Introduction to Darwinian Perspectives on Electronic Communication

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Abstract—*This article provides an introduction to the Special Section on Darwinian Perspectives on Electronic Communication. It starts with a discussion of the motivation for the Special Section, followed by several sections written by the Guest Editor (Ned Kock) and the Guest Associate Editors (Donald Hantula, Stephen Hayne, Gad Saad, Peter Todd, and Richard Watson). In those sections, the Guest Editor and Associate Editors put forth several provocative ideas that hopefully will provide a roadmap for future inquiry in areas related to the main topic of the Special Section. Toward its end, this article provides a discussion on how biological theories of electronic communication can bridge the current gap between technological and social theories. The article concludes with an answer to an intriguing question: Are we as a species currently evolving to become better at using electronic communication technologies?*

Index Terms**—***Computer-mediated communication, Darwinian perspectives, electronic communication, evolutionary psychology.*

Evolutionary explanations of human behavior are not new. Ever since Darwin's publication of his theory of natural selection [1] there has been a great deal of speculation about how natural (and later sexual) selection has shaped the human species. Darwin's original ideas have stood the test of time, and benefited from the inputs of many researchers who significantly contributed to extending the original theory. Among those researchers are the following, listed in approximate chronological order of contribution of key ideas and theoretical insights that expanded on Darwin's original theory: Ronald A. Fisher, John B. S. Haldane, Sewall Wright, Theodosius Dobzhansky, Ernst W. Mayr, William D. Hamilton, George R. Price, John Maynard Smith, George C. Williams, Edward O. Wilson, Amotz Zahavi, and Robert Trivers.

One field of research that has been gaining particular attention recently is the field of evolutionary psychology [2], [3]. The main goal of this field of investigation is to hypothesize and explain the existence of brain mechanisms, often reflected in behavioral patterns, by arguing that selective pressures in our evolutionary past created and shaped those mechanisms.

For example, our craving for high-calorie (generally very sweet and/or fat) foods today is explained based on the scarcity of high-calorie foods in our evolutionary past and their advantages as body fuel sources. Those individuals who consumed high-calorie foods had more energy, vitality, and probably a higher resistance to diseases than those who did not. Consequently, those individuals who craved high-calorie foods in our evolutionary past had a higher reproductive success than those individuals who did not. As a result, the genes that led to the craving eventually spread to the entire species.

A particular realm of human behavior that has been receiving increasing attention from researchers and practitioners is behavior toward electronic communication technologies. Sometimes referred to as electronic communication behavior, it can take many forms, such as the following: behavior of individuals who are part of virtual communities, online learning behavior, online dating behavior, and online purchasing behavior.

This Special Section on Darwinian Perspectives on Electronic Communication aims at starting a discussion on how ideas from the field of evolutionary psychology can be used to explain behavior toward electronic communication and related technologies. While there are undoubtedly many types of behavior that can be explained based on human evolution theories, electronic communication researchers have largely ignored

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this potential so far. Hopefully this Special Section will contribute to change that.

The Guest Editor, Ned Kock, conceived the original idea of this Special Section around 2001, but was not able to put that idea into practice until now. One of the reasons for the delay was the difficulty of finding an appropriate venue for the Special Section. Being able to publish it in the prestigious IEEE TRANSACTIONS ON PROFESSIONAL COMMUNICATION was well worth the wait!

The following scholars (listed in alphabetical order of surname) agreed to serve as Guest Associate Editors, and Ned is very grateful to them: Donald Hantula, Stephen C. Hayne, Gad Saad, Peter Todd, and Richard Watson. They are among the most prominent scholars in the world in the following disciplines and research areas that provide the basis for this Special Section: evolutionary psychology, consumer behavior, cognitive science, and information systems. Their involvement with this Special Section not only made it possible, but also significantly enhanced the prestige associated with it, which led to an excellent set of targeted submissions.

In the following sections, the Guest Editor and Associate Editors put forth several provocative ideas that hopefully will provide a roadmap for future inquiry in areas related to the main topic of this Special Section. It is important to note that not all behavior can be explained based on human evolution ideas, a topic that is emphasized in the first section, written by the Guest Editor. That section is followed by a section summarizing the four articles selected for publication in this Special Section.

NED KOCK: A NOTE OF CAUTION REGARDING EVOLUTIONARY EXPLANATIONS

One of the main goals of this Special Section is to stimulate research on electronic communication from a Darwinian, or evolutionary, perspective. This goal may implicitly convey the euphoric idea that perhaps a great deal of electronic communication phenomena, and perhaps a great deal of behavioral phenomena in general, can be fully explained based on a human evolutionary perspective. This section is a note of caution in that respect. Incidentally, it was a blind belief in evolutionary explanations of human behavior that led to the eugenics and social Darwinism movements. Those movements formed the basis on which extremely racist assumptions emerged, leading to massive wars, destruction, and genocide.

In looking for evolutionary explanations of electronic communication behavior, one has to bear in mind that many adaptations that have conferred reproductive fitness enhancements on our Stone Age ancestors are maladaptations today. Let us consider again our craving for high-calorie foods, discussed earlier. Unfortunately, in most of today's urban societies, high-calorie foods are both cheap and abundant. That craving, which has conferred on our ancestors a reproductive advantage in our evolutionary past, is in fact a maladaptation to today's urban life that can lead to a variety of life-threatening diseases.

