BULLETIN N° 128
ACADÉMIE EUROPEENNE INTERDISCIPLINAIRE DES SCIENCES

Séance du mardi 14 octobre 2008 :
Conférence de nos Collègues Alain Cardon et Pierre Marchais :

« système psychique humain - système psychique artificiel »

Prochaine séance le mardi 18 novembre 2008 :

Assemblée générale annuelle de l'A.E.I.S.

Académie Européenne Interdisciplinaire des Sciences
Siège Social : Fondation de la Maison des Sciences de l'Homme 54, bd Raspail 75006 Paris
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ACADEMIE EUROPEENNE INTERDISCIPLINAIRE DES SCIENCES

FONDATION DE LA MAISON DES SCIENCES DE L'HOMME

octobre 2008

N°128

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Prochaine séance: Mardi 18 novembre 2008
MSH, salle 215-18heures
ASSEMBLEE GENERALE ANNUELLE A.E.I.S.

Académie Européenne Interdisciplinaire des Sciences
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ACADEMIE EUROPEENNE INTERDISCIPLINAIRE DES SCIENCES
Maison des Sciences de l'Homme, Paris.

Séance du Mardi 14 octobre 2008

Maison des Sciences de l'Homme, salle 215, à 18 h.

La séance est ouverte à 18 h. 00 sous la Présidence de Michel GONDRAN et en la présence de nos collègues, Gilbert BELAUBRE, Michel BERREBY, Irène HERPE-LITWIN, Jacques LEVY , Pierre MARCHAIS, Victor MASTRANGELO.

Etaient excusés :François BEGON, Bruno BLONDEL, Alain CARDON, Gilles COHEN-TANNOUDJI, Françoise DUTHEIL, Jean Pierre FRANCOISE, Marie-Louise LABAT, Saadi LAHLOU, Gérard LEVY, Alain STAHL

L'Ordre du jour appelle d'abord la présentation de la conférence de nos Collègues Alain CARDON et Pierre MARCHAIS ***« système psychique humain - système psychique artificiel ».***

Dans une première partie Pierre MARCHAIS nous explique qu'il a cherché à affiner certains diagnostics cliniques de pathologies mentales en confrontant clinique et informatique. Toutefois il ne s'agit pas selon lui d'une informatisation du psychisme. Il s'agit de construire un outil de modélisation permettant de construire des diagrammes pertinents dans la recherche d'un diagnostic rigoureux.

Il illustre ses conceptions au moyen de l'exemple d'un trouble mental , à savoir la Phobie traumatique et plus particulièrement l'agoraphobie traumatique.

Notre Collègue Alain CARDON explique ensuite sa modélisation.

Pour une présentation détaillée nous vous suggérons de lire le document détaillé relatant cette problématique page 9.

Après quoi la séance est levée à 20heures.

Bien amicalement à vous,

Irène HERPE-LITWIN

Compte-rendu de la section Nice-Côte d'Azur

Etudier sans réfléchir est vain.
Réfléchir sans étudier est dangereux
Confucius

Compte-rendu de la séance du 25 septembre 2008

(118ème séance)

Présents :

Jean Aubouin, Richard Beaud, Sonia Chakhoff, Patrice Crossa-Raynaud, Guy Darcourt, René Dars, Jean-Pierre Delmont, Jean-Paul Goux, Yves Ignazi, Gérard Iooss, Jacques Lebraty.

Excusés :

Alain Bernard, René Blanchet, Pierre Coullet, François Cuzin, Michel Lazdunski, Jean-François Mattéi, Daniel Nahon, Maurice Papo, Jacques Wolgensinger.

1- Approbation du compte-rendu de la 117ème séance.

Le compte-rendu est approuvé à l'unanimité des présents.

2- Organisation d'un débat.

Comme le programme des « Lundis de la connaissance » a été assez bien établi, il devrait nous rester du temps, lors de nos réunions prochaines, à consacrer à des débats. Pour cela, il conviendrait que le sujet soit défini pour le mois suivant afin que chacun ait le temps d'y réfléchir.

Il est proposé, pour le 16 octobre, le sujet suivant : « Autour de la sélection naturelle ». Patrice Crossa-Raynaud a joint au compte-rendu de notre séance, une page de réflexions et d'interrogations sur ce sujet pour que ceux qui le souhaitent puissent intervenir.

Il ne s'agit évidemment pas de « conférence », mais d'une information réciproque faite de questionnements.

3- Les lundis de la connaissance.

Comme suite au renouvellement de l'équipe municipale de Nice, nous nous sommes inquiétés de savoir si la nouvelle équipe dirigeante du CUM, placée sous la direction de Mme Gasquet, était dans les mêmes dispositions vis-à-vis de l'AEIS que l'équipe précédente. Des contacts ont été pris par notre Président et Guy Darcourt.

Il semble que le Maire de Nice, M. Christian Estrosi, veuille orienter le CUM vers le projet d'Union pour la Méditerranée du Président Sarkozy dont Mme Gasquet est la responsable.

Dans ces conditions, notre Académie n'aurait plus qu'une place accessoire. Il serait peut-être souhaitable que nous nous rapprochions plutôt de l'Institut Robert Hooke de Pierre Coullet et de l'Université de Nice, d'autant que l'on doit prochainement inaugurer la « Maison de la Science » dotée d'un amphithéâtre moderne à St Jean d'Angely, bien desservie par le tram. Nous serions assurés d'avoir aussi l'appui de Mme Rampal.

Nous pourrions non seulement y poursuivre nos activités, mais faire inviter quelques « vedettes » qui attireraient du public.

Il faut veiller à conserver notre indépendance pour nos activités et nos publications.

4- <u>Distinctions</u>.

- Le Docteur Emile Girard (membre d'honneur), a été nommé Chevalier dans l'Ordre du Mérite national.

- Le Professeur Gérard Iooss a reçu l'important prix Ampère de l'Académie des Sciences décerné aux mathématiciens.

Toutes nos plus amicales félicitations à nos confrères.

5- <u>Divers</u>.

Notre confrère Richard Beaud organise un cycle de conférences au Couvent des Dominicains, 9 rue St François de Paule – Nice, sur « Les commencements » :

- **15.10.2008 à 17 heures** :
Les origines de l'Univers
Professeur C. Sigismondi, astrophysicien

- **12.11.2008 à 17 heures** :
Les origines de la vie
Professeur Marc Battini

- **17.12.2008 à 17 heures** :
Entrer dans l'interrogation philosophique : forme et enjeux du commencement dans la réflexion de l'homme avec lui-même
Professeur Jean-François Lavigne

- 11.02.2009 à 17 heures :
Et un commencement : les deux récits de la Création dans la Bible
Professeur Annie Raffali

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Prochaine réunion
le jeudi 16 octobre 2008 à 17 heures
au siège : Palais Marie Christine - 20 rue de France
06000 NICE

Annonces

- Notre Collègue Manuel GALAN nous a quitté brusquement après un accident vasculaire. Nous nous associons au chagrin de ses proches et sa présence nous manquera.

- Au cas où vous auriez omis de lire précédemment l'annonce de l'Assemblée générale du 18 novembre, vous trouverez en pièce jointe une nouvelle convocation ainsi que les formulaires de pouvoir, d'acte de candidature et d'inscriptions de questions à l'Ordre du Jour.

- Vous trouverez également en pièce jointe les modalités d'inscription au prochain congrès sur « Emergence : de la fascination à la compréhension »

Documents

Nos Collègues Alain CARDON et Pierre MARCHAIS nous ont communiqué le texte de leur conférence du 14 octobre 2008 :

P. 9 :système psychique humain-système psychique artificiel
La phobie traumatique

Notre Collègue Michel CABANAC, Professeur à l'Université Laval de Québec nous propose deux textes en anglais sur l'Emergence de la conscience dans la phylogénie et sur l'origine de la conscience.

P. 15 : The Emergence of Consciousness in Phylogeny
P. 26: On the Origin of Consciousness, a postulate and its corollary

SYSTÈME PSYCHIQUE HUMAIN-SYSTÈME PSYCHIQUE ARTIFICIEL
La phobie traumatique

Versant clinique : Pierre Marchais
Versant informatique : Alain Cardon

Pour éclairer le sens d'une collaboration entre la clinique et l'informatique, nous allons tenter de l'expliciter à la lumière de notre pratique personnelle. Toutefois, il n'est pas possible d'en évacuer totalement les aspects théoriques, car la pratique leur est intimement liée. Le thème « Système psychique humain-système psychique artificiel » sera donc traité ici à partir d'un trouble mental élémentaire qui en constitue une illustration : la phobie traumatique.

Rappelons déjà quelques informations sur notre collaboration. Celle-ci dure depuis deux ans à la suite d'exposés présentés ici-même où nous nous sommes aperçus que des points de rencontre entre nos démarches respectives pouvaient être possibles. Son efficacité s'est d'ailleurs manifestée par trois communications présentées à la Société Médico-Psychologique : l'une sur « le saut des niveaux d'organisation psychiques », l'autre sur « l'émotion », la dernière faite en collaboration avec le logicien J.-B. Grize sur « le positionnement de l'observateur en interdisciplinarité »[1], cette dernière communication visant à montrer comment chacun de nos positionnements respectifs pouvait bénéficier des apports des deux autres. Rappelons aussi que certains aspects théoriques de cette collaboration ont été aussi rapportés dans nos derniers ouvrages respectifs. Enfin, signalons que nous travaillons depuis une bonne année sur les transcriptions informatiques possibles des troubles mentaux.

I- GÉNÉRALITÉS

A priori, les problématiques psychiques et celles du monde de l'informatique sont fort éloignées les unes des autres.

- Notre **objectif** n'est pas de nous livrer à une quelconque reconnaissance informatisée des troubles mentaux à partir de diagnostics automatiques ou à des études statistiques, voire épidémiologiques. Il s'agit pour nous d'essayer de pénétrer dans le vécu psychopathologique et d'en effectuer une reconstitution approchée afin de mieux saisir la nature des dysfonctionnements psychiques et, à partir de là, de mieux comprendre la nature même du fonctionnement mental.

- A cet effet, il nous faut déjà évoquer schématiquement **la nature de la pensée humaine** pour mieux établir notre terrain de rencontre qui est constituée d'automatismes et d'esprit, comme l'écrivait déjà Pascal dans ses Pensées[2].

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[1] Marchais P. et Cardon A. - Rencontre entre modèles cliniques et robotiques. Du saut entre les organisations psychiques. *Ann.Méd.Psychol.* 2007, 2, 122-129.
Marchais et Cardon A.- L'Émotion. Approche clinique et informatique. *Ann.Méd.Psychol*. 2008, 166, 5, 375-383.
Marchais P., Grize J.-B. et Cardon A. – Le Positionnement de l'observateur en interdisciplinarité. *Ann.Méd.Psychol*., 2008, 166, 8, 656-663

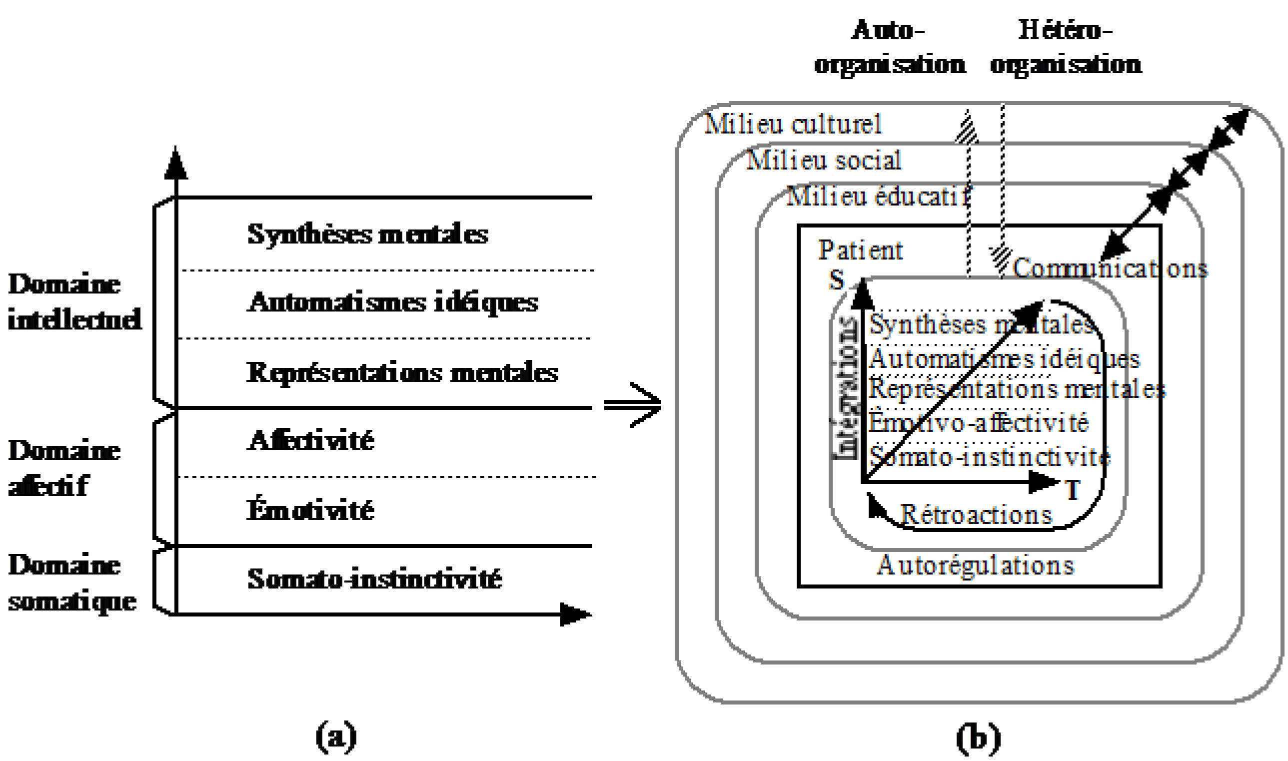
[2] Pascal B. : « ... il ne faut pas se méconnaître : nous sommes automates autant qu'esprit... (la coutume) incline l'automate, qui entraîne l'esprit sans qu'il y pense » (Pensées, 470. Utilité des preuves par la machine : l'automate et la volonté. *Oeuvres complètes*, Paris, Gallimard, La Pléïade, 1954).

