EUR 22424

A NEST PATHFINDER INITIATIVE

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Contact: Pilar Lopez
E-mail: pilar.lopez@ec.europa.eu

European Commission
Office: MADO 05/09
B-1210 Brussels
Tel. (32 -2) 29 57 581

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MEASURING THE IMPOSSIBLE

A NEST PATHFINDER INITIATIVE

Directorate-General for Research
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MEASUREMENT IS AT THE HEART OF SCIENTIFIC WORK

The progress of scientific discovery goes hand-in-hand with the developments of technologies and instrumentation for measurement and analysis. The practical challenge facing scientists nowadays is often to 'measure the impossible'.

This initiative is about supporting interdisciplinary research and novel investigative methods that could present prospects for advancing the measurement of multidimensional phenomena which are mediated by human interpretation and/or perception – to be able to advance the frontiers of the science of measurement and to respond to future requirements for measuring properties such as comfort, naturalness, perceived quality, feelings, body language and consciousness.

The emphasis is placed on the capability to measure the impossible, with the difficulty lying in the multifaceted character and multidisciplinarity of the research needs of physical, chemical and biological metrology. The Measuring the Impossible initiative aims to promote the creation of new interdisciplinary partnerships between researchers stemming from a wide range of research fields because the goals can only be achieved by pooling the creative potential of these researchers with their different scientific backgrounds.

From basic neurosciences to applied physics, the impact is expected to be important. For example, the future understanding of multidimensional perception of time, so poorly understood, will impact not only on distributed sensor networks but also in robotics, particularly in the development of humanoids simulating human cognitive processes.

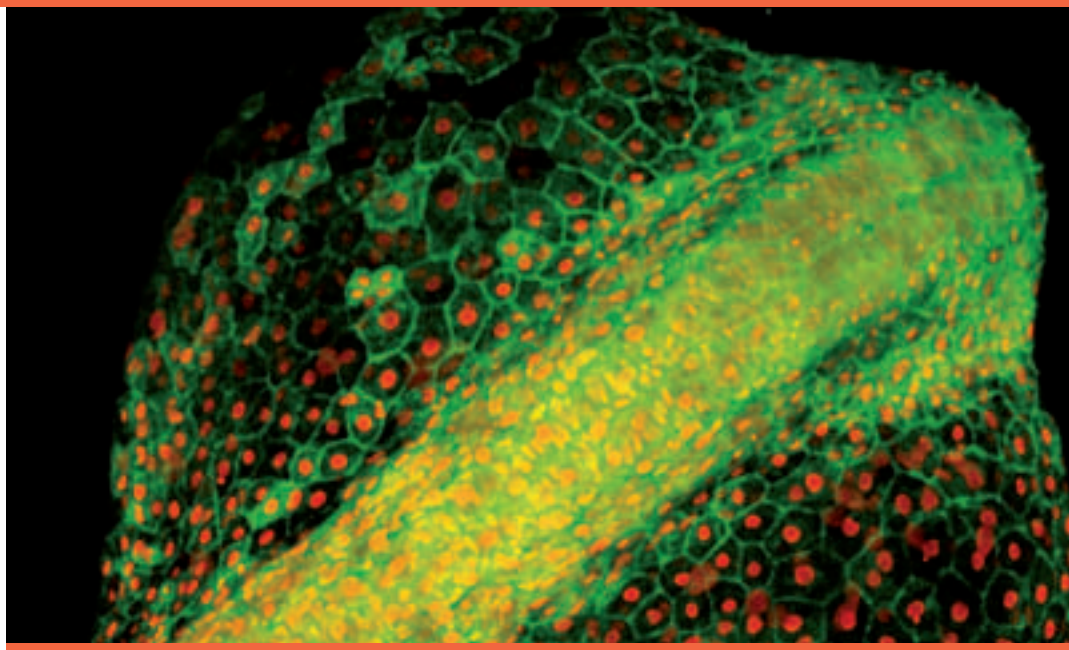
Successful cooperation will result in innovative theories and methods for measuring complex human perception and interpretation. This will boost better sensor technology, better expert diagnostic systems and, last but not the least, better products. The perception and interpretation of these products by the consumer is key to securing sales. Product appreciation and interpretation should enable a more effective adaptation of products to specific consumer groups worldwide (if you cannot measure it, you cannot improve it). This measurement based on novel kinds of technical cognitive systems will help understand human behaviour without neglecting the ethical and gender impacts.

