

Commentary on “An Evolutionarily Informed Education Science”

by David C Geary

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***Abstract:** Dr Geary’s paper centers on the concept of inherited folk psychology modules, together with the idea of a transition from primary to secondary learning. This paper suggests that there exist only effective folk psychology modules, which are the result of interaction of inherited primary emotional systems with the physical, biological, and social environment. Consequently there is no transition from primary to secondary learning; all cognitive modules result from the process characterised by Dr Geary as secondary learning. Furthermore, an evolutionary psychology analysis does not support the idea of a phoneme-based approach to learning how to read, as suggested by Dr Geary; rather all evolutionary processes are top-down as well as bottom-up, and hence rather support holistic, meaning – based approaches. Finally the issue of proof and evidence in these contexts is raised; it is suggested that no adequate criteria have been given for proving existence of the suggested folk psychology modules, whereas such criteria do exist for the primary emotional systems that are in fact the lynchpin of evolutionary psychology effects.*

This interesting paper tackles an important issue: in what way our evolutionary biological heritage affects educational issues. David Geary states the overall theme as follows: “Evolutionary educational psychology is the study of how an evolved bias in children’s learning and motivational systems influences their ability and motivation to learn evolutionarily novel academic abilities and information in school”. The focal article presents a multifaceted and complex analysis of that topic, and Geary makes strong claims that this theory can be useful in the educational context: “This evolutionarily informed education science has the potential to answer key questions in instruction and learning the mechanisms I outline here provide a means for generating empirically testable hypotheses about children’s academic motivation and their ease of learning in school, as well as equally important hypotheses about the effectiveness of alternative instructional methods”. However

this statement is controversial. There are some significant points I wish to raise about the argument in the article, which I think need clarification and development. In doing so, I will make some suggestions as to how they might be taken further and become closer to the educationally important theory claimed.

The Claimed Modules

The first point is that the proposals made in this article center on a set of claimed evolutionary salient information processing domains and associated cognitive modules, comprising the domains of folk psychology, folk biology, and folk physics. These modules are the assumed lynch-pin between evolutionary forces and current behavior. What we are presented with is essentially:

Evolution → *folk modules* (1)

Folk modules → *learning effects*. (2)

As to the latter, in effect, it is claimed that there is a tension between these folk modules and the educational needs we have in order to fit into today's society, which, for example, expects writing and mathematical abilities that cannot be built into folk modules which relate to evolutionary needs in the distance past. Geary continues: "The cross-generational accumulation of secondary knowledge has resulted in academic disciplines (e.g., mathematics) and other knowledge-based features of modern societies that are becoming increasingly remote from folk systems. The result is a conflict between children's bias to rely on folk systems and the need to inhibit these systems in order to engage in secondary learning"

Thus, a key feature of the article is the claim of the existence of 16 special-purpose evolutionarily determined functional modules (see Figure 1 of the article). It is implied that these modules are genetically determined, having been formed by Darwinian evolutionary processes in response to conditions in the hunter-gatherer epoch in our evolutionary history, and that they are repositories of implicit folk psychological, biological, and physical knowledge. However, no biological evidence is given for their existence, and no biological mechanisms are proposed that could lead to their coming into being in either evolutionary or developmental terms. Their existence is presumed from psychological behavior; but that gives no evidence as to structure or evolutionary or cultural origins. As to their possible evolutionary origin, as they supposedly relate to specific human understandings, it is hard to see how

they could come into being in this way except through some form of Lamarckian mechanism, which in terms of current evolutionary theory is forbidden. The key point here is that according to standard genetic theory, nothing you understand or think influences the genes you pass on to your progeny, for they are fixed the day you are born. Hence any intellectual understandings you may have cannot be selected for in biological terms, as they do not influence your genetic inheritance.

