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Evolution and executive functions: Why our toolboxes are empty

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Abstract: Despite the recent findings with regard to our origins as human primates, we still struggle to find tools that evaluate executive functioning adequately and reliably. Despite some evidence of ecological validity, our toolboxes remain largely empty. With regard to how we produce common behaviours by using individually distinct, multiple areas of focus, each brain is individual. In a sense, not many complex, human, behaviours follow a normal distribution. This work traces the probable origins of executive functioning in humans in a social context, defining in passing the nature of human self-regulation. A discussion follows which integrates these ideas within a second order, cybernetic neuroepistemology of human thought and emotion, and questions the logical paradox of assuming that isolated cortical areas such as the frontal lobes generate executive functions in a linear progression. A brief exploration follows with regard to the nature of human consciousness, and the difficulties in measuring such a homeostatic mechanism as executive function. Using alcohol related brain changes, and cross-cultural issues as exemplars, an attempt is made to define a neuroepistemology for understanding the dynamic interplay between executive function and consciousness. **Key words:** Brain´s Evolution, executive functioning.

Evolución y funciones ejecutivas: por qué nuestras cajas de herramientas estan vacías

Resumen: A pesar de los recientes hallazgos en relación a nuestros orígenes como humanos primates, aún luchamos para encontrar instrumentos que evalúen el funcionamiento ejecutivo adecuadamente y de manera fiable. A pesar de algunas evidencias de validez ecológica, nuestras cajas de herramientas están vacías. Cada cerebro es distinto en la forma en que producimos la conducta usando diferentes y múltiples áreas. En este sentido no hay muchas conductas humanas complejas que sigan una distribución normal. Este trabajo traza los probables orígenes del funcionamiento ejecutivo en humanos en un contexto social, definiendo la naturaleza del auto-control. En la discusión se integran estas ideas en un segundo orden, la neuroepistemología cibernética de la emoción y el pensamiento humano, y se plantea la duda de la paradoja lógica de asumir que áreas aisladas del

cerebro como los lóbulos frontales generan las funciones ejecutivas en una progresión lineal. También hacemos una breve exploración de la naturaleza de la consciencia humana y de las dificultades para medir las funciones ejecutivas. Utilizando los cambios producidos en el cerebro a causa del alcohol, en ejemplos cros-culturales, intentamos deficir una neuroepistemología para comprender la relación dinámica entre el funcionamiento ejecutivo y la consciencia. **Palabras clave:** evolución cerebral, funcionamiento ejecutivo.

Hunting is of no particular value when you can herd. This comment, from one of the few biohistorians in existence, summarises what one finds in the literature on the development of speech, forearm pronation, erect stature, and so on in the archihistory of the hominids (McElvaine, 2000). Five million years ago, we split from the chimpanzees. Four million years ago, Homo Erectus arose from all fours, and two million years ago, bodies and brains and tools interacted, with Homo Habilus having much more success now that the forelegs were free. The rotation of the radius over the ulna in the forearm allows for pronation, and the hands and digits are free, enabling such future tasks as manipulating a computer keyboard.

Being on all fours, with claws and jaws has its advantages. With binocular forward vision, a predator is equipped for the visually guided chase. Visual working memory is essential, so are the abilities to communicate on a simple level, and with this, the ability to produce tools is also of evolutionary significance. If you can advance your equipment during your lifespan, you need to chat about it to others, and pass the skill along the generations.

The erect, toolmaking-talking stance too has its advantages: evolution allows little by chance, all is finally linked with a purpose, with evolutionary advantage the driving force. The modern- looking human emerges a scant 130,000 years ago, and 50,000 years ago, there is a modern agrarian society (Conway Morris, 2001).

The erect toolmaking-talking stance has its disadvantages as well, more than just varicose veins and premature birth. With the loss of claws and jaws, speech and keyboard typing are released as future possibilities; however, a biped is easily outrun by a predatory quadruped, and when caught, a clawless, fangless creature is at a disadvantage, certainly when alone. These disadvantages, which allow for effective use of the pronated forearm and the articulated buccal cavity, need to be balanced by choosing other paths to follow socially.

How evolution made choices is not always clear. There is emerging evidence from evolutionary biology that the brain is not a tabula rasa to be

shaped by society, but most likely an organ that has adapted over time in order to deal with its changing environment. This is done by solving the key problems of social competition and cooperation (Francis Fukuyama, 2001; Gogarten, 2001).

The first of the choices evolution makes in order to deal with these key problems indicates at some level the use of an experimental approach with a control. In this instance, the right hemisphere represented the more static 'control group'. In evolutionary terms, this early brain was a success, with the right side structures and functions mirrored in a laterally redundant brain: injury to the right or left side would leave the contralateral structure and function intact to fill in the gaps in performance. This was a good evolutionary tactic, and at that time, the forces of evolution could allow for specialisation of the left hemisphere. This created a dominant, left hemisphere with the capacity for more complex speech and now handedness, mostly dexterous, but more importantly, this enabled an ability to take a meta-perspective of the functioning of the right hemisphere (Barkley, 1998; Gazzaniga, 2000), a method of enabling humans to be humans with consciousness of that fact. Such a meta-perspective probably involved the use of internal language, or thought, and thus the emergence of a more mature set of internal controls on many levels, which would now constitute meta-cognition.

