EXPLAINING LATERALITY

The following is Section 5 of:

‘How Is Your Experience in the Reconstruction Paradigm of Memory?’

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Short Abstract

The paper attacks rigid conceptions of experience to reveal a dimension of experience that only appears in memory. Bringing this endangered species of experience to life enhances our understanding of the reconstructive processes of memory. Reasons central to the reconstruction paradigm of memory motivate ‘rotating’ it about its axis of strength, a movement divorcing it from the accuracy-oriented approach. Sections 1 and 2 provide existence proofs of recollective memory this approach leaves unaccommodated. Sections 3 and 4 supply matters of degree memory cases. In Section 5, I explain mammalian laterality, showing our brains and selves have features in the existence proofs. In Section 6, I make clear that understanding how our hemispheres experience and remember is hampered by facile attitudes towards experience.

5 *EXPLAINING* LATERALITY

> *The whole world is a fire pit. With what state of mind can you avoid being burned?*
> KAO-FENG

One starting point is the principle that to explain laterality, we need a better understanding of why the mammalian brain is the way it is generally, i.e., two hemispheres rather than one neocortical sphere, and why mammalian brain evolution comes with increases in split-braininess (as allometric laws would suggest it shouldn't).[26] Questions are: What two basic functional capacities might be optimally selected for in mammalian evolution generally, and that would need an increase in functional separation with greater neocortical capacities? Why are our self-identifying processes of experience lateralized as they are? Answering them shows *experience* is a driving force behind anomalies for the current paradigm of recollective memory.

First function: One fundamental capacity that all mammals and birds will need is an *executive system.* My account is like most any theory of brain and behavior in having an executive system. In particular, my account's executive system is: a set of (predominately) neocortically represented abilities to control environmental items and the mammals' relation to them with efficient representations and cognitive processes, using heuristics to access and apply a schematic knowledgebase. In most marine mammals, birds, and primates, this basic executive system serves for extensive social calls, mating songs, and in humans, of course, language. In birds and marine mammals, these communication systems are accelerated. Some humans (one) sings like Mariah Carey, but none dreams of making a fraction of the sounds that come out of those committed to the skies or sea. In humans, the left hemisphere contains motor engrams necessary for elaborative, skilled, and purposeful movement Heilman, et al. (1985), and our left hemisphere language ability is an integratively networked motor, premotor, and abstract thought manifestation of this system.

Second function: Nearly all mammals survive in groups. This is overwhelming evidence that nearly all mammals didn't survive alone. Because they all locomote, nature must select for brains that have the abilities to stay together (first function), but also that developmentally fill with reasons to stay together. In short, nature must supply means and ends. As I show, these two functions are (i) highly incompatible, and (ii) map to the two mammalian cerebral hemispheres (I predict also to birds' hemispheres). So, the second function will be a set of capacities attuned to group members, oneself, and social bonds. Representational states must covary with the environmental content to which those capacities are attuned, and be sensitive to the magnitude to which those elements are under threat. On land, assuming brain evolution produces *ceteris paribus* higher levels of representational significance, and accelerated syntactical and abstract thought in the executive system, the two capacities will need higher split-braininess as it evolves. In fluid environments, animals will need greater capacities for keeping contact and not becoming separated from group members, but as importantly, they will need deeper reasons for keeping contact and preferably with larger numbers. Human survival is the result of overall unities of clans and tightly bonded families, which require that human conspecifics see one another as significant. This second function requires surrendering control to facilitate a stance of appreciation and respect towards the things in that dimension and is therefore highly incompatible with the first function. Attachment experiences between the mammalian neonate and the caregiver early in life are necessary for having this 'significance capacity.' Therefore, others and our attachments to them are what fill this capacity at maturity and developmentally.

I will start with the more conceptual stuff and work towards the empirical and developmental. The downside of the significance dimension is death, loss, or evolutionary failure. Therefore, nature selects for nervous systems that covary with evolutionary success steeply and deeply. Emotion is an expression of the significance capacity for most mammalian species, but emotion seems conceivably unnecessary for adaptive behaviors supported by the significance dimension. We might imagine a scenario where adaptive species are attuned to the elements of their significance dimension and be unemotional about it, e.g., I can imagine bats to be this way. However, I cannot imagine a mammalian species to have adaptive behavior without having a set of representational states that covary with the elements of significance for that species, conspecifics, the bonds to them etc. If we look at many studies, theories, and reflections, we can see that emotional states are Darwinian manifestations of *something else*. William Hazlitt once wrote that "We weep at what thwarts or exceeds our desires in serious matters: we laugh at what only disappoints our expectations in trifles" (1819[1967], p642). Or take empirical studies that have found negative mood to produce more narrow and constricted processing, but processing that is *deeper and more determined* (Vosburg and Kaufmann, 1999). Or other studies finding positive affect to promote cognitive flexibility and improved creative problem solving, but where processing is *more superficial and shallow* (Clore, Schwarz, and Conway, 1994). Or consider a theory where several elements come together: Kahneman and Tversky's (1979, 1984) widely applicable *prospect theory* shows a strong tendency to perceive positive events as *less significant* than negative events of equal magnitude.

When we look at brain studies, we see that laterality has not so much to do with emotion, but something much more significant. Tapping into deep meaning of events is profoundly a right hemispheric capacity. The primary loss incurred by right frontotemporal atrophy is overall emotional flatness, coldness, distance, and *uncaring about others* (Miller et al. 1993; Perry and Miller, 2001). *A catastrophic reaction* commonly follows left hemisphere damage, while *an indifference reaction* commonly follows right hemisphere damage.[27] Wada tests show these reactions are dispositional and internal to the hemispheres themselves, since the reactions are not to brain damage. As a left hemisphere injection was wearing off, thus allowing speech to return, "the patient expressed a sense of *guilt*, of *deep concern* for *family members* and *self*, a *sense of nothingness*" (*my emphases,* cited by Galin p578). A subject recalled being *scared to death* after a car crash because he could have killed *himself* or *nearby children*. However, with his right hemisphere asleep, he recalls no such elements of the significance dimension (Ross et al. 1994). Moreover, he *downplays the event and its significance*.

Only a representational system unattuned to significance will be able to supply the behavioral means. If such means require efficient processes and schematic representations, then the right hemisphere does not supply them. The right hemisphere of most split-brain patients has the linguistic syntax comprehension of a two-year old (Galin, 1973). The right hemisphere of split-brain patients has very little if any schematic knowledge and cannot make simple inferences. For example, a woodpile, followed by a match, naturally implies a burning woodpile; or a finger, followed by a pin, implies blood. With pictures, single words, or multiple-choice, it doesn't help, the right hemisphere cannot make simple schematic inferences (Gazzaniga 1992, p1398). This evidence is always interpreted as what the right hemisphere doesn't do, but I see it as what the right hemisphere does do. In a major paper comparing feeling and thinking, Zajonc (1980) makes the point that one way cognition is different from emotion is that 'preferences need no inferences.' The right hemisphere capacity of appreciating significance requires no inferences. The right hemisphere capacity requires *non*inferential state transitions: any others might allow an escape from a state of significance, on which the significance dimension depends.