In terms of the link to biology, we are supplied with some comments on brain imaging data but given no real evidence this is useful in terms of understanding either the evolutionary psychology or educational claims made, and in particular these data are not used to support the existence of the claimed special purpose functional modules. In contrast to this lack of a biological connection is the kind of multi-faceted solid biological evidence provided by Panksepp (1998) for the primary emotional systems he claims exist (if you like, emotional modules), which I will return to later.

Overall, while evolutionary arguments are presented in this article, the link to biology is weak; but it is that link that must underpin whatever argument is used. Claims that are not underpinned by solid biological evidence are not very convincing. Lacking a Darwinian rather than Lamarckian mode of production for such genetically determined folk modules, I dispute that they indeed exist. However *effective* modules may exist that are developmentally created in response to environmental conditions, in that systems may be developmentally set up leading to reliable behavior mimicking the effect of folk modules, even if such modules do not exist as identifiable physical entities.

Effective Modules and Adaptation

The second point is the way folk systems relate to cultural innovations. Geary states “I am suggesting that the components of fluid intelligence enable the creation of secondary abilities by modifying folk systems”. But this is wrong if folk modules do not exist *a priori* with genetically inherited knowledge inbuilt, so that they then have to be modified to fit a new environment. I claim the effective folk modules do not have this nature: rather, the effective folk systems develop in response to the ambient environment in an adaptive way and hence this conflict does not arise. Thus I propose that the identified folk systems do not exist as genetically determined modules; rather, given a set of basic intellectual capacities, these effective modules develop as a result of interactions with the social and physical environment.

The key difference is that in the article the supposed folk modules are taken to be inherited (genetically determined), whereas I propose they are of developmental origin, and hence environmentally shaped. Then they will automatically adapt to cultural innovations, as they will indeed be shaped by the culture in which the individual is situated. There will be no need of experiential modification to fit a new set of circumstances that clash with basic primary modular competencies; rather, the behavior that gets inbuilt in effective folk modules will be suitably tuned *ab initio* to the culture in which the individual lives, because they are created through interaction with that culture. This experiential shaping of these systems to fit the local environment is an aspect of the crucial feature of brain plasticity (Donald, 2001).

Emotional Systems as the Core Link

By what kind of mechanism can brain plasticity lead to the formation of these effective modules in this adapted way? This has to be an adaptive process, of the kind labelled 'Neural Darwinism' by Gerald Edelman (1989), implemented by neuromodulators such as dopamine broadcast to the neocortex from the limbic system. But that system is the seat of emotional processes, so the fitness function guiding these adaptive processes (Toronchuk & Ellis, 2005) is provided by the genetically determined primary emotional systems of the kind examined in detail by Panksepp (1989). Hence, evolutionary pressures in the ancestral environment developed various psychological traits that are experienced by us as emotions and feelings, which result in behavior enhancing our evolutionary adaptation to the ancestral environment. What is inherited are basic cognitive abilities, rather than specific cognitive modules, plus the basic sensory and emotional systems. Any effective cognitive modules that result develop from interactions of these systems with the social and physical environment, with the salience of reactions guided by the inherited emotional systems.

Thus, I suggest that what we have instead of (1) and (2) is,

Evolution → *emotional systems*; (3)

Emotional systems + experience → *effective folk psychology behavior* (4)

Effective folk psychology behavior → *learning effects*. (5)

This proposal is based on the following series of causal mechanisms:

1. Emotional systems play a key role in brain function (Damasio, 1995; Damasio, 2000), and are causally effective in changing behavioral patterns; conscious emotional feelings emerged because they furthered this process, particularly in social contexts.

2. Some emotional systems are more beneficial than others in terms of their effect on the capacity to survive. Thus, emotional systems are selected for in terms of their enhancement of survival capacity in the ancestral environment; this results in the evolution of relatively hard-wired primary emotional systems, which underlie the development of both intellectual capacities and more soft-wired secondary emotions.

3. Individuals experience these as emotional systems underlying psychological and developmental events, particularly through subjective feelings thereby induced, without being aware of their evolutionary origins and function. These mechanisms share a common evolutionary imperative to meet developmental needs in the ancestral environment, and they continue to act in analogous ways today although in a completely changed environmental context.