At first, emotion was unconscious and sufficient to allow for choices to be made (Damasio, 2000). Intentional control was left to the right hemisphere (Heilman & Watson, 1991). The growing awareness of what was emotional valence in decision-making came to enhance the organism's choices and functions:

> "I suspect that in earlier stages of evolution….emotions –were entirely unknown to the organisms producing them. The states were regulatory and that was enough; they produced some advantageous actions, internally or externally, or they assisted indirectly the productions of such actions by making them more propitious. But the organisms carrying out those complicated operations knew nothing of the existence of those operations and actions since they did not even know, in the proper sense of the word, of their own existence as individuals" (Damasio, 2000; p 30).

Evolution was faced with another choice: in this case the evolution of society meant the evolution of social competition (Sugarman, 2000). A creature that evolves to make fantastic tools at the cost of increasing physical vulnerability is faced with the need to aggregate (Barkley 1998).

The other possibility is that a creature that can make tools no longer needs physical prowess or for that matter, isolation as a way of life is over with. The likelihood however is that social aggregation grew out of necessity, and together with the development of advanced speech from two million to 50,000 years ago, humans developed the wherewithal and the need to build communal shelters, to bury their dead in graves, and chat about it all (Conway Morris 2000). It was also largely the end of at least some of the more terrible forces of natural selection, as the environment lost the sheer unmitigated weight of its predatory component, but gave humans the power of meta-cognitive internal process. Hominids would now have to "mount somatic states to complex stimuli charged with social significance" (Damasio, Tranel & Damasio 1991; p 222). Ideas could be shared or bartered, and whilst environment still played the role it always had, environmental factors now made people different from, rather than similar to, their relatives, whilst nearly all behaviours showed otherwise moderate to high heritability (McGuffin, Riley & Plomin, 2001), and self-regulation a very high heritability (Barkley 1998).

Hence a new social pressure emerged: with the verbal, communal processing of creative information; public behaviour was now open to the scrutiny of nearby kinfolk, and thus socially competitive behaviour would become a new source of natural selection: ideational Darwinism if you will (Barkley, 1998; Sugarman, 2000).

In order to effectively aggregate previously disinhibited hominids, social rules had to evolve and hence the evolution of rituals. In order to effectively compete, a system had to emerge whereby previously public behaviour became more private, more internal. This obeying of rules could now be transmitted by verbal agreement, and together with the aforementioned burial of public behaviour, internal rule-governed behaviour was to become a two-headed coin. Rule-governed behaviour implies inner control: both sides of this coin require inner speech. Homo Sapiens in this way thwarted some of the very evolutionary forces that created this upright, left-hemisphere-dominant, thinking, speaking, tool-using hominid. In order to pass on the skills of toolmaking whilst staying competitive, the hominid needed to be able to both speak, and hide such speech when necessary, pass on rules, and have an internal system to control and utilise such rules internally, all under volitional control: it was the birth of self-regulation and inhibition via internal meta-analysis and meta-cognition.

The sine qua non of this self-reflexive, pensive, internal, self-regulating languaging was that one aspect of internal language could remain 'meta', or in executive judgement over another, allowing a behaviour to be judged

within a class of behaviors, with the risk of confusing the two. Meta-cognition allows thinking about thinking, and this is describing a second-order cybernetic process. Aspects of the content of such processes requires illumination and definition, if measuring such processes is to take place with better than face validity, or without the spectre of reductionism.

Verbal Working Memory, self-regulation and inhibition

From a reading of Baddeley's 1995 work it becomes clear that verbal working memory lies at the base of all executive functioning. This is clearly Barkley's public speech made private. A lone solitary, semi-upright creature with jaws, claws, and primitive weapons was not enough of a guarantee for advantageous evolution. An upright biped with various levels of abstraction in outward and inward systems of language was necessary for further evolutionary advantage. Medial limbic circuits certainly had developed to mediate information related to internal states, important aspects of memory and learning, connections with sexual-visceral and endocrine functions. Lateral limbic circuitry however now evolved to mediate information related to the body surface, external world and social-personal interactions, empathy, social cognition, mood and civil behaviour (Trimble, Mendez & Cummings 1997). Internal and external worlds could now communicate across the temporal lobe.

But in the same way as external language became important, so now was private behaviour. Fire-making skills are one thing; preserving the genetic line with full advantage requires a selective approach to information processing and display. One gives to one's offspring the advantage selectively if one can, not to the world at large, at least, not willingly. Choice is the privilege of those who can consider the options quietly, in private, in pictures and in words, before the event that will weigh heavily, necessitating sentience of mind.

A child is born with visual working memory, and by adulthood has a fully developed working memory as well. Verbal and visual working memory later come together to allow for the acquisition of culture, socialisation and creativity (Barkley, 1998). Initially the child may render its experiences out loud, but from 5-10 years old, the speech quietens and becomes more internal, leaving only micro-electronic evidence of evolutionary antecedence (Russell Barkely, references supplied by personal communication). Once the human internalises the communities rules, the actualisation of these as internal systems of governance depends on cultural

integrity within and externally, in a recursive and evolving way, much as modern courts interpret and modify law. Intelligence plays a role.

In David Wechsler's 1944 definition, intelligence is the global or aggregate ability to act with purpose, to think rationally, and to deal effectively with the environment (Walsh, 1992). To act with purpose suggests an appreciation for goal-directed activity and also an appreciation of the connected continuity of events across time. To think rationally applies purpose to thinking, namely an ability to run an approximation of connected past, present and future events through a simulator comprising of internal speech and vision. To deal effectively with the environment implies both volition as well as a widespread processing system that will measure external outcomes by integrating multi- and heteromodal incoming information across time against both purpose and rationale, and to compare the results in an ongoing way across temporal history. As Damasio, Tranel & Damasio write in 1991:

> "Because there is no single neuroanatomic region that holds the integrated "image" of a polysensory based set of events, meaning is critically dependent on timing. And because implied meanings require a far larger set of components for their definition than manifest meanings do, the problem of synchronisation and subsequent attention looms larger. In short, from this perspective, the response selections required for appropriate decision making in social cognition and equivalent realms, necessitates the holding on line, for long periods of time (in the order of several thousand milliseconds), highly heterogeneous sets of cognitive components that must be attended effectively, if a choice is to be made" (pp 219-220).