Similarly, it is reasonable to believe that our brain has been designed to excel in face-to-face communication, since that is the primary communication mode used during over 99% of our evolutionary history. That in turn leads to the conclusion that we are generally maladapted to today's intense use of electronic communication technologies [4]. Does this mean that we have to revert back to face-to-face communication only? The answer is "no" because electronic communication solves a number of problems that did not exist during the Stone Age. The problems associated with geographically distributed work collaboration, for example, are very recent problems from a human evolutionary perspective.

Another trap that researchers looking for evolutionary explanations of electronic communication behavior should be mindful of is related to the human ability and tendency to adapt our behavior to solve problems. The ability to adapt probably has much to do with the plasticity of our brain. As far as our adaptability to complex tasks and technologies in today's modern society is concerned, especially important is the plasticity of the brain's outer area, known as the neocortex. Both the ability and tendency to adapt probably have a decisive genetic basis.

When some of our ancestors migrated from the hot African savannas to a cooler Europe they did not grow fur over successive generations to protect them from the cold. They instead changed the environment around them, building shelters and using animal skin as clothing in order to survive. They also adapted their behavior accordingly. This adaptability has conferred survival advantages to our hominid ancestors, even dating back to the emergence of Australopithecus, because probably all of our hominid ancestors have had to regularly deal with environmental changes that happened in geological time.

The connection of the above discussion with electronic communication is that we also tend to adapt to the arguably unnatural media created by electronic communication technologies, which in some cases leads to the curious result that we perform some complex collaborative tasks better through electronic than face-to-face media [5], [6]. The message here is that biologically deterministic explanations of electronic communication phenomena are unlikely to be very helpful in our understanding of those phenomena.

Yet another possible trap for researchers refers to EXAPTATIONS, which are adaptations that shift their original function and end up being used for something else. This concept can be traced back to Darwin [1], although the term “exaptation” is believed to have been introduced by evolutionary biologist Stephen Jay Gould.

One classic example of exaptation in the human species is the morphology of our hands, which are undoubtedly well adapted for the manipulation and use of tools. Tool development and use is one of the distinguishing characteristics of the human species, even though it is also observed to a certain extent in other so-called intelligent species, such as chimpanzees. Interestingly, our hands actually owe much of their morphology to adaptations evolved by our more distant tree-dwelling ancestors, at a time when they were used for other purposes such as grasping tree branches. The adaptations related to tool development and use are more recent and build heavily on unrelated adaptations that make good sense for tree-dwelling species.

In a similar way, our marvelous ability to use symbolic language for communication of knowledge and information is most likely a form of exaptation. (The letters that form words that you are reading now are a good illustration of symbolic language.) The reason is that the use of symbolic language dates back only to approximately 5,000 years ago, when it is believed to have been developed by the Sumerians in the form of what is known as the pre-cuneiform script. That is too recent a development to have significantly influenced the evolution of our biological communication apparatus. Cave paintings date back to about 40,000 years ago, but most evidence suggests that they were used in religious rituals and not for communication of knowledge or information [7]. Researchers looking for evolutionary explanations of electronic communication behavior should be very careful about developing theoretical propositions based on the evolution of symbolic language. The truth is that we do not yet know for sure why our species seems so well adapted to use symbolic language.

Finally, researchers looking for evolutionary explanations of electronic communication behavior should be mindful of the fact that the environment we live in today is very different from the Stone Age environment in which our ancestors evolved. Those researchers more often than not will have to test theoretical propositions with human subjects today under conditions that may be significantly different from those faced by our ancestors, which may lead to misleading expectations, results, and conclusions.

One example is the study of surprise-induced learning effects in this Special Section, reported by Kock, Chatelain-Jardón, and Carmona. The study is based on the evolutionary theory-based expectation that a surprise event will enhance cognition in connection with elements that surround that surprise event. An example would be someone remembering vividly the ideas in an article that was being read at the time he or she was surprised by an approaching snake. The reason for this expectation is that the enhanced cognition effect leads to better memories of environmental markers (e.g., specific vegetation patterns) that characterize certain surprise situations such as a snake attack, thus enhancing the future survival chances of individuals who encounter those surprise-inducing situations and live. The study uses a web-based snake screen to surprise subjects engaged in an online learning task. While the results of the study are compatible with an evolutionary psychological explanation of the phenomenon, there are a number of things that could not have been predicted. For example, the snake screen did not seem to scare the study subjects very much, probably because it was a poor approximation of the real snakes faced by our ancestors, even though it seems to have triggered the enhanced cognition phenomenon.

DONALD HANTULA: FINDING OUR NATURE ONLINE, QUICKLY

We are Pleistocene era hunter-gatherers staring at our computer screens, pecking at keys, and pushing pointers as we search for information, goods, and mates in an internationally interconnected web of unthinkable complexity. It is tempting to assume that complicated technology demands similarly complicated cognition, but it is our technology that mutates rapidly while our biology remains unchanged. When faced with a new environment and seemingly new challenges, we adapt to that environment and solve problems in the same manner we have for eons.