Overall this process is of Darwinian rather than Lamarckian nature, because it does not propose genetically determined modules with specific cognitive content, but rather genetically determined emotional systems that guide cognitive development.

Education and Motivation

The key to learning and education is motivation. The article by Geary refers to the motivational biases that are important educationally, but the underlying systems are not considered in their own right, as they should be if they are the foundation of evolutionary psychology behavior, which I propose is the case. I suggest they are, on the one hand, the primary emotional systems studied in particular by Jaak Panksepp (1998, 2001), and on the other, the secondary (culturally based) emotional systems that derive from the primary (genetically based) ones through developmental and social interaction. If this is correct, an important facet of what is going on is to determine the nature of the genetically fixed primary emotional systems.

Their nature as proposed by Toronchuk and Ellis (2005), as a modification of Panksepp's work, is set out in Table 1. The educational issue is which of them are important for learning, and how this happens. This cannot be considered in depth here, but in brief, firstly there is the deep-seated need to understand and find meaning, enabled by modelling and extrapolation, the relevant emotional system

being the SEEKING system. Then there is the consecutive importance firstly of bonding with the caregiver (Schore, 1994), facilitated by the NEED/ ATTACHMENT system, secondly of both rough and tumble play and intellectual play, facilitated by the PLAY system (Russ, 2004), and thirdly of social cohesion with peers (inclusion) and inspiration by role models, facilitated again by the NEED/ATTACHMENT system, together with competition and social ranking, facilitated by the POWER/dominance system. If this is correct, a key educational issue is how to adapt the learning environment to acknowledge these emotional systems and how to regulate the emotional climate of the school, which can be crucially important in either facilitating or impeding learning. For instance, in early childhood contexts, this provides support for a re-emphasis on play as a key learning mechanism.

Similarities and Differences

This has similarities with what is proposed in Geary's paper, but with significant differences. He states that "children's evolved behavioral biases such as social play, and their observation of and learning from culturally successful adults results in the automatic and effortless modification of folk systems and the learning of the forms of culturally-important activities, such as hunting, that have a long evolutionary history. For these domains and activities, there are corresponding motivational biases that ensure that children engage in the necessary activities".

While the statement about motivational biases essentially agrees with what I propose above regarding the primary emotions, the claims of behavioral biases towards activities such as hunting are hypothetical. The myth of the blank slate (Pinker, 2001) is being replaced by the myth of the prepared mind. If this were indeed the case, one could prove it by showing children adapt naturally to hunting! There is, as far as I am aware, no evidence that present-day children are any more prepared for this activity than they are for mathematics. Liebenberg (2001) presents the reality of hunting in a hunter-gatherer society:¹ animal tracking demands as much learning and hard work as mathematics does. Geary's strictures about the necessity of the effort apply in this case too. A key issue here is the self-motivation arising from the need to know and understand, motivated by the SEEKING system, and how this can be educationally enhanced. Partly learning maturity is associated with the transition of socially based motivation from the ATTACHMENT system to the POWER/ DOMINANCE system: from hanging out with your peers to competing

with them (this is mentioned by Geary as a key requirement, but not in these terms). Additionally, an important point is that when Geary talks about the social systems that lead to learning, he omits mention of the crucial motivational and educational power of role models in guiding development (Longres, 1990). In order to sustain the effort required to learn either high level hunting or mathematics abilities, this plays a major role: the issue is whether a parent is a hunter or an engineer.

But what about the main claims Geary makes of the need to overcome the folk systems and make a transition from primary to secondary knowledge and learning? The core issue here is, What is the distinction between primary and secondary knowledge? Based on the above analysis, I suggest there is none: all learning takes place by the mechanism Geary identifies as secondary learning, because there is no inherited primary cognitive capacity of the kind suggested, for example, by a proposed innate ability to hunt. Hence, there is no need for a transition from primary to secondary learning: it is all of the nature described in his paper as 'secondary'.