Working memory is thus the imperative force that guides internal human volition, goal setting, and effective action, as Lezak framed executive functions (Lezak, 1982; 1995). It is also clearly heteromodal, requires large areas of heteromodal cortex, and damage limits conscious awareness across time (Prigatano 1996). In Mesulam's formulation, these areas provided a fairly faithful representation of what the outer world is all about, or providing what we call our phenomenological or subjective experiences (Prigatano 1996). The idea of emotional valence, or what it means to attach an emotion to such experience will be discussed further on. In the meantime though, it is reasonable to see conscious awareness, or an appreciation of the verbal/visual simulator, as an offshoot of this application of intelligent executive meta-functioning of working memory. An interaction between the outside and inside milieus across time creates an awareness of both, and

given varying levels of internal consideration, certain logical approaches are prescribed, and others proscribed, consciously and with presience of mind.

Defining the parameters of executive functioning as a dynamic

Defining aspects of executive functioning as Lezak has done is helpful, but may be reductionistic. By this I mean that a circular and homeostatic mechanism may not be reduced to its components parts without running into logical paradoxes, as Lezak, to her credit, notes (Lezak, 1995) in the fractionation of executive functions. Language is linear, and without careful definition, the pragmatic aspect of language reifies concepts that then induce individuals to create tools to measure their linear strength, and then apply this as if it were a measure of the circular events themselves. In linear terms, action 'A' causes result 'B' (such as hitting someone). In circular epistemologies, action 'A' influences not only result 'B' but in turn influences 'A' in a recursive interaction (by applying feedback, such as complaining to the law).

There is no surprise then that metaphors created by Freud, such as Ego and Super Ego, were then subject to measurement instruments as if the metaphor represented a real continuous linear 'thing', and not a process, as has happened with executive functions. Time and paradox are strongly interconnected (Watzlawick, Beavin & Jackson, 1967), and any definition of a process should consider the interaction of time and content.

Barkley (1998) set out to define how working memory influences inhibition and self-regulation, and how these then interact with the so-called executive functions. His is one of the few formulations that use an appreciation of *temporally distant ev*ents as part of the definition of the dynamic activities of self-regulation. Gualtieri (1995) earlier summarised the same kind of approach in passing, but without formal definition, or reference to time and class of events:

> "Self regulated behaviour in humans also requires the development of guidance systems and programs that are appropriate to a chosen goal, flexible in the face of obstacles, protected from extraneous or internal distractors, and liberated from the proactive interference of previously learning programmes (p157)",

and is referring to the principle of autonomy since this must all occur in the absence of extenal direction or structure (p153). He does however note that

> "conceptual thinking comprises the ability to draw abstractions from perceptual experience and to manipulate abstract ideas in an organised and effective way" (p 152)

without reference to the different levels of abstraction evident in such a formulation, or the essential nature of the passage of time.

As far back as 1920, Head noted that brain activity at any moment is not an isolated event, but rather is related to the brain's activity of a moment before; Greenfield in 1995 identified aminergic neuromodulation as evidence of the contingency of previous neural and neurochemical events on a neuron's functioning (see references cited and argument in Mazabow, 1999). In short, icons of information need to be echoic for perception to take place.

The first concept, response inhibition, is defined in Barkley's terms as the innate capacity to inhibit a 'prepotent' response, namely, that response that is reinforced by the immediate environment in which one finds oneself at any given moment. This implies the ability to ponder about, or delay a decision about a response, as well as the capacity to interrupt any response when the feedback information is that this response is not having the desired effect. This also implies the capacity otherwise to avoid competing responses which act as distractors. Efficient working memory thus underlies this pondering-monitoring process, and is clearly self-recursive in that it involves both outer and inner worlds in circular interaction across linear time, with the goal of homeostasis.

The second linked concept, self-regulation, includes any self-directed intervention that changes a present/future behaviour so as to alter a temporally distant, likely outcome. The elements of this are that this:

- Is self-directed (internally, silently mediated)
- Relies on internal utility of outcome (a value system that observes homeostasis)
- Is future-orientated in that the future is valued over the present (comparitive)
- Requires a special form of sequential working memory (icons that are echoic)
- Bridges uncertain outcomes by allowing for contingencies (abstract problem solving)
- Binds events across time (related to the special sense of temporal events in logical sequence)

What is also clear from studies cited elsewhere by Barkley, is that the further forward in the future a favourable outcome may be, the more prefrontal cortex is needed. Executive interactions are thus strongly intertwined with future outcomes based on this connected quality of the events upon which the process focus directs, and is linked to the social

environment. (Burgess et al. 1998, see reference below) note that this particular form of sequential memory, the correct ordering of events in memory, is best described as executive memory, pathology here related to perseveration.

Finally, the last and most troublesome concept is that of dynamic executive functioning. Following on the above, executive functioning is best described as those forms of self-directed activity that delay prepotent, unfavourable responses, and replace these with behaviour that binds events across time in order to favourably alter future outcomes.