PROJECTS

NEST
Pathfinder

TOWARDS PERSONALISED HEALTH

BIOEMERGENCES



Susceptibility to genetic diseases and responses to medical treatment are highly individual, depending in part on the genes and in part on the environment of the genes. BIOEMERGENCES is establishing strategies and tools to measure variations between unaffected healthy individuals, between those with the same genetic defect and between those receiving specific therapies. The result will facilitate the development of fully personalised treatments. It will also enable high throughput preclinical tests of anticancer drugs using an artificially assisted, high resolution microscope system.

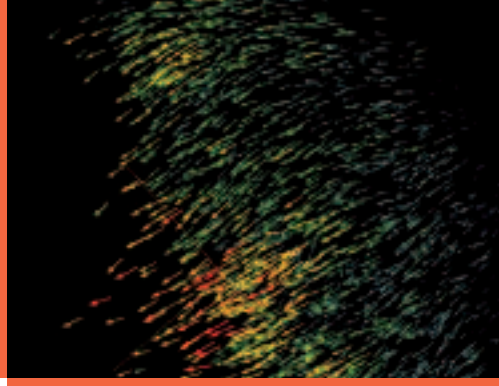
How to identify the similarities and differences between individuals is a fundamental question in biology. Advances in nanomedicine are driving developments in personalised medical therapy. However, the possibility of personalised medicine requires understanding the basis for individual variation; being able to record individual responses to defects as well as to treatments; and measuring the qualitative and quantitative differences between individuals or groups to identify the best approaches to therapy.

Susceptibility to disease and response to treatments are influenced both by individual genes and by their interaction with environments. No two living organisms react in exactly the same way to genetic defects or to medical treatments. The BIOEMERGENCES project, therefore, focuses on determining how to measure the individual differences in living beings at all levels.

Comparisons will be made on a vertebrate organism, the zebra fish (*Danio rerio*), using different fish populations (wild-type, mutant, treated and untreated). Zebra fish were chosen as they have a number of interesting characteristics, including transparent tissues, that allow high resolution *in vivo* imaging of cellular behaviour. These fish have already been validated as powerful models for investigations relating to humans, with growing interest from the pharmaceutical industry for their use in preclinical drug screening.

BIOEMERGENCES will record and reconstruct cellular behaviour at different scales.
The project's strategies will be applied to the characterisation of *in vivo* cell responses to a new class of anticancer drugs (Dbait) and to the establishment of individual susceptibility to holoprosencephaly, a condition which results in dramatic abnormalities of the brain and face in a genetically deficient fish population.
This work will serve as a test bed for a European platform to considerably enhance performance in the screening of new therapies and drug combinations.

" 'Artificial assistance' to help analyse susceptibility to genetic diseases and individual responses to treatments."



Individuality is controversial

Determining how much and in what way one individual differs from another is subject to considerable controversy as the answer depends on human perception, interpretation, culture and context. A scientific definition of the difference between two individuals from the same species is important, not least because of its social implications.

The BIOEMERGENCES project will attempt to measure and model individual differences using a non-mammalian vertebrate model that would allow high throughput *in vivo* investigations for future pharmaceutical screening. The complexity of this work involves a highly interdisciplinary and mainly academic team with world class expertise in developmental biology, toxicology, computational vision, applied mathematics, cognitive science, computer science and optical physics.

BIOEMERGENCES will use the latest developments in optical physics for four-dimensional (4D) microscopy imaging. The project's consortium has already developed a common language to express very different perspectives when dealing with biological objectives at the nano level, cellular level or at the level of the whole organism. The project will apply mathematical and computational tools to reconstruct and compare individual traits.

Advances expected from BIOEMERGENCES include the design of suitable markers to enable measurement of biological parameters as well as development of a standardised format to allow mathematical manipulation. Work will include validation of the selective plane illumination microscope (SPIM) prototype, built at the European Molecular Laboratory, for imaging the whole zebra fish embryo with resolution at cell level for extended periods.

Progress will also be made in the conception of a database able to handle the vast amount of data (particularly 4D measurements) to be stored and processed, in systems modelling for the multiscale analysis and integration of differences measured at all levels.

Automated measurement

A key goal of BIOEMERGENCES is the specification of a European platform to provide biologists with systematic and automated comparison of cell behaviour in chosen organisms. It will provide sophisticated 'artificial assistance' to help analyse susceptibility to genetic diseases and individual responses to treatments. The result will be fast access to phenotypic traits, which is almost impossible with currently available tools.