- En ce sens, **les automatismes de pensée** apparaissent le terrain de choix pour un rapprochement possible.

- Ce rapprochement est en outre rendu effectif par **l'aspect constructiviste** de la clinique psychiatrique que nous avons envisagé à partir des théories logicomathématiques ensemblistes, hyperensemblistes, et catégoriques, et de la nouvelle informatique constructiviste élaborée par Cardon à partir d'agents.

- La **médiation nécessaire** pour faire entrer en contact ces deux mondes passe par la modélisation, c'est-à-dire par la confrontation de modèles cliniques des troubles mentaux et de modèles informatiques d'un fonctionnement psychique artificiel.

- En ce qui nous concerne, **les modèles cliniques** sont extraits à partir d'un outil particulier fait d'une échelle virtuelle de la structure psychique incluse dans un module d'observation propre à la méthode systémale, puisque l'individu ne saurait être conçu sans tenir compte du milieu auquel il appartient. Rappelons qu'il ne s'agit que d'une simple conduite opératoire. Celle-ci ne vise pas à signifier entièrement le trouble et encore moins le psychisme de l'individu ; il s'agit simplement de virtualiser ce psychisme en un système constitué pour essayer d'en préciser certaines fonctions automatisées.



ÉCHELLE ET MODULE D'OBSERVATION SYSTÉMALE

Chaque trouble est considéré ici à partir d'invariants obtenus par des analyses comparatives et différentielles, invariants placés dans chacun des sous-ensembles envisagés. Leur traitement permet ensuite d'élaborer des modèles de troubles, qui peuvent être comparés facilement avec des modèles informatiques constructivistes isolés par A. Cardon.

Afin de mieux nous faire comprendre, nous prendrons le modèle simple et facilement compréhensible d'une phobie, plus particulièrement celui de l'agoraphobie traumatique.

II- L'AGORAPHOBIE TRAUMATIQUE

1-Définitions

- Une ***phobie*** est une réaction d'angoisse jugée absurde par le patient face à un objet, un être, une situation, un acte, qui provoque une conduite d'évitement pouvant être momentanément apaisée par une conduite rassurante.
- L'***agoraphobie*** est ainsi une phobie qui a pour objet la traversée d'un espace vide. C'est, par exemple, l'incapacité pour un sujet de traverser seul une rue ou une place sans raison apparente, mais qui arrive à la traverser s'il est simplement accompagné par une personne, voire un animal.
- Sa ***forme traumatique*** suppose un choc émotionnel déclenchant.

L'objet d'étude étant ainsi délimité, son analyse permet de le modéliser.

2-Les faits

Un sujet traverse une rue et se trouve brusquement confronté à l'arrivée soudaine d'un véhicule qui arrive à toute vitesse sur lui. Il subit aussitôt une vive émotion et l'angoisse suscitée peut engendrer une phobie. En effet, le sujet ressent un **malaise** qui peut le bloquer sur place. Cet événement suscite dès lors en son esprit une image angoissante qui va l'empêcher de traverser à l'avenir seul une rue. Il sait que c'est absurde, mais il ne peut se dominer. La phobie est constituée.

On sait aussi que si l'on dissocie cette angoisse de la représentation de la rue en agissant sur l'un et/ou l'autre de ces composants, le sujet peut être délivré de son trouble.

On sait encore que cette angoisse imagée peut se diffuser par analogie à tout autre situation suscitant la sensation de vide, ceci faisant partie des automatismes de pensée imagée.

3- Analyse des faits

L'analyse de ce vécu particulier montre en fait une situation complexe. De **nombreux facteurs** sont mis en jeu : les structures, liens, dynamiques, résonances du stimulus, substrat physiologique, référentiels de l'observateur...

- La **structure imageante globale** d'un vécu implique l'espace : la rue à traverser, le véhicule qui surgit, le trottoir à atteindre, sa propre représentation…
- **Les liens entre les structures** sont multiples :

Liens directs entre la structure vécue préalable et la structure vécue seconde. Cette tension se diffuse en chaîne à l'imagination et à des images en formation, avant de se terminer par la construction d'une structure pathologique.

Liens indirects par l'intermédiaire de processus dynamiques multiples qui font intervenir en rétroaction d'autres structures du système psychique touchées par l'effet percolateur du stimulus traumatisant.

Liens soumis à des flux variables suivant les sujets. Ceux-ci peuvent vivre leur phobie de façon limitée aux rues ou étendue ultérieurement à d'autres situations par analogies imagées signifiantes (par exemple : longer un trottoir bordé de voitures en stationnement mais entrecoupé de bateaux d'entrées d'immeubles, traverser un pont, descendre ou monter dans une cage d'escalier, emprunter un chemin escarpé, etc.).

- La **résonance de l'intensité du stimulus** se fait tout au long de la chaîne structurée de l'édifice psychique par diffusion et percolation d'énergie. Un stimulus faible peut fort bien ne laisser subsister qu'une crainte sans phobie réellement constituée, alors qu'un stimulus fort provoque un trouble durable.

- Le **processus dynamique** implique la temporalité : l'arrivée brusque du véhicule, l'absence de temps suffisant qui ne permet pas au sujet de se créer la représentation d'un espace de sécurité entre le véhicule et le sujet, d'où le brusque sentiment d'une collision éventuelle ou probable. Ce processus dynamique issu d'une perception suscite une réaction neurovégétative avec une sensation d'angoisse .

- Le **substrat physiologique** est essentiellement la réaction neurovégétative impliquée, le malaise suscité inhibant l'action motrice. Cette structure neurovégétative peut avoir été elle-même fragilisée par des tensions préalables conflictuelles ou autres. En effet, la structure initiale émotionnelle de tout homme est une construction en rapport avec un sous-système neurovégétatif relié au système neurologique central et périphérique. Elle est ici soudainement soumise à une forte tension pathogène appelée angoisse qui est cliniquement objectivable (notamment par une douleur provoquée à la palpation profonde du plexus solaire). D'ailleurs, une émotion se traduit très souvent par des troubles vasculaires (rougeur ou pâleur du visage, suées, accélération du pouls, malaise lipothymique), des troubles respiratoires (striction thoracique, dyspnée), parfois des troubles visuel, digestifs, urinaires… tous témoins d'un dysfonctionnement soudain de la régulation du système neurovégétatif.

En somme, l'évocation de ces divers facteurs montre que le choc émotionnel provoqué suscite une **compactification des diverses fonctions** impliquées dans cette conduite particulière, compactification qui signe le trouble. Des distinctions sont donc à faire, notamment entre la structure émotionnelle, la structure neurovégétative, les processus mis en jeu avec leurs diverses fonctions, ainsi que les fonctions isolées et les variables spécifiques à chaque individu.

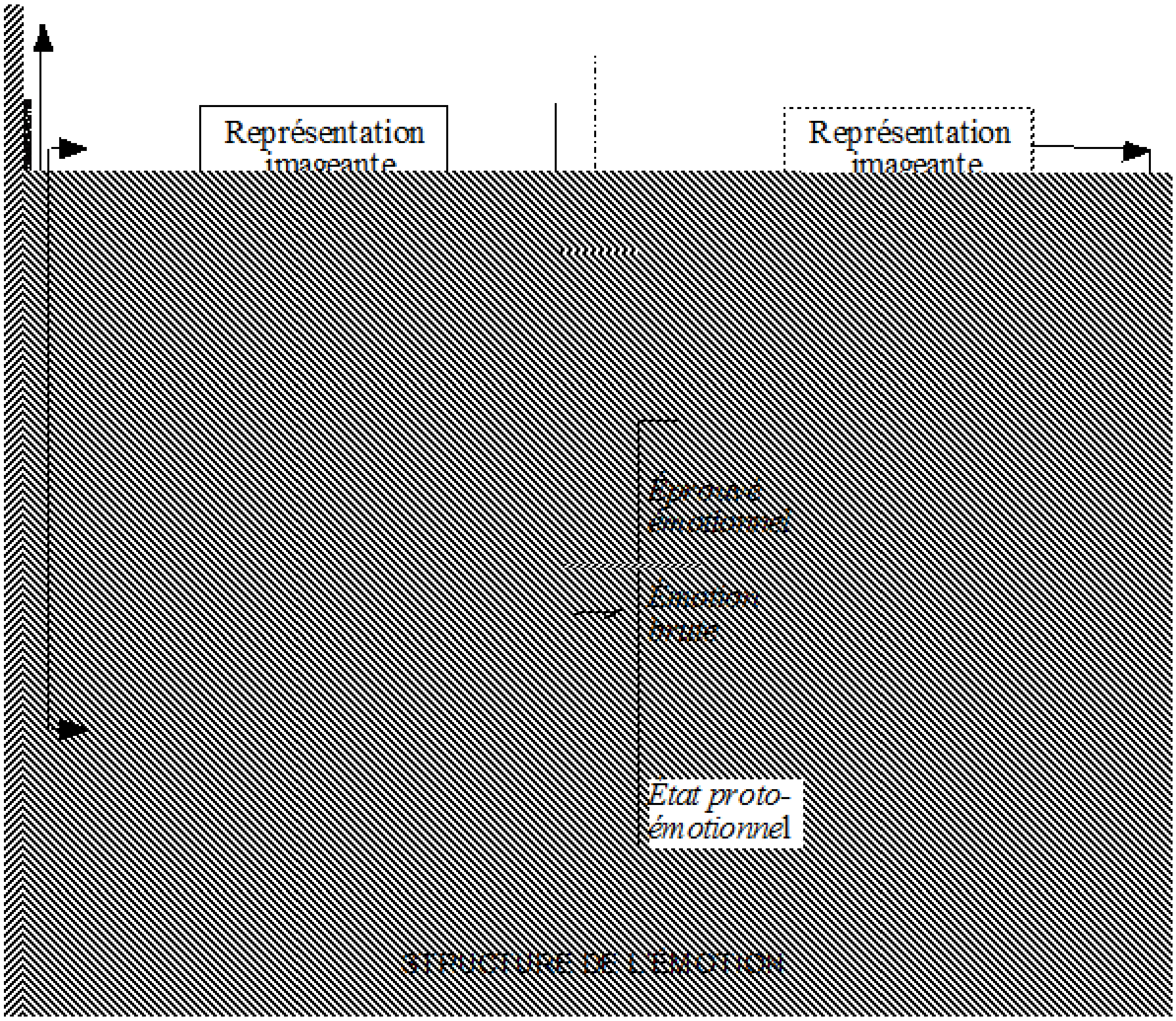
- Les référentiels de l'observateur organisent et retentissent naturellement sur l'analyse de ce phénomène pathologique, et permettent encore d'en affiner la saisie. Ainsi la pensée logicomathématique est utile dans la mesure où ses matrices ensemblistes et catégoriques permettent une mise en ordre des divers facteurs envisagés, même s'il ne s'agit pas bien entendu de mathématiser la situation étudiée.

Signalons enfin que **d'autres facteurs physiologiques et psychiques** fragilisant le sujet pourraient être encore évoqués. En effet, il peut exister une prédisposition physiologique de dysrégulation neurovégétative du sujet, soit naturelle, soit acquise par suite de maladie, d'épuisement. Il peut encore exister des chocs émotionnels anciens ou des conflits anciens angoissants qui vont être réactivés à cette occasion, des conflits anxiogènes latents sources de fragilité, etc. Tenons-nous en déjà à ces quelques facteurs préalablement énoncés et procédons à une abstraction réductrice.

III – MODÉLISATION

Une représentation de ces faits peut être obtenue à partir d'une matrice ensembliste à visée purement opératoire pratique. Elle implique cependant des limites. Elle est donc complétée par un fléchage de type catégorique qui permet de mieux suivre à chaque instant le processus dynamique.