The high functioning human may thus wrest control of life outcomes from the environment by judicious usage and overview of the events in working memory. This is simulation, again, an internal process of premeditation, and this is the process that influences natural selection, or the pruning of the environmentally disadvantaged.

A failure of such a (circular/homeostatic) mechanism must result in poor social functioning, and a despairing resort to other (more linear, perhaps pathological first-order) mechanisms, such as social aggression, social manipulation, social withdrawal, and so on (Sugarman, 2000). This would then result in social withdrawal being a common, non-specific, almost invariate sequel to serious mental dysfunction, and in a review of the available literature, this indeed appears to be the case (Sugarman, 2000). In other words, when homeostasis, a second order phenomenon breaks down, simpler, more first order solutions are attempted, linear shots across the bow as it were.

Executive function as a process can thus be seen to have a content to it, as well as the meta-analytic ability of self-reflection. However, in itself, executive functioning is not merely content, but a process, and to compare and confuse the two is to make a class of actions a member of the class itself, an epistemological error that will bedevil attempts to measure it reliably (Dell 1982; Watzlawick, Weakland & Fisch, 1974).

Over-analysing this content may lead to fractioning of the dysexecutive syndrome, but there may be limits to this, such as the differential loading of some tests on the factors of inhibition, intentionality and executive memory (Burgess, Alderman, Evans, Emslie & Wilson 1998). These authors conclude, with regard to the first aspect, that inhibition, is:

> "inextricably bound up with concepts of "general intelligence," and the behavioural manifestations of deficits in these processeas are seen most often as poor control of social behaviour" (p555),

an idea mirrored in the comments of Matarazzo (1990) some time before. Burgess et al (1998) note that their findings are consistent with the view that

the executive functions, as a system, provide "control" (their emphasis) functions for a wide range of more informationally encapsulated resources, as put forward by the principle author the previous year. Hence different tests measure different aspects of the dysexecutive syndrome, with poorer representation of motivation and personality aspects; more attention is paid to this below, with regard to motivation and emotion (see references to Damasio 1994).

The idea that this process of "control" is of a somewhat higher order of abstraction than the other "informationally" encapsulated resources is again put forward, suggesting the danger again of confounding logical confusion.

Epistemological confusion in systems theory

Whitehead and Russell (1910-1913) wrote of the theory of logical types. In this theory, whatever involves all of a collective class must not be one of the class itself. Any attempt to deal with one in terms of the other leads to confusion and logical errors (quoted in Watzlawick, Weakland & Fisch 1974). By virtue of its position, meta-analytical thought, or meta-cognition cannot be divided up into its component parts, and deliver information about itself any more than one person is defined by dividing results on 10, 000 subjects by a factor of 10,000. Change to any system automatically involves a higher level of abstraction, and hence from Barkley's definitions, executive functioning embodies changes in level and abstraction in thought processes across time, and involves multiple and heteromodal aspects of brain functioning. If there is a content which can be measured during the process of thinking, e.g. the content of memory or of the hippocampal input-output, then modifying or observing such a process from within implies another level of abstraction, such as homeostatic process. Content and process are two different entities, and to confuse the two leads to paradox. Yet psychological assessment does just that in creating norm tables for the assessment of executive functions (Lezak 1982; 1995). Testing and assessment are again, two concepts at two different levels of abstraction.

Testing vs. Assessment: Matarazzo, Walsh and Damasio

Joseph D. Matarazzo, past president of the American Psychological Association, said in his plenary address at his inauguration in 1990 that psychological testing is not equivalent to psychological assessment (Matarazzo, 1990). Reading further, it is clear that the content of testing is not equivalent to the process of assessment, and to confuse the two is again

a confusion of one level with another level of abstraction, a meta-level. In the same way, the content of IQ is normally distributed across its own population, but the process of how that IQ is produced, namely the subtests, themselves do not follow a normal distribution. Since the basis of all normative testing is that the attribute being assessed is normally distributed, norm tables for individual subtests are meaningless. Also then, it is acceptable that intersubtest scatter is a function of normal human performance. A normally distributed IQ cannot thus be broken down into the sum of its parts with any indication of more than face validity.

Walsh (1992), in considering neuropsychological test equipment, notes that all tests have only face validity, and that different persons fail the same test for different reasons. Clinical Neuropsychology is, Walsh argues, a matter of making inferences. In short, neuropsychological inferences represent a meta-analysis of test outcomes, and as Matarazzo notes:

> "Assessment…..is a highly complex operation that involves extracting diagnostic meaning……Rather than being totally objective, psychological assessment involves a subjective component…..Objective psychological *testing* and clinically sanctioned and licensed psychological *assessment* are vastly different enterprises" (Matarazzo 1990; p 1000, italics in original).

One of the main concepts in modern clinical neuropsychology, from Matarazzo's work, and incorporating newer findings, is that single-aspect functional output of the brain involves multiple neural substrata (Mazabow 1999), and therefore by inference, pathology of the human brain produces individualised sequelae that do not represent a normal distribution. Despite this, Lezak (1982) notes:

> "Without assessment techniques that can be standardized and that can produce data subject to statistical analysis, much of our understanding of executive functions will remain at an anecdotal level" (p282).

In a sense, Lezak falls into the universalist trap that so often rears its head in the field of transcultural neuropsychology, for which she is criticised elsewhere when making species-wide comparisons (Nell, 2000). She deals with the paradox of assuming that such complex operations are reducible to content only in passing, despite her appreciation even in 1982 of the 2nd order process that appears to be the basis for these functions:

> "A look at some of the important differences between executive and cognitive functions may help us appreciate why systematic measurement of the executive functions has lagged so far behind…..One distinction between cognitive and executive

> functions lies in the kind of question each class of functions calls for……The structure of the usual neuropsychological or psychological examination makes it very difficult, if not impossible, to observe some of the most important executive functions……" (pp 282-283).