The basic problems we have to solve are those governed by our limbic system, the famous four f's (fighting, fleeing, feeding, and fornicating). The first two concern immediate survival but the latter two are more long-term in their implications. Although each is slightly misnamed, both feeding and mating are consummatory acts that are predicated upon successful search and procurement in uncertain, patchy environments. A more formal term for search and procurement is FORAGING. It is most likely the case that successful foragers were those who were able to acquire sufficient resources to allow them to escape or fight off enemies and predators, as well as, be maximally attractive to a mate when a suitable one was located.

Indeed, foraging encompasses much more than feeding. Given that food and other resources were scarce and stochastic in our ancestral environments, it would make sense that one generally adaptable mechanism for surmounting the problems raised by environmental uncertainty would be a much more elegant and economical solution than a mechanism or module for food, another for clothing, another for tools, another for information, and perhaps another for goods that had not yet been invented. Thus, foraging may be seen as the general process for decision-making in uncertain environments. Casting decision-making under environmental uncertainty as the same basic, natural process that our ancestors used to solve survival problems may then lead to reconsider the degree to which many alleged "higher level" processes are necessary for contemporary human decision-making. Parsimony demands that we do not invoke more complex processes when less complex processes are explanatory.

Foraging theory predictions are appropriate for describing human behavior, whether it is indigenous peoples engaging in subsistence foraging [8] or current consumers shopping in grocery stores [9]. Extending the foraging model to behavior on the internet, Rajala and Hantula [10] tested predictions from foraging theory [11] in an online shopping simulation and found very good fits (VAC > 0.75) to the functions envisaged by foraging theory. Further research and theory development led to the BEHAVIORAL ECOLOGY OF CONSUMPTION, a naturalistic foraging-based account of consumer behavior [12]. Foraging is not limited to consumer goods online. For example, Pirolli [13] and Dennis and Taylor [14] have shown that foraging theory predictions are also confirmed in studies of information searching online. Although foraging theory was initially developed from studies of animals searching for food in the wild, its simple but powerful equations and predictions are equally applicable to adult humans searching for goods and information on the internet. We remain hunter-gatherers, but this time the mice are tools, not prey.

Foraging theory's basic predictions have been confirmed in the online environment, yet many more questions remain, some of which may be a bit counterintuitive, or even "irrational." For example, following from Rajala and Hantula [10], patch sampling is the norm, not the exception, suggesting that quests for brand loyalty and ultra-sticky websites will be frustrating and unfulfilled (see article in this issue by Hantula, Brockman, and Smith). Online foragers will not find the "best" site and stay with it; instead they will be expected to stray occasionally, testing and trying other sites. Consumers and information seekers will not remain on a site until all available options have been exhausted; instead they will switch to another site based on travel time and availability of other sites. Speed is of the utmost importance, and delays are discounted steeply, in a hyperbolic function. Faster websites will attract more users, and quicker e-stores will have a strong competitive edge and higher user satisfaction. Faster education sites provide better education: download delay degrades online learning [15].

Rapid transitions between websites (less travel time) should result in less time spent on a particular site. It would also be expected that quicker travel times would result in less searching and purchasing on a site, as found by Dennis and Taylor [14]. Elements in the environment that reduce travel time or search time will also lead to more transitions between sites; for example, using Google to search for information should increase the probability of a quick exit from a site due to both the power of Google's search engine as well as its download speed.

Pirolli's research suggests that the more information scents a site provides (i.e., navigation tools, keywords), the longer an informovore (in Pirolli's terms) will remain on a site [13]. On the other hand, longer travel times and delays should result in more searching and time spent on a site, as well as increased "capture" of less than desired items and information. Exceptionally risky choices, preferences for variability in website offerings and for long-shot odds in searching for goods or information would increase as due dates, ordering times, or other temporal limits draw near. Presence of predators such as keylogging hackers, and perhaps even the Recording Industry Association of America (RIAA) in the context of downloading music, would make sites with "safety signals" much more attractive. This is especially true as the probability of predators' presence increases, inhibiting switching, especially if there are long travel times between sites or download delays on sites. Signs of a predator's presence will induce caution and timidity until the end of a time horizon approaches, which might lead to riskier choices and confrontations with predators.

The online forager is confronted with a world as vast as the savannas. The horizon is endless. Clusters and constellations of data await. Much of it is clutter, cryptic, and largely irrelevant. Some trails and scents may appear, but they may also lead to dead ends. Prey items may be found, sometimes in abundance and sometimes fleeting, but the time and cost associated with their capture may be too much. This world is not simply a benign treasure hunt; diseases (computer viruses) and predators will trap the unwary forager. We will solve these cybersurvival problems in the same manner we have solved them throughout our history. Foraging theory provides a parsimonious explanation for decision-making and adaptations to uncertainty; its elegant mathematical models lead to straightforward predictions. We are foragers, gradually finding our nature online.

Stephen Hayne: Are Stories a Naturally Selected Collaborative Tool?

Clearly, Darwin had a gift of insight into the natural kingdom and for theorizing its origins. I found it interesting to reflect on how Darwin might inform us about useful tools for collaboration. My musings lead me to the use of stories for knowledge transfer and shared cognition.

