European Cooperation in the field of Scientific and Technical Research
- COST -
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Secretariat

Brussels, 13 December 2006

COST 326/06

MEMORANDUM OF UNDERSTANDING

Subject :	Memorandum of Understanding (MoU) for the implementation of a European Concerted Research Action designated as COST Action BM0605: Consciousness: A Transdisciplinary, Integrated Approach

Delegations will find attached the Memorandum of Understanding for COST Action BM0605 as approved by the COST Committee of Senior Officials (CSO) at its 166th meeting on 20/21 November 2006.

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MEMORANDUM OF UNDERSTANDING
FOR THE IMPLEMENTATION OF A EUROPEAN CONCERTED RESEARCH ACTION DESIGNATED AS

COST ACTION BM0605

Consciousness: A Transdisciplinary, Integrated Approach

The Signatories to this 'Memorandum of Understanding', declaring their common intention to participate in the concerted Action referred to above and described in the 'Technical Annex to the Memorandum', have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 299/06 'Rules and Procedures for Implementing COST Actions' the contents of which the Signatories are fully aware of.

2. The main objective of the Action is to increase the understanding of (1) the defining features, (2) the behavioural markers, (3) the computational principles, and (4) the neural mechanisms associated with conscious experience in humans and animals, and to identify the clinical, societal, and ethical implications of such findings.

3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at 46 million EUR in 2006 prices.

4. The Memorandum of Understanding will take effect on being signed by at least five Signatories.

5. The Memorandum of Understanding will remain in force for a period of four years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of the document referred to in Point 1 above.

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COST ACTION BM0605

Consciousness: A Transdisciplinary, Integrated Approach

A. ABSTRACT

Consciousness is considered to be one of the most significant scientific problems today. Understanding the mechanisms involved in the conscious states we enjoy when perceiving, feeling, thinking, or acting requires a highly interdisciplinary approach that involves different disciplines (from neuroscience to philosophy; from artificial intelligence to psychology), different methods (behavioural, computational, and brain imaging methods), and different populations (from animals to pathological cases). While a majority of researchers in the domain works in Europe, there is little concerted effort to bring this community together, and the domain's interdisciplinary nature is a genuine challenge for junior scientists. This COST Action therefore aims to create a strong network of active senior and junior scientists so as to contribute to the emergence of a "consciousness community" in the EU. The Action is focused on improving the understanding of (1) the defining features, (2) the behavioural markers, (3) the computational principles, and (4) the neural mechanisms associated with conscious experience in humans and animals. These objectives are achieved by coordinating research efforts on four central topics: (1) fundamental issues, (2) technologies, (3) experimental paradigms, and (4) clinical, societal and ethical implications.

Key Words: Consciousness, Cognitive Neuroscience, Philosophy of Mind, Experimental and Social Psychology, Brain Imaging

B. BACKGROUND

Current state of knowledge. What is consciousness? The short answer is: Nobody knows. Consciousness has long been considered as inaccessible to the scientific approach, and remains a mystery — "a phenomenon that people don't know how to think about — yet" (Dennett 1991, p21). Of course, in an intuitive sense, we all "know" what consciousness is, at least roughly: It is "experience" — each of us knows, from the inside, what it is like to undergo seeings, feelings, hopings, that is, each of us *is* conscious. But what would a *science* of consciousness look like? How should one go about developing a scientific approach to consciousness, that is, to understand its mechanisms and physical basis?

Because consciousness is so basic to human (and much animal) life, it is now widely taken to be one of the most important outstanding scientific problems. This is reflected in the spectacular renewed interest that the study of consciousness currently enjoys, in fields ranging from neuroscience to psychology and philosophy. As a case in point, while 1950 only saw the publication of five articles dedicated to consciousness in the biomedical literature, many thousands are now published every year. Entering the keyword "consciousness" in the Google search engine returns a truly staggering 55.000.000 documents. Dozens of books, several journals, a number of new scholarly societies (foremost among which the Association for the Scientific Study of Consciousness), and annual conference series further document what one could call a paradigm shift: the "Consciousness Boom", also reflected in the fact that Scientific American listed the topic among its recent "top ten unsolved problems".

This surge of interest has several distinct sources: the recognition of the limitations of behaviourism; the recent development of novel non-invasive imaging techniques for studying the brain in action in healthy subjects (e.g., PET, MRI, EEG/MEG, or TMS); the discovery of new drug therapies for mental illness; novel insights gained from computational neuroscience. However, despite this enormous commitment to the study of consciousness and the outstanding scientific advances that have been achieved over the past decade, genuine progress in understanding its mechanisms will only come through interaction between the neurosciences and other disciplines that have analysed, described and engaged with the nature of experience, including cognitive psychology, philosophy, psychiatry, neurology, &c. This synergy — which this COST Action aims to achieve — is necessary because the study of consciousness poses unique definitional, methodological, technological, and ethical challenges.

A first challenge is definitional. There is currently no widely accepted definition of consciousness. Operationally however, a useful distinction can be made between the overall *level* of consciousness and the *content* of consciousness. The former is associated with arousal, with sleep/waking cycles and, in pathological cases, with coma. The *levels* of consciousness are subtended by numerous deep cerebral structures (brainstem, thalamus, hypothalamus, basal forebrain). The *content* of consciousness is what one is conscious of — "subjective experience". These contents include percepts of the environment, memories of past events as well as intentions concerning future actions, and are thought to depend primarily on reciprocal cortico-cortical and thalamo-cortical interactions. Consciousness is closely related to cognitive functions such as attention, working memory, long-term episodic memory, mental imagery and language. It is usually believed that consciousness emerges from the specific way information is processed and transmitted through cerebral networks, but these processes still have to be discovered and characterised. While there are numerous proposed computational mechanisms (e.g., recurrence, amplification, selection, global competition, synchrony, stability, strength, &c.) that explain some aspects of the difference between conscious and unconscious information processing, these proposals currently lack integration and generally fail to provide insight into the nature of conscious experience itself. Importantly, the study of the contents of consciousness also includes so-called "altered states of consciousness", which comprise both psychopathological cases as well as cases that involve loss of (e.g., coma) or profound changes (e.g., schizophrenia, autism, drug use) in both the level and the contents of consciousness. This research in particular has significant clinical and ethical implications.