She was certainly even more aware of the nature of epistemological confusion in 1995, and used the term 'paradox' in this regard. One of the "important executive functions" will appear in Lezak, 1995 as 'volition', in which the temporally distant will become part of the definition. Motivation is one of the preconditions for volitional behaviour, and the awareness of self. Again, executive functioning is seen to be dependent on conscious awareness and motivation (Lezak, 1995; p 651), which Damasio equates with emotion (Damasio 1994). What patients report in terms of self-reference across studies and across cultures does not correlate with their overall neuropsychological status, but what their relatives or caregivers report, clearly does (Prigatano 1996).

Emotional valence, consciousness, and emotions in the 'visceral brain'

Emotional valence is a term used in another context, that of a loss of awareness of deficit after traumatic brain injury (Prigatano, 1996, with reference to Weinstein's work, and about Brodal's stroke, written up in 1973). For the brain-injured individual with widespread heteromodal cortical damage, the valence of the inner experience is lost, thus the outside context is always to blame. For Brodal, he had to learn to re-experience his internal sense of his body. This lead Prigatano (1996) to comment:

> "It is a tremendous argument that consciousness is the highest of all the integrative brain functions, and disturbance of brain function in any way will alter consciousness in some capacity, even though our ability to measure it may be quite far from what the phenomenological experience is for the patient. If these problems were all psychiatric or purely straight-forward neurological problems, these patients would have not shown it" (p 17, transcription by R Sugarman, 1996).

Awareness is clearly cleaved off from mood (Prigatano, 1996, commenting on Starkstein's 1992/1993 work) as much as IQ is cleaved off from executive functioning (Barkley, 1998). Prigatano believes there are *interactive variables that change with time.*

Meta-analysis is thus the ability to stand apart from the content, and in a process-oriented way, examine the process itself. Bringing together the

object and itself, as Damasio (2000) defines it, comprises a unified mental pattern from its basic to most complex levels, and thus defines human conscious awareness. It is clear from his work that Damasio regards one of the issues of defining the neuroepistemology of consciousness is that of meta-analysis as a twofold problem, that of simulating reality, and secondly:

> "Generating the appearance of an owner and observer for the movie within the movie; and the physiological mechanisms…..have an influence on the mechanisms behind the first (p11)".

There is thus a basis here for why the interaction between tester and test-taker influences the quality of executive functioning, or the creation of what Walsh has termed 'surrogate frontal lobes'. The extent to which so many authors resort to the use of metaphors is also interesting, as in post-modern systemic thought, metaphor also has credentials as second order process.

Damasio also has difficulty with the reductionism of those such as Starkstein, and comments that separating these two interactional entities is the same as breaking consciousness into parts, and in so doing, making the investigation of consciousness manageable, as has been done in analysing executive functions by fractioning. Consciousness and emotion are not separable, so that biological consciousness has several levels of organisation and depends on conventional memory and working memory (Damasio, 2000, p16). That Damasio shares the view that this is all a second order cybernetic process is also likely, given his comment that consciousness consists of constructing knowledge about two facts, namely, that the organism is involved in relating to some object, and that the object in the relation causes a change in the organism (p20). Mazabow has argued that this reflects on a cybernetic system that is partially open and partially closed, but still capable of self-creating and self-regulating (autopoietic in the von Glasersfeld tradition: Mazabow, 1999). Mazabow was working with the strongly afferent/efferent connections of the visual system, as much as Blessing (1997) is interested in the afferent/efferent connections of the 'visceral brain'.

True to the tradition of Maturana and Varela, Damasio notes that the organism in the relationship play above relies on the brain-based simulator provided by Barkley's model, "holding within itself a model of the whole thing" (p22), a thought akin to Blessings "visceral brain" (Blessing, 1997). Damasio refers to this visceral brain as perhaps the single most important clue to the substance of the unconsciousness. Damasio comments later:

> " If actions are at the root of survival and if their power is tied to the availability of guiding images, it follows that a device capable of maximising the effective manipulation of images in the service of

> the interests of a particular organism would have given enormous advantages to the organisms that possessed the device and would probably have prevailed in evolution" (2000; p 24).

Blessing (1997) appears critical of Damasio's earlier work ('Descartes Error' in 1994), but Damasio (in Damasio, Tranel & Damasio, 1991) had even earlier noted:

> "Activation of the amygdala would in turn result in reenactment of a somatic state whose signal, intensity, and somatic distribution would be pertinent to the sensory set" (1991; p225).

Damasio et al.'s model appears, at face value at least, to meet Blessing's criteria of homeostasis, taking in a wider view of the limbic-emotional areas than did earlier writers.

A concept vital to self-regulating mechanisms is that of dynamic homeostasis, a second-order cybernetic entity that follows the universal laws of thermodynamics and is involved in the evolutionary task of maintenance of the organism in its environment.

Dynamic homeostasis: dynamic assessment of 'the right stuff'?