Right frontotemporal dementia is more commonly associated with disinhibition syndrome, (Mychack et al. 1999).[28] Sufferers report a preserved conceptual awareness of "appropriate" states of empathic concern, but are incapable of having them.[29] Things just don't matter anymore. So, if you damage your right hemisphere's "executive system," chances are poor you'll be able to see others and their mental states with the significance you now see in them.[30] Again, emotion does not explain that:

Moreover, human emotion anthropomorphizes laterality and we need mammalian-wide concepts. We are mammals that talk. Aristotle, Locke, and Hume knew that.

Finlay, Darlington, and Nicastro (2001) show how allometry is a good way to move people “away from essentialism”[31] so that we are “alive to a wider range of causal scenarios” about a deeper (than cortical-sheet) understanding of brain evolution (p278). Anthropologist and respectful critic of spandrel theories Ralph Holloway says: “Spandrel theories cannot explain…brain structures such as the corpus callosum.”[32] I believe Holloway is right. However, I must say that only by Finlay, Darlington, and Nicastro’s new ways of looking at brain evolution through spandrel theories,[33] and allometry,[34] was I ever able to see what the *corpus callosum problem* really is: Why does the brain evolve *away from* a cerebral neocortical sphere?[35] To give some idea: Bogen’s measurements (1990) say that the least number of connections one human hemisphere could have within itself is 100 billion, and the most number of connections it could have to the other hemisphere is 0.8 billion. That means humans have an intra-to interhemispheric connection ratio of 125:1, making for speedier recovery from commissurotomy surgery for the patient, and the surgeon. Several theorists (e.g., Ringo et al. 1994) have argued that greater duality in mammalian brain evolution can be explained by neural constraints, axon diameters, etc. Olivares et al. (2000) conclude “callosal area may not keep up with the increase in cortical surface that occurs in larger brains” (p40). In Figure 5, I combine Olivares’ land mammal data with data from eight species of *Delphinidae*.[36] This graph makes trouble for the neural constraint argument: marine mammals with the same size brains as land mammals have substantially less between hemisphere connections. The graph illustrates that dolphins and whales are more split-brained. No straight single line will connect the dots. Finlay et al.’s call for other scenarios must be brought to life.

Figure 5. Corpus Callosum and Brain Size

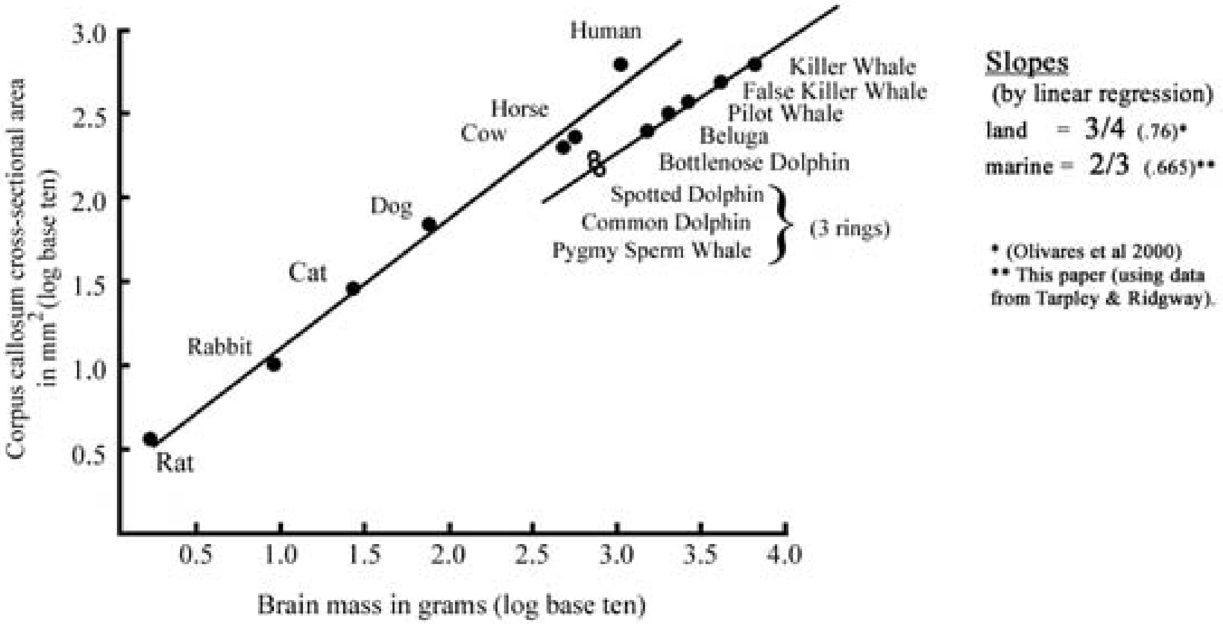


Figure 6 is my computational prediction for split-braininess for land and marine mammals (Table 1 contains values). I expected marine mammals to have a smaller slope. But, I found that land mammals and marine mammals have nearly the same slope, and I realized I was only being reminded of the philosophical reasons behind my theory of laterality: selecting at the level of adaptive mammalian behavior, nature is selecting for experiential significance as incompatible with the executive system and, these selective processes should not be dramatically different for marine mammals. We all still breath the same air, nurse live young, have family bonds, and so the slope should be the same regardless of environment.[37] Researchers have been onto a 'greater duality law' of mammalian brain evolution. My contribution is to suggest that, despite first appearances, the mathematical equations of greater duality in evolution will work for mammals on land or at sea. *Significance is significance:* Dolphins and whales will refuse to leave an area without a group member. They will even beach themselves in attempts to find or rouse the other, sometimes to their demise. Killer Whales will remain with their natal pods even in adulthood (Baird, 2000), and the alpha male by his mother's side throughout her life. Several *Cetaceans* studied do not exhibit brain activity or behavior of bihemispheric sleeping or REM. Even after dolphins participated in bihemispheric sleep deprivation studies, the dolphins still only slept in one hemisphere at a time (Rattenborg, et al.).[38] A possibility is that each hemisphere may *need* to be independent so they never sleep bihemispherically.