How about then the need to alter or override folk systems? In my view, folk systems develop to fit the ambient environment and so do not have to be altered. But what is needed, and this may in effect be what Geary is referring to in his discussion of educational issues, is on the one hand curbing emotional demands in favor of intellectual understanding (Damasio, 2000) so as to attain a rational understanding of the situation, and on the other learning to counter the sometimes deceptive leanings given us by our intuition (Myers, 2002). Intuition is not inherited genetically but rather is developed through interaction with the environment, leading to the automatic behavioral rule of thumb responses that Geary refers to. This is generally very effective, but sometimes importantly misleading (Myers, 2002).

Bottom-up and Top-down

A final key issue in all of this is whether the learning process is primarily top-down or bottom-up: whole to part, or part to whole. Geary's article implicitly takes a stand on this important issue, in effect suggesting it is all bottom-up. This viewpoint underlies much present day educational psychology and the highly politicised 'reading wars' over approaches to teaching reading which Geary refers to in his article.² Along with critics such as Krashen and Tracey (1983) and Goodman (2005, 2006), however, I believe it is seriously mistaken and can have harmful effects.

Whole-part causation is a key ingredient of both development and function (Ellis, 2008), and hence of evolutionary processes. It is therefore necessarily important in education too. I believe this is a key issue in all learning and education. It shapes the nature of the evolutionary origin, development, and function of both capacities and ideas. Consequently, I suggest that in an evolutionary-based approach to education, the primary emphasis should be on top-down development, later (or consecutively) filled in by bottom-up analyses. Skills are best learnt in a meaningful context, for that is the evolutionary reason they came into existence: behavior is purposeful. As regards language acquisition, words such as *kangaroo* are not understood bit by bit and then assembled (*kan-ga-roo* → *kangaroo*), they are heard in a context that enables them to be experienced as a meaningful whole and then understood in terms of their parts. Learning will work best in a similar way through the equivalent of an apprenticeship system, where the whole is experienced and appreciated first and the component parts comprehended simultaneously or later. How this occurs in the case of language is indicated by Tomasello (2003).

With regard to reading instruction, by emphasizing the primacy of teaching skills related to phonics instruction and phonemic awareness, Geary isolates the technical skills aspect of the process from the holistic practice of reading (or writing) and does not refer to the large body of significant research that views literacy as social and cultural in nature, forming part of people's daily lives (Brice Heath, 1983; Street, 1995; Barton, 1994). According to Goodman and Goodman (1979/2003), though written language is not the same as oral language, it can be learned in similar ways to the way oral language is learned when it is used in personally meaningful ways to communicate, to understand and be understood. The various aspects of language --- talking, listening, reading and writing --- are learned together with an emphasis on making meaning (Wells, 1987).

In this emergent literacy approach, a focus on holistic activities, including imaginative play and story reading and telling allows children to develop symbolic representation and rich and complex forms of language. Phonemic and phonological awareness can thus develop as part of and as a consequence of language play, based in the PLAY system, making the need for explicit teaching less necessary. Motivation is high because as with learning how to talk, where babies are nurtured and encouraged to behave like language users, children learning to read and write are apprenticed into literacy by being encouraged to behave like readers and writers,

in an environment that is conducive to written language learning (Holdaway, 1979). Gradually, through many purposeful and meaningful interactions with people and print over time their performance moves from immature approximations of reading and writing (pretend reading and emergent writing with invented spelling) to conventionally accepted modes (Ferreiro & Teberosky, 1993).³

The various ways that children are (or are not) introduced and exposed to literacy related activities at home and in the community thus informs and influences school learning. According to Krashen, the natural approach to language acquisition in the classroom is based on the theory that language acquisition occurs only when students receive comprehensible input. The emphasis is on reading and listening comprehension for beginning students, not repetitive meaningless drill in phonemes, which, in my view, kills the wish to learn.⁴ According to Goodman (2005, 2005a), in the whole language approach, reading is construction of meaning during a transaction between the reader and the text. It is making sense of print. The whole language belief is that learning needs to involve complete meaningful texts. The basis for this is the primary emotional need to understand what is going on, driven by the SEEKING system. Thus, rather than there needing to be a conflict between children's bias to rely on folk systems and the need to inhibit these systems in order to engage in secondary learning as Geary states, the challenge is to create the conditions that enable children to use their substantial learning abilities to make sense of a complex but meaningful whole.

