

# **PALESTRAS**

**86 BILLION BRAIN NEURONS: THE ADVANTAGES AND COSTS OF THE REMARKABLE, BUT NOT EXTRAORDINARY, HUMAN BRAIN**

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Neuroscientists have become used to a number of “facts” about the human brain: it has 100 billion neurons and 10-50 times more glial cells; it is the largest-than-expected for its body among primates and mammals in general, and therefore the most cognitively able; it consumes an outstanding 20% of the total body energy budget despite representing only 2% of body mass, because of an increased metabolic need of its neurons; it is endowed with an overdeveloped cerebral cortex, the largest compared to brain size. These “facts” led to the widespread notion that the human brain is literally extraordinary: an outlier, defying evolutionary rules that apply to other species, a uniqueness seemingly necessary to justify the superior cognitive abilities of humans over mammals with even larger brains. These “facts”, with deep implications for neurophysiology and evolutionary biology, are however not grounded on solid evidence nor sound assumptions. Our recent development of a method that allows rapid and reliable quantification of the numbers of cells that compose the whole brain has provided a means to verify these “facts”. In this talk I will review this new evidence and argue that, with 86 billion neurons and just as many non-neuronal cells, the human brain is a scaled-up primate brain in its cellular composition and metabolic cost, with a relatively enlarged cerebral cortex that does not have a relatively larger number of brain neurons, yet is remarkable in its cognitive abilities and metabolism simply because of its extremely large number of neurons. I will also argue that, because of metabolic limitations due to the number of hours available for feeding on a raw diet, such an enormous number of neurons could only be afforded in evolution with a shift to a cooked diet by our ancestors.

25/09/2012 – TERÇA-FEIRA

**BASES NEURAIS DA PERCEPÇÃO DO SABOR**

Araujo I

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Os circuitos centrais que mediam a percepção gustatória integram os sistemas cerebrais que regulam comportamentos ingestivos. As características de um alimento não se resumem, porém, a seu aspecto gustatório, mas incluem outras propriedades como o odor, textura e temperatura. Evidência obtida em estudos anatômicos e funcionais demonstra que o sistema gustatório central, especialmente seu aspecto cortical, opera como um circuito integrativo no qual seus neurônios prototípicos também respondem à estimulação somatosensória e olfatória. Além disso, circuitos gustatórios também são regulados pelo estado fisiológico do organismo, sendo que respostas neuronais a estímulos gustatórios são moduladas parâmetros fisiológicos tais como hormônios gastrointestinais e níveis de glicose no plasma. Em resumo, antes de funcionar como campo receptivo associado aos receptores gustatórios da cavidade oral, os circuitos gustatórios centrais parecem operar como um sistema multimodal dedicado à avaliação do significado biológico de estímulos intra-orais.

**SENSIBILIDADE E HISTÓRIA; NOTAS PARA UM DEBATE SOBRE AS RELAÇÕES ENTRE NATUREZA E CULTURA**

Furtado JP

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Na linha de investigação que vimos desenvolvendo no âmbito do projeto História e Linguagens, e da qual o presente trabalho é um dos desdobramentos, procuramos analisar e discutir a natureza das relações entre sensibilidade, linguagens e produção cultural, de um lado, e as representações e ações políticas que com elas interagem, de outro. No tempo presente, para além do relativo enxugamento da esfera política pública, processo que obedece aos imperativos dos processos de urbanização e modernização capitalistas, ocorreu um processo de redefinição do campo cultural e político no qual também a intimidade, o corpo, e as subjetividades passaram a ser objeto de atribuição de novos sentidos, o que conferiu também novo sentido à politização da intimidade e das representações culturais. Representações culturais, e/ou obras de arte e da cultura, não seriam, portanto, apenas epifenômenos de alguma coisa abstrata (a “Sociedade”) que está fora ou na base delas. É por isso que, a nosso ver, as representações culturais são crescentemente consideradas como um objeto particularmente interessante no que diz respeito ao exame dos problemas da contemporaneidade. Isto se dá na medida em que expressam e consolidam, de maneira peculiar, o tipo específico de sensibilidade que se transforma a partir do processos de industrialização e urbanização e seu impacto sobre a geração e recepção de “produtos culturais” das mais diversas naturezas. Aqui estudam-se, para além do discurso estritamente racionalizável, as estruturas lingüísticas, as estruturas de pensamento, o conhecimento disponível e os conceitos, as formas de sensibilidade e percepção. Tal enfoque amplia os horizontes da pesquisa histórica e sugere um diálogo interdisciplinar, ponto sobre o qual os principais fundadores dos “Annales”, em especial Febvre e Bloch, muito se detiveram. O estudo da cultura, da psicologia, da lingüística encontram-se em suas fronteiras e o historiador, ávido por “interpretar” e se imiscuir numa época que só se revela a partir de seus fragmentos, deve lançar mão de quaisquer recursos que estejam à sua disposição. Situando-me, portanto, a partir de uma perspectiva teórica que dialoga com as mais substantivas tendências da “História Cultural” pretendo discutir o problema da produção historiográfica em relação às práticas comunicativas concretas que a instituem.

