the species brain weight devoted to the neocortex or neo-mammalian brain which processes intersocial interaction and communication. Once primates began to live in social groups, natural selection began to balance the benefits of cooperative defense, hunting, and child-rearing behaviors against the cost of intragroup competition. Brain size and social group size tend to have evolved together (Dunbar 1992, 1993, 1996). The larger brain confers evolutionary advantages on the species, and is necessary to handle the volume, complexity, and sophistication of social interactions which increase geometrically with the size of the social group. The larger the social group, the greater the percentage of brain weight devoted to the neocortex or neo-mammalian brain (Sawaguchi & Kudo 1990). Macaque monkeys interact in social groups of approximately twenty and have neocortexes that account for 50% of their brain weight. More advanced, intelligent, and social than macaques, chimpanzees live in groups of approximately fifty, and have neocortexes accounting for approximately 65% of their brain weight. In humans the neocortex accounts for 80% of brain weight and includes the language centers (Table 1).

Table 1. Primate Neocortex Size

Primate species	*Social group size*	*Neocortex % of total brain weight*
Macaque monkeys	20	50 %
Chimpanzees	50	65 %
Humans	100-200 ?	80 %

Note: Kudo and Dunbar 2001. Only mammals possess the neocortex, aka the neo-mammalian brain.

Regressing information for 38 primate species, Dunbar (1992) found a predicted human social group size of 148, with a 95% confidence interval ranging from 100 to 230. Alternative estimates by Killworth, Bernard, and others, are somewhat larger, with a median of 231 and a mean of 290 (Bernard, Shelley & Killworth 1987; McCarty et al. 2000; Bernard 2006). With only three data points, and depending on the value taken for humans as Dunbar's number, social group size explains 97-99.5% of the percent of total brain weight accounted for by the neocortex (Table 2).

Table 2. Regression results: Neocortex % of brain weight explained by ln(*n*)

Assumed size of human social group (Dunbar's number)	*Regression equation*	*t-statistics*	*Adjusted R-square*
100	$P = -0.061\ n^{0.185}$	(-1.05) (12.49)	.9873
150	$P = 0.060\ n^{0.148}$	(1.91) (19.14)	.9946
200	$P = 0.127\ n^{0.129}$	(2.09) (8.49)	.9726

Ethical norms held across group members apparently help maximize the benefits of social cohesion while minimizing the destructive potential of group life. Individuals living in groups engage in such undesirable practices as deception, politicking, coalition formation, cheating, stealing, adultery, and various other negative activities. Although the argument is made that primate's need to engage in and overcome these negative behaviors forced us to develop larger brains, social norming, including morality and religion, seems to act as a brake against unbridled wantonness—however imperfectly.

Toleration makes Larger Groups Possible

Among several competing societies, the one imposing the most socially beneficial and cohesive behavioral rules on the individual would have an evolutionary advantage over the others. Normally the most adaptive behavioral rules would be those minimizing harm to others in the society. The need to devote significant resources to enforcing conformity must also grow geometrically with group size. This ever-expanding resource burden, together with the information processing burden imposed by interaction in large groups, acts as a brake on community expansion—a form of x-inefficiency (Liebenstein 1966). One way to mitigate this burden, or shift it from enforcing social conformity to information-processing, is to tolerate differences among individuals. This is initially done on only one margin, but eventually individual sovereignty triumphs over the collective will to conform.

The modern concept of toleration was forged in the crucible of the Thirty Years War of 1618-1648. Though this war had many political aspects, it was the last major conflict that was so dominated by religious divisions, and the last major conflict between Catholic and Protestant powers in Europe. The peace of Westphalia established that independent states could peacefully pursue different religions, a freedom which was eventually recognized for individuals. If larger groups generally have an advantage against smaller competitors, then toleration of diversity provides an advantage over conformity. Tolerant groups can combine to form larger communities, while groups which enforce conformity generally seek to destroy their competitors, or at least remain separate from them.

Larger Groups allow Greater Division of Labor

In addition to making cooperative behavior easier to facilitate, social interaction allows for development of other evolutionary adaptations like language and abstract reasoning. Once primates began to live in social groups, natural selection began to balance the benefits of cooperative defense, hunting, and child-rearing behaviors against the cost of intragroup social competition. Brain size and social group size evolved in parallel (Dunbar 1996). Darwin (1871, p. 152; Eiseley 1958, p. 295) hypothesized that humans evolved from weaker anthropoids who would have gained advantages from socialization and cooperative hunting. More formidable gorilla-like primates were not then thought to be capable of the relatively sophisticated socialization which has since been observed in mountain gorillas, though it should be noted they live in smaller groups than chimpanzees or humans. Physically weaker animals face greater incentives to live socially, but the social adaptation can result in weaker though better-adapted successor species. Particularly large wasps, about whose ferocity and venom we can fortunately only speculate, began to live in proximity for mutual protection against predators. They eventually became true social insects, giving rise to far smaller modern wasps. Some species lost their stingers entirely, and have largely lost the ability of flight, evolving into ants, whose morphological resemblance to wasps remains particularly striking. Ants became more successful and prolific than their ancestors through socialization, and many ant species have become as docile as their environment will allow.[1]