Figure 6. Callosal and White Matter Volumes

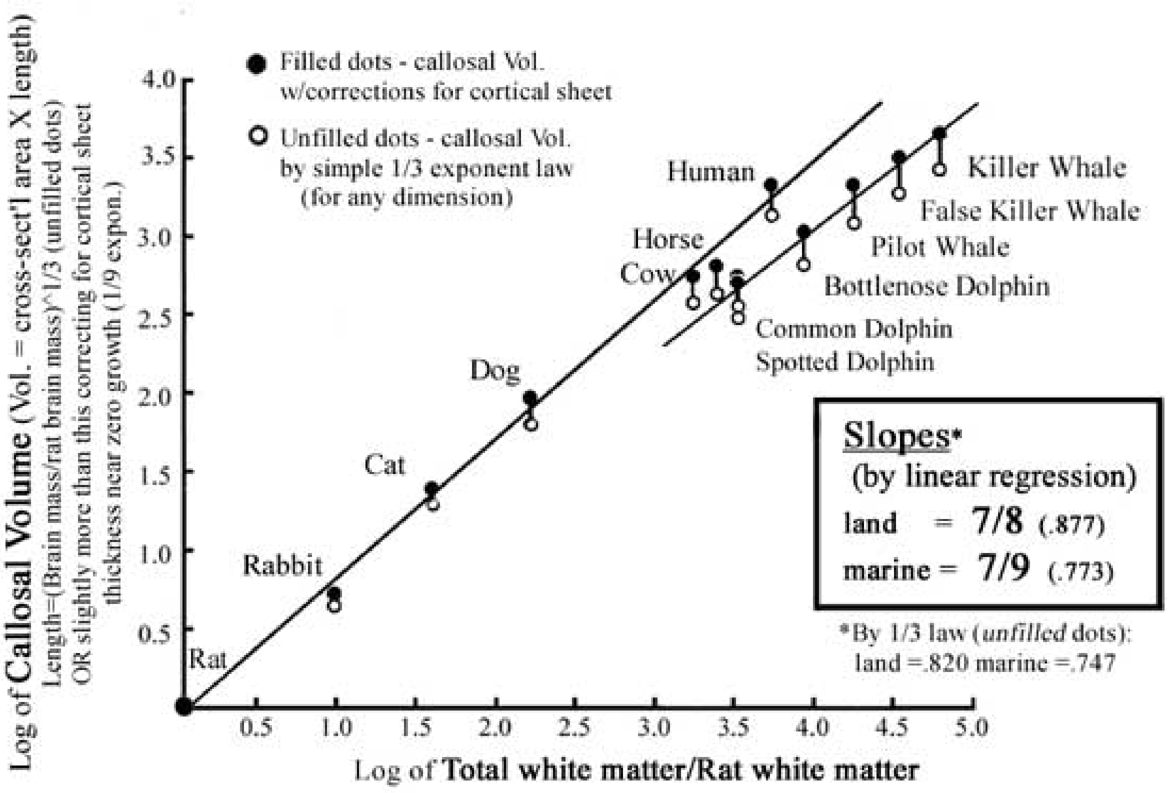
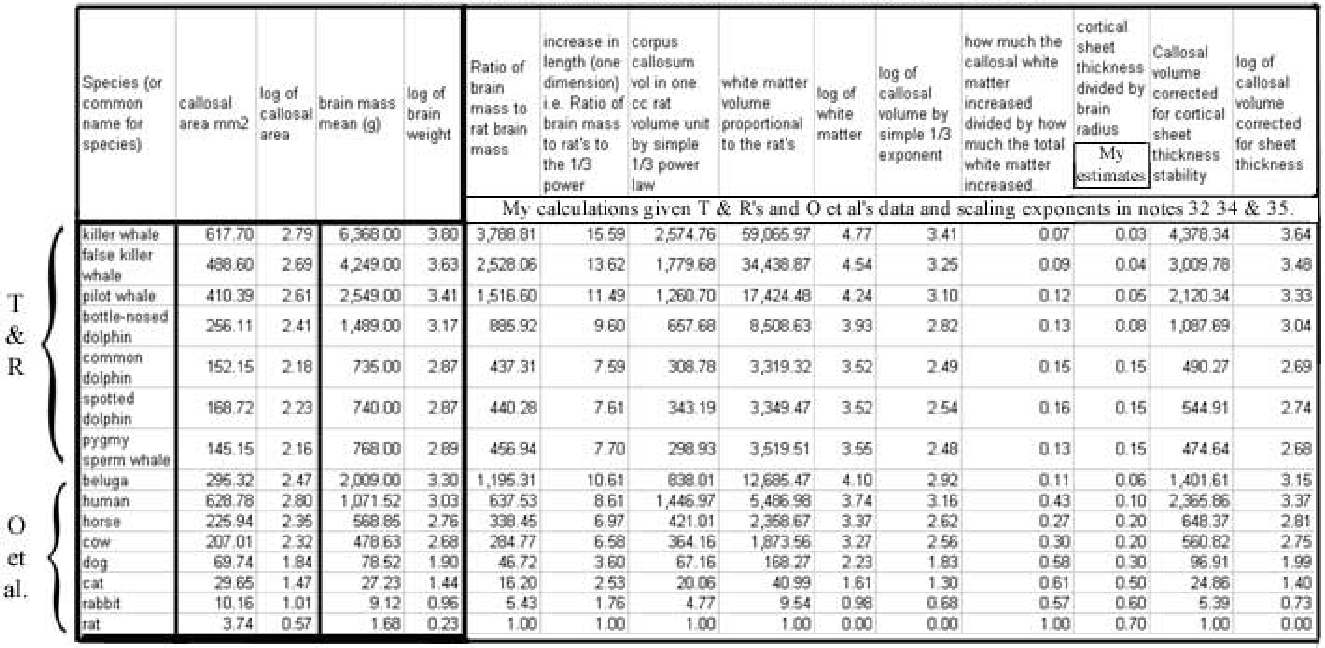


Table 1. Computed values and proportions for neocortical scaling in land and marine mammals

land mammalian measures were obtained from Olivares et al (2000) and for marine mammals, from Tarpley and Ridgway's (1994)



	Species (or common name for species)	callosal area mm2	log of callosal area	brain mass mean (g)	log of brain weight	Ratio of brain mass to rat brain mass	increase in length (one dimension) i.e. Ratio of brain mass to rat's to the 1/3 power	corpus callosum vol in one cc rat volume unit by simple 1/3 power law	white matter volume proportional to the rat's	log of white matter	log of callosal volume by simple 1/3 exponent	how much the callosal white matter increased divided by how much the total white matter increased	cortical sheet thickness divided by brain radius My estimates	Callosal volume corrected for cortical sheet thickness stability	log of callosal volume corrected for sheet thickness
						My calculations given T & R's and O et al's data and scaling exponents in notes 32 34 & 35.									
T & R	killer whale	617.70	2.79	6,368.00	3.80	3,788.81	15.59	2,574.76	59,065.97	4.77	3.41	0.07	0.03	4,378.34	3.64
	false killer whale	488.60	2.69	4,249.00	3.63	2,528.06	13.62	1,779.68	34,438.87	4.54	3.25	0.09	0.04	3,009.78	3.48
	pilot whale	410.39	2.61	2,549.00	3.41	1,516.60	11.49	1,260.70	17,424.48	4.24	3.10	0.12	0.05	2,120.34	3.33
	bottle-nosed dolphin	256.11	2.41	1,489.00	3.17	885.92	9.60	657.68	8,508.63	3.93	2.82	0.13	0.08	1,087.69	3.04
	common dolphin	152.15	2.18	735.00	2.87	437.31	7.59	308.78	3,319.32	3.52	2.49	0.15	0.15	490.27	2.69
	spotted dolphin	168.72	2.23	740.00	2.87	440.28	7.61	343.19	3,349.47	3.52	2.54	0.16	0.15	544.91	2.74
	pygmy sperm whale	145.15	2.16	768.00	2.89	456.94	7.70	298.93	3,519.51	3.55	2.48	0.13	0.15	474.64	2.68
O et al.	beluga	295.32	2.47	2,009.00	3.30	1,195.31	10.61	838.01	12,685.47	4.10	2.92	0.11	0.06	1,401.61	3.15
	human	628.78	2.80	1,071.52	3.03	637.53	8.61	1,446.97	5,486.98	3.74	3.16	0.43	0.10	2,365.86	3.37
	horse	225.94	2.35	568.85	2.76	338.45	6.97	421.01	2,358.67	3.37	2.62	0.27	0.20	648.37	2.81
	cow	207.01	2.32	478.63	2.68	284.77	6.58	364.16	1,873.56	3.27	2.56	0.30	0.20	560.82	2.75
	dog	69.74	1.84	78.52	1.90	46.72	3.60	67.16	168.27	2.23	1.83	0.58	0.30	96.91	1.99
	cat	29.65	1.47	27.23	1.44	16.20	2.53	20.06	40.99	1.61	1.30	0.61	0.50	24.86	1.40
	rabbit	10.16	1.01	9.12	0.96	5.43	1.76	4.77	9.54	0.98	0.68	0.57	0.60	5.39	0.73
	rat	3.74	0.57	1.68	0.23	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.70	1.00	0.00