## INOVAÇÃO E PERCEÇÃO

Campos E

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A capacidade humana de perceber o mundo de modo diferenciado tem sido fundamental para a sobrevivência e evolução da humanidade. Nesta palestra, serão abordados diferentes aspectos da percepção e o seu impacto em inovação, abrangendo ciência, arte e tecnologia.

## 26/09/2012 – QUARTA-FEIRA

### INVESTIGAÇÃO NÃO-INVASIVA DA FUNÇÃO DAS VIAS VISUAIS

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Assim como outros sistemas sensoriais, o sistema visual é composto por células que transmitem informações específicas da cena visual de forma paralela. Entre o trajeto da retina ao córtex visual primário, destacam dois grupos de células que processam informações distintas. As células P são maioria na retina e apresentam melhores respostas para altos contrastes, altas frequências espaciais, baixas frequências temporais e para o contraste de cor verde-vermelho, enquanto as células M respondem melhor para contrastes baixos, baixas frequências espaciais e altas frequências temporais. O registro não invasivo de potenciais bioelétricos oriundos do córtex visual é chamado potencial cortical provocado visual e através desta técnica têm-se encontrado resultados que sugerem contribuições diferenciais das vias paralelas visuais M e P para a geração da resposta cortical visual. O desenvolvimento de métodos que possam avaliar de forma não invasiva o funcionamento das vias visuais possibilitará a investigação fisiológica e clínica não invasiva destes neurônios.

### NEURAL PROCESSING AND LEARNING OF VISUAL STIMULI IN HONEYBEES (APIS MELLIFERA)

Mota T

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Vision in honeybees has been extensively studied at the behavioral level by training free-flying insects to choose visual targets rewarded with sucrose solution, and, to a lesser degree, at the physiological level using electrophysiological recordings of single neurons in the visual neuropils of the bee brain. However, our knowledge of visual processing in honeybees is still limited by the lack of: 1- conditioning protocols for studying visual learning and memory in harnessed animals under controlled laboratory conditions; 2- anatomical and physiological characterizations of visual neuropils in the central brain; and 3- techniques for performing functional studies of visual processing at the neuronal circuit level. In the present work, we aimed at filling these gaps by providing a multilevel study of visual processing in harnessed bees. We developed novel aversive and appetitive conditioning protocols for studying visual learning and memory in harnessed bees. In an aversive framework, we showed that harnessed bees can learn to discriminate punished from non-punished visual stimuli by relying on their chromatic or achromatic cues. In an appetitive framework, we showed that harnessed bees are able to solve a non-elemental bimodal discrimination in which visual cues act as modulators of appetitive olfactory learning. These two behavioral protocols open new doors for accessing the neural correlates of visual learning and memory in honeybees. We also provided a comprehensive neuroanatomical description of unstudied visual circuits in the central bee brain. More specifically, we characterized the organization and neural architecture of the anterior optic tubercle (AOTu) and revealed a segregation of dorso-ventral visual information into this structure. Having established a novel protocol for performing optophysiological recordings of visual-circuit activity in the honeybee brain, we studied the responses of AOTu interneurons during visual stimulation of the compound eye. We showed that light stimuli presented in different parts of the visual field induced distinct patterns of activation in these interneurons, consistent with the dorso-ventral segregation revealed by our neuroanatomical data. Stimulation of AOTu interneurons with monochromatic lights and with chromatic mixtures induced distinct signal intensities, time-course dynamics and activity patterns, thus revealing intricate chromatic processing properties in this visual neuropil. Our studies provide therefore an innovative, multilevel analysis of visual processing in honeybees, spanning from behavioral studies on elemental and non-elemental visual learning to neurobiological studies on visual processing and coding in the honeybee central brain.