Hayek's construction of the sensory order contributes to understanding a number of developments in modern neurobiology and cognitive psychology. The sensory order is itself one of the tools individuals exploit to achieve evolutionary advantage, and with further development and sophistication, contributes to the cortical interconnectivity necessary to attain and understand further advantages. Recent findings in neurobiology show that nerve cells are structured to implicitly categorize related sensory data in proximity (Nader et al. 2000; Si et al. 2003a; Si et al. 2003b; Duvarci & Nader 2004; Harvey & Svoboda 2007). This may be the very physical mechanism through which the sensory order works. Humans clearly economize on physical energy and mental effort by attempting to preserve classificatory schemata, once these schemata are established and verified by experience, suggesting at least a temporary justification for confirmation bias.

6. TIME HORIZON AND EFFICIENCY ARGUMENTS

The lyf so short, the craft so long to lerne.
—Chaucer, *The Parliament of Fowles* (1380-86)

Social conformity confers survival benefits on both societies and individuals because it allows a general lowering of time preference. Time preference is one of the most basic economic concepts and a fundamental category of human action. Theories of interest, term structure, and opportunity cost all depend on time preference, which is also the basis for capital budgeting in modern finance. Social conformity supported a reduction of time preference, allowing for employment of capital in time-consuming roundabout means of production.

Time preference explains why conforming behavior conferred survival value as we evolved, and why beyond a certain point, non-conforming behavior offers similar benefits. Time preference is the preference for immediate over delayed gratification. Though a universal determinant of human action, it has been observed to vary greatly in intensity across individuals. For example, time preference is especially high in children who lack experience and maturity, and in individuals with low life expectancy. Time preference is also high for criminals, and the general lowering of time preference both facilitates and is facilitated by the development of civilization and the increase in complexity of social relationships. The essence of low time preference is planning for the future, a willingness to delay gratification, and patience to wait for future benefits.

Our distant ancestors, who experienced both an appalling brief life expectancy and very high infant mortality, were fully absorbed with problems of immediate survival. Homo sapiens evolved in an environment where infant mortality approached 100% and life expectancy *for those surviving infancy* was certainly below 20 years. Our remote ancestors had little reason not to consume all their seed corn at once, and one problem which had to be overcome was rapid discrimination between members of one's own group, competing hunter-gatherers of the same species, dangerous predators of other species, and potential prey.

Rituals, practices such as characteristic dress, behavior, or tattooing, could serve as adaptations which distinguished members of one's own group from that of groups which could be competitive rivals, enemies, or prey.

It appears unlikely that people with notably high time preference would bother to engage longer-term reasoning or *planning*. Increasing peoples' time preference leads to more impulsive and short-sighted decision-making and weakens community cohesion. High-time-preference individuals live in the moment and do not characteristically deliberate, philosophize, or plan for the future. In contrast, low-time-preference individuals can still be alert to immediate threats like predators. Fundamental cognitive categorizations like belief in agency for inanimate objects, would enable low-time-preference individuals to respond immediately. Low-time-preference individuals have comparative advantage for deliberation and debate, but any benefits this capacity may have conferred could only have been realized *after* immediate threats had been addressed. The low-time-preference savers are the group which makes the more intensive use of the available neocortex, and in whom it likely evolved. They are, incidentally, the ones with comparative advantage in entrepreneurial planning.

Once life expectancy lengthens to the point where, in and of itself, it results in lowered time preference and more responsible, more forward-looking behavior from the majority, at some point, the survival dynamic of conformity reverses. Once competing groups of other humans cease to be the greatest danger, toleration of diversity becomes increasingly adaptive, or at least less maladaptive. In the context of hunter-gatherer societies, high time-preference recommends and rewards the attitude of "kill the outsider," but in the more civilized context lower time-preference makes possible, the lower one's time preference, the more accepting one becomes toward "outsiders"—even to the point where they are no longer considered outsiders. The Talmud has the famous expression of Hillel the Elder, "That which is hateful to you, do not do to your fellow," (Shabbat 31a), the lesson of the Good Samaritan parable. The intense small-group cohesion which is a high time-preference liability in a civilized society, though atavistic, is one behavioral adaptation which made the attainment of civilization and low time-preference possible. It seems to be a ladder to be discarded once it has been climbed.