The brain imaging data referred to by Geary does not by itself prove the best approach to written language learning in general is via phonemics (this might be a key ingredient in the case of remedial work for children who are dyslexic, but even then whole-part processes must remain crucial). The brain imaging data (see, for example, Shaywitz et al., 1996) confirms that phonemic processing occurs in particular brain areas, but does not show how reading comprehension occurs, for phonemic processing is only one part of what is involved in reading. In particular, this data does not prove that this process is bottom-up only, as claimed by Shaywitz et al.,⁵ nor does it show what motivation is crucial for education.⁶ In particular, studies based on nonsense word strings cannot engage the full range of faculties engaged in language processing and understanding, and the lack of meaning of such word strings is surely likely to demotivate learners forced to memorise them (Goodman, 2005a; Goodman, 2006; Willis, 2007). Additionally, there are deep

theoretical problems with the concept of intensive phonics instruction (Strauss & Altwerger, 2007), as it tries to simplify systematically the complex and variable nature of the English language which is in fact not strictly alphabetic, but displays significant logographic features. Thus from an educational viewpoint, this approach has been claimed to have a narrow and limiting character (Taylor, 1998; Meyer, 2002).

As regards the argument presented from an evolutionary psychology viewpoint for a phoneme based approach to written language learning, as explained above I do not buy into the supposed transition from primary to secondary learning that underlies that argument, nor do I accept that the human brain is hardwired to process spoken language but not written language.⁷ But suppose I did accept both items, I still don't see why this is supposed to support a bottom-up rather than top-down approach to language learning. I suggest that this result is simply assumed rather than being shown to be an inevitable consequence of an evolutionary approach. Indeed I suggested above that a thorough analysis of such an approach will come to the opposite conclusion, because top-down processes play a key part in evolutionary development.

Overall, my view is that *the core competency of language is communication*; if spelling, pronunciation, or syntax are defective, that is not particularly serious if the intended meaning is conveyed. The causative link is top-down from meaning to grammar, syntax, and phonemes, not the other way round. I suspect an open-minded evolutionary analysis will support this contention.⁸

Proof and Evidence

My final concern is the relation of this article to proof and evidence. Numerous predictions are made on what appears to be a somewhat tenuous basis, but no evidence is provided that these predictions are correct. Indeed we don't even know how hard-nosed these predictions are intended to be, in terms of possible proof or disproof. Would a single counterexample suffice to show them wrong?⁹ If not, what level of support would be taken as confirmation and what level of disagreement as showing them wrong?

In essence, it is not clear what a prediction means in this context, how it is tested, and to what degree the claimed predictions are in fact proven, except for those cases where the answer is already known and a "prediction" is made after the fact.¹⁰ Furthermore it is not clear how many of these predictions (I counted 37) are

specifically related to evolutionary theory as claimed, and how many are rather related to functional needs, which therefore have to be fulfilled and are related to evolutionary aspects simply because all our capacities are derived in an evolutionary way. They can be deduced on functional grounds without specifically mentioning evolution.¹¹ The lack of a clear relation to proof and evidence applies in particular as regards the claimed existence of folk modules, already critiqued above. Indeed we are not even given a clear set of criteria that characterize their existence and can be used to test this hypothesis.