Une topographie clinique du trouble peut alors être proposé et étendue à l'étude de l'émotion.



Or, cette modélisation rencontre celle qui a été isolée d'un point de vue informatique, comme va nous le montrer Alain Cardon.

III- CONCLUSIONS DU CLINICIEN

1-*Les bouclages des circuits de pensée cliniques et informatiques apparaissent complémentaires et similaires*, mais il se font en quelque sorte en sens inverse. Le clinicien va du réel au virtuel en modélisant les troubles et en se représentant le fonctionnement mental pour revenir sur la réalité des dysfonctionnements, afin de pouvoir mieux agir sur eux ; l'informaticien va du virtuel au réel cherchant à construire un fonctionnement psychique artificiel pour transposer ensuite ce dernier sur le fonctionnement virtuel des troubles.

Tous deux reconstruisent donc le fonctionnement psychique à partir de deux pôles différents. C'est par leur rencontre au niveau des automatismes mis en jeu que peut se manifester l'efficacité de leur collaboration. Des différences subsistent néanmoins quant à la nature de la représentation du fonctionnement psychique, qui reste d'ordre naturel dans un cas et artificiel dans l'autre.

2- *L'intérêt pratique de cette collaboration* tient au fait que l'informaticien, partant de données virtuelles, a besoin de données cliniques pour ouvrir et assurer sa démarche. Réciproquement, le clinicien peut toujours omettre des dimensions devant la complexité du vivant qu'il doit affronter : les modèles et l'ouverture de l'informaticien assurent son analyse.

Cependant, leurs réalisations restent dans le domaine des automatismes de pensée ; le problème de la nature du fonctionnement psychique n'est donc toujours pas pour autant pleinement résolu.

3- *L'anticipation de travaux futurs* s'ensuit. Après les transpositions informatiques en cours des troubles mentaux, il resterait évidemment à connaître les rapports existant entre le monde des automatismes et celui de l'esprit, puisque ce dernier a été ignoré par l'attitude opératoire. Ceci est un autre problème. Cependant, la tâche ne paraît pas insurmontable, à condition de ne pas s'enfermer a priori dans une idée préconçue de rupture ou de continuité entre ces composants de nature apparemment dissemblable. Pour notre part, nous venons d'achever un ouvrage sur les rapports de l'esprit et des démarches rationnelles qui permettent d'analyser le rôle des automatismes de pensée. Le travail informatique entrepris en ce domaine pourra vraisemblablement susciter un jour de nouvelles confrontations utiles, sans prétendre pouvoir naturellement en prédire les résultats.

The Emergence of Consciousness in Phylogeny

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Number of pages: 19 Number of figures: 5
Indexable title: Consciousness and Phylogeny

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Abstract

The brains of animals show chemical, anatomical, and functional differences, such as dopamine production and structure of sleep, between Amniota and older animals. In addition, play behavior, capacity to acquire taste aversion, sensory pleasure in decision making, and expression of emotional tachycardia and fever started also to be displayed by Amniota, suggesting that the brain may have began to work differently in early Amniota than in Lissamphibia and earlier vertebrates. Thus we propose that emotion, and more broadly speaking consciousness, emerged in the evolutionary line among the early Amniota. We also propose that consciousness is characterized by a common mental pathway that uses pleasure, or its counterpart displeasure, as a means to optimize behavior. *Keywords: amniotes, amphibians, birds, consciousness, evolution, fish, mammals, phylogeny, sauroptides, zoology*

Introduction

What is consciousness? Bering & Borklund [1] define it as "a higher-order cognitive system enabling access to intentional state." That new property may have emerged because of the increasing complexity of life in a terrestrial environment [2]. In this new adaptive landscape, existence required more and more stimulus-response pathways; eventually, a point was reached where it became more efficient, in terms of speed and flexibility, to route all decision making through a single mental space. Within this space, different possible responses could be simply matched according to the criterium of maximal pleasure [3]. With Rial *et als.* [4] we may acknowledge that " attaining a positive proof of adaptiveness is extremely difficult." However it seems obvious that such a simplified process gave a survival advantage to those animals that acquired it, and pleasure/consciousness was maintained and transmitted to us.

Based on experimental as well as theoretical arguments [3, 5] in the following we shall define it as an abstract private model of reality, with four dimensions: quality, intensity, hedonicity, and duration.

The first dimension of sensation is qualitative and describes the nature of the stimulus or the mental object. A blue color, a sweet taste, a remembrance, etc., describe the nature of the mental experience. The second dimension of sensation is quantitative and describes the intensity of the stimulus, a bright color, a loud noise, etc. The third dimension is affective (hedonic). It may be difficult to disentangle affectivity from intensity because they most often covary together. Yet, this can be done (e.g. in the cases of sensation). All sensations are either unpleasant, indifferent or pleasant. Incidentally, this includes pain, a sensation most often unpleasant but sometimes indifferent or even, but rarely, pleasant. Sensory pleasure possesses several characteristics: Pleasure is contingent, pleasure is the sign of a useful stimulus, pleasure is transient, pleasure motivates behavior. The fourth dimension of sensation is duration, which describes the extent of time a stimulus is present.

These dimensions allow the human mind for example to call up a broad range of recollected, apprehended, or even totally imagined realities. The result is increasingly complex mental activity: thoughts, feelings, and emotions assume a life of their own within a space that is relatively independent of simple stimulus-response pathways. When this space includes a representation of oneself and how this self interacts with reality, we have the beginnings of self-consciousness.

Consciousness was long considered a human privilege, all other animals being merely machine-like beings [6]. This view was challenged when [7] pointed-out that other mammals could express emotion. The question then faded into the background, largely because of the excesses of psychoanalysis and the efforts of the behaviorist school to make behavior the only object of study, to the exclusion of *underlying* thought processes [8]. Recently, there has been renewal of interest in animal consciousness [9, 10] and a growing acceptance that humans are not the only thinkers. Indeed, if we accept indirect evidence for the existence of human consciousness in other people, *i.e.*, from the verbal and behavioral signs that they provide, why should similar indirect evidence be rejected when it comes to animals? Although less direct than that provided through verbal communication, such evidence is available [9-13].

Yet, one must be prudent and always remain aware that the evidence is always indirect [14]. For example many fish display complex behaviors such as cheating, altruism, species recognition, individual recognition, cleaning symbiosis [15] that we would be tempted to consider signs of consciousness, but can be explained on the basis of simple reflexes. Also, the complex foraging and social communication behavior of bees is often considered intelligent and 'conscious;' however [16] have shown that it was purely reflexive, in the same way as a computer can be artificially intelligent.

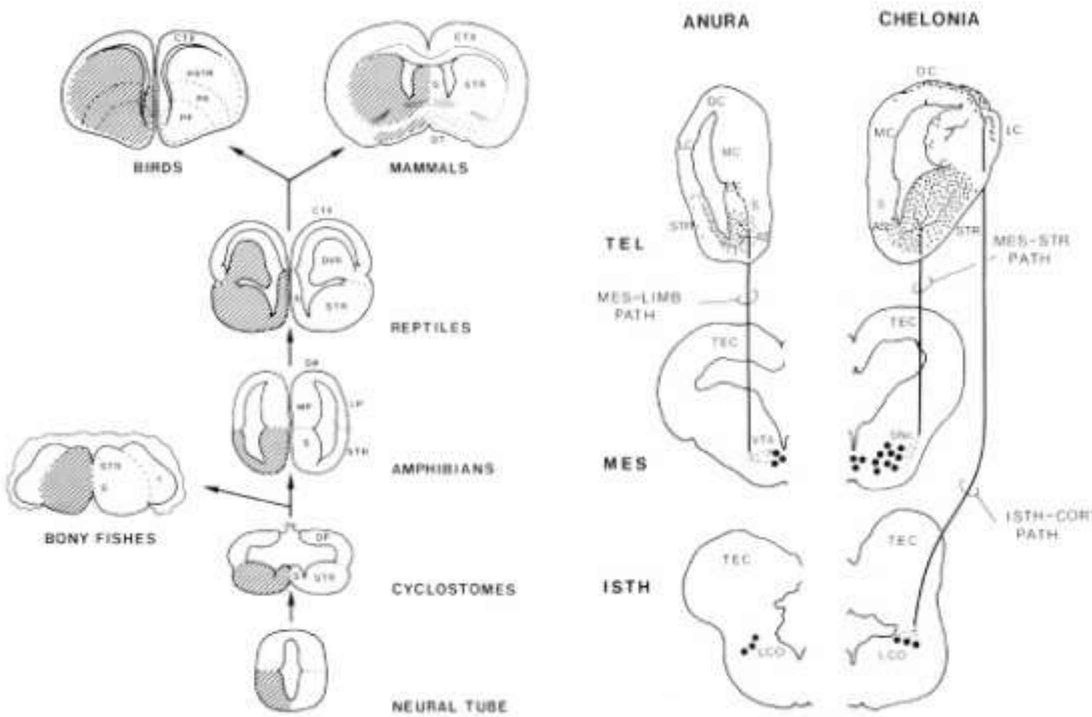
If we exclude self-consciousness -a human property[3]-from the private model of reality that consciousness is, we may ask the question of which animals are conscious? And which are not? At what point in evolution did nervous systems cease to operate only on a reflexive basis [17, 18]? Before apes? Mammals? Vertebrates? In the following we will argue that the transition occurred between Lissamphibia and Amniota, *i.e.*, among the amniotes, common ancestors of present-day Mammalia, Chelonia, Lepidosauria, and Archosauria.

This argument has support from the two lines of evidence developped below: Anatomy and Behavior.

Anatomy

1) Brain volume and structure. Because consciousness places a high demand on brain capacity, it should vary with brain size. For interspecies comparisons, brain size is best measured by the ratio of brain mass to body mass, i.e., the Encephalization Quotient (EQ), which corrects for differences in overall body size. EQ shows a clear-cut difference between two categories of vertebrates: ectotherms on the one hand, and endotherms on the other. The latter are warm-blooded tachymetabolic animals and have brains that are about ten times larger than those of coldblooded bradymetabolic vertebrates with the same body mass. In ectothermic vertebrates, the brain has the same general structure with five vesicles at the cephalic end of a neural tube. In most Lissanphibia, the telencephalon retains the structure of a simple embryonic vesicle. In Lepidosauria, we see a major change with the appearance of a new structure: the cortex (Fig. 1.a). Not that the cortex should necessarily be accepted as the locus of consciousness (see [19] but this new structure shows that complexity rose qualitatively between frogs and lizards. This anatomical difference coexists with a histological one in dopamine production.

[3] And possibly of some apes



1

1a 1b

Fig 1 from [20]. Anatomical evolution of the cephalic end of the neuraxis. 1.a -gross anatomy: the cross-sections show that the cortex, which takes up so much of the mammalian brain, first appeared in Amniotes. Before Amniotes, the neuraxis was a relatively simple tube.

1.b shows the telencephalon and the difference in density of dopamine receptors between an amphibian (frog) on the left and a chelonian (turtle) on the right.

2) Neurotransmitters. Brain dopamine production differs so much between Amphibia and Lepidosauria that it reaches the level of a qualitative difference (Fig.1.b) [20]. Although there is some doubt about the exclusive role of dopamine in hedonic experience, the difference remains significant given its likely involvement in Mammals' hedonic experience, *i.e*. a conscious process [21-23].

Thus, although the coefficient of encephalization may be similar in Amphibia and lower Sauropsides, neuronal signaling has undergone a substantial qualitative change in the latter. This change is paralleled by behavioral and sensorial differences.

Behavioral signs of consciousness 1) Emotion

Handling a mammal or a bird produces tachycardia and fever [24-28], the same physiological responses of humans when they experience an emotion. Such responses are produced in Lepidosauria, [27, 29-31] but not in Amphibia [32] or in Teleostea [31, 33](Figs. 2 & 3).

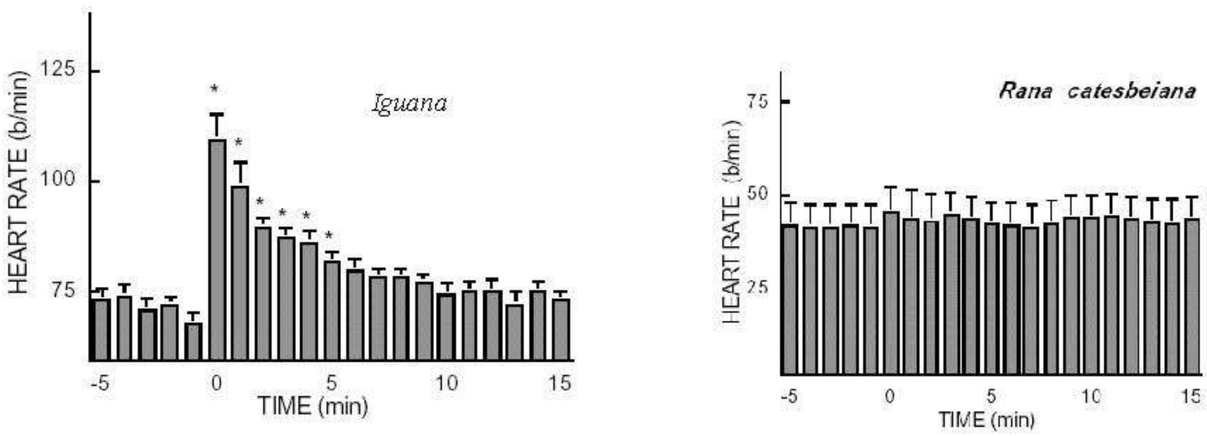


Fig. 2 Mean heart rates, over several sessions, of a lizard (left) and a frog (right) while being gently handled for one minute at time 0. Emotional tachycardia was present in the Squamate but not in the Amphibian [31].