A careful reading of the above demonstrates that the process of conscious self-regulation is not unlike the unconscious processes of self-regulation, and thus represents homeostasis, hard to evaluate if the central nervous system is closed off from other areas. As Blessing writes:

> "It is likely that darwinian natural selection has resulted in the development of patterned commands that integrate visceral and behavioural components of bodily homeostasis, without the necessity for immediate feedback…….Mammals have so evolved that the programs that encode both the physiological and the behavioural patterning necessary for survival are contained within the brain, not in peripheral ganglia…..Our studies of bodily homeostasis can then take place in a wider context. Thus in a study of fluid and electrolyte balance, observations of behavioural strategies used to find water and salt in deficient environments will take their place along with relevant hormonal and neural control of absorption and excretory mechanisms" (Blessing, 1997, p 236).

Blessing clearly has a strongly homeostatic view of nervous regulation of human behaviour. He comments (as noted above) that a critical reading of Damasio (1994) with regard to isolating elements of limbic cortex or other area of the brain has little to offer. Blessing reminds us of Brodal's view that one must be careful not to substitute names for explanations (Blessing,

1997). Conscious awareness in the Damasio (2000) context however, emerges as a 'feeling of what happens' and allows for an appreciation of object-agent relationships that are an essential part of wresting control from the environment as Barkley defines executive control (*vide infra*). One has to be aware at some level of the object (environment) and the agent (one's self) in order to simulate the outcome ahead of time. In other words, the capacities for formulating future outcomes that are perceived as favourable to the organism (goals), determining by simulation what steps must be taken (planning), and the effective realisation of those plans, are essential executive functions for independent, creative and socially constructive behaviour (Lezak, 1982), for which Lezak forwarded the Tinkertoy Test. Yet from Damasio's point of view, in 2000 anyway, emotional valence is a necessary adjunct to decision making. Indeed, limbic tagging, or preservation of a prefrontal activity by stimulating pathways from limbic system to prefrontal areas via the cingulate, is some evidence of this correction mechanism (Gualtieri, 1995).

By 1982, when Lezak was querying the nature of assessing executive functions, James Papez's 1937 limbic formulations, and Paul MacLean's later and additional theories were yet to conclusively illuminate on the role the amygdala in regulating human emotion (see Iverson, Kupfermann & Kandel 2000; Killcross 2000). Evolution had found it critical to evaluate the threat in another object's facial expression, the approachability of another, responses to linguistic threat, memory for emotional events, and necessary learned responses to pleasant and aversive stimuli.

In concluding thus, it can be seen that self-regulation constitutes a second order cybernetic process that allows the organism to consciously reflect on its internal visceral self with some emotional valence, and place this position in relation to an external context. By simulating this interaction across time utilising verbal and visual working memory, the best temporally distant outcomes can be determined and acted on accordingly. The above process is a process in which the frontal lobes clearly play only a partial role, divisible only perhaps according to some formulations of content (Lezak ,1995).

However, this is a process, and follows no normal distribution, being unique to each individual, and involving multiple central nervous system, emotional and somatic elements in a recursive, self-reflexive and homeostatic way. In terms of this neuroepistemology, no testing instrument has the necessary capacity to quantify the rapidly evolving content of this process, as it is homeostatic in nature, and hence subject only to punctuation: the nature of observation changes this process, and hence the test

room toolbox is empty of tools that have criterion validity, and is not a good context to assess executive functioning (Barkley, 1998).

As Killcross (2000) notes, damage to the amygdala selectively impairs the formation and utilisation of mental representations or rewarding outcomes or goals. This again shows reference to the internal simulator of outcomes, and the role of the amygdala, seldom if ever referred to in the literature of executive outcomes. This is however part of what Blessing calls the "real brain" (personal communication) in angry response to considerations of isolated and artificial constructs such as 'limbic structures' or 'temperolimbic' areas in the Papez or MacLean formulations.

This would imply that trying to measure dysexecutive syndromes in the presence of various pathologies would prove problematic, as behavioural measures would lack ecological validity.

Dysexecutive syndrome and alcoholism: a case in point

An example which aptly demonstrates the difficulty of dynamic assessment of executive functioning is that of alcoholic dementia in the absence of dysmnesia, where multiple brain systems are involved: the existence of such a syndrome is rendered contentious (Joyce, 1994; Sugarman, 1992). Such a syndrome would be difficult to measure in terms of its executive events. Even where 'ecologically valid' tools such as Wilson et al.'s behavioural assessment of the dysexecutive syndrome BADS, are used to address the controversial existence of an adaptive behaviour syndrome, the experimenters note of the subjects who later were found to do poorly on the BADS:

"……Nor did they show impaired social or occupational functioning or present a significant deficit from a previous level of functioning" (Ihara, Berrios & London, 2000, p. 732).

This is an interesting formulation: the existence of the dysfunction on the testing is now seemingly held up as proof of actual brain dysfunction, either that, or that a dysexecutive syndrome is something that only exists as a response to a test which measures, well, the subject's ability to do the test. (Elsewhere, of course, Wilson and her colleagues have found ecological validity for the BADS, in its tying together with patient and family report of executive failures: Barbara Wilson, personal communication).

Ralph Tarter had found significant changes outside of the central nervous system (cirrhosis, motor-nerve end-plate activity) that influenced subjects' performance on various test instruments (Tarter, Panzak, Switala, Lu, Simkevitz & Van Thiel 1997). Poor childhood executive functioning pre-

alcoholism was deemed a major factor (Ayataclar, Tarter, Kirisci & Lu 1999), and largely the tangle of environment and genotype was found to be confounding in such an assessment (Vanyukov & Tarter, 2000). Recently, there is substantive evidence that withdrawing from chronic alcohol consumption may be the risky venture associated with alcohol abuse (Davidson, Shanley & Wilce 1995; Hoffman 1995; Nutt 1999), not dose-dependant on consumption, but in certain individuals (Nutt 1999). The complex interaction of glutamate receptors and parvalbumin containing cells (Krill, 1995) may influence the outcomes for executive functioning in this way. The superior frontal association cortex, hypothalamus and cerebellum are certainly involved, but conflicting evidence for damage to the hippocampus, amygdala and locus ceruleus exists, and no change is found in the basal ganglia, nucleus basalis or raphe nuclei (Harper, 1998).