Orca expert Erich Hoyt remarks, “unlike land mammals...They cannot afford unconsciousness” (p101). I do not imagine that those who slept bihemispherically tended to drown since they are born creatures of the sea. Predator detection is a better explanation, and relates to another purpose: to insure pod connectedness. A recent study found Pacific white-sided dolphins to form a tight group during the night, slowly circling with one eye open and one eye shut. The dolphins alternated hourly through the night, swimming clockwise, then counterclockwise. The eye patterns switched so the social others were always in sight (Rattenborg, et al.).[39] So, unihemispheric sleep may serve the group as much as the individual. My account of laterality supplies another scenario. Perhaps, the first whales and dolphins had gained enough hemispheric independence necessary for unihemispheric sleep only after their land-tied ancestors had achieved deep enough significance capacities to need more hemispheric isolation. Gathering evidence about elephants supports considering such a scenario, and with it a more frequent interface between land and sea evolution.[40] The view that we “make do” with the little commissural tissue our neurological constraints have spared us is a theoretical constraint. And it may not be a good constraint. Although it hasn’t been fully disproved yet, it certainly hasn’t been shown. Reflective and empirical evidence suggests that the mammalian hemispheres must be isolated as opposed to merely specialized. For example, at times when most is at stake, both functional capacities become most activated. Feeling the reasons you have for adaptive behavior, will pull you one way, while mobilizing to take action pulls you another way. The double nature of life has an irony that may apply psychologically and socially. Commonly, when the significance dimension threatens to become destabilizing through social bonds, the functions of the executive system will be needed. For instance, a significant other comes to you with a serious problem in a state of panic. To help her best, you must listen empathically, and oftentimes you must attain a psychological state closer to hers. However, this threatens to become maladaptive if it impairs your ability to help her, to be clearheaded and resourceful.[41] I will now show how my conception of laterality is attuned to developmental sciences and how two mutually exclusive conditions—psychopathy and depression—relate to the two hemisphere capacities.

Our right hemisphere-significance capacity is well-developed before age 3: Evidence from development, disorder, and brain imaging show that the adaptive right hemisphere contributes significance to an individual's life in an impersonal, unselfish way. Developmentally, children's self-awareness takes the same shape as empathic understanding of others: Psychologist John Barresi (2001) reviews and explains evidence from childhood self-development and empathy studies with his colleagues. Studies by Thompson, Barresi, and Moore (1997) found 3-year-old children's concern for others to be equal to their self-concern, and equivalent to 4-year-olds and 5-year-olds for present states, as measured by scores on sharing behavior tasks. Their studies show that the 3-year-old has an empathic capacity for others that is not exceeded by her self-awareness across time: The abilities of the three-year-olds for imagining future states of others was no worse than for imagining future states of themselves. These developmental findings may be related to brain and development studies. At times of early attachment experiences, between one and three years of age, brain activity is highest in the right hemisphere, mainly the right posterior cortex (Chiron et al. 1997). In reviewing neuropsychological evidence, Allan Schore (1998) argues that emotional experiences of the infant are stored more in the right hemisphere (p58). Intense emotions from social interaction between mother and infant were found to be common during the first 10 months of life.[42] Much of the second year of life is quite different, especially between 13–17 months. At this time, the walking infant's explorations and initiatives for interaction receive a rejecting expression from mother on an average of once every nine minutes (p64). Shame experiences are not essentially negative, or pathological. Rather, they are new *kinds* of states for the infant. In shame, emotional expression is inhibited, and impulses are managed internally, awakening the development of a capacity to feel and experience emotions internally, and a new self-awareness.

We get executive functions only after age 3: The greater activity shifts from the right hemisphere to the left hemisphere during the fourth year of life (Chiron et al.). Karen Lemmon and Chris Moore (2001) have investigated the relation between children's abilities to connect temporally to their past states and the ability to develop a sense of self extended into the future: by age 4 "children have acquired a notion of self that includes the awareness that the present self is connected to other stages of self in a continuous sequence from past through to future" (p178). The work of Thompson, Barresi, Lemmon, and Moore along with the work of Hughes (1998a, 1998b) supports temporal structuring and theory of mind capacities that go beyond the present, as being highly related to executive functions and decision-making in 3- and 4-year-olds. On tasks requiring delayed-gratification, the 3-year-olds scored very low compared to the older children, which suggests that capacities for an awareness of future mental states develops after awareness for present states. That the left hemisphere executive system is needed for temporal ordering and abstract representations fits with the data.

What happens if an infant is not given early attachment experiences? My answer is that the infant never becomes instilled with the significance dimension, but, nevertheless, develops a distilled executive system. Because the significance dimension is the reason why we have laterality, the executive system alone becomes a component of a non-dichotomous mind. My account *explains* laterality: the significance capacity is the reason we have lateralization in the strong sense, meaning asymmetry *and isolation*, because without the early attachment experiences where the significance dimension is gained, as I will show, we would not need our lateralized brains.

Denenberg et al. (1978) showed that early experiences in the neonate rat are asymmetrically distributed between the two hemispheres. Nonhandled rats became hyperactive to the same degree after left neocortex ablation as did nonhandled rats after right neocortex ablation. In rats handled for each of the first 20 days of life, activity was substantially greater after right neocortex ablation than after left. After several studies, Denenberg concludes that “handling in infancy does two things: (1) it exaggerates laterality differences already present, and (2) it induces laterality effects where none previously existed.... [And] Handling also plays a major role in nonemotional tasks as revealed by the left-right spatial choice data where again the right hemisphere is involved” (1983, p34-5). The Denenbergian criterion that any explanatory account of lateralization must meet is the recognition as a first principle that “functional lateralization, when present, will tend to have the same overall features across species (i.e., affective and spatial function contralateral to communicative function)” (1981, p14).[43] Denenberg found rats raised (a) without any contact or human handling (b) did not acquire characteristically right hemisphere behaviors, and (c) *failed to undergo normal lateralization*. The Denenbergian condition predicts that “nonhandled humans” would be the same way. Here’s my argument by analogy. First (a) the “psychopath typically has a history of parental deprivation” (Wilkes, p90). Second, the psychopath (b) does not acquire right hemisphere functionality or behaviors. Third, psychopaths (c) *fail to undergo normal lateralization*.