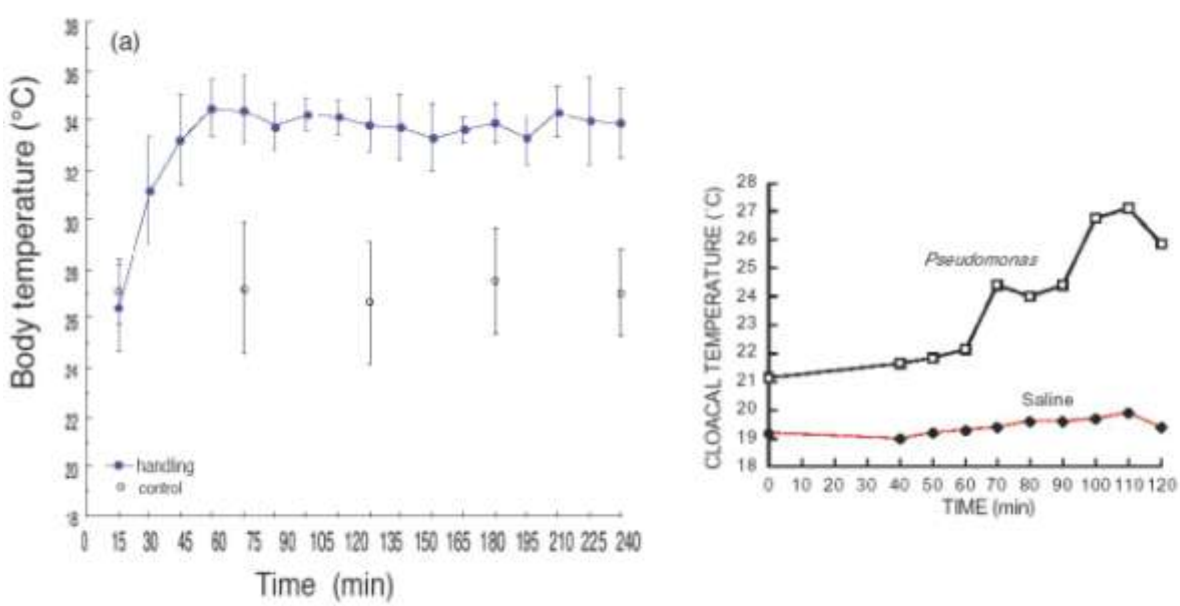


Fig.3 Behavioral fever in a lizard (left) and a frog (right). In the lizard the fever (continuous line) was produced simply by repeated gentle handling to record cloacal temperature. The separate dots, below, give the lizard's normal temperature at the same time of day when not handled [29]. (Right) No such association is present in the amphibians. Injection with pyrogens produced fever, but subsequent injection with saline caused no temperature change [32].

2) Sensory pleasure

Rats display different facial and gestural responses when different stimuli are injected into their mouths [34-39]. These motor patterns resemble the ones that humans display when feeling pleasure or displeasure in response to the same stimuli. Similar evidence of sensory pleasure has been obtained from rats in response to temperature stimuli and temperature rewards in the absence of shivering [40]. Taste stimuli likewise induce pleasure in birds, as evidenced by a verbal response [41].

When mammals suffer nausea or diarrhea in the hours following first contact with a new food, they develop an aversion to the taste stimulus. Such "taste aversion learning" exists also in humans, who will describe an initially pleasant taste as now unpleasant if it has been associated with indigestion [42]. We investigated this associative learning in lizards and amphibians, both Anoura and Urodeles, by first presenting a new food and then giving intra-peritoneal injections of lithium chloride, which is known to produce nausea in mammals. When subsequently shown the same food item, the lizards avoided it if previously injected with lithium chloride, but the amphibians did not. In control sessions, intra-peritoneal saline injections produced no taste aversion learning in the lizards [43].

Because taste aversion learning in mammals is a conscious experience of what is pleasant and what is not, it is likely that Lepidosauria but not Amphibia can experience pleasure (Fig. 4).

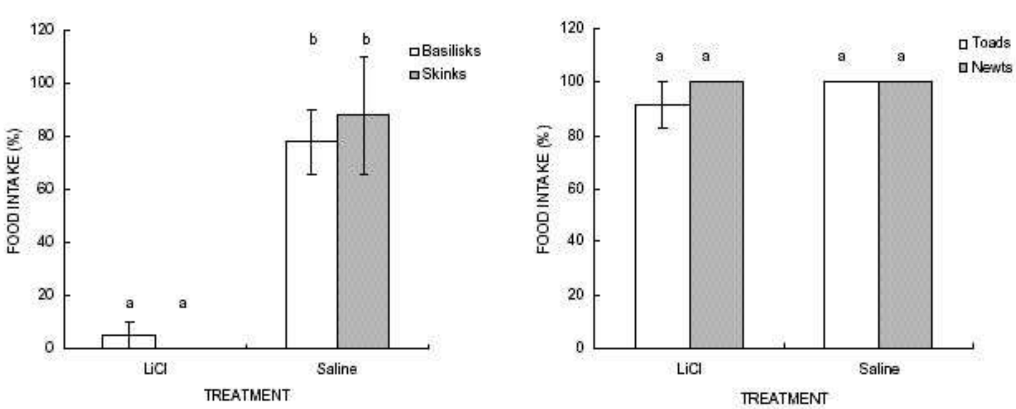


Fig. 4. Taste aversion learning in Lepidosauria (*Basiliscus vitattus*, *B. basiliscus*, *Eumeces schneideri*, *Mabuya multifasciata*) (left) but not in Amphibia (*Bufo paracnemis*, *Pachytriton breviceps* right).

Left: Pooled results from all species of lizards expressed in % of the food intake before treatment. LiCl columns: Intake of novel food one week after first intake of it followed with *i.p.* injection of LiCl (0.15 M, 190 mg/kg). LiCl reduced intake of the novel food with which it was paired, but intake of normal food remained unaffected (102.5%, P=0.92, not shown on the figure). This difference in response points to the presence of taste aversion learning. Injection of isotonic saline had no significant effect. Right: Pooled results from all amphibians expressed in % of food intake before treatment. Left-hand columns: Intake of novel food after *i.p*. injection of LiCl (0.15 M, 190 mg/kg). LiCl had no significant effect ($P > 0.10$). This similarity of response in Amphibia points to an absence of taste aversion learning. Injection of isotonic saline had no significant effect. Columns marked by the same letters are not significantly different. Those marked with different letters are significantly different ($P<0.01$) [43].

3) Pleasure and decision making

In humans, conscious hedonic experience, *i.e.* pleasure, is the common currency that allows motivation~~s~~ to talk to each other. Thus, pleasure maximization provides a shortcut for making decisions without thinking them through rationally [44]. Other mammals and lizards show evidence of this mechanism: if forced to choose between avoidance of cold and hunger, lizards will maintain food intake by going out into the cold for shorter and more frequent periods [45]. But when the choice is between cold avoidance and consumption of tasty but unnecessary food (as judged from their good health and indefinite survival in the laboratory), they will go out into the cold less often and eventually give up, thus showing that the motivation is pleasure and not need (Balaskó & Cabanac, 1998)(Fig. 5). They behave like mammals in similar situations [46-48].

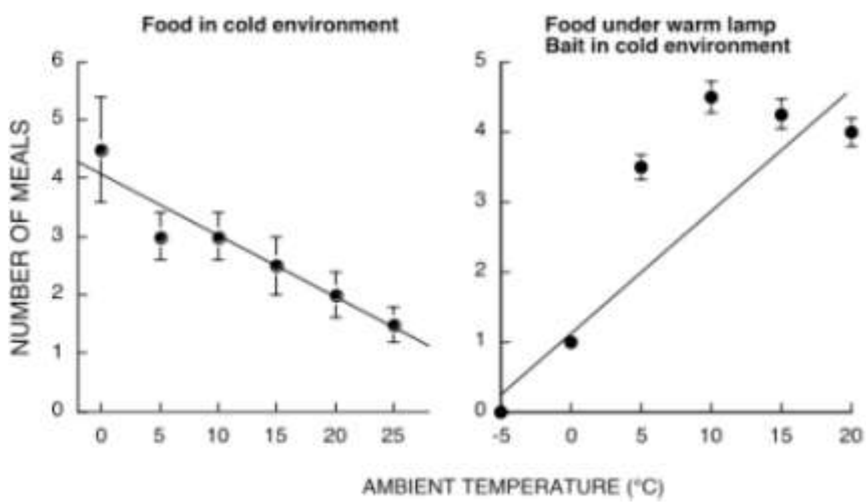


Fig.5 Lizard food intake as a function of ambient temperature in the climatic chamber (y axis: number of trips to food; x axis: ambient temperature). Lizards were placed in a terrarium with an infrared lamp at one end and food at the other Left (*Tupinambis teguixin*): when there was no food in the warm corner, they ventured into the cold to feed but did not stay long; they returned to heat themselves when their core temperature dropped. As ambient temperature fell, they made more trips to the food and back [45]. Right (*Iguana iguana*): same experiment, except that tasty food (fresh lettuce) was available at the far end while less

tasty food was available under the lamp. As ambient temperature fell, the lizards made fewer trips to the far end and back. The tastiness of the food was balanced against the unpleasantness of the cold [46].

4) Sleep, play, and detour behavior

Mammals are awakened via the cortex whereas lepidosauria retain a simpler system controlled by brainstem neural mechanisms [49]. This older system persists in mammals but was transformed into slow wave sleep when the cortex was developed. No sleep/wake system exists in amphibians.

Burghardt [50] defined play as an "incompletely functional activity, deliberately initiated because pleasant, non serious, repetitive, when the subject is relaxed." Such a definition implies consciousness, especially because pleasure implies consciousness. Play can be easily recognized in mammals, birds, and lepidosaurians but has never been observed in amphibians [50], thus seems "to have been originated in amniotes" [4]. However, many fish, especially Teleost displayed behaviors that fulfilled the criteria for play, including mental properties as established by [50]. Bshary et als. [15] examined Fish behavior and found social strategies, social learning and tradition, and co-operative hunting. that resembled those of primates. including foraging skills, tool use, cognitive maps, memory, anti-predator behaviour, and the manipulation of the environment.

The detour behavior, consists in being able to reach a goal with moving around an obstacle and temporary loss of the target in the process. Such a behavior, that implies a memory of the target objet, can easily be observed in mammals, birds, and reptiles but not in other animals [4]. Yet, as reminded by Rial *et als*. [4] such a response can be produced but pure artificial machines such as GPS; detour as a sign of consciousness should, therefore, be accepted with caution.

Discussion and Conclusion

The theoretical and anatomical arguments, and the direct experimental evidence of sensory pleasure and signs of emotion mentioned above are an updated version of a previous paper drawing similar conclusions, but based on emotion data only [51]. They suggest that consciousness, understood not as self consciousness but simply as the presence of a mental space, emerged in the Permian Amniotes common ancestors to present-day Sauropsides and Mammalia rather than converging emergence in those various groups (Fig. 6).

The question of when in phylogeny did consciousness emerge, was also asked by Rial *et als.*[4], who studied the structure of sleep, and by Aarhem *et als.* [52]. Both teams also raised the possibility that consciousness might have been a quantitative (progressive) process rather than qualitative (threshold). Their conclusions on the first question was that "consciousness should have appeared in amniotes" *i. e.*, the same as ours. In the data presented above, the presence of consciousness is suggested not from behavioral decisions or even "intelligence," -like computers that can behave and possess artificial intelligence but may not be considered as having consciousness (see [18])-, but rather from signs in the animals that exist properties indicative of consciousness defined above as a four-dimensional mental state. Are there signs of consciousness before Amniotes? Slugs displayed aversion learning [53], Lymnaeas [54, 55] and terrestrial mollusks [56, 57] displayed operant conditioning of escape behavior. Yet the most striking performance was that of cephalopods who were described as playing [50] and as being able to learn by looking only [58].