Individual treatment response will be investigated by testing reaction to recently developed Dbait molecules, designed to act as intelligent anticancer drugs targeting tumours which are resistant to conventional treatments. Results of this part of the study should make a significant contribution to the evaluation of the therapeutic potential of Dbait molecules and to improving their design.

BIOEMERGENCES will play an important role in the development of personalised medical therapies that require an integrated understanding of biological processes at all levels. The project will aid the development of high throughput preclinical screening for anticancer drug treatments, particularly bi- and tri-therapy combinations, on non-mammalian organisms.

AT A GLANCE

Official Title
'In What' and 'How Much' are Individuals Similar and Different? Towards the Measurement of the Individual Susceptibility to Diseases or Response to Treatments

Coordinator
Centre National de la Recherche Scientifique (France)

Partners
- Institut Curie (France)
- Alma Mater Studiorum - Universita di Bologna (Italy)
- Slovenska Technicka Univerzita v Bratislave (Slovakia)
- Universidad de Malaga (Spain)
- DENALI SA (Belgium)
- European Molecular Biology Laboratory (Germany)

Further Information
Dr Paul Bourgine
Centre National de la Recherche Scientifique
CREA – Ecole Polytechnique (UMR7656)
1 Rue Descartes
75005 Paris
France
email: bourgine@shs.polytechnique.fr
fax: +33 1 69 82 34 47

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€ 2 539 450

EU funding
€ 1.7M

Project reference
Contract No 028892 (NEST)

NEST
Pathfinder

STRIKING A TUNE: MUSIC AND THE BRAIN

BRAINTUNING

Music plays a key role in our lives, offering emotional richness and inspiration that is enjoyed within all cultures. It activates our brain in a special way, different from speech or other sounds. This difference lies in the emotions music induces. BRAINTUNING is applying innovative neuroscience to investigate how music and music-induced emotions are processed in the brain. The results of the project will be used to improve our quality of life, enhance learning and provide effective language therapy.

Despite having no obvious survival value, appreciation of music – from classical and folk to pop and dance (and the gamut in between) – is regarded as a fundamental phenomenon of life and has a profound effect on our emotional wellbeing. While we enjoy listening to and performing music, people in almost every culture also use it to communicate. Music is widely represented culturally and commercially in our modern electronic age in concrete and virtual forms. Moreover, music plays an important role in areas such as overcoming language impairment and other areas of therapy.

A newborn infant is already able to enjoy music and appreciate the emotions evoked by it. Subsequent development of musical skills prior to school is a mixture of innate capabilities, mimicry and individual temperament. Furthermore, even people without formal training show sophisticated abilities in acquiring knowledge about musical syntax, and in understanding and enjoying music.

All this supports the idea that musicality is a natural ability of the human brain – yet the biological basis of musical appreciation is unclear. A close connection between music and speech is corroborated by the overlapping and shared neural resources for music and language processing in both adults and children.

Understanding the impact of music scientifically – in terms of its effect on the brain – is highly complex. The BRAINTUNING project is investigating both the musically sophisticated and the musically untrained to gain a greater understanding of emotions in relation to music.

Overcoming scientific limitations

BRAINTUNING will examine the multifaceted relationship between the structure of music and how it affects our emotions. It will focus on the dynamic aspects of music-induced emotions and determine how manipulation of different acoustic cues in different musical

"Once we can understand the subjective benefits of music better, this information can be used to improve our quality of life."

genres can influence emotional perception and communication.

This aspect of human behaviour was previously considered to be beyond scientific investigation. While human auditory cognition in language learning has been analysed extensively, music emotions and their effect on the brain are a novel area of research. Such work has only been made possible by recent advances in theoretical and methodological domains in cognitive neuroscience.

The consortium proposes to reveal the multidimensional stages of the development and maturation of the brain functions that enable us to perceive, perform and enjoy music. It will attempt to determine how music appreciation and emotions emerge in the human brain and how we can account for individual differences in emotional sensitivity. It will examine how to implement its findings on emotional processing in music-based therapy.

The scope of the project requires the skills of a consortium capable of building a bridge between neuroscience and music studies – the two main poles in investigating the human brain and its auditory functions. These disciplines are broadly complemented by psychologists, technical experts and philosophers. The project will also collaborate with medical doctors.