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## TIME PERCEPTION AND IMPULSIVITY

Wittmann M

*Alemanha*

Impulsive individuals experience time differently. Several studies provide empirical evidence for the association between impulsivity and time perception. Impulsive subjects such as with various neurological and psychiatric diagnoses – i.e. patients with drug dependence, with borderline personality disorder, or with orbitofrontal cortex lesions – overestimate the duration of time intervals and, as a consequence, discount the value of delayed rewards more strongly than more self-controlled individuals and they have a less pronounced future perspective. The literature on time perception and impulsivity, however, is not unequivocal and needs a better theoretical foundation. Here, a theoretical background of concepts and methods of time perception is developed which could lead to an empirically based notion of the association between an altered sense of time and impulsivity. Moreover, an event-related functional magnetic resonance imaging (fMRI) study is presented examining the influence of impulsivity on neural activation patterns during the encoding and reproduction of intervals with durations in multiple-seconds range.

## NEUROSCIENCE IN CORPORATIONS AND MARKETING RESEARCH

Dias AM

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The last two decades have been characterized, from a scientific perspective, by a progressive increase in multidisciplinary approaches to highly complex problems related to information processing, mind-matter integration, nature-nurture paradigms, among others. These integrative developments have defined the main characteristics of contemporary cognitive science, which to a certain extent resembles the biological revolution that took place a century before, leading to the creation of neo-Darwinism as a new field, as the boundaries between natural selection, genetics, and geographic/speciation were abandoned. Among the fundamental developments that the recent cognitive revolution has produced so far, one could not avoid mentioning social neuroscience; the modeling and treatment of most psychiatric disorders as simultaneously neurodevelopmental and neurodegenerative disorders, whose course is defined by a complex association of genetic, epigenetic, and contingent determinants; the use of semi-symbolic and connectionist models to the understanding of brain process, and the other way around; and so on. Under this perspective, one thing that is becoming increasingly clear is that there is room for matters that are relevant to the corporate world under this integrative approach. During the last couple of years, I have created prototypes of some of the first neuroscientific-based systems for the corporate world that have come to my knowledge, which I will describe in this presentation. Moreover, I will discuss the state of the art in neuromarketing (including the presentation of a panel where all the technologies from all major neuromarketing companies of the world is presented in a straightforward fashion) and provide the audience with some conclusions regarding what I assume that must be included and avoided in a neuromarketing research, if the objective is to produce the most valuable results to the industry.

Keywords: Neuroeconomics, Neuromarketing, Business Solutions, Social Neuroscience, Assessment Grants by Fapesp.

## 27/09/2012 – QUINTA-FEIRA

### NEUROSCIENCE OF ILLUSIONS

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All our life, every object we see, every person we know, and every incident we experience are derived from brain processes, and not necessarily the result of an event in the real world. The same neural machinery that interprets the sensory inputs also creates our thoughts, imaginations, and dreams; thus the world we experience and the world we imagine have the same physical bases in the brain. Just as physicists study the most minute subatomic particles and the largest galactic conglomerates to understand the universe, neuroscientists must examine the cerebral processes underlying perception to understand our experience of the universe.

## NEUROCIÊNCIAS E PSIQUIATRIA

Graeff F

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Ao longo da história da Psiquiatria observar-se uma oscilação entre a perspectiva biológica e a mentalista. A primeira enfatiza explicações baseadas no conhecimento do sistema nervoso central e intervenções psicofarmacológicas ou físicas. Por outro lado, a perspectiva mentalista prioriza a experiência subjetiva e intervenções psicoterápicas. Nesta apresentação defenderei a tese de que as duas abordagens são necessárias e complementares. Acredito que os progressos realizados pelas neurociências nas últimas duas décadas, sobretudo no campo da genética molecular e da neuroimagem permitem investigar correspondências entre dados fenomenológicos e neurais gerando uma neurociência cognitiva e emocional consistente. Procurarei exemplificar isto abordando alguns transtornos de ansiedade.