These observations lead to three possibilities: -The first is that play and these other apparently signs of consciousness, actually do not necessitate consciousness. True consciousness emerged actually with Amniotes. -Another possibility is that elements of consciousness already showed by Mollusks and Fish are the results of convergence only, as there is a clearcut absence of any sign of consciousness among Amphibians. Thus, these early elements did not evolved to the full four-dimensional consciousness displayed in Amniotes, possibly by lack of a large enough nervous system. -The last possibility, as suggested by Rial *et als.* [4], is that consciousness emerged quantitatively in phylogeny as early as Mollusks, but became exploded only with Amniotes. If that were the case, then there would remain to find an explanation to the total absence of any sign of consciousness in Amphibians.early late entails implicitly that the process was more likely to have been qualitative rather than quantitative.

The existence of consciousness in an animal does not imply that behavioral responses are rational in those animals that possess a mental space. On the contrary, this mental space may simulate several possible lines of action and use the feelings they evoke to decide which response is best. For example, hibernating mammals increase their caloric stores in the autumn, but this is not a rational choice that they make to avoid starvation during the winter. Their behavior is driven not by reason but by a fear-like emotion: a negative perception of insufficient food intake at that time of year [59]. Dictionaries provide no precise term for this kind of non-rational mental modeling when the response is purely reflexive. It may be appropriate to use mentalist terminology, *i.e.*, emotions, feelings, etc., but only for Amniota. For other Tetrapoda and below, we should describe behavior only in terms of behavior only. Fear is clearly lacking in such organisms. Their behavioral responses that can be mimicked in artificial models [60], should be described in a way that does not imply consciousness . When a clam, for instance flees away from a predator, it does not “fear.” In the case of fleeing we would suggest the use of a new word from the Latin: *timor,* to describe such non-cognitive behavioral response that precedes consciousness in phylogeny.

Consciousness may have emerged because of the increasing complexity of life in a terrestrial environment [2]. In this new adaptive landscape, existence required more and more stimulus-response pathways; eventually, a point was reached where it became more efficient, in terms of speed and flexibility, to route all decision making through a single mental space. Within this space, different possible responses would be compared and judged according to the degree of pleasure they evoked, the aim being to maximize pleasure and to minimize displeasure. The hedonic dimension of consciousness thus became a common currency in decision making to select the final behavioral path [61] . It proved to be so successful that it was passed on to all descendants of these early Amniota.

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References

[1] Bering JM, Bjorklund DF. The Serpent’s Gift: Evolutionary Psychology and Consciousness, in Cambridge Handbook of Consciousness, P.D. Zelazo, M. Moscovitch, and E. Thompson, Editors. 2005, Cambridge University Press: New York.

[2] Merker B. The liabilities of mobility: A selection pressure for the transition to consciousness in animal evolution. Consc Cognit, 2005;14: 89-114.

[3] Cabanac M. On the origin of consciousness, a postulate and its corrollary. Neurosci Biobehavi Rev, 1996;20: 33-40.

[4]
Rial RV, *et als*. The evolution of consciousness in animals, in Consciousness Transitions - Phylogenetic, Ontogenetic, and Physiological Aspects, P. Århem and

H.
Liljenström, Editors. 2008, Elsevier: Amsterdam. 45-76.
[5] Cabanac M. La cinquième influence, ou La dialectique du plaisir. 2003, Québec: Presses de l'Université Laval. 287.
[6] Descartes R. Traité des passions de l'âme. 1650, Amsterdam: Elsevier.
[7] Darwin C. The expression of the emotions in man and the animals. 1872, Chicago: University of Chicago Press. 372.
[8] Watson JB. Psychology from the Standpoint of a Behaviorist. 1919, Philadelphia: Lippincott.
[9] Griffin DR, Animal Minds. 1992, Chicago: University of Chicago Press.
[10] Dawkins MS. Through our eyes only? 1 ed. 1993, Oxford: W. H. Freeman & Co. 192.
[11] McFarland DJ. Animal Behaviour. 1985, London: Pitman. 576.
[12] Burghardt GM. Conceptions of play and the evolution of animal minds. Evol Cognit, 1999;5: 114-122.
[13] Jerison HJ. Evolution of the Brain and Intelligence. 1973, New York: Academic Press.
[14] Heyes CM. Theory of mind in non human primates. Anim Behav, 1994;47: 909-919.
[15] Bshary R, Wickler W, Fricke H. Fish cognition: a primate's eye view. Anim Cognit, 2002;5: 1-13.
[16] Gould JL, Grant-Gould C. The Honey Bee. 1995, New York: Scientific American Library.
[17] Bullock TH. Simple systems for the study of learning mechanisms, in Neurosciences Research Symposium Summaries, F.O.S.e. al., Editor. 1967, MIT Press: Cambridge, Massachusetts. 203-327.
[18] McFarland D. Defining motivation and cognition in animals. Int Stud Philos Sci, 1991;5: 153-170.
[19] Merker B. Consciousness without a cerebral cortex: A challenge for neuroscience and medicine. Behav Brain Sci, 2007;30: 63-81.
[20] Parent A. Comparative Neurobiology of the Basal Ganglia. 1986, New York: John Wiley & Sons. 335.
[21] Berridge KC, Robinson TE. What is the role of dopamine in reward: hedonic impact, reward learning, or incentive salience? Brain Res Rev, 1998;28: 309-369.
[22] Wyvell CL, Berridge KC. Intra-Accumbens Amphetamine Increases the Conditioned Incentive Salience of Sucrose Reward: Enhancement of Reward "Wanting"without Enhanced "Liking" or Response Reinforcement. J Neurosci, 2000;20: 8122–8130.
[23] Kudryavtseva NN. An experimental approach to the study of learned aggression. Aggr Behav, 2000;26: 241–256.
[24] Cabanac A, Briese E. Handling elevates the colonic temperature of mice. Physiol Behav, 1991;51: 95-98.
[25] Briese E, Cabanac M. Emotional fever and salicylate, in Contributions to Thermal Physiology, Z. Szelényi and M. Székely, Editors. 1980, Pergamon-Akadémiai Kiadó: Budapest. 161-163g.
[26] Briese E, Cabanac M. Stress hyperthermia: Physiological arguments that it is a fever. Physiol Behav, 1991;49: 1153-1157.
[27] Cabanac M, Aizawa S. Fever and tachycardia in a bird (Gallus domesticus) after simple handling. Physiol Behav, 2000;69: 541-545.
[28] Cabanac A.J, Guillemette M. Temperature and heart rate as stress indicators of handled common eider. Physiol Behav, 2001;74: 475-479.
[29] Cabanac M, GosselinF. Emotional fever in the lizard Callopistes maculatus. Anim Behav, 1993;46: 200-202.
[30] Cabanac M, Bernieri C. Behavioral rise in body temperature and tachycardia by handling of a turtle (Clemys insculpta). Behavi Proc, 2000;49: 61-68.
[31] Cabanac A, Cabanac M. Heart rate response to gentle handling of Frog and Lizard. Behav Proc, 2000;52: 89-95.
[32] Cabanac AJ, Cabanac M. No emotional fever in toads. J Therm Biol, 2004;29: 669-673.

[33] Cabanac M, Laberge F. Fever in goldfish is induced by pyrogens but not by handling. Physiol Behav, 1998;63: 377-379.
[34] Norgren R, Grill HJ. Brain-stem control of ingestive behavior., in The Physiological Mechanisms of Motivation., D.W. Pfaff, Editor. 1982, Springer-Verlag: New York. 99-131.
[35] Berridge KC. *et al*. Sodium depletion enhances salt palatability in rats. Behav Neurosci, 1984;98: 652-661.
[36] Cabanac M. Lafrance L. Postingestive alliesthesia: The rat tells the same story. Physiol Behav, 1990;47: 539-543.
[37] Breslin PAS, Davidson TL, Grill HJ. Conditioned reversal of reactions to normally avoided tates. Physiol Behav, 1990;47: 533-538.
[38] Berridge KC. Measuring hedonic impact in animals and infants microstructure of affective taste reactivity patterns. Neurosc Biobehav Revi, 2000;24: 173-198.
[39] Myers KP, Sclafani A. Conditioned enhancement of flavor evaluation reinforced by intragastric glucose II. Taste reactivity analysis. Physiol Behav, 2001;74: 495-505.
[40] Cabanac, M. Serres P. Peripheral heat as a reward for heart rate response in the curarized rat. J Comp Physiol Psychol, 1976;90: 435-441.
[41] Cabanac M. Do birds experience sensory pleasure? Abstr Psychonom Soc, 2001;6: 25 (173).
[42] Garcia J, *et als*. A general theory of aversion learning. Ann NY Acad Sci, 1985;443: 8-21.
[43] Paradis S, Cabanac M. Flavor aversion learning induced by lithium chloride in reptiles but not in amphibians. Behav Proc, 2004;67: 11-18.
[44] Cabanac M. Pleasure: the common currency. J Theor Biol, 1992;155: 173
200.
[45] Cabanac M. Strategies adopted by juvenile lizards foraging in a cold environment. Physiol Zool, 1985;58: 262-271.
[46] Balaskó M. Cabanac M. Behavior of juvenile lizards (Iguana iguana) in a conflict between temperature regulation and palatable food. Brain Behav Evol, 1998;52: 257-262.
[47] Cabanac M, Johnson KG. Analysis of a conflict between palatability and cold exposure in rats. Physiol Behav, 1983;31: 249-253.
[48] Cabanac M. Palatability *vs.* money: experimental study of a conflict of motivations. Appetite, 1995;25: 43-49.
[49] Nicolau MC, *et als.* Why we sleep: the evolutionary pathway to the mammalian sleep. Progr Neurobiol, 2000;62: 379-406.
[50] Burghardt GM. The Genesis of Animal Play. 2005, Cambridge, Massachusetts: The MIT Press. 5001.
[51] Cabanac M. Emotion and phylogeny. Jap J Physiol, 1999;49: 1-10.
[52] Aarhem P, Lindahl BIB, Manger PR. On the origin of consciousness -Some amniote scenarios, in Consciousness Transitions -Phylogenetic, Ontogenetic, and Physiological Aspects, P. Århem and H. Liljenström, Editors. 2008, Elsevier: Amsterdam. 77-95.
[53] Delaney K, Gelperin A. Post-ingestive food-aversion learning to amino acid deficient diets by the terrestrial slug Limax maximus. J Comp Physiol, 1986;159A: 281-295.
[54] Kobayashi S, *et als.* Operant conditioning of escape behavior in the pond snail, Lymnaea stagnalis. Zool Sci, 1998;15: 683-690.
[55] Sangha S, *et als.* The effects of continuous versus partial reinforcement schedules on associative learning, memory and extinction in Lymnaea stagnalis. J Exper Biol, 2002;205: 1171-1178.
[56] Gelperin A. Rapid food-aversion learning by a terrestrial mollusk. Science, 1975;189: 567-570.
[57] Kojima S, *et als*. Optical detection of neuromodulatory effects of conditioned taste aversion in the pond snail Lymnaea stagnalis. J Neurobiol, 2001;49: 118
128.
[58] Denton D. The Pinnacle of Life. 1994, San Francisco: Harper Collins.

[59] Blumstein DT. Developing an evolutionary ecology of fear: how life history and natural history traits affect disturbance tolerance in birds. Ethology, 2006;71: 389-399.
[60] Blumstein DT, Bitton A, DaVeiga J. How does the presence of predators influence the persistence of antipredator behavior? J Theoret Biol, 2006;239: 460
468.
[61] McFarland DJ, Sibly RM. The behavioural final common path. Philos Trans Roy Soc, 1975;270: 265-293.

ON THE ORIGIN OF CONSCIOUSNESS, A POSTULATE AND ITS COROLLARY

Running head: Origin of consciousness
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ABSTRACT
A hypothesis is presented according to which structure of consciousness is quadri-dimensional. The four dimensions are duration, quality, intensity, and affectivity. One may reach this conclusion by introspection alone, or by deduction along the following steps: 1) Consciousness should be examined from the point of view of evolutionary psychology. 2) This leads to the following postulate: consciousness evolved from sensation. 3) The postulate entails a corollary: consciousness has kept the quadridimensional structure of sensation. The above postulate could explain the phylogenetic origin of pleasure as the common currency, and in turn the trade-offs for access to the behavioral final common path. It would also entail that joy is the transient sign of a useful conscious event, whereas happiness is the indifferent experience of a satisfied mind.

***Keywords**: consciousness pleasure usefulness happiness joy sensation*

*"Philosophers -and psychologists alike-have had a difficult time trying to comprehend consciousness. I make no pretence to solving the problem of consciousness in this paper. My more modest aim [is...] to begin sketching a map that can guide future thinking about consciousness" **(35) .***

I start this article with a quotation because my intention is superimposed with that of Nelkin. My aims are to look at consciousness from the point of view of evolutionary psychology, to offer a postulate about the phylogenetic origin of consciousness, and to draw the implications of the postulate.