A second challenge is methodological: How can one explore a phenomenon that is intrinsically private and subjective from a scientific perspective? How can one design appropriate measures of consciousness? What are the best experimental paradigms one can deploy to study the differences between conscious and unconscious processing?

A third challenge is technological. The widespread availability of powerful brain imaging methods such as functional Magnetic Resonance Imaging or Magnetoencephalography now make it possible, for the first time, to observe the brain in action, that is, to record its activity as the subject is performing a cognitive task. But current methods have tended to emphasize localization over dynamics, and most suffer from limitations in their spatial or temporal resolution. Progress can be achieved by combining existing methods, by improving data analysis, and by developing novel empirical paradigms in which a better contrast can be made between processing with or without consciousness.

Finally, a fourth challenge is ethical. Given that the mind, and hence consciousness, emerges from the activity of the embodied brain as it interacts with the environment, how should one think of "free will"? Is our subjective experience of the world a pure epiphenomenon? Which organisms should be considered as "conscious" and how should one behave towards them? Is it acceptable to use drugs that modify or enhance one's cognitive functions? Neuroethics is a new area of research that is meant to embrace the ethical implications of advances in neuroscience and neuropsychiatry,

ranging from the ethical issues connected to technical interventions, such as the use of psychotropic drugs, or deep brain stimulation, to the implications for human self-understanding on topics such as the nature of ethical judgment or the character of personal responsibility. Research on consciousness, and especially on human consciousness, is thus extremely broad and has far reaching consequences on various aspects of human life, including ethics, education, and medicine.

Accordingly, characterising the neural correlates of consciousness is now considered as a priority for most of the leading laboratories in cognitive neuroscience. Efficient research in the domain requires (1) the collaboration of large teams that concentrate expertise in various domains of cognitive neuroscience, (2) the ability to integrate and compare research that uses different paradigms and approaches, and (3) access to the latest technology, such as multimodal functional neuroimaging.

To address these issues, this Action is thus focused on the analysis of the qualitative and quantitative differences between conscious and unconscious processing (1) in different cognitive functions, such as perception, attention, memory and learning, or language, (2) in different populations, ranging from normal spontaneous or induced conditions (sleep, hypnosis, illiterate subjects) to pathological conditions (neglect, minimally conscious, vegetative or comatose patients), and (3) through different, but highly complementary methods, including behavioural and clinical methods, structural and functional neuroimaging methods, and computational modelling methods. Such an integrated multi-disciplinary approach is both necessary, as well as most likely to foster significant advances in the domain.

In this light, the **main reasons for the proposed cooperation** under this COST Action is to coordinate ongoing research dedicated to consciousness in Europe so as to make it possible to achieve the close interdisciplinary interactions that are necessary to advance knowledge in the domain. In particular, the Action aims (1) to create, on a European scale, a strong network of active researchers in the domain, and (2) to foster interactions between junior and senior scientists so as to contribute to the emergence of a "consciousness community" in Europe. Both objectives make it possible to advance knowledge in the domain by stimulating interdisciplinary work, by sharing expertise in relevant methods, and by pooling scientific resources (in particular, large instruments such as fMRI and MEG scanners) across the teams.

No similar effort has been proposed yet anywhere in the world, with the significant exception of the ESF EUROCORES Action titled "Consciousness in a Natural and Cultural Context" (Coordinator: Pr. Dan Zahavi, Denmark). However, the CNCC program is more topical and is essentially targeted towards funding fundamental research in the Humanities. Nevertheless, participants to this COST Action are not only aware of, but also in close contact with many participants of the CNCC initiative, and it is aimed that such interactions increase through this Action. This COST Action would thus not only build on the synergies already in place through the CNCC program, but also expand them more specifically towards the neurosciences, and be focused on community-building.

The **expected results** are (1) dissemination and sharing of the expertise necessary to conduct research in this highly interdisciplinary domain, (2) emergence of novel interactions between participating teams, (3) advancement of basic research and clinical applications, (4) training of a new generation of researchers.

COST is the appropriate instrument to develop these objectives for (1) it specifically aims at supporting networking activities, and (2) the domain of interest is not one that is easily funded by the EU programs because of its interdisciplinary nature. The NEST program is relevant here, but its scope is too focused to be appropriate for the wide range of proposed activities necessary to stimulate a coherent scientific programme on consciousness. The European Science Foundation's "Consciousness in a Natural And Cultural Context" programme is also relevant, but is specifically

targeted toward funding fundamental research in the Humanities, and is thus not an appropriate instrument through which to develop the objectives of this Action.

C. OBJECTIVES AND BENEFITS

C.1. OBJECTIVES

Main Objective

The main objective of the Action is to increase the understanding of (1) the defining features, (2) the behavioural markers, (3) the computational principles, and (4) the neural mechanisms associated with conscious experience in humans and animals, and to identify the clinical, societal, and ethical implications of such findings.

Secondary Objectives

- To contribute to the understanding assessment, and treatment of disorders of consciousness, including (1) coma, minimally conscious state, and vegetative state conditions, and (2) certain psychiatric diseases (e.g., schizophrenia)
- To promote the emergence of a consensus on the definition of consciousness
- To improve both behavioural and brain imaging methods used to explore differences between conscious and unconscious information processing
- To improve the design of educational curricula based on current neuroscientific knowledge
- To translate neuroscientific knowledge about subjective experience to fields where it can provide wide human benefit, such as education or mental health care.