## AURA DA ENXAQUECA E PERCEPÇÃO

Domingues R

Sta Casa Misericórdia – ES

A Migrânea ou enxaqueca é uma condição que tem alta prevalência na população. Cerca de 15% dos adultos no Brasil têm esta doença. A migrânea resulta em grande impacto por comprometer a qualidade de vida além de levar a custos sociais significativos, uma vez que compromete a capacidade de trabalho. Os sintomas mais frequentes são dor de cabeça, em geral pulsátil e de forte intensidade, além de náuseas, intolerância à luz e ao barulho. Além destes sintomas, alguns pacientes com migrânea apresentam um fenômeno chamado de aura. A aura caracteriza-se em geral por alterações da percepção visual, tais como alucinações visuais complexas ou perda de parte do campo visual. A migrânea resulta de predisposição genética que, por sua vez, determina alterações químicas cerebrais. Normalmente não há lesões cerebrais na migrânea mas, estudos recentes, têm mostrado a presença de alterações sutis à ressonância magnética no encéfalo de portadores desta doença. As anormalidades cerebrais da migrânea e da aura serão discutidas com profundidade na palestra. O tratamento se faz através de modificações no estilo de vida, incluindo a prática de exercícios físicos, melhora nos hábitos de sono e controle do estresse, além de medicamentos preventivos que podem diminuir a magnitude das alterações bioquímicas cerebrais. Além destes itens do tratamento os portadores de migrânea devem ser orientados quanto ao uso correto de analgésicos. Um percentual significativo de portadores de migrânea passa a fazer, ao longo da vida, uso abusivo de analgésicos, o que pode levar inclusive à piora das crises de dor de cabeça. Embora seja uma doença com bom prognóstico, alguns estudos recentes têm mostrado que pacientes com migrânea, especialmente quando têm aura, apresentam risco ligeiramente aumentado de acidente vascular cerebral. O tratamento da migrânea visa, portanto, avaliar fatores de risco de doença vascular cerebral, além de proporcionar melhora qualidade de vida, prevenindo os riscos do uso abusivo da auto-medicação com analgésicos.

## 28/09/2012 – SEXTA-FEIRA

### A RODENT MODEL OF KORSAKOFF SYNDROME REVEALS THE CRITICAL NEUROANATOMICAL SUBSTRATES OF MEMORY DYSFUNCTION AND RECOVERY

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Investigations into the alcohol-related disorder of Korsakoff Syndrome (KS) have shed light on the role of brain structures involved in memory. Although the thalamus and mammillary bodies are the primary sites of neuropathology in KS, functional deactivation of the hippocampus and frontal cortex also contribute to the chronic cognitive dysfunction. The rodent pyridoxamine-induced thiamine deficiency (PTD) model has been used to study the neural adaptations that occur in KS. In the PTD model, the hippocampus, and frontal cortical regions display loss of cholinergic innervation, decreases in behaviorally stimulated acetylcholine release and reductions in neurotrophins and synaptic protein involved in neurotransmission. However, behavioral recovery can be stimulated in the PTD model by increasing acetylcholine levels in the medial septum, hippocampus and frontal cortex. Our recent data suggest that exercise is one means to improve cholinergic functioning. In sum, our data indicate that although the hippocampus and frontal cortex are involved in the pathogenesis of KS, these regions retain neuroplasticity and may be critical targets for improving cognitive outcome in KS.

## THE VOCAL BRAIN – CEREBRAL BASES OF VOICE PERCEPTION

Belin P

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The human voice carries speech but also a wealth of socially-relevant, speaker-related information. Listeners routinely perceive precious information on the speaker's identity (gender, age, etc.), affective state (happy, scared, etc.), as well as more subtle cues on perceived personality traits (attractiveness, dominance, etc.), strongly influencing social interactions. Using voice psychoacoustics and neuroimaging techniques, we examine the cerebral processing of person-related information in perceptual and neural voice representations. Results suggest a voice processing architecture highly similar to the one established for faces.

## PREDICTIVE CODING IN THE VISUAL SYSTEM

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The predictive coding framework represents a paradigm shift in neuroscience and impacts on concepts of mind and experience (Clark 2012). Brain processes in primary sensory areas are traditionally studied as a function of sensory stimulation. In contrast, predictive coding states that the brain continually generates models of the world based on context and information from memory in order to predict sensory input. In terms of brain computation, a predictive model is created in higher cortical areas and communicated to lower sensory areas through feedback connections. To investigate the information content of feedback projections, we have exploited a strategy based on non-stimulated sections in retinotopic regions (apparent motion path: i.e. Alink et al. 2010, Vetter et al. 2012; occluded natural scenes: Smith & Muckli 2010, blindfolded subjects). We investigate the information content of activation patterns in non-stimulated parts of retinotopic visual areas and can therefore decode cortical feedback. Our results show that contextual predictions are processed in V1. High resolution MRI indicates that the cortical feedback is especially strong in outer layers of V1. To investigate prediction error, we have used probe stimuli that were presented in a matching or non-matching context (i.e. apparent motion illusion). The results demonstrate that non-stimulated regions in V1 contain predictions that influence subsequent perception. **References:** Alink, Schwiedrzik, Kohler, Singer & Muckli (2010) Stimulus predictability reduces responses in primary visual cortex. *J Neurosci.*;30(8):2960-6; Clark (2012) Whatever Next? Predictive Brains, Situated Agents, and the Future of Cognitive Science. *Behav. Brain Sci*; Muckli (2010) What are we missing here? Brain imaging evidence for higher cognitive functions in primary visual cortex V1. *International Journal of Imaging Systems and Technology*. 20 (2 SI): 131-139; Smith & Muckli (2010) Nonstimulated early visual areas carry information about surrounding context. *PNAS*, 107(46):20099-103; Vetter, Edwards & Muckli (2012) Transfer of predictive signals across saccades. *Frontiers in Psychology*.