Let me first discard and clarify three annex difficulties, zoology, anatomy, and semantics. We are not concerned here with the zoological question of *when* sensation and consciousness began in the evolution of living beings. Medicus has proposed that the emergence of behavioral properties and consciousness took place progressively over the animal kingdom (31) . We know for sure that, when the nervous system became complex enough to allow it, consciousness emerged (or supervened (39)), somewhere between Molluscs[4] or Arthropods and *Homo*. The fascinating problem of the actual time of emergence is not addressed here. Its solution does not modify the question of the usefulness of consciousness that is the lead followed in the present article.

The nature of the link between the brain and the mind, the binding problem, is still unknown. Patients with split-brain respond verbally to a signal received by their right visual field and gestually to a signal received by their left visual field (19, 33, 37) . This led to the proposal that consciousness might be not a coherent but rather a multiple phenomenon (2, 48) . However, intact subjects experience the intimate conviction of the unity of the self.

[4] An octopus seems to be able to learn an operant behavior just by watching "intensely" the behavior of a congener, Denton D. The pinacle of Life,Harper Collins, San Francisco, 1994.

It is likely that although the brain operates with multiple parallel anatomical and functional networks (5, 24, 40) , the emerging consciousness of the intact brain is an experience of self unity. I shall consider it as such in the following which deals with intact subjects and normal functions.
Words are tricky. Mental phenomena are not necessarily described by the same words in different disciplines and the same word may be used differently in different languages or by different individuals and thus cover slightly different spectra (32). Marcel and Bisiach (28) have recently described the difficulties psychologists find in defining consciousness. They showed that one of the problems of the study of consciousness is fuzzy semantics, sometimes functionalist, e.g. in the case of neuropsychology, sometimes phenomenological, e.g. in the case of cognitive psychology. Words like short-term memory, attention, control, verbal expression do not enter the same category as intention, consciousness, self-perception, qualia or subjectivity. Although we must accept some degree of fuzziness in our attempts to communicate about mental invisible phenomena that cannot be shared by common sensation, we must also try to limit the uncertainty of words and eliminate the "intolerable vagueness" of discussions about consciousness as denounced by Tulving (46) . One way to achieve this is to adopt the mathematical language thus removing indeterminacy. The present article is an attempt on these lines since mental phenomena will be presented conceptually and graphically as a four-dimension model.

According to evolutionary psychology (16) we should look at mental phenomena with a Darwinian eye and incorporate the concept of natural selection into psychology. From this point of view one should accept that consciousness gave such an advantage to the animals that first acquired it, that they were selected and they transmitted the faculty to their offspring. Yet, it is not clear how consciousness is advantageous because all the responses and behaviors of conscious organisms could exist without consciousness and it is difficult to see what advantage consciousness brings. Robots become more and more complex, one may foresee future robots with sophisticated artificial intelligence function, performing complex tasks involving decisions similar to those performed by conscious organisms (39) . Since consciousness is not a built-in element of robots this lack raises the problem of the usefulness of consciousness and in turn of the validity of the law of natural selection. "The more we understand mental processes in computational terms, the less need there seems for consciousness" (36) . Dawkins lucidly analyzed the problem (18) : *enten*, consciousness did not appear as a result of natural selection, a hypothesis that would contradict the universality of the Darwinian mechanism and that one would hesitate to accept; *eller*, consciousness is advantageous, but it is difficult to distinguish how, up to the point where some psychologists claim that it is impossible to see a difference between agents with and without consciousness. I shall offer a tentative answer to this problem as a conclusion of this article.

Postulate: Consciousness evolved from sensation, which was the first conscious experience.

Although new as expressed above, the postulate follows the historical trend called sensationalism. Sensation has always been a matter of interest to philosophers. Plato (38) held that sensation and opinion are the main screens masking Truth, but the opposite view tended to dominate both before and after him. Heraclitos (26) taught that knowledge comes to man "through the door of the senses", and Protagoras (17) that the entire psychic life consists only of sensations. Aristotle (3) , Plato's own pupil, returned to the sophists' view that sensation is the gate of the soul. This notion can be traced through history up to nowadays. Hobbes (25) wrote: "There is no conception in man's mind, which hath not at first, totally or in parts, been begotten upon the organs of senses". Condillac (15) , taking the theoretical example of an inert statue, showed that the progressive attribution of the senses would allow the development of a complete mind in the statue. Thus he made it clear that the mind must use the senses to know and understand the world, and that the senses are necessary and sufficient to develop a mind. This notion was also accepted by Kant (27) for whom, however, the senses were but one of the two sources of human knowledge, the other one being understanding. "Sensationalism is the theory that all knowledge originates in sensations; that all cognition even reflective ideas and [...] intuition can be traced back to elementary sensations" (44) .

"All science, whatever the realm of application, has a common origin: the immediate experience of the observing person of the scientist himself" (42) . The scientific process then proceeds in the sharing of evidence by two or more persons. Both processes take the sensory channels. The study of this obligatory channel is the origin of experimental psychology (23) .

Although less radical than Condillac's sensationalism the above postulate attributes to sensation an important role in the phylogenic, rather than ontogenic, emergence of consciousness. Let me describe briefly what I have proposed in previous publications about the nature and structure of sensation. The corollary of the postulate will follow from the nature of sensation.

What is sensation?
Sensation is a conscious experience in response to a stimulus. Sensation is quadri-dimensional, each dimension describes one property of the stimulus (Fig. 1) (14) .

The first dimension of sensation is qualitative and describes the nature of the stimulus. A blue color, a sweet taste, a carnation fragrance, etc., describe the physical or chemical nature of the respective stimuli. Anatomically different sensory input pathways carry the information that allows the qualitative discrimination. Since Aristotle, and for the following two millennia sensation was considered as originating only from the five sense organs, eye, tongue, nose, ear, and skin. However, the physiologists have discovered many more afferent pathways that can arouse sensations. Table I, gives a list of the accepted sensations. N.B.: The information provided by these sensations are all properties of the external world. Although this list is longer than the Aristotelian senses, one may keep a Platonician doubt about the true information provided by this narrow physical and chemical window on the world. The range of the variables detected is narrow compared to their actual range of variation in nature; the number of physical characteristics not detected far outnumbers those that are sensed. It would be useful to detect ionizing radiation, time, speed, etc.
discovered, originating from various regions deep in the body. Through afferent pathways these sensitivities inform the centers about the In addition to the exteroceptive afferent pathways, many more afferent fibers have been
physical and chemical state of the various tissues and organs. It is highly likely that all afferent fibers to the central nervous system, including the various visceral inputs (Table II) are able to arouse sensations (Fig 2). Thus, sensations are not limited to the five senses but find their origin in all the parts of the body (for additional discussion on afferent inputs, see 14).
Perception is a conscious experience occurring when several sensations and/or memory merge at the same time into consciousness, as sketched Fig 3.
The second dimension of sensation is quantitative and describes the intensity of the stimulus, a bright color, a loud noise, etc. This is the domain of election of psychophysics. The intensity of the sensation is somewhat related to the frequency of afferent action potentials (including temporal and spatial recruitment) but it is not fully understood how this is achieved and how the peripheral nervous system encodes the message carrying the intensity of the stimulus. Sensation increases in intensity with the increase of the stimulus magnitude in a continuum rather than in discrete steps. However, one may distinguish in this continuum degrees of intensity in sensation: sensitivity (not conscious), threshold sensation, conscious sensation, intense awareness.
The third dimension of sensation is affective. It may be difficult to disentangle affectivity from intensity because they most often covary together. Yet, this can be done (e.g. in the cases of taste (43) , and temperature (34)). All sensations are either unpleasant, indifferent or pleasant. Incidentally, this includes pain, a sensation most often unpleasant but sometimes indifferent or even, but rarely, pleasant. Sensory pleasure possesses several characteristics: Pleasure is
contingent, pleasure is the sign of a useful stimulus, pleasure is transient, pleasure motivates behavior (10, 13) .
Sensory pleasure is not fixed but contingent and depends on i) the nature of the stimulus, ii) the internal state of the subject, and iii) the past history of the subject. A given stimulus can arouse pleasure or displeasure according to the combination of these three parameters. Alliesthesia is the faculty of a sensation to move up and down the affective axis of figure 1 (10) .
Sensory pleasure describes the usefulness of the stimulus. Usefulness is understood here as improving physiological fitness, i.e. as the capacity for the stimulus to correct a physiological trouble or deficit. Usefulness of sensation is thus appreciated from its short-term survival value, but learning can extend to the long-term survival value the association of sensory pleasure with long-term usefulness (e.g. Garcia effect (22)).
Sensory pleasure is transient. Since the usefulness of a stimulus can change with time, so does its pleasantness. On the short-term, sensory pleasure is only transient, lasting only as long as the physiological state has returned to normal. Then the stimulus arouses only indifference or displeasure. Different from pleasure is comfort: the state of physiological normality and of indifference towards the environment (1, 11) . Comfort is

the state of sensation with a nil affective dimension. Whereas sensory pleasure is dynamic, aroused when a stimulus is useful, comfort is a stable state, which can last indefinitely if the environment and the subject remain in stable conditions.

Sensory pleasure is the motivation for physiology oriented behavior (4, 21) .

The fourth dimension of sensation is duration, which describes the extent of time a stimulus is present. In figure 4 duration is added to the three other dimensions.

Corollary of the postulate: Consciousness has kept the four dimensions of its origin, sensation, and is therefore also represented by the model of figure 4. Consciousness is congruent (Fr.:*homothétique*) to sensation.

We may accept this statement as a result of mere introspection: I can analyze any thought I have and recognize a quality, an intensity, an affectivity, and a duration. However, the postulate entails its corollary according to the following steps:

1) The affective dimension of sensation, pleasure and displeasure, is the sign of the physiological usefulness of a stimulus (10) . Pleasure is both the tag of a useful stimulus and the force that orients behavior to approach and eventually consume this stimulus.

2) Since behavior is a final common path, the brain needs a common currency to rank the motivations for access to behavior in a time-sharing pattern (29, 30) .

3) Since maximization of sensory pleasure is the motivation for behaviors adapted to physiological goals and since motivations with physiological goals compete with other motivations such as ludic, aesthetic, and social ones, pleasure is this common currency (12) . In the same way as sensory pleasure tags the usefulness of a stimulus, joy tags the usefulness of any other conscious
experience.

4) The affective axis is thus the motivational dimension of consciousness. If consciousness possesses the affective dimension, then the other dimensions of sensation also were inherited by consciousness.

The qualitative dimension of consciousness

This dimension does not pose much problem. It is not difficult to accept that there are mental events of different natures. In the same way as there are different sensations there are different conscious experiences. One may list them as sensations, perceptions, illusions, hallucinations, premonitions, emotions, memory recalls, ruminations, dreams, reasoning, observing, Gestalt, self consciousness, etc., all qualitatively different categories of conscious experience. Each category can be divided into sub-categories; e.g. emotions can be divided into fear, surprise, love, etc. The presentation of the various mental events on a qualitative axis may render obsolete the problem of unitary consciousness. Rather than asking whether there is one or several consciousness we should represent consciousness as applying to the various, qualitatively different mental experiences.

This dimension identifies the nature of the conscious event as it does identify the stimulus in the case of sensation. An idea, like a sensation, is a copy, or a filter, of truth. An X-axis for the quality of mental experience does not imply that several structures in the brain support the function of consciousness. A useful discussion on this point will be found in Baars (5) and Baars and Newman (6) .

The quantitative dimension of consciousness

If the quantitative dimension is easy to understand in the case of sensation, this is less true in the case of consciousness.

The principle of non-contradiction implies that one cannot at the same time be conscious and non-conscious. Yet, blinsight shows that visual signals can be received and treated adequately by the brain without the awareness of the patient with occipital cortical lesion (47) and patients are able to store and somewhat process information presented under general anesthesia(41) . I suspect that some semantic and conceptual difficulties disappear when consciousness is defined in terms of intensity. Again here, rather than asking whether there is one or several consciousness we should represent consciousness as more or less intense, or acute.

Let us examine consciousness from this point of view and see whether the sensory schema applies to it. Tulving has proposed that retrieval operations governed by different memory systems may be associated with an ordering of forms of consciousness, from anoetic (not-knowing) through noetic (knowing) to autonoetic (self-knowing) (45) . In the general case of mental events one may accept that the intensity of consciousness is a continuum, as is the case with sensation, and it is also possible to identify discrete increases in intensity in at least four similar steps: not conscious (blinsight), threshold consciousness (daydream, or automatic motor behavior), reflexive consciousness (I think it over, Fr.: *je réfléchis*), intense consciousness (panic, orgasm, etc.). Table III presents these landmarks in
sensation and their counterparts in consciousness.

We may accept that the most intense idea or conscious event at a given time occupies the forefront of consciousness, hiding the other less intense ones. Thus the existence of selective attention (5) may find an explanation. When no conscious event is intense, several ideas can simultaneously coexist. An experienced driver can drive a car and at the same time think of something else or listen to the radio. Can we compare the intensity of the thought of a banana flavored yogurt with that of reading a scientific article? No doubt that cross-modality matching experiments would provide a positive answer to this question.
A dimension of intensity of consciousness does not imply that only one structure in the brain supports the function. Blindsight for example, a mere sensitivity producing reflexive behavior below the level of consciousness, seems to be permitted by a network different from that of conscious seeing. A stronger stimulus of the 'blind' side of a brain lesioned patient would not result in a conscious sensation. Yet, this would be the case in an intact subject where a parallel structure would enter into play.