As stated above, the central objective of the Action is, essentially, to contribute to the understanding of mechanisms associated with consciousness. This is achieved by coordinating ongoing research dedicated to consciousness in Europe so as to make it possible to achieve the close interdisciplinary interactions that are necessary to advance knowledge in the domain. In particular, the Action aims (1) to create, on a European scale, a network of active researchers in the domain, and (2) to foster interactions between junior and senior scientists so as to contribute to the emergence of a "consciousness" community in Europe.

The means to achieve these objectives are essentially consisting in:

1. bi-annual Training Schools
2. bi-annual Scientific Dissemination Meetings
3. Annual Working Group Meetings focused on horizon-scanning and identifying innovative collaborations
4. Short-Term Scientific Missions implementing identified collaborations
5. The creation of electronic tools to facilitate interactions and knowledge building: A web site providing detailed information about ongoing research, conferences, training opportunities, as well as a basis for forum discussions (tentative); several mailing lists; an e-print archive.

The **target audience** of the Action is essentially the transdisciplinary scientific community from the many disciplines for which conscious experience and its neurobiological bases are central research topics (neuroscience, psychology, philosophy, psychiatry etc.), with a specific focus on junior scientists. Because the proposed Action also has societal relevance, it is also targeted towards the educational and mental health care communities.

Relevant **deliverables** resulting from the Action include (1) scholarly publications in leading journals, (2) prospective foresight documents from Working Group Meetings, Conferences, and Training School proceedings, (3) high-level training opportunities for junior scientists.

C.2. BENEFITS

The expected **scientific impact** of the Action is (1) to bring greater coherence, rigour and visibility to the field as a whole, (2) to foster new collaborative research, (3) to provide transdisciplinary training for young scientists. The expected benefits of the Action independently of its networking aspects are numerous. Understanding how the brain produces mental activity is clearly a fundamental scientific problem, but also one that has significant societal and ethical implications — from designing informed educational curricula to assessing residual mental activity in comatose patients, from understanding psychiatric disease to considering cognitive enhancement.

D. SCIENTIFIC PROGRAMME

The scientific programme is be focused on four topics central to the study of consciousness:

- Fundamental issues in the study of consciousness,
- Tools and technologies for the study of consciousness,
- Experimental paradigms for the study of consciousness, and
- Clinical, societal and ethical implications.

Collectively, these four topics (1) span the range of questions one can ask about consciousness, (2) require interdisciplinary collaboration between philosophers, psychologists, and neuroscientists, and (3) make it possible to advance the state of the art in the domain by combining the expertise of often disparate efforts that take place in different disciplines.

Each of these topics are addressed by an **interdisciplinary** Working Group. Note that these topics are closely linked to each other, in different ways. Contributing to the understanding of the mechanisms that underpin consciousness is an ambitious aim that minimally requires (1) defining operational criteria to distinguish between information processing with and without consciousness, (2) identifying the best tools and methods that make it possible to characterize differences between neural states associated with consciousness from those that are not, (3) developing sensitive behavioural paradigms in which these differences can be contrasted.

Each component of this experimental strategy can inform the others; for instance, the development of novel data analysis methods for fMRI images may lead to novel characterizations of the neural signature of conscious processing, which in turn might change the way in which this is defined operationally. Likewise, novel cognitive tasks, or novel demonstrations that a known task may in fact be performed without consciousness under novel conditions, might likewise lead one to reconsider the range of functions that consciousness serves in information processing. Finally, this research may also result in changes in the manner in which conscious awareness in patients is assessed. As a case in point, neural activity typically associated with consciousness in normal subjects was recently demonstrated through brain imaging in a vegetative state patient, leading investigators to reconsider the clinical criteria used to assess awareness in such patients.

In all these cases, close transdisciplinary interaction is critical for progress to be achieved. Philosophers have long provided useful characterizations of the differences between conscious and unconscious processing on analytical and logical grounds, have highlighted what the main

conceptual knots are in the domain, have pointed out what the limitations of current neuroscientific research may be, and have reflected upon the ethical and societal implications of our changing conceptions of agency and free will. Cognitive neuroscientists possess the expertise and the technology that is necessary to advance the understanding of the neural mechanisms associated with consciousness. Finally, cognitive and social psychologists have a long tradition of developing sophisticated, sensitive behavioural paradigms in which the differences between conscious and unconscious processing can be revealed.

In the following paragraphs, the scientific objectives are detailed for each of the four topics that form the backbone of this Action, as well as the research methods that are deployed to address each of them.

D.1. FUNDAMENTAL ISSUES IN THE STUDY OF CONSCIOUSNESS

WG1 focuses on several philosophical, theoretical, and epistemological issues that need to be addressed to advance the understanding of the mechanisms that subtend consciousness, addressing questions such as the following:

- Can consensus be reached on a definition of consciousness?
- What is agency?
- Does conscious experience have a function?
- Which computational principles differentiate information processing with and without consciousness?

Though there is much fundamental disagreement about what consciousness is in the ultimate analysis, below the surface, there *is* substantial agreement about various dimensions of consciousness. First, as described in Section B, a useful distinction can be made between the overall *level* of consciousness and the *content* of consciousness. The former is associated with arousal, with sleep/waking cycles and, in pathological cases, with coma. The *levels* of consciousness are subtended by numerous deep cerebral structures (brainstem, thalamus, hypothalamus, basal forebrain). The *content* of consciousness is what one is conscious of — "subjective experience".

Second, philosophers have proposed several additional distinctions: The concept of consciousness can refer exclusively to the "felt qualities" of experience ("phenomenal consciousness"); it can refer to the functional effects of knowledge held consciously ("access consciousness"), making such contents available for the global control of action; it can refer to awareness of oneself as an intentional agent ("self-consciousness"); and finally, it can refer to those processes that monitor and evaluate unfolding behaviour ("monitoring consciousness").