By contrast, there are seven criteria for primary emotional systems laid out in Toronchuk and Ellis (2005), relating to origin, structure, and function, and one can test the proposals made by checking these criteria. We propose that a well-established primary emotional system should have *all* of the following characteristics:

C1. *Concept*: It corresponds to a specific range of human feelings and characteristic behaviors, associated with clear eliciting stimuli and with universal affective outcomes, expressed in specific bodily behavior that may include facial expressions.

C2. *Structure*: It is effective through neural circuitry that can be traced by neuroanatomical techniques. Nevertheless, each primary emotional circuit supervenes on a distinct pattern of neural activity rather than on an exclusive set of structures. These circuits comprise distributed networks extending from brainstem to neocortex; each is integrated with the pathways of other primary emotions that may use components of common brainstem pathways.

C3. *Function*: Each primary emotion system affects immediate affective functioning, and, because a particular combination of neurochemicals is used by each primary system, each can functionally take part in neural Darwinism.

C4. *Development*: Development of these systems will be mainly genetically determined by multiple genes and therefore susceptible to alteration by mutation or deletion.

C5. *Origin*: It can be associated with ancestral survival needs in a convincing way that is related to homologous traits based in evolutionary ancestry, and hence can be clearly related to an evolutionary origin by affecting adaptive fitness.

C6. Occurrence: It occurs universally in humans and can be associated with homologous systems and evolutionary precursors; this enables a correspondence of the features listed above (2-5) between humans and other vertebrates.

C7. Outcome: Usually, its dysfunctional aspects can be associated with behavioral or psychiatric disorders, whose nature is related to the missing standard function and/or disinhibition of lower level components of its circuitry, or to over-activation of these functions; and hence such disorders shed light on normal function (see Stevens & Price, 2000, for illuminating examples).

In practice one cannot show that all of these criteria are satisfied for a particular proposed system, but showing that about half are true will be quite convincing. Any proposal for important evolutionary effects on education must face proper testing, and I suggest this testing is possible for the proposals made here of emotionally based mechanisms underlying evolutionary psychology.

Conclusion: The Key Issues

The central picture in Geary's article is pre-existent folk modules clashing with educational needs. I suggest the real picture is basic abilities (observation, pattern matching, classifying, extrapolation)¹² plus emotional assessment developing both effective folk modules and sophisticated understanding through interaction with the social, biological, and physical environment. The natural abilities of students will develop understanding in line with intellectual and socio-cultural opportunities offered if the emotional climate does not inhibit this taking place¹³, and the material is presented in a way that enables holistic engagement and understanding. I believe this picture can be supported in evolutionary, developmental, and functional contexts with a proper biological base, and can provide a fruitful way that evolutionary origins can be tied in to education projects. The need in educational terms is to understand, on the one hand, the proper mix of top-down and bottom-up presentation that will make for real comprehension, and, on the other, the way the various emotional systems aid and hinder learning in evolutionary and developmental contexts, each feeding in to the other.

I believe evolutionary psychology in general, and evolutionary educational psychology in particular, will become much more solid in terms of prediction and proof, and will be much closer to biological mechanisms, when it acknowledges the key role of the primary emotional systems, explicitly examining their significance as links between the complex of behavior, development, and evolution, on the one

hand, and the physical and social environment, on the other. A central task then is investigating how, in developmental terms, they reliably lead to the kind of effective folk systems identified by Geary in his article, and in particular how they relate to development of language, where emotional systems play a key role (Shanahan, 2008; Panksepp, 2008).

The core mantra for education that derives from all this is, *be aware of and nurture the emotional and motivational climate in the classroom* (Willis, 2006, 2007). This is what policy makers, teacher trainers, teachers, and parents need to be more explicitly cognizant of; in most education institutions and curricula at present, although it is implicit in some developments such as group-learning methods, it tends to be treated as a supplementary rather than a core educational issue.

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Footnotes

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1. Liebenberg has lived with San hunter-gatherers in the Kalahari, and runs a school of tracking for bushman youth -- see <http://www.cybertracker.co.za/ArtOfTracking.html> and http://www.mg.co.za/articledirect.aspx?area=mg_flat&articleid=42349.