We have little memory of practices which may have increased time preference, perhaps because societies with such practices were evolutionarily disadvantaged. The more foresightful the behavior of individuals in a community, and the longer their time-horizon, the more resources are saved instead of being immediately consumed. Saving output allows for time-consuming, capital-using, roundabout means-of-production, which are more productive and lift a community above subsistence. Once a community saves some of its output, its wealth is virtually guaranteed to grow more rapidly than groups which save less. Lower time-preference behaviors spread because they enabled social groups to outcompete groups which failed to plan for the future. The obvious structural transition this suggests is the transformation from hunter-gatherer to agricultural societies.

Conformity of belief and behavior rewards high time-preference individuals, making more efficient information processing possible by restricting the range of possibilities confronting the individual. Individuals with high time preference or short time horizons benefit more from information processing efficiencies. However, it is the ability to engage in inefficient or more burdensome information processing, relying on low time preference or a long time horizon, which allows eventually for the development of a larger and more efficiently-organized brain. Toleration of "the other" is clearly a more advanced trait. It is this transformation from the simplistic black-and-white logic of "identify-friend-or-foe," to a multidimensional continuum of value scales, which represents the civilization and domestication of the human animal.

7. CONCLUSION

Evolutionary neurobiology has developed explanations for adaptive brain development which appear at least superficially in conflict. Clearly, both efficiency and inefficiency arguments cannot both be valid in the same respect. This paper argues that social conformity is an efficiency promoting and exploiting evolutionary strategy. However, it was argued that beyond a certain population threshold, diversity and toleration become the dominant strategies. Hayek's construction of the sensory order was used to evaluate developmental strategies as either promoting or exploiting, efficiency or inefficiency, as well as being more or less successful.

The conformity defined by a cultural tradition confers survival benefits on societies and individuals which adopt it to the extent it allows a general lowering of time preference. Although social customs can be arbitrary in the sense that they are not necessarily subject to any objective, naturalistic justification, they enhance the survival and reproductive opportunities of the societies they shepherd through adverse selection. Only the most adaptive practices survive and contribute to the evolution of a cultural tradition. The emergence of religion and morality supported a reduction of time preference, allowing for employment of capital in time-consuming roundabout means of production.

Cultural traditions which did not confer survival benefits, if adopted, clearly would have disadvantaged communities which may have died out as a result. Researchers arguing for the adaptive benefits of cultural norms cite such characteristics as group cohesion, the facilitation of ready explanations, and impacts on cognitive burden. Some feel the efficiency of minimally inconsistent narratives benefits a cultural group by lowering the cognitive burden through simple, intuitive, though usually objectively false or unverifiable, explanations. Others feel the multiple burden of competitive alternative explanations is beneficial because it contributes to the evolution of a more powerful brain.

Wallace observed that brain evolution is the most rapid form of biological evolution. As social animals, humans have adopted an even more rapid strategy of achieving adaptive advantage through spontaneously evolved institutions and other self-organizing systems which arise as a natural outgrowth of our social interaction and unplanned social organization. Efficiency strategies, including the social conformity which facilitates the generation of minimally counterintuitive narratives and strong group cohesion, are more powerful and effective over shorter time horizons and for individuals with higher time preference. Inefficiency strategies, when they are not dominated in the short run by more urgent efficiency strategies, force and reward the development of a larger, more powerful brain, and thus contribute more to neurological complexity. Larger group size calls for greater processing capacity, as well as greater toleration of behavioral diversity. Another problem with conformity for larger groups is that enforcement costs expand exponentially.

NOTES

1 Insect brain size lends mixed support to the hypothesis that socialization helps animals evolve a larger brain (Lihoreau, Latty, & Chittka 2012, Godfrey & Gronenberg 2019). Solitary wasps generally have smaller brains than social wasps. In particular, the tiny parasitic wasp *Megaphragma mymaripenne* has the smallest measured insect brain with 7,400 neurons (Polilov 2012). The house fly *Musca domestica* has 340,000 neurons (Strausfeld 1976) and the honeybee *Apis mellifera* has the largest insect brain, with workers having 850,000 neurons and drones having 1,200,000 (Witthöft 1967). Honeybees are among the most docile and domesticated insects. Various bumblebee species (Bombus) form colonies between 20 and 1700, far smaller than honeybee hives which typically average 50,000 (Cueva del Castillio, Sanabria-Urbán, & Serrano-Meneses 2015). Though bumblebees seem to have fewer brain neurons than honeybees, their brains account for a larger percent of the insect's total weight. Ants generally have smaller brains (c. 250,000 neurons) than many of the social wasps they presumably either evolved

from or in parallel with. Entomologists suggest this anomaly arises from the fact that social wasps retain the power of flight which ants have largely lost, requiring a larger brain for 3-dimensional navigation. The solitary parasitic wasp *Dasymutilla occidentalis* variously known as the cow killer or velvet ant would be especially interesting to analyze in this regard, since males fly but females do not.

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