Third, neuroscientists have focused on identifying what has been dubbed "the neural correlates of consciousness", that is, the neural processes and representational systems that subtend conscious (vs. unconscious) information processing.

Finally, exploring consciousness empirically also poses genuine epistemological challenges: How does one investigate a phenomenon that is, prima facie, inaccessible to observers?

Significant debate continues in these different areas of investigation, despite the relative consensus that currently exists. For instance, there is significant discussion, in both the neuroscientific and philosophical literatures, about whether a distinction between phenomenal and access consciousness is sound, and about whether it can be approached empirically. Likewise, there is a significant ongoing debate about how attention — the cognitive processes through which an agent selectively focuses on some percepts — is associated with consciousness. The same holds for the role that language plays in the occurrence of conscious representations.

Similar discussions occur for the notion of " neural correlates of consciousness" — what is it precisely that neuroscientists are searching for? — a set of specific cerebral regions?, specific neural processes, such as amplification, recurrence, or synchrony? In other words: How should one characterize the form of a "neural correlate of consciousness?". The answer one gives to that question have strong implications for the design of appropriate empirical paradigms and for the use of specific technologies (e.g., fMRI) vs. others (e.g., MEG).

Conceptually, there is now a cornucopia of theories of consciousness, many of which make very different assumptions concerning the mechanisms involved in the emergence of conscious states and about how one should think of conscious experience. Some theories, for instance, hold that that conscious experience — the subjectively "felt" properties of conscious information processing episodes — are nothing more than a pure epiphenomenon and have no function per se. Others, on the other hand, claim that consciousness has specific functions that have been shaped by evolution. One way to address such issues consists of developing computational models that one can then compare the "behaviour" of with actual empirical data, thus engaging in what one could call a "search for the computational correlates of consciousness".

WG1 addresses these issues by engaging in transdisciplinary reflection focused on the objectives listed above. Experience demonstrates that such transdisciplinary interactions often prove critical in reaching consensus. In this domain more than in any other, such interactions are a necessity, in particular because the manner in which consciousness is characterized conceptually has strong implications on the sorts of methods and paradigms that one uses to explore its properties. Thus, a generally acceptable definition for "consciousness" would characterize a specific role played by conscious episodes, as compared to nonconscious episodes, and refer to both the actual neurobiological substrate that sustains this functioning, as well as to the phenomenal experience that this generates.

Finally, most researchers agree that there is a close connection between conscious experience and the sense of self. In psychiatric populations, the ability to function at a personal and social level is strongly dependent on presence or absence of hallmark conscious experiences, such as being an agent. A scientific definition of consciousness is going therefore to have profound impact on mental health theory and practice, and indeed on the concepts of personal identity, and free will.

D.2. TOOLS AND TECHNOLOGIES FOR THE STUDY OF CONSCIOUSNESS

WG2 focuses on the integration of novel methodologies for the study of consciousness, addressing the following questions:

- How can one "measure" consciousness?
- What are the most promising online methods (e.g., MEG, fMRI, EEG, TMS)?
- How may such methods be best combined?
- How can brain imaging data analysis be refined?

Human neuroimaging studies have provided strong evidence for a close link between mind and brain. Numerous studies have now demonstrated how sometimes extremely specific cerebral regions are closely associated with conscious experience, and have characterized the differences in neural activity that result from conscious vs. unconscious processing. For example, single-cell recording in humans has recently been used to demonstrate the existence of individual hippocampal neurons that act as very high-level detectors — in one case, a single neuron would only fire when the subject was presented with pictures of former American president Bill Clinton. Other studies have focused on the differences that exist between conscious and unconscious processing,

demonstrating for instance that words presented subliminally elicit activity that remains restricted to cerebral regions involved in language processing (e.g., the left fusiform gyrus) whereas the same material presented supraliminally elicit not only increased activity in the same areas, but also an entire network of cortical areas involving temporal, parietal, and frontal lobes. Still other studies have focused more specifically on the interactions between different cerebral regions, suggesting for instance that correlated or synchronous activity between widely separate areas are associated with conscious, but not with unconscious processing of a stimulus.

Striking results such as these demonstrate the usefulness of imaging methods such as functional Magnetic Resonance Imaging (fMRI) or Positron Emission Tomography (PET) in advancing the knowledge of the neural correlates of consciousness. Further advances can be expected with the availability of much more powerful (e.g., 11T) instruments that make it possible to improve the spatial resolution of the data, and with other methods such as diffusion MRI or optical imaging. Transcranial Magnetic Stimulation (TMS) technology even makes it possible to induce reversible virtual lesions in some areas of cortex, which in turn enables research methodologies in which the causal effects of such lesions can be ascertained. Finally, Electroencephalography (EEG), and more recently, Magnetoencephalography (MEG) make it possible, in virtue of their excellent temporal resolution, to appreciate the dynamics of information processing.

Nevertheless, significant research questions remain, in particular concerning (1) data analysis, (2) how to best design experimental protocols, and (3) how to best combine different methods. **WG2**'s work is dedicated to exploring these issues, again from an transdisciplinary perspective, and with the twin aims of (1) keeping non-neuroscientists participants abreast of the latest available methods, and (2) training young scientists to use the best methods.

A substantial part of the work of **WG2** is thus dedicated to refining existing methods. The research described above suggests that it should in principle be possible not just to measure the brain activity of an individual under different conditions, but to use that brain activity to predict their conscious (and unconscious) thoughts. In practice, the large majority of neuroimaging studies have accumulated data across very long experimental sessions in order to efficiently detect relatively small changes in activation in different brain regions. Such analyses provide very useful information about how brain activity relates to behaviour, but do not provide a practical methodology to decode human thoughts from brain activity.