## 29/09/2012 – SÁBADO

### EMOTIONAL PROCESSING AND THE MENSTRUAL CYCLE

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Although there is evidence of sex differences on cognitive and emotional processing, the magnitude and the adaptive meaning of these differences are not fully understood. Briefly, men perform better on tasks related to math and spatial skills, whereas women tend to perform better on tasks related to verbal fluency, memory and fine motor tasks. Data from studies comparing the performance of healthy volunteers in the identification of basic emotion in facial expressions are controversial, with some, but not all, pointing to differences between the sexes. In general, these positive results suggest a better performance and a greater physiological responsiveness of women in the identification of facial expressions, regardless of emotion evaluated. There are, however, divergent data, showing that men are faster than women recognizing angry and fearful faces. Although neuroimaging studies point to sex differences in neuronal activation caused by emotional faces, results are quite variable, which prevents the definition of a pattern which could distinguish one sex from the other. The absence of sex differences observed in some studies can be due to the lack of control of the phase of the menstrual cycle. Women identified facial expressions of fear more accurately during the phases of the menstrual cycle characterized by high levels of estrogen. Moreover, higher levels of progesterone were associated to a better accuracy in the identification of faces of fear and disgust. However, there are also conflicting results: women in the follicular phase, characterized by lower levels of progesterone, were more accurate in identifying all emotions than women in luteal phase, characterized by higher levels of progesterone. We showed that the early follicular phase was associated with a better recognition of anger in comparison to the ovulatory phase or the luteal phase and the blood levels of estrogen were negatively correlated to the accuracy in identification of angry faces. Taking together the data available so far reinforce the hypothesis that women pay more attention and react more intensively to emotional faces. Evidence from the neuroimaging studies suggest that men and women use different neural networks for the processing of emotions, reinforcing the hypothesis of different strategies for the identification of emotions. Despite the evidence of sex differences in brain functions, this variable is rarely controlled in neuroscience research related to cognitive and emotional components involved in both normal and pathological processes. Several mental disorders have a clear sex difference in the prevalence, clinical presentation and response to treatment, making vital controlling this confounding variable in future studies. **Reference:** Del-Ben CM, Graeff FG. Modulation of emotional faces processing and its implication for depression and anxiety. In: *Neuroimaging*. Rijeka: SCIYO, 2010, p.49-69.

## O CONSUMO DE MACONHA, COCAÍNA E CRACK PELA POPULAÇÃO BRASILEIRA

Laranjeiras R

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## MUSIC, LANGUAGE, AND MODULARITY FRAMED IN ACTION

Peretz I

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I will examine to what extent music and speech share processing components by focusing on production, that is, singing, speaking and dancing. In shaping my views and research, the modularity concept has been and continues to play a determinant role. Thus, I will first provide a brief background on the contemporary notion of modularity. Next, I will present evidence that musical abilities depend, in part, on modular processes. The evidence I will cover comes mainly from selective cognitive disorders, such as tone deafness and beat deafness. These conditions are particularly informative for the comparative study of music and language because these deficiencies appear innate, music-specific and associated to anomalous brain connectivity. In this perspective, music disorders are as interesting as language disorders because both types of disorder will provide unique and complementary answers to fundamental questions of innateness and modularity, such as: how can genetic abnormalities lead to domain-specific disorders while genes code for brain growth not cognition? Such questions can only be answered by studying the full complexity of the relations from cognition to brain to gene and vice versa.