With regard to memory, there is no surprise however in the findings that confabulation is related to a sense of self and continuity (Mattioli, Miozzo & Vignolo, 1999) or that this is related most strongly to temporal context confusion (Schnider, von Daniken & Remonda, 2000).

It is clear that what defines executive dysfunction in the ecological sense ('anecdotal' in Lezak's formulation) is somewhat different to what testing reveals on a neuropsychologically sensitive measure (as with Ihara's group, and which riles Eileen Joyce and Steven Bowden before her). The extent to which interaction with a neuropsychological instrument corresponds to interaction with the environment is after all a determination of its ecological validity. In this context, what constitutes a "latent dysexecutive syndrome" found on testing is unclear (Ihara et al. 2000 p 731). The answer perhaps lies in their later comments:

"At the same time, analysis of individual cases confirms marked interindividual and intraindividual differences in cognitive performances" (p 735) confirming what was said earlier, that such functioning is vitally unique and not normally distributed.

A further discussion follows on the use of progressive matrices and the nature of general ability but as Matarazzo (1990) has noted, the only real common factor on which all testing loads is approximately that of Spearman's "g", or a factor of general intelligence. Ihara et al. 2000 note further that in "two thirds of these patients executive function impairment is independent of general intelligence" (p 735) echoing Barkley's (1998) formulation that IQ is split off from executive functioning. None of this is surprising as Ihara et al. 2000 later comment that the functional independence of executive functioning from memory leaves room for further investigation, but also: "we excluded patients with alcohol induced amnesic

disorders in the initial interview" (p 736) something Bowden stated should not be done as it artificially biases the findings in alcoholism research.

It is thus clear from the above that patients with no clinically evident difficulties in their lives may or may not respond to test instrument in ways which may or may not reflect on brain pathology or normality in the face of complex genotype-phenotype interactions, as Tarter noted, via multiple, recursive pathways (Tarter et al., 1984), and against 'substitute control groups' such as norm-based evaluation tables (Matarazzo, 1990).

The same difficulty faced Herrnstein & Murray (1994) in their evaluation of the performances of various cultural groups. They ignored what an individual may accomplish, and the variable, culturally loaded, cross-cultural meaning of intelligent functioning (Nell, 2000).

Cross cultural evidence

Testing settings appear to be universals, but whether or not a subject understands the demands of the test situation, in other words is test-wise or not, will often depend on their knowledge of what a test situation in the western paradigm really encompasses in terms of expectations.

The distant and silent tester, using supplied manuals with prescribed language in non-western test paradigms, results in a form of gatekeeping, favouring the advantaged and test-wise western subject, clearly in the service of the tester, and not the subject (Taylor, 1999). What then is being measured in executive terms is unclear.

Test situations and indeed, test manuals in western settings deliberately minimise the interaction between tester and testee, and focus on correct answers rather than processes, such as those important to learning (Taylor, 1994) although Walsh and other have constantly reiterated that the way a subject fails is as important as their failure (Walsh, 1992). In this way, western test procedures focus on overlearned information, not potential to learn, thus working to the advantage of those who have actualised their executive potential via interaction with education systems, and against those who were not educated in terms of the demand of western paradigms.

Taylor (1994) identifies three approaches to cognitive assessment: firstly, the structural approach, based on factor analytic research, secondly, the information processing approach, and finally the dynamic approach, which draws on the Vygotskyian-Lurian belief that the material conditions of culture shape cognitive structures, in keeping with Barkley's formulations above. Luria's field studies in Uzbekistan have been replicated in Africa with near identical results (Nell, 2000).

Psychiatry too, as slow as neuropsychology in developing an awareness of such principles, is now beginning to respond, wondering if it is measuring the 'right stuff' in outcomes in schizophrenia (Green, Kern, Braff & Mintz 2000). It too is focusing on a more dynamic and integrated approach to assessing the brain and behaviour (Koopowitz, 1999).

Despite these issues being common to most non-western settings, Global IQ scores, common neuropsychology batteries, and various protocols of assessment ignore what Taylor (1999) and others propose, namely the value of a more dynamic testing approach, which would create programmes that fulfill Vygotsky's desire to foster the functions that have not yet matured, but are still embryonic (Vygotsky, 1978). One sees discussion of this later referred to as personal intelligence, or social competency, or fluid intelligence in the Cattell (1971) mode (see also Ihara et al.'s 2000 mention of this in passing).

Feuerstein (1979), Budoff (1987), Campione and Brown (1987), Carlson and Wiedl (1979, 1992), Green *et al. (op cit.*) and others have attempted to apply and develop Vygotsky's original formulations *of the zone of proximal development* (see Nell 2000), but with mixed, and much criticised success (Taylor 1994; 1999).

Uncritical universalism thus dominates assessment of cognitive abilities in western and non-western test settings, and some critics are now arguing for a more humane relativism, with the expectation that wide variations in normative performances must occur (Nell, 2000). Since test instruments can be constructed that do not show statistical evidence of bias between culturally divergent groups, (Taylor, 1999; TRAM 1 & 2, APIL-B), or assume species wide comparisons (Lezak, 1995), a dynamic, neurobehavioural assessment is feasible (Green *et al., op cit.*; Nell, 2000; Sugarman, 2001). Such an approach would be of use where cultural effect is noted and cannot be explained or dealt with (e.g. Johnson-Selfridge, Zalewski & Aboudarham 1998) in the individual styles of executive functioning.