Psychopathy and depression are mutually exclusive at the philosophical, psychological, and neuropsychological levels. Luria (1973) warned long ago that the right frontal hypofunctioning patient has a common disregard for others, while Baron-Cohen et al. (1994) found highest activity in the right orbitofrontal cortex area during other mind tasks. The right hemisphere’s orbitofrontal-limbic network is thought *to be* the right hemisphere’s executive system (Schore, 1998). The orbitofrontal cortex, which is the *only limbically connected* prefrontal cortex, undergoes extensive development during infancy (Schore, 1998). The orbitofrontal cortex is larger and more prominent in the right hemisphere, where it also matures earlier than in the left hemisphere (p64). Compared to any area of the brain, the right hemisphere’s orbitofrontal cortex showed the highest magnitude of decreased activity after successful treatment for severe depression with *bilateral* electroconvulsive therapy (Goffinet et al., 1996). Robinson and Downhill (1995) concluded from hundreds of brain damage cases that the only pattern associated with denial of depression was the absence of any tissue damage to the left hemisphere (p699). The psychopath is *incapable of depression*, and lacks guilt and remorse (Cleckley, 1982). The depressive never wanted to leave this world, but somehow everything was just too significant. The psychopath continually wants to die but can’t because nothing is significant enough (Cleckley, 1942; or Camus’ infinitely indifferent Meursault 1942). The psychopath is someone hard to inhibit even with punishment, someone with airy thin empathy and superficial affect (Lovelace and Gannon 1999). The depressive is steeped in guilt with a paralyzing depth of empathy and profound affect. The psychopath has difficulty differentiating positive and negative affect (Christianson, 1996). But, the real severity of his problem is not an emotional one, but something hard to comprehend: Cleckley (1942, 1982) describes it as a failure at the level of experiencing life as a total integrated organism, a form of psychosis, and ultimately concludes the psychopath is constitutionally incapable of experiencing human value and elemental meanings that define human life. Kathleen Wilkes’ profound litotes is ‘the prognosis is poor’ (p90). Depressives have an intact significance system, as they are usually people of deep significance. Rather, the problem is how deep they go. Psychopaths have an intact executive system, as they’re usually capable people. Rather, the problem is what they’re capable of.

Rebecca Mills (1995) selectively projected emotional faces to the left (RVF) or right (LVF) hemispheres of psychopaths and nonpsychopaths, and recorded brain activity (ERPs).[44] After seven studies, Mills concludes that “the cortex of the psychopaths is organized in a somewhat more diffuse manner, with odd inter-and intra-hemispheric communication” (p110). In Robert Hare’s words, Mills studies show: “that in psychopaths both hemispheres are able to access the neural structures necessary to process the information" (p127). A word I have come up with for this odd, diffuse, dual-access brain style is: *ambihemisphericity*. Could ambihemisphericity really be an advantage?[45] 'Ambihemisphericity' requires an erasure of between hemisphere processing lines, and thus indicates that the psychopath has, with the neglected rat, escaped the need for laterality.[46] If the hemispheres have no special functions, then more enhanced processing means neural structure, not more neural bihemispheric structure. All allometric roads lead to one Rome of the brain, not two. More enhanced ambihemispheric processing means more neural structure in one neocortical sphere, not two hemispheres. So, ambihemispheric processing would facilitate a solution to the corpus callosum problem, literally. Organisms with a fattening corpus callosum would have scaling laws of a whole new dimension because it would include increases in between hemisphere connectivity—the *spherical spandrel of ambihemisphericity* (see endnotes [32-36] on Allometry). However, whatever appeal there might be to ambihemisphericity, nature cares that you care for others, yourself, and survival; she cares not about your level of ambihemisphericity with which you do so. The accounts of other theorists, e.g., Ringo et al.'s (1994) have tried to explain the increasing split-braininess. Their argument does not fit with allometric values [note32] and they do not explain why the absence of mammalian early attachment experiences essentially erase the cognitive tasking that drives their argument. My account explains this. If the foundation for the significance capacity is missing, there is no need for a dichotomous mind: *There's nothing much of significance that executive functions must achieve a psychological distance from*. Psychopaths have slick means, but it's of no significance. They are selected against in the relevant evolutionary context relying on *significant* others.[47] Whether it's modernity, the meme, the gene, or something in between, it's all the same, nothing really matters.

Why is conscious experience lateralized as it is?[48] During Wada testing with right-sided injections, the subjects' overall sense of self tends to be remarkably the same as normal. A vertical visual analogue scale is used, Glosser et al. (1999). At the top is an alert face labeled 'alert.' At the bottom is a confused face labeled 'confused.' Subjects were instructed to mark a line indicating their current state. There were no significant differences between subjects' ratings before the Wada test and while the right hemisphere was anesthetized. However, with the left hemisphere anesthetized, subjects' ratings were dramatically affected. The subjects reported being somewhat confused and non-alert. If there was anything the subjects' self-ratings were correct reports of, it was not something able to be objectively measured. Self-reported awareness, arousal, and alertness did not correlate with objectives measures of arousal, and did not correlate with explicit memory test scores. In other words, the right hemisphere saw itself as confused, and not alert, but its objective ratings and memory capacities did not reflect this.[49]

This pattern shows that the left hemisphere is disposed to see itself as sufficient for a normal sense of self, and the right hemisphere to see the left hemisphere as necessary for a normal sense of self. These prominent dispositions to self-identify with left hemisphere functions must remain in place to promote adaptive behavior: In settings where tremendous significance is appreciated, a great achievement, a great loss, or aesthetic experiences, the organism's behavior is adaptive only if it has executive control. For example, while her mate is on a hunt, a woman loses her child to wildlife. Becoming engrossed in the devastation will be maladaptive. Consciously identifying with the steep and deep significance dimension may take her down it. For then, she may impair her ability to take action to prevent losing her *other* child. Generally, the more complex is one's self-concept and self-schemata (which the right hemisphere lacks), the less susceptible one is to depression and mood swings (Linville, 1985, 1987). Evidence from a diverse range of sources shows that, under emotionally aversive conditions or inductions of depressive states, cognitive processing becomes impaired, e.g. encoding (Richards and

Gross, 2000); and in the right hemisphere particularly—processing (Hartikainen et al. 2000) and olfactory identification (Postolache et al. 1999). In sadness, depression, PTSD flashbacks, panic attacks, phobia, and many other states of internally felt significance, the right hemisphere shows increased activation, especially frontally (Pauli et al. 1999), suggesting tendencies for the right hemisphere to dominate conscious processing with maladaptive overloads of the significance dimension.

Warfare provides good examples because significant events task both systems at the same time: Dr. Beecher (1959), a neurosurgeon in WWII, found that many soldiers wounded in battle reported little or no pain despite having major injuries and tissue damage. WWII veteran JG Gray writes “becom[ing] so absorbed in a spectacle that they overcome fear of pain and death... is a common-enough phenomenon on the battlefield that men expose themselves quite recklessly for the sake of seeing” (p36). Gray does “not mean that there is lack of interest... or lack of emotion in this detachment,” but that “the self is no longer important to the observer” (p36). Gray explains this absorption on the battlefield as dissociation, which is in keeping with combat PTSD and the sociology of warfare. From cultures across the world, Watson (1973) found a strong correlation between the degree of warrior disguise (masks or paint), and the brutality of warfare (torture or mutilation).