## ILUSÕES ESCAPAM DO LABORATÓRIO E FOGEM PARA O CAMPO

Baldo MV

ICB – USP

Muitas ilusões, sobretudo as visuais, vêm intrigando por séculos a humanidade. Um exemplo é a nítida impressão que nos causa a Lua, a qual vemos muito maior ao nascer ou se por, em comparação a quando vai alta no céu. E são também as ilusões que, muitas vezes, tornam tão próximas a ciência que se faz na aridez de um laboratório daquilo que nos surpreende ou nos intriga ao observarmos o mundo que nos cerca. Ao contrário da ilusão da Lua, que do mundo exterior passou a ser e ainda é dissecada por cientistas em seus laboratórios, outras ilusões podem trilhar um caminho contrário. Uma delas é o efeito “flash-lag”, no qual um objeto em movimento é observado como se estivesse à frente de sua posição real, no momento em que um “flash” indica o momento da observação. Com quase vinte anos de idade, essa jovem ilusão nasceu e cresceu em laboratórios ao redor do planeta, onde tem sido estudada por todos aqueles que se interessam pelos mecanismos básicos da percepção visual. Recentemente, no entanto, pudemos constatar que essa ilusão tão singela pode não ser o produto apenas de um complicado experimento de psicofísica visual, mas pode existir lá fora, nos campos. Literalmente, nos campos de futebol! Tem se mostrado que muitos erros dos árbitros assistentes (os conhecidos “bandeirinhas”), tão xingados quando erguem suas bandeiras e interrompem erradamente uma jogada legítima, podem ser tão somente o fruto dessa singela ilusão, o efeito “flash-lag”. Afinal, o chute do jogador lançando a bola ao seu companheiro, que corre em direção ao gol, é o evento (um “flash”) que marca o momento em que o bandeirinha deve observar a posição do jogador em movimento. Sob o efeito da ilusão, o bandeirinha verá o jogador em movimento à frente de sua posição real, dando-lhe a percepção de uma posição irregular, e então erguerá, honestamente, sua bandeira. Portanto, esta jovem ilusão, o “flash-lag”, que nasceu nos equipamentos frios dos laboratórios, pode hoje ser vista solta nos campos, complicando ainda mais a vida dos bandeirinhas, agitando as torcidas e colocando muito mais emoção nos já acalorados jogos de futebol.

## EVOLUTION OF THE VISUAL SYSTEM AND CORTICAL PROCESSING IN PRIMATES

Herculano S

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Cortical expansion, both in absolute terms and in relation to subcortical structures, is considered a major trend in mammalian brain evolution with important functional implications, given that cortical computations should add complexity and flexibility to information processing. We have investigated the numbers of neurons that compose seven structures in the visual and auditory pathways across 11 non-human primate species to determine the scaling relationships that apply to these structures and among them. We find that primary visual cortex, area V1, as well as the superior colliculus (SC) and lateral geniculate nucleus (LGN) scale in mass faster than they gain neurons, while auditory cortex (A), inferior colliculus (IC) and medial geniculate nucleus (MGN) scale in mass proportionately to their numbers of neurons. Areas V1, MT and A gain neurons proportionately to the entire cerebral cortex, and represent fairly constant proportions of all cortical neurons (36%, 3% and 0.7%, respectively). In contrast, both V1 and A gain neurons much faster than the associated subcortical structures examined. Across species, V1 neurons amount to from 50 to over 130 times more than the number of subcortical visual neurons, while A neurons represent only about 3 to 6 times more neurons than in the related subcortical auditory structures. Despite the larger ratio of cortical to subcortical neurons in the visual structures, larger primate brains have similarly increased ratios of cortical to subcortical neurons involved in processing both visual and auditory information. Moreover, a constant proportion of all cortical neurons is dedicated to the primary visual and auditory representations, and there is a fairly constant ratio of about 45 times more neurons in primary visual than in primary auditory cortical areas across species of different brain sizes. These findings are consistent with a uniform expansion in cortical over subcortical processing abilities in primate evolution, and suggest that brain expansion in evolution has not been accompanied by a relative increase in visual processing.

## **SLEIGHTS OF MIND: MAGIC IN THE BRAIN**

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Magic tricks fool us because humans have hardwired processes of attention and awareness that are hackable — a good magician uses your mind's own intrinsic properties against you in a form of mental jujitsu. The insights that magicians have gained over centuries of informal experimentation have led to new discoveries in the cognitive sciences, and they also reveal how our brains work in everyday situations. If you've ever bought an expensive item you'd sworn you'd never buy, the salesperson was probably a master at creating the "illusion of choice," a core technique of magic. The implications of "neuromagic" go beyond illuminating our behavior; they inform neuroscience about the most powerful illusion of all, the one happening in your mind.