Telling someone a story is a powerful way to transfer knowledge, and, I will argue, an impressive collaborative tool. Stories not only have interesting cognitive and collaborative properties, but they have a deep evolutionary history. Long before humans could write or communicate through symbols, knowledge was passed from one person to the next using the oral tradition, and it was much more of a daily presence in people's lives than it is in our world today. Many oral traditions are highly structured and are told faithfully without alteration; they have been found to be as reliable as other non-oral ways of recording and passing on experiences. In this way, the force of oral tradition can continue through generations although small details in the telling may change.

Oral traditions or stories can be categorized into several different types, including legends, myths, folktales, and memorates. A MEMORATE is an account of a personal experience or encounter with the supernatural, such as a ghost story or other expression of the spirit to a human being. Legends are oral traditions related to particular places and often involve cultural heroes, witches, ghosts, or some other phenomenon related to that place. They can involve the recent or distant past, but are most important in linking people and the land. The "Legend of Sleepy Hollow" is exactly that: an account of events which happened in a particular place. Myths are those accounts which portray the earliest possible time, including creation stories. Other myths account for the organization of the world and society, for instance how men and women were created and why they are different from one another. Because of their power to dictate how things should be, myths can be very powerful in shaping and propagating culture. In contrast to other types of oral traditions, folktales are acknowledged as things which did not really happen, but are useful stories for providing moral or social lessons or for amusement. "Once upon a time" stories which involve fictional characters such as Hansel and Gretel are folktales.

A substantial body of research in cognitive science now recognizes stories as a basic representation for everyday knowledge, cultural heritage, descriptions and explanations of events, and even emotions. Individuals and cultures work out emotional and moral dilemmas through narrative prototypes [16]. Human verbal interactions consist to a great extent of exchanging stories. People often tell stories to one another when they try to explain how things work, that is, they narrate a scenario of use, instead of citing the underlying principles and causal relationships [17]. The narratives people use to understand and organize their lives are strongly bound to specific contexts and situations [18]–[20]. To a first approximation, people appear to understand the world episodically, that is, in terms of specific situations. The main cognitive structure proposed is that of the schema [21], and prior work on story schema has provided evidence of their existence [22], [23].

But I suggest that the story is not just a schema, it is a "template." Template Theory [24] has most recently been proposed as a refinement to chunks in order to correct some of the shortcomings of chunk theory. TEMPLATE THEORY assumes that many chunks develop into more complex structures having a "core" of data to represent the pattern, and "slots" for variable data to enhance the core. Templates appear to be distinguished and retrieved by reference to a set of core features. Once learned, templates are encoded very rapidly (about 250 ms) and retrieved from memory two orders of magnitude faster than previously thought.

Templates are thought to reside in episodic or production memory. Placing the story template in episodic memory has extra benefits, because evidence shows that episodic memory may be less vulnerable to the effects of stress. We know that time pressure is associated with the release of a cortical steroid that impairs declarative memory [25], but not episodic memory. Thus, individuals operating under stress may experience difficulties with basic memory because they cannot recall the data. However, people should remember a story, as a sequence of templates, very quickly.

The core features of a story template would describe an element of the story: for example, the setting or the conclusion. Slot features of any element might include contextual information about the story or associations with subsequent elements of the story, such that differences in context link to different templates, which describe new elements of the story. In this way, the "plot" of the story is dependent on context.

Perhaps we have naturally selected people who could quickly encode knowledge through stories and the oral tradition, or at the very least, we learn the story template when we are children. If you tell a story to someone (or many people), they encode the story quickly and effortlessly in a template for fast future retrieval. This leads to shared cognition! Subsequently, any collaboration should be enhanced.

Reports from the field provide evidence that this may be a fruitful area for research. Julian Orr found that Xerox copier maintenance personnel developed their expertise and helped their peers essentially by telling "war stories" of their maintenance adventures. Smart describes how the top executives used stories to structure complex economic knowledge that, in the course of its production, served to organize, consolidate, and give textual expression to the differentiated expertise and intellectual efforts of a large number of people [26]. More recently, consider the example of a threaded discussion tool (CAVNET) used by the military, which allows several hundred company commanders to post experiences. With over 100,000 posts per month, this system attempts to achieve a common operational picture to improve the commanders' situational awareness through the sharing of information. But the most effective sharing seems to be in the form of a story. For example, in Iraq, a platoon leader posted that his unit experienced an improvised explosive device (IED) that was cloaked by a poster of Moqtada al-Sadr. On the other side of the city, Lieutenant Keith Wilson read this "be on the look out" posting; he told the story to his men, and a few days later a soldier whom he'd sent to peel a poster off a wall peeked behind it first. Sure enough, a grenade was waiting. Clearly, this organizational collaboration, through stories, was useful.

GAD SAAD: SPAM, LOVE DOLLS, VOICES OF MALE ENDORSERS, AND CELL PHONES

Numerous products, services, and advertisements found within the electronic media can be analyzed from a Darwinian perspective, including a pervasive form of business-to-consumer communiqué (spam), online advertisements of love dolls, the choice of male endorsers as a function of the quality of their voices, and the motives that drive consumers to use cell phones.