Typical analysis techniques also strongly underestimate the amount of information encoded in single brain images. Conventional analytic approaches indeed consider each single data element (a voxel in the case of fMRI, or a sensor in the case of EEG/MEG) in isolation from the others. More recently, it has become apparent that multivariate analysis approaches may be able to reveal substantially more information. Such techniques seek to decode patterns of activity across multiple data elements and can efficiently combine weak information across multiple data elements. By training a classifier (a mathematical algorithm) to recognise patterns, they can be applied to independent test data in order to directly predict experimental conditions on the basis of brain data alone. Such predictions can be very accurate. For example, distributed patterns of activity in the ventral visual pathway can predict which category of object is currently being perceived or indeed infer patterns of behaviour from brain activity. These novel analytic approaches allow successful classification of patterns of brain activity as being evoked by different oriented stimuli at over 80% accuracy. Moreover, such successful prediction extends to unconsciously perceived stimuli and to predicting dynamic changes in consciousness during, for instance, binocular rivalry. Innovative decoding-based approaches have also shown that category-specific cortical activity precedes retrieval during memory search. Decoding-based approaches thus show excellent initial promise in dynamic decoding of conscious states.

D.3. EXPERIMENTAL PARADIGMS FOR THE STUDY OF CONSCIOUSNESS

WG3's main focus is dedicated to exploring the most promising behavioural paradigms to contrast information processing with and without consciousness, both in humans and in animal models. It addresses the following questions:

- What are the most promising behavioural methods to assess subjective states?
- How subjective and objective data may be best combined?
- What are the best empirical paradigms to study consciousness, as distinct from attention or memory?
- How unconscious cognition may be demonstrated?
- What are the implications of dissociation findings?

Exploring the mechanisms of consciousness poses a genuine methodological challenge: How can one *measure* consciousness, if it is but a subjective, private state that is a priori unobservable? A general distrust in the contents of subjective reports has dominated scientific approaches to human mental life: Comte argued that human beings' states of mind, their subjective experience or consciousness, could not fit into scientific methodology. It was thus considered impossible in principle that any methodology could collect reliable data based on subjective information. The problem is in its essence a problem of measurement: How can one claim to measure something that seems can only be registered subjectively and, at the same time, claim live up to the scientific criteria of validity, and reliability?

This issue is particularly salient when one compares the wide array of so-called "objective" methods that make it possible to characterize information processing (e.g., brain imaging and electrophysiological methods such as fMRI, PET, EEG/MEG; but also behavioural methods such as eye-tracking, pupil dilation measurements, skin conductance measurements, &c.) with the striking paucity of so-called "subjective" methods, that is, methods that specifically probe participant's subjective experience of a given situation. Here, one is limited to verbal reports (for humans) and to metacognitive methods such as confidence or perceptual judgments. These methods can nevertheless prove extremely useful when they are (1) correlated among themselves and with objective measures, (2) administered in different experimental conditions designed to reveal qualitative rather than quantitative differences.

In this light, a particularly productive way of operationalising the study of the neural bases of consciousness consists of contrasting cases where information processing takes place with or without conscious awareness. Research on the neural, behavioural and computational correlates of consciousness nevertheless raises complex methodological and conceptual issues: How can one measure and define consciousness operationally? How can one differentiate between conscious and unconscious processes? To address these issues, many authors have adopted methods that erroneously associate tasks and processes. In this framework, subjects' behaviour is exclusively attributed to conscious or unconscious influences depending on the experimental situation. However, many studies have since then demonstrated that no task can be considered to be "process pure": Consciousness cannot be "turned off" in normal participants, and hence it is likely that both conscious and unconscious processes systematically contribute together to performance in any cognitive task. It might thus be more plausible to assume that any task will always be sensitive to both conscious and unconscious influences. To differentiate between conscious and unconscious processes, one therefore needs methods that take this "contamination problem" into account.

A substantial part of the work of **WG3** is thus dedicated to contribute in developing sensitive methods to obtain uncontaminated measures of conscious and unconscious knowledge in behavioural studies and brain imaging studies. Psychologists are interacting with cognitive

neuroscientists in a reflexion about how sensitive behavioural methods can be successfully adapted to brain imaging protocols; on how to best tease apart conscious and unconscious processing within a single cognitive task; on how to obtain neural correlates of subjective judgments. This makes it possible to go far beyond simple associations or dissociations, and to identify more precisely the cerebral regions involved in the conscious or unconscious component of performance in brain imaging studies.

To conclude, **WG3**'s work is focused on developing measurements of human subjective states using a number of converging methods, ranging from subjective reports to behavioural measures. In every case, the main goal is to develop methods that make it possible to study subjective conscious states in combination with data obtained through objective methods.

D.4. CLINICAL, SOCIETAL, AND ETHICAL IMPLICATIONS

The study of consciousness raises substantial clinical, societal, and ethical implications. **WG4**'s work is dedicated to the study of altered states of consciousness, to consciousness in pathological cases (such as vegetative state) and in special populations (e.g., blind subjects or synaesthetes), to the design of new assessment scales, and to a consideration of the ethical and societal implications of the findings. It addresses the following issues:

- What makes a subjective experience "altered" or even "abnormal" and what does it mean for the experiencing subject?
- What is the relation between consciousness, self-consciousness and social consciousness?
- What are the relations between consciousness and personal identity?
- What is the relation between the concept of conscious intention and the social notion of moral responsibility for action?
- What are the ethical issues and social implications for artificial manipulation of consciousness?