The affective dimension of consciousness
We find little difficulty in accepting that conscious experience is either unpleasant, indifferent or pleasant, as is sensation. Duncker listed four types of causes of pleasure: i) sensory enjoyment (or displeasure) i.e. to enjoy the stimulus or the consequences of behavior; ii) aesthetic enjoyment, i.e. strive for a better understanding; iii) desire (for a steak, a book, a love, etc.), not a reaction but the fulfillment of a need, and iv) pleasure in achievement, dynamic joy of
succeeding, in victory (20) . Thus, showing that various conscious events could be listed in the same affective dimension.
Like the quantitative dimension, the affective dimension of consciousness is also a continuum where the following landmarks merge into one another: distress, extreme displeasure, acute displeasure, slight displeasure, indifference, slight pleasure, acute pleasure, delight, rapture. The affective dimension can be nil; in that case the conscious experience is indifferent.
Having established the contingent, transient, and useful properties of sensory pleasure, there remains to examine whether affectivity also possesses these characteristics in the general case of consciousness.
The notions of behavioral final common path and of common currency are helpful here. To rank according to their order of satisfaction the multiple motivations that compete for access to the behavioral final common path, the brain needs a common currency (29, 30) . Sensory pleasure serves as the common currency for the trade-offs that take place in the mind to achieve the ranking of priorities and insure that the most urgent motivation has access first to the behavioral final common path (12) . Thus, this affective axis defines the desire to consume a stimulus or to achieve a goal, but the intention to act depends on the algebraic sum of several simultaneous positive and negative desires on this axis. This is especially conspicuous in the case of food intake. P.
T. Young (50) and others (7, 8) have underlined that sensory pleasure is but one of the various signals producing the excitement to eat. In this special behavior that is food intake, the reminding that all pleasures and displeasures compete
against one another before their algebraic sum results in intention, is helpful to understand the resulting behavior.

Indeed, a common currency for motivations as different from one another as those of Duncker's four categories is necessary to permit competition for access to behavior. Therefore, physiological, ludic, social, esthetical, moral, religious motivations can be compared to one another from the amount of pleasure and displeasure they arouse. Thus, the main properties of sensory pleasure should belong also to consciousness.

One can easily recognize that the affective dimension of conscious events is contingent. The thought of my bunch of keys is normally indifferent. If I discover at work that I have lost it, the thought of it is unpleasant. If I find my bunch of keys on my way back home, the thought of it is now quite pleasant.

The transience of pleasure can be found also with consciousness. Happiness is considered generally as the aim of life. Yet, the pursuit of happiness is fallacious if one does not know what happiness is. In the same way as there are two different elements in sensation: sensory pleasure highly positive but transient, and comfort indifferent but stable, it is possible to recognize two elements in the affectivity of global consciousness: positive and transient joy, and indifferent but stable happiness (9) . Happiness is to joy what comfort is to pleasure (Table IV). This duality explains the disappointment expressed by many a writer and some philosophers when they deal with happiness. They use the word happiness to describe a pleasant experience, which they expect to last and, when they see that it is only transient, erroneously conclude that happiness does not exist. They
should have used the unambiguous word joy (for additional discussion on the nature of happiness, see 9).

Knowing that sensory pleasure is an index of the physiological usefulness of a stimulus; the corollary of the above postulate renders inevitable that joy is the index of a useful conscious event. The relationship of joy with usefulness may become non univocal with the increased complexity of the mind process. It is obvious that among those events or behaviors that arouse joy there are some for which we cannot foresee how useful they could be. The case of drug addiction comes immediately to mind. The answer to this argument is twofold. First, from a Darwinian point of view it is not necessary that joy be useful on each and every mental event. To be passed on to future generations, it is sufficient that joy gives some advantage to the subjects who possess it. From this point of view, we can compare pleasure and joy to curiosity. On some occasions the outcome of curiosity may be noxious. Yet, everybody will agree that curiosity gives an evolutionary advantage to the subjects who possess it. Second, usefulness of sensory pleasure is mostly proximate, usefulness being judged from its immediate survival value. However, sensory pleasure can be also associated to long term usefulness. Sexual pleasure is a powerful reward of reproductive behavior. Its usefulness may be assigned to the species, rather than the individual. Similarly, joy can be the sign of an integrative behavior, useful on the short term for the subject or on the long term for the species. The joy of love may have no immediate survival usefulness (arguably the opposite), but find its usefulness in the outcoming reproductive behavior. Pleasure, as an index of useful sensation can be innate or acquired. Similarly, one may easily accept that homologous joy can be acquired. The hormic joy associated to effort has to be taught and learnt.

The last property of sensory pleasure is its capacity to motivate behavior. The seeking and the maximization of sensory pleasure resulting in a stimulusseeking behavior. Does this apply to joy? The philosophers generally accept this. Duncker (20) has sorted the philosophers in hedonists for whom pleasure (joy) is the motivation to behave and hormists for whom pleasure (joy) is the outcome of behavior. In both cases pleasure (joy) is one way or another both the goal and the motor of behavior. It is possible that the pursuit of pleasure/joy for its own sake has been the motor of the complexification of the human mind because this axis defines the desire to consume a stimulus or to achieve a goal, but the intention to act depends on the algebraic sum of several simultaneous positive and negative desires. Thus this axis is the seat and the source of permanent prerational computation.

The time dimension of consciousness

The notion that any conscious event has a limited duration should raise no other problem than the existential problem of time itself.

Conclusions

The postulate that sensation was the early stage of consciousness and that consciousness evolved from sensation led us to the corollary that all conscious events retain the four dimensions of sensation, their congruent origin.

The distinction of quality from intensity may be helpful in explaining some states of consciousness considered as qualitatively different when they are rather intensively different from one another.

It is the affective dimension of consciousness that allows us to offer a tentative answer to the paradox pointed out by Dawkins (18). The answer to this paradox is to accept the second branch of her alternative: consciousness is useful. Affectivity is what makes consciousness useful and different from robots. Before sensory pleasure, behavior may be understood as a combination of reflexes. Pleasure introduces cognition. The evolutionary advantage of sensory pleasure, for the animals that first had it, is that it saved the nervous system from storing astronomical numbers of potentially useful or noxious stimulus-response reflexes. Sensory pleasure added flexibility to the behavioral pattern of those, which possessed it and passed it to their offspring. Similarly joy saves the brain from storing an infinite number of rules of thumb, and provides a formidable advantage both in amount of information stored and in flexibility of the behavioral responses. The major advantages of affective decision process as compared to pre affective decision process (in living or inanimate agents) is to facilitate the ranking of priorities and to add flexibility to this process. The brain has evolved into an information processing apparatus. In this evolution it has acquired the property to talk to itself. Thus consciousness became self-awareness.

The advantage of consciousness is thus primarily in the affective dimension, the dimension that makes living brains different from computers and robots. Robots can detect the nature and the intensity of external or internal signals. Sophisticated robots include a goal function serving as a flexible reference for the robot's behavior; yet, such flexibility is limited to one function. Despite the talents of their programmers they lack the affective dimension of thinking. The affective dimension of consciousness is there of paramount importance because among all the thoughts that compete for access to the first rank in the final common path of consciousness (5), the winners will be the most intensely pleasant or unpleasant. The affective dimension of the conscious experience focuses the attention on the relevant conscious event on the qualitative axis. If, as analyzed by Oatley (36), the role of consciousness is to provide an infinite flexibility to the decision-making process by allowing selection of new priorities and to rearrange plans in unexpected situations, then this function is fulfilled by affectivity. In the particular case of sensation, it is the affective dimension of sensation that indexes the physiological usefulness of stimuli. One may expect also affectivity to play this role in the general case of consciousness. Thus, we tend to seek and perform behaviors that produce joy. The main consequence of this finding is that merit does not exist. Merit consists only in sorting out those motivations that are the most rewarding. Yet, moralists and philosophers have long recognized that the altruistic behaviors belong to this category.

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TABLE I

BEYOND THE FIVE SENSES

After J.M. Wolfe (1988) (49)

Sensation	*Sensor, organ*
Vision	retina, eye
Audition	cochlea, inner ear
Gustation	gustatory buds, tongue
Olfaction	olfactory neurones, nasal mucosa
Thermal	nerve free endings, derma
Tactile	nerve endings, hair and Paccini's Meisner's and Krause's corpuscles, derma
Spatial	labyrinth, inner ear; muscle spindles, muscles; Golgi endings, tendons
Algic	free ending C fibres, everywhere

TABLE II

LIST OF THE NERVOUS SENSORS WITHIN THE ORGANISM

Sensor	*Location*	*Sensed variable*
Mechanoreceptors	big arteries: sino-aortic cardiac pulmonary venous gastrointestinal tract muscular tendinous and articular	blood pressure cardiac repletion (blood volume) pulmonary tension (volume) venous volume gastrointestinal repletion muscle length tension
Chemoreceptors	big arteries: glomus, aorta, carotid artery gastrointestinal tract medulla hypothalamus liver	blood Pa02 content of digestive tract blood PaC02, pH blood hormones portal glucose
Thermoreceptors	Hypothalamus spinal cord digestive tract	local temperature local temperature local temperature
Osmoreceptors	Hypothalamus liver	Osmotic pressure Osmotic pressure

TABLE III:
INTENSITIES OF CONSCIOUS EXPERIENCE

Intensity	**Tentative phylogenic landmark**	**Sensation**	**Consciousness**
level four		alarm	"nothing else exists"
level three	Homo	attentive sensation	"I think it over" Fr. "*je réfléchis*"
level two	mammals, birds	sensation	thinking
level one	vertebrates	sensory threshold	humor "I am hardly aware"
level zero	arthropods	sensitivity	blindsight

TABLE IV:
JOY IS TO HAPPINESS WHAT PLEASURE IS TO COMFORT

	Sensation	**Consciousness**
pleasant	pleasure	joy
indifferent	comfort	happiness

Legends of figures

Fig. 1 Sensation seen as a multidimensional event in response to a stimulus.Quality, describes the nature of the stimulus; quantity, describes the intensity of the stimulus; affectivity (pleasure or displeasure), describes the physiological usefulness (survival value) of the stimulus. From (14).

Fig. 2 Diagrammatic representation of the functional structures of sensation. A sensitivity is a histological sensor whose afferent message is fed to the centres. If this message reaches consciousness the conscious event is a sensation. It is assumed here that sensation can originate from all sensitivities. From (14).

Fig. 3 When several sensations reach simultaneously consciousness, with or without additional messages from memory, the conscious event is a perception. From (14).

Fig. 4 Duration is here added to the three other fundamental dimensions of sensation. It is argued here that this model describes equally sensation and consciousness.