Our central nervous systems endow us with adaptive capacities of a paradoxically sounding principle—*experiencing* without experiencing: ‘*experiencing,*’ i.e., experiential attunement to significance to promote social bonds and self-concern, but ‘without experiencing,’ i.e., endowed with mechanisms capable to bias our self-identifying process to favor the conscious contents in the left hemisphere, as needed at critical moments when the right hemisphere is experientially loaded with significance.[50] It would of course be a mistake to conclude that right hemisphere processes are nonconscious at these times of *high significance*.[51]

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ENDNOTES

[26] See endnote 43.
[27] Gainotti (1989) points out that the right hemisphere's catastrophic reaction to brain damage is appropriate and it is the left hemisphere's indifference reaction that is pathological.
[28] Mychack et al. (1999) classified 31 patients as right or left FTD patients. The differences were striking. 12 of 13 right-sided FTD patients and only 1 of 18 left-sided FTD patients presented with antisocial behavior as an early presenting symptom. The chi-square was highly significant ([chi] = 23.3, $p < 0.001$).

[29] Damage to orbitofrontal areas tends to produce the “pseudo-psychopathic” syndrome (Stuss and Benson, 1978) involving loss of foresight, and disregard for codes of conduct, and a general “disinhibition syndrome.” Early psychosurgeries on orbital cortex reduced anxiety and depression (Flor-Henry, 1977). Blumer and Benson (1975) found two basic conditions to result from frontal brain damage, one, pseudodepression with behavioral retardation, and two, pseudopsychopathy with “disinhibition, facetiousness, sexual and personal hedonism, and a lack of concern for others” (p. 127). A drastic measure to treat severe bipolar mood disorder is selective brain “lesions [that] target neuronal connections between the mid-line thalamic nuclei and the orbito-frontal cortex” (Happe, et al. 2001, p. 86). Happe et al. report a patient PB who received this treatment, Afterwards, he scored significantly worse than healthy controls on cartoon and story quizzes that required mental state attributions.

[30] Such a loss would impair one’s capacity to value, generally. The significance of this loss is not a measure of the cognitive neuropsychological deficits (there often aren’t many with damage to these areas), and not by the experiential loss of being unable to have emotions. Rather, if certain moral philosophers are right with their idea that the only thing about humanity that is intrinsically valuable is our capacity to value, then the loss will be mirrored as the representational discrepancy of all the things that are no longer seen with significance.

[31] Locke agrees with Finlay and Darlington. Locke believed “nature has made me so: but there is nothing I have [that] is essential to me.….Other creatures of my shape may be made with...faculties...very different from mine. [But] None of these are essential to the one or the other, or to any individual whatever, till the mind refers it to some sort or species of things; and then presently,...something is found essential” (3.6.4).

[32] Holloway also says spandrel theories cannot explain genius or the sexes (2001 this Journal, p286). (I was always under the impression that these are two entrance cards to being a theory, the first because to explain it, would be erase it, and the second, because the male and female theorists couldn’t understand it). Other theories can seem to explain hemispheric specialization or the corpus callosum only by relying on one in order to show the other. No prior theory, which does not assume the line between the hemispheres as a line of functional and/or neural fissure, has an explanatory answer to that question. Ringo (1991) and Ringo, Doty, Demeter, and Simard (1994) offer this argument: (P1) Since neurons do not scale-up with brain size, the brain grows larger from numerous neurons and axons not bigger neurons and axons, but this means, geometrically speaking, that the time delay of neural signals will tend to increase with brain size. (P2) In humans, for example, the right to the left temporal lobe have an interhemispheric delay of about 25ms which would make for “prohibitively slow” integrative processing. (P3) Temporal limits may be avoided if brain areas required to perform a task are gathered in one hemisphere. (C) Therefore, greater brain size means greater hemispheric specialization. The argument may be challenged. First, premise two uses the relation between two areas of the brain as a template for how to think of callosal downscaling, which is a part to whole error. If distance is the reason for “gathering,” then someone (perhaps Ringo et al.) may want to explain why posterior areas do not “gather” against anterior areas within hemispheres. And, the allometric figures do not fit the gathering picture. Mark Changizi (2001) provides an empirically supported model indicating that, what he terms ‘area-connectedness,’ is invariant to brain volume increases. In other words, all roads in allometric science lead to one neural Rome, not two; one neocortical sphere, not two hemispheres. This is not “allometry’s problem.” This is everyone’s problem. Finlay and her colleagues have just provided enough insights and data to expose it to us.

[33] The ‘spandrel theorist’ says, in effect, that Darwin wants you to develop a big brain, and worry how to ask questions with it later.

[34] Allometry is the measure of the evolutionary growth of some biological part by relation to another. A set of cross-species studies has computed the volumes of white matter relative to brain size to find that “white matter increases faster than grey matter, whereas grey matter increases

proportionately with brain size" (Barton, 2001). Changizi (2001) cites four studies that indicate a 4/3 exponent for white matter to brain size (Allman, 1999; Hofman, 1991; Hofman, 1989; and Frahm et al. 1982). A fifth cited study indicated a linear relation, Prothero, 1997. What does all this mean? Suppose I were a shrew and you were a mouse with twice my brain mass; then, your white matter would weigh about 2.5x mine. But, were I a chimpanzee with a brain with 1000 times your mousy brain mass, my white matter mass would be 10K times greater than yours (10004/3 = 10,000). An allometrically inspired theory, such as a spandrel theory, has the idea that "enlarged isocortex could be . . . a by-product of structural constraints later adapted for various behaviors" (Finlay, Darlington, and Nicastro, 2001).

[35] As the brain gets bigger, the corpus callosum gets proportionally smaller. The result is an acceleration towards neocortical evolution of greater duality quotients: white matter within the hemispheres growing, while white matter between the hemispheres is proportionally shrinking with respect to brain size. The cross-sectional area of the white matter between the two hemispheres increases slower than grey matter with a slope of 3/4 (see Figure 5). The brain's convolutions allow that the cortical sheet is almost invariant (but still not quite) with brain volume: surface area to brain volume is measured to have an exponent of 8/9 (Changizi, 2001). And, Olivares et al. computed a 3/4 exponent for callosal area/cortical surface area. In other words, the cross-sectional area of the corpus callosum can't keep up with the cortical surface area, which itself can't keep up to the increase in brain size.

[36] Tarpley and Ridgway report 18 Delphinid species. However, about ten of these had only a couple of specimens. I report 8, seven of which had the most specimens (3 to 15 for a total of 40 specimens total). Ridgway (1986) reported that Orcinus orca's (Killer Whales) corpus callosum is the same cross-sectional area as the human corpus callosum, while the size of their cerebral hemispheres is fivefold ours.