Consciousness research is especially interesting with respect to so-called altered states of consciousness, which provide another important window to the contents of subjectively experienced conscious states. These comprise disturbances of the level of consciousness (e.g. anesthesia, vegetative state, coma) or of the content of consciousness (e.g. blindness, synaesthesia, hallucinatory or illusory experiences). Certain pathological conditions where modifications of the contents of consciousness are conditional upon a decrease in the level of consciousness. During somnolence, the content of consciousness may suddenly be enriched by internally generated material whereas awareness of the environment decreases. (i.e. hypnagogic imagery). The description of brain activity during somnolence with and without such hypnagogic imagery is thus a window on the interaction between the level and the content of consciousness. Another similar condition concerns subjects in the hypnotic state. The functional neuroanatomy of hypnosis can be characterized. In this state, the subject is seemingly somnolent: there is a muscular relaxation, heart and respiratory rates decrease and electroencephalographic activities slow down. However, after regaining full alertness, the subject reports a phenomenological experience of vivid multimodal hallucinations. Hypnotic state is thus another condition during which arousal is decreased while awareness depends on internally generated representations. Likewise, narcoleptic patients are known to have hallucinations on falling asleep and at awakening (hypna-gogic and –pompic hallucinations, respectively).

Lastly, patients suffering from an acute cerebral insult (e.g., traumatic, hypoxic, toxic, infectious) may fall into pathological states characterized by a dramatic reduction of consciousness and a variable level of arousal. Coma, vegetative state, minimally conscious state and locked-in syndrome all exhibit specific patterns of outstanding interest for the investigation of the relationships between arousal, awareness and behaviour. A better understanding of the brain function of such patients would make early and more accurate prognosis possible, as well as help improve rehabilitation programs.

In addition, the systematic study of altered states of consciousness are potentially of high interest for the study of clinically relevant syndromes comprising neuropsychological syndromes (e.g. brain lesions) or psychiatric illnesses (e.g. schizophrenia). A lack of social cognition referring to the ability to adequately understand interpersonal communication is a prominent symptom that appears early in schizophrenia and autism. This is related to social retreat, which is relevant for the functional outcome of both diseases. However, the underlying neurobiological correlates remain unclear.

In this light, a research topic of growing interest is the relation between self-consciousness as the awareness of one's own cognitive acts and the ability to ascribe certain mental states, such as perceptions, judgments, thoughts, feelings to others, the latter of which could be referred to as "social consciousness". Recent advances in cognitive neuroscience have started to tackle these issues, which are of great interest for the understanding of certain psychopathological states including hallucinations, ego-disturbances, and delusions, respectively. With respect to self-consciousness and social consciousness, integrating these different cognitive capacities of self-other-distinction and taking the perspective of others, consciousness can be considered to be constitutive for the experience of personal identity. In the domain of neuroethics, this leads to debates concerning the status of moral responsibility for one's own actions in relation to their neurobiological underpinnings ("free will debate") and, of course, to questions related to systematic manipulations of either the level or the contents of consciousness employing drugs, either in therapeutic (e.g. brain stimulation devices, neuropsychopharmacology, psychotherapy) or non-therapeutic circumstances (e.g. "neuroenhancement"). These debates of course considerably contribute to anthropological and sociological debates on the biological and psychological basis of humanity.

WG4 explores these different issues in light of the work of other WGs, and again in a resolutely interdisciplinary manner.

E. ORGANISATION

E.1. WORKING GROUPS

This Action is coordinated by a Management Committee and is implemented by four Working Groups, as outlined above:

- **WG1**, dedicated to "Fundamental issues of consciousness", with the aims and content outlined in section D.1.
- **WG2**, dedicated to "Tools and technologies for the study of consciousness", with the aims and content outlined in section D.2.
- **WG3**, dedicated to "Experimental paradigms for the study of consciousness", with the aims and content outlined in section D.3.
- **WG4**, dedicated to "Clinical, societal, and ethical implications", with the aims and content outlined in section D.4.

Each Working Group is directed by two coordinators, and involves existing research teams from the different participating countries and from different disciplines. Several teams contribute to each Working Group, and may be involved in more than one WG. Each Working Group is responsible for the organization of an annual Meeting. One such meeting is organized each year, for a total of four meetings. In addition, a Training School (14 days) are organized on Years 1 and 3. This is specifically targeted towards promising young scientists (Ph.D. students and post-doctoral researchers) and involve representatives from each of the four Working Groups as well as leading invited speakers from Europe and from the USA. The Training Schools are organized in liaison with the Association for the Scientific Study of Consciousness and be based on the format adopted for the highly successful 2005 event organized by the initiator of the Action and other participants. Finally, two Conferences are going to be organized, one each on Years 2 and 4. Section F describes the timing of these different events.

In the spirit of COST, the network is open to any interested party over its duration.

E.2. ORGANISATIONAL STRUCTURE

The structure of this COST Action follows the recommendations contained in the Rules of Procedure document. It includes the following actors: A **Chair** and a **Vice-Chair**, both elected, who preside over the **Management Committee**, which in turns oversees the work of the four **Working Groups**, each of which is managed by a **coordinator** and **co-coordinator**. Together with the chair and vice-chair, WG coordinators and co-coordinators form a **core group**, which include two additional members: One participant assigned the responsibility of managing the Short-Term Scientific Exchanges, and another assigned the responsibility of **overseeing the dissemination plans** (including the website). The organisational structure is depicted in Figure 1.

Chair and Vice-Chair

The Chair and Vice-Chair of this Action is elected by the Management Committee (MC) during its first meeting. Their main responsibility, together with the Core Group and with the Management Committee, is to coordinate and monitor the Action.

Core Group

The Core Group consists of the chair, the vice-chair, coordinators and co-coordinators of the four Working Groups, and two additional members (STMS manager and Dissemination Manager), for a total of 10 members. The Core Group manages the Action, coordinates, monitors and evaluates it in collaboration with the Management Committee.

Management Committee

The Management Committee (MC), as per the Rules of Procedure, is responsible both for the actual management of the Action as well as for its evaluation. The MC continuously monitors progress of the Action. An email list is to be set up to make this possible. The MC is also responsible for liaison with other COST Actions and with other programs, in particular with the ESF Program "Consciousness in a Natural and Cultural Context", and with European Commission Programs in the domain (e.g., some NEST program under FP6, as well as forthcoming new initiatives under FP7). It meets at least once a year, twice if practical (as intended).