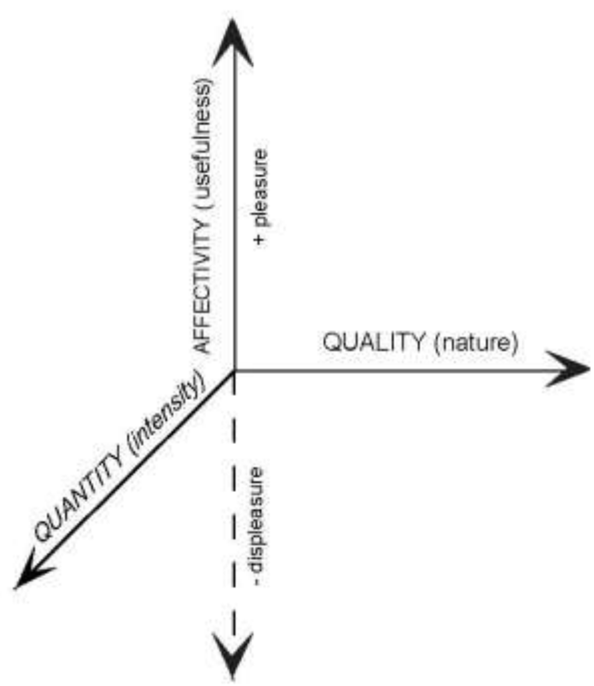

Fig. 1

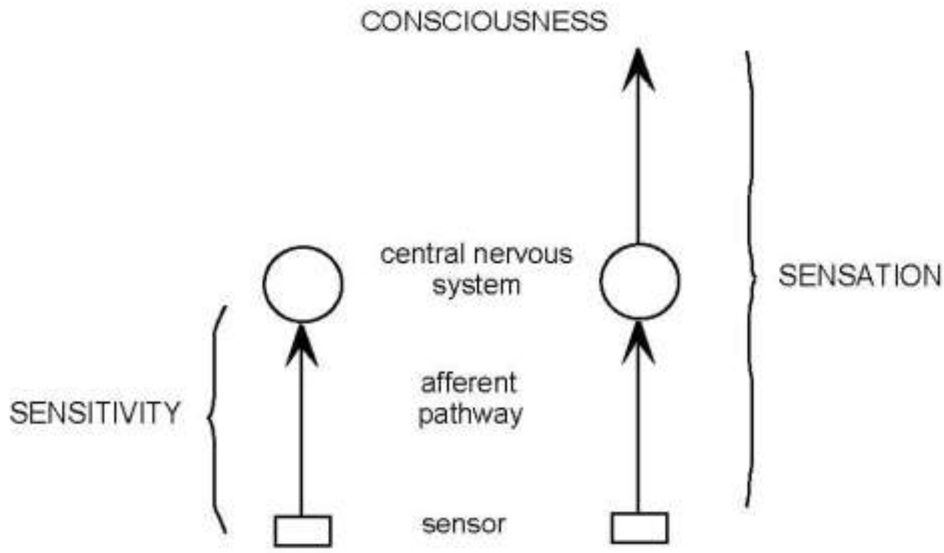

Figure 2

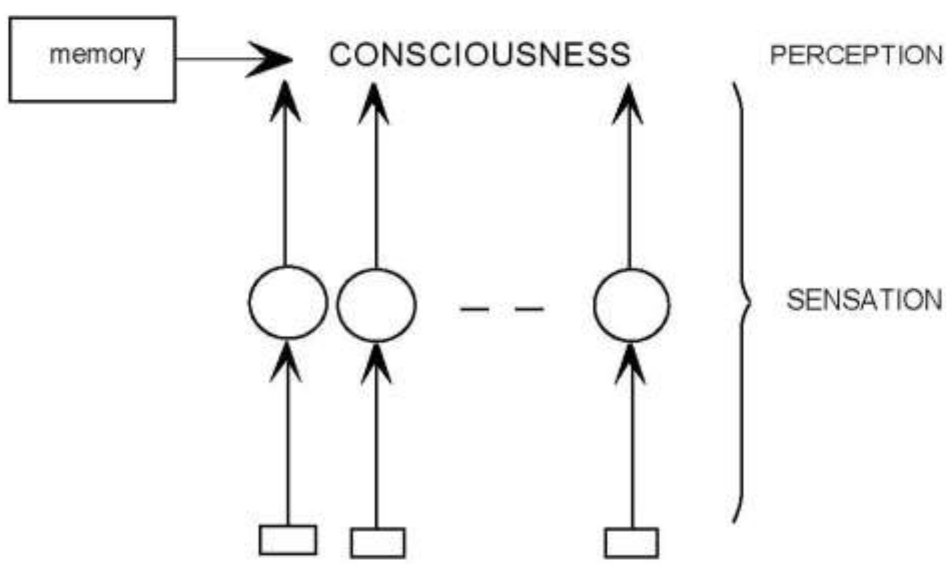

Figure 3

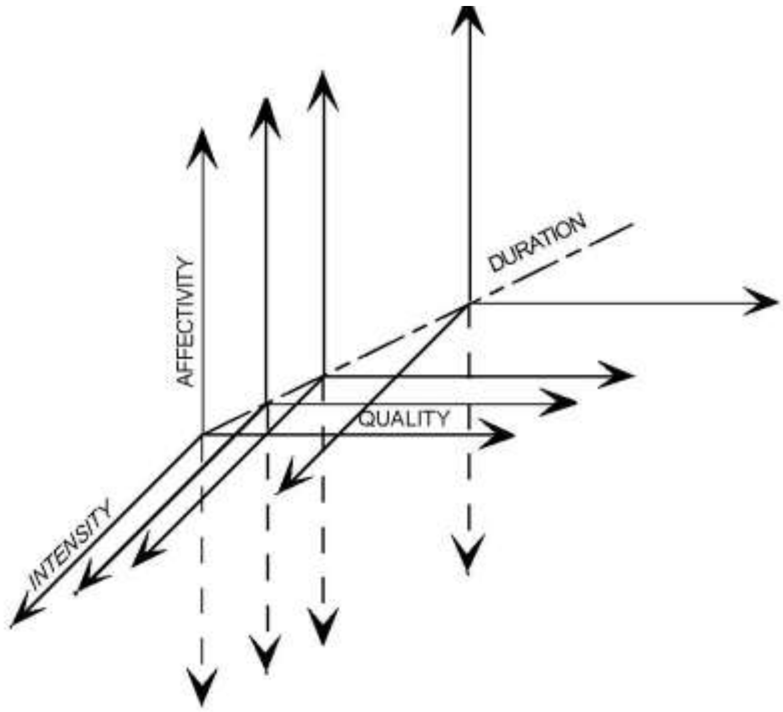

Figure 4

References

1. (IUPS), C. f. t. p. Glossary of terms for thermal physiology. Pflüg. Arch. 410:567-587, 1987.
2. Allport, A. What concept of consciousness? In: Consciousness in Contemporary Science. Marcel, A. J. and Bisiach, E., ed. Oxford: Oxford University Press, 1988: 159-182.
3. Aristote. Éthique de Nicomaque 10. J.Voilquin, 1965 Paris: Flammarion,
4. Attia, M. Thermal pleasantness and temperature regulation in man. Neurosci. biobehav. Rev. 8:335-343, 1984.
5. Baars, B. J. A global workspace theory of conscious experience. In: Consciousness in Philosophy and Cognitive Neuroscience. Revonsuo, A. and Kamppinen, M., ed. Hillsdale, New Jersey: Laurence Erlbaum Associates, 1994: 149-171.
6. Baars, B. J. A neurobiological interpretation of global workspace theory. In: Consciousness in Philosophy and Cognitive Neuroscience. Revonsuo, A. and Kamppinen, M., ed. Hillsdale, New Jersey: Laurence Erlbaum Associates, 1994: 211-226.
7. Berridge, K. C. Puzzles of reward: palatability, appetite, brain and consciousness. Neurosci. biobehav. Rev. , 1994.
8. Booth, D. A. Learned ingestive motivation and the pleasures of the palate. In: The Hedonics of Taste. Bolles, R. C., ed. Hillsdale, N.J.: Lawrence Earlbaum Associates, 1990: 29-58.
9. Cabanac, M. Du confort au bonheur. Psychiatr. fr. 17:9-15, 1986.
10. Cabanac, M. Physiological role of pleasure. Science 173:1103-1107, 1971.
11. Cabanac, M. Physiological signals for thermal comfort. In: Bioengineering, Thermal Physiology, and Comfort. Cena, K. and Clark, J. A., ed. Amsterdam: Elsevier Scientific Publ., 1981: 181-192.
12. Cabanac, M. Pleasure: the common currency. J. theoret. Biol. 155:173-200, 1992.
13. Cabanac, M. Sensory pleasure. Q. Rev. Biol. 54:1-29, 1979.
14. Cabanac, M. What is sensation? In: Biological Perspectives on Motivated Activities. Wong, R., ed. Norwood, New Jersey: Ablex, 1994:
15. Condillac, E. B. d. Traité des sensations. (1984 ed.) Paris: Arthème Fayard, 1754:438.
16. Cosmides, L.; Tooby, J.; Barkow, J. H. Introduction: evolutionary psychology and conceptual integration. In: The Adapted Mind. Barkow, J. H., Cosmides, L. and Tooby, J., ed. New York: Oxford University Press, 1992: 3-15.
17. Croiset; Nodin. Protagoras. Paris: Les Belles Lettres, 1935
18. Dawkins, M. S. Through our eyes only? (1 ed.) Oxford: W. H. Freeman & Co., 1993:192.
19. Dennet, D. C. Consciousness Explained. Boston: Little, Brown, 1991
20. Duncker, K. On pleasure, emotion, and striving. Philos. phenomenol. Res. 1:391-430, 1940-1941.
21. Fantino, M. Role of sensory input in the control of food intake. J. auton. nerv. Syst. 10:326-347, 1984.
22. Garcia, J.; Hankins, W. G.; Rusiniak, K. W. Behavioral regulation of the milieu interne in man and rat. Science 184:824-831, 1974.
23. Geldard, F. A. The Human Senses. (2nd ed.) New York: John Wiley & Sons, 1972:584.
24. Heiligenberg, W. Distributed systems in sensory information processing. In: Dean, J. and Cruse, H., ed. Emergence of prerational Intelligence in Biology: from Sensorimotor Intelligence to Collective Behavior. Bielefeld: ZIF-Universität Bielefeld, 1994: .
25. Hobbes, T. Human Nature, or the Fundamental Elements of Policy. baron

d'Holbach, 1772 Paris: Librairie Philosophique J. Vrin, 1971, 1651

26. Jeannière, A. La pensée d'Héraclite d'Éphèse et la vision. Paris: Aubier Montaigne, 1959
27. Kant, I. Kritik der praktischen Vernunft. F. Picavet, 1983 Paris: Presses Universitaires de France, 1788; vol 1).
28. Marcel, A. J.; Bisiach, E. A cautious wellcome: an introduction and guide to the book. In: Consciousness in Contemporary Science. Marcel, A. J. and Bisiach, E., ed. Oxford: Oxford University Press, 1988: 1-15.

29. McFarland, D. J.; Sibly, R. M. The behavioural final common path. Philos. Trans. roy. Soc. London 270:265-293, 1975.
30. McNamara, J. M.; Houston, A. I. The common currency for behavioural decisions. Amer. Natural. 127:358-378, 1986.
31. Medicus, G. Toward an etho-Psychology: A phylogenetic tree of behavioral capabilities proposed as a common basis for communication between current theories in psychology and psychiatry. Ethol. Sociobiol. 8:131S-150S, 1987.
32. Montefiore, A.; Noble, D. General introduction. In: Goals, No-Goals and Own Goals. Montefiore, A. and Noble, D., ed. London: UnWin Hyman Ltd., 1989: 3-13.
33. Mortensen, C.; O'Brien, G.; Paterson, B. Distinctions: subpersonal and subconscious. Commentary on Puccetti on Split-Brain. Psycholoquy 93.4.62, 1993.
34. Mower, G. D. Perceived intensity of peripheral thermal stimuli is independant of internal body temperature. J. comp. physiol. Psychol. 90:11521155, 1976.
35. Nelkin, N. Unconscious sensations. Philos. Psychol. 2:129-141, 1989.
36. Oatley, K. On changing one's mind: a possible function of consciousness. In: Consciousness in Contemporary Science. Marcel, A. J. and Bisiach, E., ed. Oxford: Oxford University Press, 1988: 369-389.
37. Pessin, A. One mind too many? Commentary on Puccetti on Split-brain. Psycholoquy :29Dec., 1993.
38. Plato. Phédon. R. Baccou, E. Chambry,1946 Paris: Garnier,
39. Revonsuo, A. In search of the science of consciousness. In: Consciousness in Philosophy and Cognitive Neuroscience. Revonsuo, A. and Kamppinen, M., ed. Hillsdale, New Jersey: Laurence Erlbaum Associates, 1994: 249-285.
40. Rolls, E. T. A theory of emotion and consciousness, and its application to understanding the neural basis of emotion. In: The Cognitive Neurosciences. Gazzaniga, M. S., ed. Boston: M.I.T. Press, 1994: 1091-1105.
41. Roorda-Hrdlicová, V.; Wolters, G.; Bonke, B.; Phaf, R. H. Unconscious perception during general anesthesia, demonstrated by an implicit memory task.
In: Memory awareness in anaesthesia. Bonke, B., Fitch, W. and Millar, K., ed. Amsterdam: Swets and Zeitlinger, 1990: 151-155.
42. Spence, K. W. The postulates and methods of behaviorism. Psychol. Rev. 55:67-78, 1948.
43. Thompson, D. A.; Campbell, R. G. Hunger in humans induced by 2 deoxyd-glucose: glucoprivic control of taste preference and food intake. Science 198:1065-1068, 1977.
44. Titchener, E. B. Lectures on the Experimental Psychology of the Thought-Process. New York: MacMillan, 1909:318.
45. Tulving, E. Memory and consciousness. Can. Psychol. 26:1-26, 1985.
46. Tulving, E. Varieties of consciousness and level of awareness in memory. In: Attention: Selection, Awareness and Control. A Tribute to Donald Broadbent. Baddely, A. and Weiskrantz, L., ed. Oxford: Oxford University Press, 1995: (in press).
47. Weiskrantz, L. Disconnected awareness for detecting, processing, and remembering in neurological patients. J. Roy. Soc. Med. 84:466-470, 1991.
48. Wilkes, K. V. ____, yìshì, duh, um, and consciousness. In: Consciousness in Contemporary Science. Marcel, A. J. and Bisiach, E., ed. Oxford: Oxford University Press, 1988: 16-41.
49. Wolfe, J. M. Readings from the Encyclopedia of Neurosciences: Sensory systems II. Boston, Massachussetts: Birkhäuser, 1988
50. Young, P. T. The role of affective processes in learning and motivation. Psychol. Rev. 66:104-123, 1959.