[37] Front-eyed visual species (e.g., cats and humans) increase the slope because they have thicker posterior fifths of the callosum. Dolphins look side-to-side, as do horses and cows. Were this factored in, it is possible that the slopes would be equal. We must make idealized predictions to motivate research to measure these quantities. If we really want an empirical confirmation of whether we are getting more or less split-brained as we evolve, then we need corpus callosal volume, scaled against total brain connectivity (the white matter) volume. Olivares et al. provide cross-sectional area, which is only two dimensions. Intrahemipheric connectivity cannot be easily translated into two dimensions, because it is convoluted. However, we already have exponents for three dimensional quantities of white matter to brain volume which is 4/3. So, I figured we should try and translate the two dimensions of the callosum into a third, by including length. To get the third dimension, I reasoned that the convolutions change the shape, but they will not, on average, make the axon lengths between hemispheres increase substantially. In any isomorphic increase in size, each dimension increases to the power of 1/3. So, the brain mass increase from one species to the next raised to the power of 1/3 is the increase in axon length if the brain preserves a similar shape. As the brain evolves, the grey outer covering of the brain stays about the same thickness, to the power of 1/9, so that means the axons will increase a little more in length. However, once the cortical sheet is proportionally thin, this is almost negligible: In an elephant's brain, "The white matter is much more abundant than the gray matter, a feature observable also with the naked eye,... [and can be] quite thin and barely visible" (Cozzi et al, 2001). Because the grey layer is staying about the same thickness, I wanted to be extra scrupulous and correct for increases in axon length that may occur from the axons traversing the extra distance that the grey layer fails to fill with its 1/9 exponent (as opposed to 1/3 exponent). These corrections made very little difference to the slope of any line, and only a 0.02 difference between land and marine slopes. I was expecting that the 4/3 exponent (of white matter volume to brain mass) would make for an even lower number, especially in *Cetaceans*. However, once the third dimension of length is added in,

nature reveals her sensibilities. One may query: It can't be that easy to deduce relations or lengths in complex things like brains? I had these reservations myself. But, for one, I am not deducing lengths but only *proportional* changes in one dimension *given known* proportional changes in volume. For another, my question is, Where else would extra length come from? The axons would have to wrap around more in highly evolved brains. The convolutions might give a surface appearance of that, but the convolutions are to allow the axons to have straighter, closer shots. The fascicula in any neuroanatomy book depict *straight long*-range connections, which the interhemispheric connections are. Cherniak (1994) has found that a vertebrate's nervous system, which british neuroanatomists mapped out to the synapse level, formed its nervous system by arranging its 12 ganglia with *the best arrangement* using the least connectivity out of 40 million possible arrangements. Thus, in higher vertebrates, it is likely that extra length will not come easy. And, thus, at most, only minor deviations will occur from the 1/3 exponent for one dimension.

[38] Many species of birds seem to do little else but keep track of one another. Birds have no corpus callosum and only tiny commissures, and they sleep unihemispherically, perhaps even in flight during migration (Rattenborg, et al. 2000).

[39] The authors of the article present a fascinating review I highly recommend. One conclusion they state to an argument needs an adjustment. They offer split-brain humans and callosal agenesis humans' not having the capacities for unihemispheric sleep as evidence against the hypothesis that the comparably tiny corpus callosum in whales and dolphins plays a role in unihemispheric slow wave sleep USWS. I like the interspecies comparison approach. But, this only shows that a small commissural factor may not be sufficient, but it still may be necessary. Whatever advantages gained through separation of function risk being compromised through interference or functional fusion by interhemispheric processes. This may help explain why species who use or need USWS in order to survive do not also have REM sleep, whose function is, ex hypothesi, interhemispheric integration. The sustaining of mind that is neuropsychologically capable of a biphasic hemispheric, not unlike partial superWada, attitude to somnolence, would be sabotaged by interhemispherically unifying processes such as REM sleep. Selection advantages concerning hemisphericity may be promoted or compromised by structures or phenomena at the neurological or psychofunctional levels. Nature at sea selects against REM or bihemispheric sleepers probably because they all drifted. REM sleep may be essentially a psychologically integrative process for the two hemispheres, as the REMs may indicate. Thus, an absence of REM sleep, along with highly limited interhemispheric connectivity, suggests, and in turn is suggested by, the fact that species needing to sleep in only one hemisphere at a time, have evolved, both neuroanatomically and psychofunctionally, to keep the hemispheres highly independent and self-sufficient.

[40] Elephants' are the only creatures on land with bigger brains than humans. Many tried to explain this away even though they are 4 to 6x bigger, tipping the scales at 4.5 to 6.5 kg. It is now more difficult to keep the truth covered. Let me share my reasons why I believe elephants are close relatives of Cetaceans. Elephants prefer large groups of 30 to 60 members, are known to caress remains of dead elephants suggesting they understand and mourn death and loss. They make subhuman vocalizations heard for several miles. On their social support, Sikes writes: "In a case where the animal is mortally wounded and cannot rise, the other members of the herd cluster round in an attempt to raise it. Failing to do so, they circle it disconsolately several times, and if it is still motionless they come to an uncertain halt. They then face outwards, their trunks hanging limply down to the ground. After a while they may prod and circle again, and then again stand, facing outwards. Eventually, if the fallen animal is dead, they move aside and just 'hang around'"(Sikes, 1971 p272). Elephants probably have an aquatic mammalian ancestor (Gaeth et al 1999). Their brains are very much like Cetacean brains, as Cozzi et al. (2001) write: "The general outline of the telencephalon is reminiscent of that of Cetacea, and especially of the Humpback whale Megaptera novaeangliae" (p221). Elephants have a large

posterior commissure strikingly similar to that in dolphins suggesting they may sleep in one hemisphere at a time (Rattenborg, et al. 2000).Elephants's esophagus and trachea are entirely separate systems, as in Cetaceans. So, they do not breathe through the oral cavity. Were an orifice to evolve at the top of the elephant's head near where the trachea actually passes, a blowhole would be formed. Believing in the value of the significance dimension may lead one to see how we humans have others to look up to for important dimensions of experience. I beg that you not see these possibilities as threats, but insights to help bend you bounds of significance farther to more species. If you have some contact with Cetaceans, e.g., by reading Rendell and Whitehead (2001), they will certainly press you with a lot momentum one way or the other. Perhaps that they do so is evidence they are significant. My scaling law of the same exponent for split-brainedness Fig. 6, whether one is a land mammal or a Cetacean shows one way we are all of the same ilk.

[41] These subtle psychological levels apply in wolf pack hierarchies, in Orca pods (Rendell and Whitehead, 2001) elephant groups (Sikes, 1971) and great apes, and this is why the corpus callosum must get smaller in bigger brains. But, it does this at the same rate. My Figure 6 represents interhemispheric connectivity volume to total brain connectivity volume.

[42] Visual experiences are a large part of emotionally intense attachment experiences. Myelination processes are prominent in the occipital areas from 3 to 9 months (Schore, 1998). Schore's work brings the tradition of Bowlby to a heightened level, while showing further that the first couple of years of life crucially form one's basic emotional self-concept. An impersonal (nonselfish) right hemisphere story is to be told in adults. Specific areas of the somatosensory cortex map to our own visceral states when we interpret others: "the right hemisphere specialization for evaluating affective facial content appears to reflect our ability to map the portrayed expression directly onto one's internal representation of the corresponding emotional state" (Anderson and Phelps, 2000). These developmental patterns of laterality and early experiences are true for mammals generally, as we'll see with Denenberg's rats.