Spam is one of the most disruptive forms of online communiqués. There are at least three spam-related issues that can be tackled from a Darwinian perspective. First, one might apply memetic theory (see, e.g., [27]) in understanding the transmission and diffusion patterns of spam throughout the internet. Specifically, a MEME is the cultural analogue of a gene albeit in the context of cultural evolution. Hence, spam can be construed as e-memes that spread throughout the internet. Second, one can explore the specific contents of spam to establish the fact that the most "infectious" or perhaps most frequently occurring e-memes are those that are directly linked to key Darwinian drives. Not surprisingly, two of the most common spam topics deal with money and sex-related issues [28]. Third, the relationship between spammers and anti-spammers can be construed as an evolutionary arms race akin to that between pathogens and hosts, or predators and their prey. Specifically, as anti-spammers "evolve" better protective filters, the spammers "mutate" their e-memes as a means of circumventing the new lines of defense.

Countless products and services that are advertised on the internet can be shown to correspond to evolutionary-based mating preferences. For example, Saad conducted a content analysis of the advertised waist-to-hip ratios (WHR) of online female escorts across 48 nations from Europe, Asia, Oceania, Latin and North America, and found that these roughly correspond to the near-universal male preference of 0.70 (mean across the full sample was 0.72) [29]. Given the extent to which sexuality is communicated and sold on the internet, this can easily be extended to a wide assortment of other sexual products and/or services. The American company Abyss Creations manufactures love/sexual dolls that are extremely lifelike both visually and haptically (see www.realdoll.com/studio.asp). To the extent that the company's key selling point is the lifelike nature of its dolls, a morphological analysis of the dolls should be congruent with evolved mating preferences. In Spring 2006, the website had ten female doll types advertised and only one male doll. This in of itself is indicative of evolved sex differences in variety seeking within the mating domain. That said, I analyzed the WHRs of the advertised dolls. These ranged from 0.61 to 0.72 for the female dolls, with a mean of 0.68 (very close to the near-universal preference of 0.70). The one male doll possessed a WHR of 0.94 (close to the female preference for men that possess a WHR of 0.90). Evolutionary-based mating preferences manifest themselves in numerous other e-settings. For example, the use of voice types perceived to be universally appealing (e.g., in telemarketing) is rooted in universal mate preferences. Specifically, a deep male voice serves as a marker of phenotypic quality (testosterone marker [30]). Not surprisingly, some of the most memorable commercial male voices including those of James Earl Jones ("This is CNN"), Will Lyman (narrator of PBS's *Frontline* and numerous movie trailers), the late Paul Winfield (original narrator of A&E's *City Confidential*), and Keith David (his replacement), are similar in that they are all deep voices that exude airs of expertise and authority.

Saad demonstrated that a great majority of consumption acts could be mapped onto one of four key Darwinian meta-pursuits, namely the survival, reproductive, kin, and reciprocity modules [31]. Of relevance to the current Special Section, cell phones, which constitute one of the most ubiquitous tools for electronic communication, not only map onto each of the four Darwinian modules, but also the reasons for using them vary across life cycle stages in a manner consistent with life-history theory. The use of fake cell phones meant to signal one's social status is a form of deceptive sexual signaling [32]. More generally, Lycett and Dunbar demonstrated that cell phones are used for lekking purposes [33]. Teenagers employ cell phones both to gossip, which is an evolutionarily relevant activity [34], and to belong (e.g., use of hip ring tones to signal membership in a "cool" group). Women and the elderly are much more likely to use cell phones for safety purposes [35], whereas jealous mates utilize cell phones as a form of electronic mate guarding to keep track of the whereabouts of their partners (as illustrated by the research of Shayna A. Rohwer). Deutsche Telekom recently reported an 11% income gain as compared to the same quarter of the previous year. This superior performance was attributed to T-Mobile's "myFaves" plans [36], which includes the slogan "Stick Together" and the key selling point: "Helps you stay connected to the people who matter most in your life." In other words, cell phones can be used as a means of increasing social connectedness [37], typically with the most important individuals in one's life, namely mates, family members, and friends. On a related note, the average size of an individual's online social network (e.g., Facebook) has been reported by the researcher Eliot R. Smith to be 150. This corresponds to the evolutionarily relevant group size as predicted from the social brain hypothesis [38]. Two final points worth mentioning regarding cell phones (1) the "cell phones cause brain cancer" belief is a meme that spread very quickly to concerned consumers despite consistent evidence to the contrary [39] precisely because memes that are of evolutionary import are highly infectious and resistant to inoculation; (2) Saad et al. [40] relied on the Darwinian Niche Partitioning Hypothesis [41] in demonstrating the links between birth order and one's proclivity to adopt innovations. This is a noteworthy finding in the context of this Special Section to the extent that many discontinuous product innovations occur within the electronic media.

Peter Todd: Selection for Fast and Frugal Decision Mechanisms

Our minds are evolved to make good decisions when confronting the environmental challenges we typically face. As evolutionary psychologists (and some of the authors in this Special Section) have shown, some of this decision-making is done by domain-specific mechanisms with built-in knowledge and algorithms particular to a certain type of task. However, there are also domain-general forces that have acted to shape many of our decision mechanisms so that they share some clear regularities across domains. In contrast to the traditional rational approach of making choices based on careful consideration using as much information as possible, people often make good decisions by using "fast and frugal" decision heuristics, or mental shortcuts, that rely on relatively little information processed in simple ways. Similarly, while the standard "right" approach to a choice would be to consider as many options as possible, people typically prefer to limit their choice sets to a reasonable size that can be tackled readily by the decision heuristics they employ (see, e.g., the article by Lenton, Fasolo, and Todd in this issue).