Working Groups

Four Working Groups (WGs) are formed for this Action, as outlined above (Section E.1). Each Working Group is chaired by a coordinator and a co-coordinator, elected by the MC during its first meeting. Coordinator and co-coordinators have the responsibility of overseeing the organization of the WG meetings for their WG. Each WG designate local organizers for each meeting. Crucially for

this Action, the composition of the Working Groups is **interdisciplinary.** Each thus include, whenever possible, philosophers, psychologists, and neuroscientists.

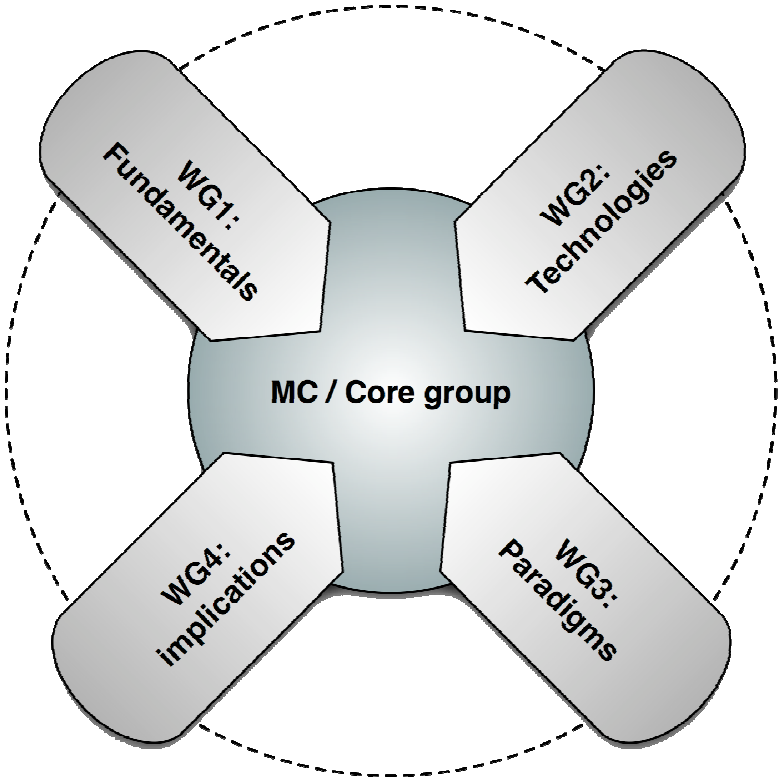

Figure 1: Organisational Structure of the Action

Finally, this Action places particular emphasis on **gender issues** by actively seeking to achieve gender balance at all organisational levels. The Action also emphasizes the involvement of young scientists, in particular by organizing activities that are specifically directed towards this group (e.g., Training Schools and Short-Term Scientific Missions).

F. TIMETABLE

The duration of the Action is four years. Figure 2 depicts the manner in which Action activities are distributed over the duration of the Action.

Management Committee Meetings

A total of eight Management Committee meetings is distributed over the four years of the Action. On each year, one such meeting is organized independently of other activities whereas the second takes place immediately before another COST activity.

Working Group Meetings

A total of four meetings is distributed for each Working Group: one per year. On Years 1 and 3, four Working Group Meetings are organized independently of each other, at times and locations chosen by the Working Group Coordinators after consultation with the Management Committee. This flexible organisation makes it possible to organize such meetings in conjunction with other events. On years 2 and 4, the four Working Groups meet together immediately prior to an open-access Conference.

Bi-Annual Training Schools

Two Training Schools are going to be organized; the first on Year 1, the second on Year 3. Both are conceived to provide an opportunity for interested senior participants to interact with junior scientists; both are conceived to help foster the emergence of a strong community of young scientists.

Bi-Annual Conferences

Two open-access conferences are going to be organized, the first on Year 2, the second on Year 4. These meetings occur immediately after a joint meeting of the Working Groups. International experts whose research is relevant to the Action are invited to address participants, who are also be able to present their own results. These conferences are open to the scientific community.

Short-Term Scientific Missions

Throughout the Action, Short-Term Scientific Missions (STSMs) are set up whenever possible and relevant, both within and between Working Groups. This aspect of the Action is viewed as critical for its success. STSMs are proposed to the Management Committee by participants on an ad-hoc basis.

Kick-Off Meeting and Final Meeting

The first Management Committee Meeting constitute the Kick-Off Meeting and is therefore particularly important insofar as management decisions are concerned. Likewise, the final set of events, which include a Management Committee Meeting, a joint Working Groups Meetings, and a Conference, provide the opportunity to evaluate the Action and to draft the Final Report.

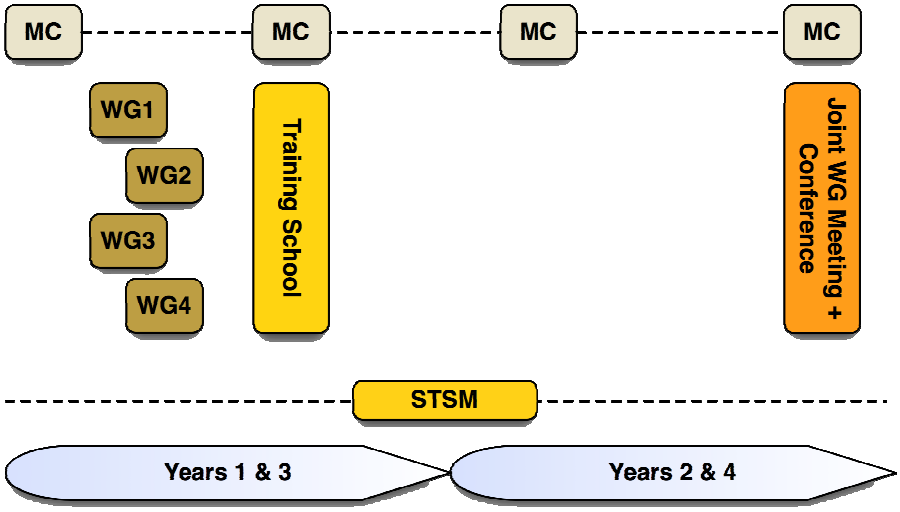

Figure 2: Scheme of activities. Note that since it is mentioned that the same activities take place on years 1 and 3 on the one hand, and on years 2 and 4 on the other, the Figure represents activities taking place on years 1/3 and 2/4 together.