2. See <http://www.ed.gov/programs/readingfirst/index.html>.

3. For a fascinating detailed account of how this occurs, see *Chloe's Story* (Bloch, 1997).

4. For example, Goodman states "One five year old, the best reader in her class, came back to the room in tears sobbing to her teacher 'I couldn't make any sense of those words'" (Goodman 2008).

5. "Once phonological processing had been identified, ... scientists had defined the basic functional cognitive unit underlying reading and reading disability." (Shaywitz et al., 1996, p. 80).

6. The words "emotion" and "motivation" do not occur in the index of Lyon and Rumsey (1996). One can suggest that brain imaging studies relating to language acquisition would be usefully enhanced by including imaging of activity in the limbic system.

7. Shaywitz and Shaywitz (2007) identify three neural systems for reading in the brain's left hemisphere. Surely they must be regarded as components of a reading module, arising in a developmental way, just as language modules do (Tomasello, 2003).

8. Indeed, a nice recent example is the development of an sms form of language.

9. See, for example, the claim that at increasingly higher academic levels "academic learning is predicted to become more difficult and any motivation to engage in this learning is predicted to decrease", which is obviously false as regards many academics.

10. See, for example, Geary's statement: "Some people are predicted to be interested in reading about mechanical things (e.g., the magazine *Popular Mechanics*)".

11. See, for example, Geary's statement: "The prediction is that novel and complex tasks will require an attention-driven, explicit representation of task goals and information patterns in working memory".

12. See Tomasello (2003) for a characterization of these capacities.

13. For example, fear and shame are often key ingredients in inhibiting mathematics learning.

Table 1. Evolutionary needs and the emotional systems that have evolved to meet them, according to Toronchuk and Ellis (2005). All the systems E2-E9 work with E0 and E1, so that dependence is not explicitly shown. Systems E2 and E9 are additional to those proposed by Panksepp (1998, 2001).

<i>EVOLUTIONARY NEEDS MET</i>	<i>PRIMARY EMOTIONAL SYSTEM</i>	<i>Works With:</i>	<i>FUNCTIONS</i>
<i>INDIVIDUAL NEEDS</i>			
<i>Basic Functioning</i>	E0: PLEASURE system (hedonic appraisal)	E1	Satisfying needs, reward, consummatory activity
	E1: SEEKING system (incentive salience)	E0	Situation Evaluation: identifies needs, provides arousal/ excitement, facilitates learning
<i>Basic Survival</i>	E2: DISGUST system (repulsion)		Avoiding harmful foods, substances, environments
	E3: RAGE system	E4,E9	Defense: aggression, protection of resources, and conspecifics, limiting of restraint on movement
	E4: FEAR System	E3,E9	Defense: flight, limiting of tissue damage
<i>Learning</i>	E5: PLAY system *	E7,E8	Bonding with conspecifics, development of basic adaptive and social skills, creativity
<i>SOCIAL NEEDS</i>			
<i>Reproduction</i>	E6: LUST system † (sexual desire, satiation)	E7,E8	Ensuring procreation, enhancement of bonding
<i>Group cohesion: Social Bonding</i>	E7: NEED/ATTACHMENT (affiliation, separation distress)‡		Creates bonding through need for others
	E8: CARE system	E6,E7,E5	Caring for others, particularly children
<i>Group function: Regulating conflict</i>	E9: POWER/dominance system (rank, status, submission)	E3,E4	Controlling aggression in society, allocating resources, especially sexual ones

(table continues)

Table 1 (cont.)

*Panksepp describes this system as "rough and tumble play", which may describe the major component in many mammals, but in humans it also encompasses many other forms of play that facilitate learning and creativity.

† This can be regarded as consisting of desire and consummation systems.

‡ Labeled the Panic System by Panksepp because of the way it functions when there is separation distress; however, that is not its only mode of functioning.