As Walsh noted in 1992, there is not a clear link between stimulus material and the dimension or process being measured even in western settings, and heavy demands are thus placed on the interpreter and tester (Taylor, 1994; 1999) to extract diagnostically meaningful information, the goal of clinical neuropsychological assessment (Matarazzo, 1990). Walsh (1992) warns against such face validity pronouncements on performance evaluations, and Franzen (1989) found that few tests in neuropsychology's tool kits share much in the domain of main effects variance anyway, really only factoring down to a measure of overall ability (Matarazzo, 1990). The

inferential skill of the tester is still a factor, western setting or not, and in non-western settings particularly, education is a factor, not race or ethnicity (Perez-Arce, 1999; Ponton & Ardila, 1999). As in Australia, many societies have significant immigrant populations, and in such groups, total number of immigrants, occupational allegiance, education, and intended area of initial residence impact on demographic variables known to have significant effects on neuropsychological performance, especially in executive functioning (Llorente, Ponton, Taussig & Satz 1999; Thomas, 1999).

While it must be accepted that the development of valid and reliable test measures for executive functioning in non-western cultural groups must be "based on empirical investigations" (Rey, Feldman, Rivas-Vaquez, Levin and Benton, 1999, p. 593), a call echoed in Nell (2000), Taylor (1994) and Lezak (1982), neuropsychological assessment in practice must not only fulfil the criterion of being fair to non-western groups, but should also not discriminate between western and non-western groups, whilst making diagnostic interpretations mistakenly based on the culture, not the brain.

Culture-fair does not mean the translation of western tests into non-western language (Artiola i Fortuny, Heaton & Hermosillo 1998; Ponton *et al* 1996), since what is culturally acceptable in one instance, such as low performance times indicate good executive achievement, may not be acceptable in another, where speed is equated with sloppiness, and slowness with being meticulous (Sugarman, 2001).

There is some value in creating novel tests that do not emanate, say from US Army testing in the pre-WW I years (Lezak, 1995), nor label non-western individuals with highly discrepant results that imply some inherent cultural bias in the test battery, as in The Bell Curve (Herrnstein & Murray 1994). Developing special norm tables for individual groups on such western tests may even be seen as discriminatory and legislated against (see Section 106, American Civil Rights Act of 1991). The latter authors did after all try to eliminate test entities that were overtly biased, but nevertheless some groups in society must be left with the sense that on the attribute supposedly measured, they are somewhat on the wrong side of the bell curve (Nell, 2000).

In developed and developing societies such as Australia, this must lead to the inevitable sidelining of growing, but impotent populations (see special issue, Australian Psychologist, 2000, 35(2)), and as Herrnstein & Murray (1994) illustrate. Such populations cannot always draw on overlearned skills, as do the psychometrics of IQ tests, even when 'norming' these in the Australian setting (Carstairs & Shores, 2000; Shores & Carstairs, 2000). Culture-fair implies that the criterion-loading of the test, language

notwithstanding, be universal, and Nell (2000) and others argue convincingly that the further you get from neurology, the worse that loading becomes as a response to pseudo-evolutionary, discriminatory views of the 'other' culture:

> Although we live in gentler times than Luria….. (the) emphasis on culture and the impact of culture on cognition is out of tune with the universalism that psychology and neuropsychology have adopted as a defence against the excesses of "culturalism" (Nell, 2000: p. 46).

Given the likelihood that executive functioning and culture have interacted for millennia, the impact of one on the other reflexively makes the goal of measuring executive functioning across cultures unlikely unless a dynamic approach to testing is adopted.

Conclusion

As Homo Sapiens emerged from the sustained activity of evolutionary pressure, a homeostatic neural mechanism evolved like any other, allowing for one side of the mind to observe another, and in doing so, created a simulation of the outside world and the organism itself in interaction. This second order machinery freed the organism from total passivity under evolution by allowing internal and accurate representations of the outside world to exist, and for the organism to come to know how it feels about that across time. The internal simulator could bind events across time, and in so doing, came to understand its own mortality.

Truly homeostatic, such a mechanism acts upon the world, and in so doing, acts upon itself, changing itself and allowing for the process of ideational Darwinism and autopoiesis. Drawing on verbal and visual working memory, and informed by emotion, the replications and simulations of strings of behaviour may sometimes be imperfect, and hence are creative or wrong, but always unique. Being unique they are not subject to statistical reductionism, and hence the operations and output of such unique systems are not normally distributed across populations, contexts or cultures. These operations constitute the most subtle and central realm of human activity (Lezak, 1995).

When the tester interacts with the test taker, the testing situation alone filters into the executive functions and insinuates its own process into the simulations of the subject's mind, and cannot stand aloof from it. A novel view of dynamic assessment is needed in order to address these and other issues.

Given the neuroepistemological concerns voiced here, and the heterogeneity and paradoxical nature of executive functions, and the status of investigation of the visceral brain, it is no small wonder our toolboxes are empty as we confuse a process with the contents that have evolved over millennia to produce the class of behaviours we call executive functions in the test room, but are more grounded in the social interactions outside.

What we call executive functioning may be so intertwined with human conscious awareness and emotion, as well as the rapidly fomenting and changing homeostatic interaction with the prepotent environment, that observing it changes its essential nature, and thus says more about the tool than the patient.

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