There are two main selection pressures limiting the amount of information sought and used by simple heuristics [42]. First, there is the cost of obtaining the information itself, which may be paid in temporal or energetic terms: Searching for information can take time that could be better spent on other activities and can involve expending other resources (physical exertion in scouting out a landscape, exchange of goods to find out about a potential social partner). Furthermore, such costs can arise in both an external information search in the environment, and an internal search in memory [43].

Second, there is the cost of actually making worse decisions if too much information is taken into consideration. Because we never face exactly the same situation twice, we must generalize from our past experiences and apply them to new situations. But because of the uncertain nature of the world, some of the features of earlier situations will be noise, unrelated to the new decision outcome. If we consider too much information then we are likely to add noise to our decision process, and **overfit** when generalizing to new circumstances—that is, make worse decisions than we would if less information had been considered [44].

Given the pressures to make good choices, but doing so using little information, what kind of decision mechanisms could possibly be built by evolution? As it turns out, there is little need for a tradeoff between good decisions and quick/simple decision-making—many environments are structured such that little information suffices to make appropriate choices, and in these cases decision mechanisms that operate in a fast and frugal manner can outperform those that seek to process all available information [45], [46]. Together, these decision heuristics form part of the adaptive toolbox of cognitive mechanisms that humans draw on to make good choices in our environments.

The mind's reliance on this adaptive toolbox of simple heuristics has implications for how we design information systems that interact with human minds. Rather than flooding users with an ever-increasing torrent of information, most of which will not be used (and may in some cases induce choice overload), systems designers need to consider how people will seek out and process a few important pieces of information. Given this knowledge, they should then adjust their designs to help ensure that it is just the appropriate information that people will find and use. This could be done, for instance, by ordering information pieces in terms of the users' perceptions of their importance, or telling the users what features others have felt were important so that they can focus on those aspects in their decisions, or limiting the choice set to the top few options as determined by the users' preferences. This heuristic-centered approach to simple design (already used in part by a number of online sites) rests on, and can be further bolstered by, an evolutionary perspective that takes into consideration the domain-general pressures for good decisions done "quick and cheap."

Richard Watson: Accounting for Evolution in Information Systems Research

Humans are an evolved, thinking, social species. All flora and fauna are evolved, some species are social (e.g., coral and ants), and some have cognitive capabilities (e.g., dolphins and birds). Humans have the most advanced cognitive and social characteristics, and thus it is not surprising that much of information systems (IS) research draws on cognitive and social psychology theory. What is surprising is that, with rare exceptions (e.g., [47], [48]), evolutionary psychology has been ignored by IS researchers as a core discipline for explaining how humans create and use information systems. Darwin's assertion that perception, cognition, and emotion evolved as biological adaptations [49] has been ignored by IS scholars.

We propose that there is a fundamental connection between evolution and our current information processing skills. Our ancestors with better information processing skills were better able to solve survival and reproduction problems. They had to be both efficient (i.e., processing environmental signals rapidly) and effective (solving the problem correctly). IS scholars could, we believe, gain a greater understanding of how humans process information if they recognize the forces that shaped our current brain, the human operating system (OS). Indeed, IS scholars need to be aware that the problems we face today are very dissimilar from the environment in which our cognitive and social skills evolved. We have inherited the finely tuned mindset of illiterate, nomadic hunters and gatherers living in small groups, and it has been a long time since there was an update to our OS despite the massive environmental changes.

The modularity hypothesis is, we believe, a good starting point for introducing evolutionary psychology scholarship in a foundational manner to the IS community. There is general agreement on the modular nature of the mind but disagreement on the degree of modularity [50]. For our purposes, at this point, the key idea of modularity is that our cognitive architecture resembles a confederation of a multitude of functionally dedicated modules designed to solve adaptive problems. Each module solves one problem (though many might receive the same signals) in what might be thought of as fuzzy object-oriented OS. The core intuitions of this system cover areas such as physics, engineering, biology, and probability [49], and the mind has fixed action patterns, such as reciprocation, commitment and consistency, and social proof [51].

As IS scholars, if we are going to incorporate evolutionary psychology into our repertory of explanatory theories, we should initially be concerned with answering some central questions:

- Are there one or more core IS modules, which information do they process, and how do they process it?
- What are the fixed action information processing patterns?
- How do the core IS modules and fixed action templates affect the way humans address today's problems?
- How do we design systems that fit the core modules and fixed action patterns to improve decision-making?
- How do we educate humans to overcome the limitations of their core IS models and fixed actions?
- What old intuitive IS modules need to be replaced by new non-intuitive IS modules (similarly to the way intuitive physics has been replaced by quantum mechanics in certain situations)?

All species process environmental information and their current information processing capabilities are the result of millions of years of evolution. It is time for IS scholars to appreciate that the way we process information today is influenced by these eons of evolution, and that evolutionary psychology can contribute to explaining many facets of current IS behavior.