[43] So, your account must include many species and be explanatorily open at least to all species that ever appear in Mammalia; except of course for one, Homo lateraliens—it's an extinct, inferior species of thought. It's been decades since "The evidence is[was] now clear: nonhumans as well as humans have lateralized brains, with which are associated concomitant behavioral asymmetries" (Denenberg, 1983, p29). By 2002 we would no longer expect to see views based on the belief that human lateralization is lateralization. Alas, we still see such views, for instance, 'Nonhuman brains, by contrast [to humans'], reveal scant evidence for lateral specialization' (Gazzaniga, 2000, p1294). Denenberg compared human centered beliefs of laterality to "the great difficulty" people had to giving up geocentrism (1983, p29), and he points out that "the study of brains of nonhuman organisms will aid us in understanding the biological and evolutionary basis of laterality" (p37). Denenberg is the Copernicus of laterality. Denenberg placed the species of thought, Homo lateraliens on the endangered species list 25 years ago. (Any survivors may gravitate towards some Homo geocentricos). Denenberg's studies explain laterality since to explain mammalian laterality is to explain human laterality, not the reverse of this, which some apparently still cling to believe. To the extent my account is successful, it is from seeing Mammalia through a mammalian theorist.

[44] The psychopaths and nonpsychopaths did not differ in frontal responsiveness of the left hemisphere, but comparing frontal responsiveness in the right hemisphere, the psychopaths' were slow and small. In contrast, the psychopaths' parietal cortex responded quickly and strongly. Mills inferred that, for the nonpsychopaths, the task was "a complex emotional discrimination task" but for the psychopath, it "was primarily a perceptual task" (Hare, p127). The next finding's as bizarre as that one is chilling. Mills reports a study of mental rotation, and expectedly, the nonpsychopaths use their right parietal cortex, a.k.a. 'the seat of spatial cognition.' However, the psychopaths use frontal cortex to perform this task (Hare, p127-8). So, psychopaths use their frontal cortices to perform characteristically right hemispheric tasks that their (underdeveloped) right hemisphere doesn't do.

Psychopaths are less lateralized, but moreover, they lack crucial right hemispherically lateralized functions, i.e. neither hemisphere has them. If a mouse is placed in with a rat, the rat will commonly kill the mouse (Garbanati, et al., 1983). Mouse killing is not a function of food or water shortage, occurs spontaneously. The highest portion of mouse killing was in nonhandled rats with an intact brain. Although they kill substantially less after ablation, no statistically significant difference was found between left and right side ablation. To me, this suggests the brains of the nonhandled rats' killing of mice before the surgery was a function of their having, not lateralized cortex, but twice as much. Handled rats kill less in the intact brain state, but after a left lesion, their killing of mice goes very high, and after right lesion, the lowest incidence of all the conditions.

[45] It is an empirically supported speculation that if nature wanted ambihemisphericity, then she could have it. And, all the indicators from others and my own suggest that she does not want it.

[46] So, the psychopath's mind is probably more like a Cartesian Theater. Not because it is well ordered, but because there is nothing of substance in there. This yields the prediction that my new paradigm of memory won't apply much to the psychopath. Evidence is compatible with this. (e.g. last half of note 55).

[47] In our modern context with large, fluid, faceless populations, he may blend in—repeatedly. Any species of hominid that cares not about its infants, or the value of social bonds will attain a high psychopathy factor, and may blend in—to the ground. A probable example is the extinction of Homoneanderthalensis. Neanderthals brain mass was 1.13x modern humans, but cranial analyses estimate comparatively small frontal cortices (Banyas, 1999, p.91-4).Neanderthal culture seems founded on behavior that resembles the orbitofrontal patient as opposed to the dorsolateral frontal patient (inaction and depression) and resembles right frontotemporal dementia, as opposed to the left frontotemporal dementia. These parallels would predict that the frontal disparity between humans and Neanderthals is more due to Neanderthals' lacking the limbically connected orbitofrontal cortex where the right hemisphere plays a substantially greater role. Thus, their significance dimension was less part of their abstract thought and processes. Evidence is supportive. Because a brain does not fossilize, the Neanderthal's brain signature is written on the inner surface of the cranium: the "Neanderthal revealed a strong development of the middle frontal sulcus [nonlimbic] and a lesser development of the inferior frontal convolution [limbic]" (Banyas, p94). This suggests to me that their frontal cortices were substantially less limbic, and functionally speaking, what we would be like with right orbitofrontal damage. Evidence indicates that Homo sapiens sapiens coexisted for at least 30K years. Records indicate that "within 3,000, or 4,000 years after the arrival of Homo sapiens sapiens, the Neanderthals vanished" (Banyas, p92). They were likely to have been better fighters than humans. Archeologists find strong evidence Neanderthals were cruel fierce warriors and perhaps cannibals, but "unlike humans, there is no evidence of couples or family-oriented activity" (Banyas, p.92). My estimate is that whatever frontal cortex their huge brains did have was more of the left hemisphere nonlimbic and executive variety. Thus they were adept at planning attacks and making weapons, as opposed to developing and appreciating social bonds. In sum, my model predicts that the extinction of Homo neanderthalensis had less to do with their living and dying by the sword/club, and more to do with the lack of care, concern, and grace with which they did so. A striking difference between Neanderthals and coexisting humans who may have displaced them was that the humans reflected a deeper appreciation for the environment in the form of magic, religion, and aesthetic experiences, e.g., as manifested in the rich expressive cave paintings. That is a reflection not of higher intelligence but of a deeper significance capacity.

[48] We make many kinds of judgments with the left hemisphere, such as temporal sequencing judgments (Efron 1963).

[49] The phenomenon of the left hemisphere's sense of self being unaffected by the normal presence or absence of the right hemisphere was so strong, it occurred independently of whether an epileptic focus

was in the left or right hemisphere. Another study found this same pattern for self-reported arousal . This pattern is especially striking, because the right hemisphere has been shown to be dedicated to arousal (Heller et al. 1997). Gazzaniga (2000) stresses the fact that split-brain patients (verbally, at least) report that there is no difference in how they feel in the before and after of commissurotomy. He argues this proves his theory that the left hemisphere unifies consciousness, but it does not, given that the left hemisphere makes self-ratings in the Wada test compatible with those by split-brain patients. Also, the split-brain right hemisphere often feels differently, if asked (Henninger 1992b, p.280).

[50] In saying that conscious experience is placed preferentially with the left hemisphere, I just mean that the internal processes of identification prefer the side of command and executive control centers in the left hemisphere, with defense mechanisms able to override processes in the right hemisphere during significant moments that also require volitional execution.

[51] To promote adaptive behavior, then, will require some mental disunity at critical moments. To the objection that we have no introspective evidence of such disunity, I respond: no, rather, we can have no introspective evidence of it, because that would defeat its purpose. But we can have introspective-memory evidence of disunity. Striking examples are Dennett's clock chimes phenomena: at chime four or five, you become consciously aware of the chimes, and you experience introspectively backwards in time to count the hour (1991, p137). Ex hypothesi, "you" were not conscious of chime two or three until after they occurred.

* Section 5 has been submitted to CogPrints because its theory of laterality makes the prediction that psychopaths would have a thick corpus callosum, and this prediction has been confirmed by a brain imaging study of psychopaths, reported by Adrian Raine and his colleagues, which finds that psychopaths have a statistically large corpus callosum.

Raine A., Lencz, T., Taylor, K., Hellige. J.B., Bihrle, S., Lacasse, L., Lee, M., Ishikawa, S., Colletti, P. (2003). Corpus callosum abnormalities in psychopathic antisocial individuals. *Archives of General Psychiatry, 60*(11): 1134-1142.