G. ECONOMIC DIMENSION

The following 12 COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: Belgium, Denmark, France, Estonia, Finland, Germany, Hungary, Italy, the Netherlands, Poland, Spain, and the United Kingdom.

On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated, in 2006 prices, at approximately 46 Million € for the total duration of the Action.

The estimate is valid under the assumption that all the countries mentioned above, but no other countries, participate in the Action. Any departure from this changes the total cost accordingly.

H. DISSEMINATION PLAN

Several initiatives are to be launched so as to disseminate the collective expertise of the network. These initiatives are targeted towards different audiences: Participants to the proposed COST Action (**CA**) itself, junior scientists (**JS**) involved in the proposed COST Action, the Scientific Community (**SC**), the General Public (**GP**), other research frameworks (**OR**). The target audience(s) of each initiative is indicated next to its heading in the following list.

H.1. ORGANISATION OF THEMATIC MEETINGS (CA, SC)

As outlined in Sections E and F, each Working Group holds an annual meeting dedicated, each dedicated to a specific aspect of its research programme. These meetings last typically one or two days, adopt the format of informal workshops, and be organized in different regions of Europe by local organizers selected by the Working Groups themselves, in collaboration with the Management Committee. The audience is typically limited to the scientists associated with the Working Group, but involving other participants is actively considered. Additionally, two larger meetings are to be organised on Years 2 and 4. These meetings are conceived to typically last for two to three days, and involve most participants to this Action as well as other interested researchers (i.e., the conferences are open to the scientific community at large), and features invited speakers whose work is particularly relevant to the objectives of this Action. The possibility of holding some of the thematic meetings jointly with other networks (e.g., the ESF's CNCC program) or institutions (e.g., the Association for the Scientific Study of Consciousness) is actively considered.

H.2. ORGANISATION OF TRAINING SCHOOLS (JS)

Two Training Schools are to be organised in the context of this Action, the first during Year 1, the second during Year 3. Holding a Training School during Year 1 is important so as to set up a community of Junior Scientists who are going to be actively involved in the Action and engage in Short-Term Scientific Missions thereafter. The second Training School is directed towards another set of Junior Scientists. The Training Schools are also an opportunity for the Management Committee to meet, and for WG participants to present and share their results. Particular emphasis is placed on involving junior members of the WGs in these activities.

H.3. NETWORKED TRAINING OF JUNIOR SCIENTISTS (CA, JS)

It is considered to exchange junior scientists across the different Working Groups to implement specific research projects resulting from WG Meetings and Training School interactions. Junior Scientists often play a central role in making such interactions possible, and hence the implementation of Short-Term Scientific Missions is viewed as critically important for the success of the Action.

H.4. MAINTENANCE OF A WEB SITE / EPRINT DATABASE / MAILING LIST (CA, JS, SC)

An essential component of the dissemination plan consists of the creation of a **web site** containing a continuously updated database of European laboratories and teams in the domain of consciousness research. This open-access, searchable database contains the following information for each team:

- Name and location
- Members
- Main lines of research and relevant publications
- Links to relevant websites
- Facilities
- Openings for training opportunities

This web site is the central repository of information concerning the Action. In addition to this formal list of member laboratories and teams, this web site also contains information about ongoing events of interest to the network, as well as a password-protected section dedicated to internal communication (interim reports &c.). It is also considered to set up web-based discussion forums.

In collaboration with the Association for the Scientific Study of Consciousness, an e-print archive is to be set up so as to make available preprints of relevant articles in the broad domain of consciousness research available to the scientific community.

Finally, in addition to a mailing list dedicated for Management Committee discussions, a general mailing list is set up for the entire network so as to keep participants abreast of ongoing events, of updates to the web site (implemented through RSS), and of other information relevant to the entire network.

H.5. PUBLICATIONS IN SCIENTIFIC JOURNALS (SC, JP)

It is aimed that this Action increases publication output in the domain as a result of increased interactions between the participating laboratories and teams. In particular, the Action should facilitate (1) interdisciplinary collaborative work between laboratories and teams with different research methodologies through the interactions made possible by the Working Group Meetings, and (2) the participation of junior scientists as active collaborators in ongoing research projects through Short-Term Scientific Exchanges. The latter point is particularly important, as collaborative work is reinforced by — and indeed often dependent on — the exchange of young scientists between participating teams.

H.6. INTERNAL REPORTS (CA)

Internal reports, as required by COST, are produced by the Management Committee for Action evaluation and monitoring purposes. Additionally, the Management Committee asks annual reports from the Working Groups so as to document their progress.

H.7. INFORMATION FOR THE MEDIA (GP, OR)

Consciousness is a domain that continues to elicit widespread media attention. The Action capitalizes on this ongoing interest of the public by further developing links with the media and

with other public institutions involved in scientific communication to the general public. A good example of such an institution is the King Baudouin Foundation, based in Brussels, which recently launched an Action titled “My neurons and me” in collaboration with similar Foundations elsewhere in Europe. Another relevant example is the “Meeting of Minds” initiative organized in 2005 by the European Commission. The proposer of this Action participated in both initiatives, as did other members of the current network. In other cases, individual links already exist with widely read science writers, which provide an excellent opportunity for the results of the Action to be made available to a larger public when appropriate and relevant. Every effort is going to be made to communicate with such institutions whenever appropriate.