The Articles in This Special Section

As can be seen in the following summaries, several of the members of the editorial team (Guest Editor and Associate Editors) behind this Special Section are co-authors of articles published in it. In no instance was anyone involved in the review process of his or her own paper. Submissions from members of the editorial team were sent to TRANSACTIONS' Editor (Kim Sydow Campbell), who managed the double-blind review process as in all submissions to the journal.

The paper by Hantula, DiClemente Brockman, and Smith expands on the theoretical model known as the behavioral ecology of consumption, which makes predictions based on foraging theory about how humans make decisions in an online environment. The authors studied subjects that shopped for music CDs in a virtual internet mall with five CD stores, and where in-stock verification delays were manipulated and lasted 2, 4, 8, 16, and 32 seconds. That is, different delays were simulated between the CD selection click and the message indicating whether the CD was in stock or not. Measuring preference as the proportion of total purchases and the shopping time associated with each delay condition, the study concludes that a hyperbolic decay function provides the best fit for the data. The higher the delay, the lower the proportion of purchases and shopping time observed, following a hyperbolic decay function. This finding is consistent with and replicates previous findings related to online shopping where delays have been manipulated.

The paper by Stenstrom, Stenstrom, Saad, and Cheikhrouhou puts forth a theoretical framework that explains sex differences in terms of cognition processes and how those differences relate to online navigation and website preferences. The framework builds on evolutionary psychological notions and is supported by recent findings in the field of cognitive neuroscience. The article proposes specific website design recommendations and presents the results of a pilot study examining sex differences in web navigation. One of those results is that males seem to spend significantly less time than females to complete tasks in deeper websites (with multiple links organized in layers of pages) than in wider websites (with multiple links on the same page). The pilot study suggests that taking an evolutionary perspective to the study of online navigation and website preferences can lead to findings that have significant implications for both electronic communication researchers and practitioners.

The paper by Lenton, Fasolo, and Todd looks into whether the broader range of mate choices afforded by online dating sites is really useful to those looking for a mate. The authors conducted two experimental studies examining the effects of increasing option set size on anticipated and experienced online mate choice perceptions. The first experimental study suggested that participants of both sexes anticipated experiencing more difficulty in choosing from a large group of possible mates, with expected difficulty increasing with group size. In this first study, the expected ideal mate group size contained 20 to 50 potential mates; these expectations were independent of the sex of the individuals selecting potential mates. In the second experimental study, the authors found that even though small (4 options) and larger (20 options) mate group sizes were experienced as equally difficult to choose from, the expected preference for the larger ideal set size (20 to 50 potential mates) in terms of greater enjoyment and satisfaction and lesser regret did not materialize: A small group of possible mate choices produced the same affective experience as the ideal group size obtained in the first study. The authors explain this effect by pointing out that there is a mismatch between the quantity of options available to choose from in our species' evolutionary past and the far greater numbers made available today by technology, arguing that our Stone Age brain is not designed to deal with the latter—even though we may think that having more choices is necessarily a good thing.

The paper by Kock, Chatelain-Jardón, and Carmona concludes the Special Section with an experimental study of the effect that computer-simulated threats have on the knowledge communication effectiveness of a web-based interface. The study builds on the assumption that it is evolutionarily adaptive for humans to have enhanced memories of events surrounding surprise situations, arguing that in our evolutionary past many situations involving surprise events were associated with survival threats. For instance, the authors point out that having enhanced memories of contextual elements (e.g., vegetation, rock formations) in the temporal vicinity of a snake attack allowed our hominid ancestors to be better prepared to avoid and deal with future attacks. That, in turn, enhanced those individuals' future chances of survival and led to the genes associated with better memorization to spread throughout the entire human species. The authors show that such enhanced memorization capacity likely endowed on us by evolution can be exploited with practical results. They do so through a knowledge communication experiment in which subjects were asked to review web-based learning modules and then take a test on what they had learned. Data from six learning modules in two experimental conditions were contrasted. In the treatment condition, a web-based screen with a snake picture in attack position displayed with a hissing background noise was used to create a simulated threat that surprised the subjects. In the control condition, the simulated threat was absent. As expected based on the evolutionary psychological view that surprise can enhance cognition, the subjects in the treatment condition (i.e., with the snake screen) performed approximately 28% better in terms of test scores than those in the control condition (i.e., without the snake screen). Also consistent with the authors' predictions, this improvement occurred only for the two web-based modules immediately before and after the snake screen.

CONCLUSION

Over the years, many electronic communication theories have been proposed and tested. The 1980s and 1990s, in particular, witnessed the emergence of many such theories, quite a few coming from researchers in the IS field. Those theories can generally be seen as falling into one of two main categories, namely technological and social theories. Technological theories place emphasis on technological features as predictors of electronic communication behavior and outcomes; social theories place emphasis on social influences as predictors. Proponents of social theories have often criticized technological theories as narrow and deterministic, whereas proponents of technological theories have sometimes retorted that social theories are somewhat imprecise and difficult to use in the development of testable predictions.

Biological theories of electronic communication can arguably help bridge the gap between technological and social theories, although this may not be self-evident. One example is the development of media naturalness theory [4] as a replacement for media richness theory [52]. The latter has been presented by social theorists as a model of technological determinism. Media richness theory essentially makes two fundamental predictions: (a) that communication media that are rich, or face-to-face-like, will be preferred by individuals engaged in complex collaborative tasks; and (b) that when media choice is constrained to lean media, the outcomes of complex collaborative tasks will be negatively affected.

Since media richness theory's publication in the 1980s, many empirical studies have shown that: (a) individuals do not always choose the richest media available to them to accomplish complex collaborative tasks; and (b) even if they choose lean media the outcomes of complex collaborative tasks are not significantly affected. That is, while some studies did support the two key predictions of media richness theory, many did not—essentially falsifying the theory. Some of the studies that contradicted media richness theory showed that social influences have a stronger effect on media choice and outcome quality than the richness of a medium. Two researchers that have been particularly effective at conducting and reporting such studies are Allen Lee and M. Lynne Markus.

Yet, media richness theory predictions have been consistent with the frequent finding that users of lean media report dissatisfaction and perceived difficulties associated with those media after they use those media to accomplish complex collaborative tasks. One problem here, though, is that media richness theory proponents have not provided a scientific explanation for their predictions. By comparison, one can predict that tangible objects will always fall to the ground, and that argument will prove correct in many circumstances. Yet it will prove wrong in other circumstances, such as inside a free-falling airplane. Without a theory of gravitation like Isaac Newton's or, better yet, Albert Einstein's, one cannot make much sense of the exceptions. Nor will one be able to explain other related observable facts such as planetary orbits.

Media naturalness theory [4] builds on human evolution theories to argue something similar to what was argued by media richness theory, but in a way that appears to open the door for its integration with social theories. Media naturalness theory predicts that individuals using an electronic medium that suppresses face-to-face communication elements (such as the ability to convey tone of voice) will experience three main effects. They will experience a perceived increase in mental effort, communication ambiguity, and dullness when using the medium to perform complex collaborative tasks. The increase will be proportional, according to the theory, to the degree of naturalness of the medium, or to its degree of similarity to the face-to-face medium. This prediction is based on the simple assumption that our brain is designed to excel in, and make us enjoy, face-to-face communication. The reason, which has been discussed earlier in the article, is that during over 99% of our ancestors' evolutionary history they communicated primarily face-to-face.

Since media naturalness theory does not make any predictions in connection with media choice or task outcome quality, it is perfectly compatible with a social theory that predicts that peer pressure will influence media choice regardless of the naturalness of the media. For example, a group of individuals may end up using email to accomplish complex collaborative tasks due to peer pressure, while another group accomplishes the same task interacting face-to-face. The email group may perform just as well or better than the face-to-face group at accomplishing the task. Nevertheless, media naturalness theory's prediction is likely to hold. That is, the email group will experience higher levels of perceived mental effort and communication ambiguity, and a higher sense of dullness, than the face-to-face group.

The discussion above must be tempered with three important comments. First, the proponents of media richness theory should be commended for having developed an ingenious theory at a time when the use of electronic communication media was much less widespread than it is today. Media richness theory has led to a vast amount of empirical and theoretical research, including the development of media naturalness theory, and is probably one of the most widely cited theories of electronic communication. Secondly, media naturalness theory is much newer, and thus has yet to withstand the test of time. Some tests of the theory have so far led to promising results (see, e.g., [53]), but it is too early to rule out the existence of major flaws in the theory. Thirdly, media naturalness theory is far from explaining electronic communication behavior in its full complexity, and it is unlikely that any biological theory will ever achieve such a feat. Technological features and social influences are too numerous and strong to be ignored, particularly in real world (as opposed to experimental) contexts.

To conclude this article, let us address a question that has probably crossed the mind of many readers interested in evolutionary explanations of electronic communication behavior. The question is whether we, as a species, are currently evolving (in a biological sense) to become better at using electronic communication technologies? To answer this question, we have to go back to a basic principle of modern Darwinian thinking. For a set of genes associated with a particular trait to spread throughout a species, the genes generally have to increase the reproductive success of the organisms that carries them. (The reason for the qualifier "generally" is that the actual unit of selection is the gene, not the carrier organism; there are genes that spread without necessarily increasing the reproductive fitness of their carriers.) In other words, the question can be rephrased as follows: Is it likely that people who are better at using electronic communication technologies will have a greater number of surviving children? The answer is probably "no," because ability to use electronic communication technologies is likely to be positively correlated with education level. And education level is generally believed to be negatively correlated with fertility, primarily because of better access to effective family planning and/or contraceptive methods.

Nevertheless, in the coming years it will look like the new generations will be increasingly more adept at using electronic communication technologies. The reason is that more and more members of the human species will start communicating electronically at an early age, when our brain is the most plastic, and will keep on communicating electronically more often than members of previous generations. That may give many the illusion that the species as a whole is getting better at electronic communication, and that there is a genetic explanation behind that.

As more and more people start communicating electronically at an early age, there may be one undesirable consequence, namely an increase in psychological (e.g., social anxiety) and medical (e.g., myopia) disorders. Very few human traits are fully determined by our genes (e.g., blood type), and the vast majority are determined by a complex interplay between genes and environment. Since we have evolved a biological apparatus apparently designed for face-to-face communication, it is likely that we need a great deal of face-to-face communication early in life to stimulate the proper development of that apparatus. That is, too much electronic communication early in life may lead to a host of psychological and medical disorders later in life.

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