Experts will construct well-controlled sound environments and investigate the behaviour of both healthy and disabled people when listening to and performing music. BRAINTUNING will also draw on expertise in developing and applying computer simulations of music perception.

Wide impact expected

In addition to boosting fundamental science, increasing the understanding of brain functions related to processing of musical information will help scientists unravel similar brain functions in speech processing. This could play an important part in the treatment of language impairment in children and adults. Better comprehension of the emotional aspects of music will also aid understanding of mood regulation and support therapists using music as a gateway to the mind.

Once we can understand the subjective benefits of music better, this information can be used to improve our quality of life in the broadest sense. European industry involved in audio-engineering, media, as well as computer and software applications will also be able to develop products and services based on scientifically validated knowledge of music-induced emotions.

Overall, investigation of the basic mechanisms of musical appreciation and its neurocognitive processes in the BRAINTUNING project will contribute substantially to a better understanding of human emotions. It will assist in the development of advanced and sophisticated models of our emotional lives that could be used for further research to improve our wellbeing as well as enable the creation of new services and products.

AT A GLANCE

Official Title
Tuning the Brain for Music

Coordinator
University of Helsinki (Finland)

Partners
- University of Jyväskylä (Finland)
- Kungliga Tekniska Högskolan (Sweden)
- Vita-Salute San Raffaele University (Italy)
- University of Leipzig (Germany)
- University of Montreal (Canada)

Further Information
Dr Mari Tervaniemi
University of Helsinki
Department of Psychology,
Cognitive Brain Research Unit
Siltavuorenpenger 20D
14 Helsinki
email: mari.tervaniemi@helsinki.fi
fax: +358 919 129 450

Project cost
€ 2 580 000

EU funding
€ 2.5M

Project reference
Contract No 028570 (NEST)

Comfortable EEG recording of the music-sound processing in a 4-year-old girl.

NEST
Pathfinder

EXPLORING SOUND: THE NEGLECTED DESIGN DIMENSION

CLOSED

The solid click of a well-made switch enhances our enjoyment of using everyday appliances, while a whining vacuum cleaner can cause great irritation. But sounds also trigger more subtle perceptions and emotions regarding functionality and overall aesthetics, which have so far eluded measurement. The CLOSED project aims to develop innovative tools that will fill this gap in the product design loop, enabling modern technology to be deployed in tailoring sonic signatures for optimal consumer satisfaction.

Superior design is one of Europe's great strengths in the global market of consumer goods, contributing enormously to the profitability of EU enterprises and the quality of life for citizens. The region pioneered the discipline of industrial design, which has evolved over the past century to satisfy the needs and desires of customers with products that are functionally and aesthetically appealing, as well as affordable.

Until recently, the aesthetics of objects were seen primarily in purely visual terms, and their ergonomic forms were based on static adaptation to the shape and postures of the human body. Today, as computing and communication elements are increasingly embedded into the artefacts that surround us, it has become more important to determine how people interact dynamically with such objects. This has led to the emergence of 'interaction design', a field in which Europe continues to lead and innovate.

Even now, however, while tactile information is gradually entering the design consciousness, functional sound (other than in a few special cases such as vehicles and office equipment) continues to be a largely unexplored territory. With consumers showing a growing preference for products that sound well-made and functional, and which contribute to a pleasant soundscape, this represents a serious knowledge gap. The need to close that gap will become increasingly urgent as the hunger for convenience goods adds more and more devices to the sonic environment.

Emotional connotations of sound

Over the past two decades, psychophysical methods have made it possible to characterise basic acoustic preferences and aversions as values on comparative scales. But these fail to account for emotional and cognitive responses related to the functional and aesthetic aspects of a product. Most classes of everyday sound are believed to have emotional connotations that influence the way listeners perceive them. It takes a fraction of a second for a person to respond emotionally to an object, and to accept what is deemed positive and avoid the negative.

"CLOSED could form the foundation for a whole new user-centred acoustic design methodology."

A systematic approach to evaluating such phenomena would provide a means to predict human responses to new everyday products. This would enable designers armed with the latest technology to tailor sounds with the express purpose of increasing consumer satisfaction. Already, for example, Apple's iPod music player emits a 'satisfying' artificially-created mechanical sound when the scroll wheel is rotated. The objective of CLOSED is to develop the tools necessary for the realisation of this progress.

Loop process

Like the design process itself, CLOSED functions as an iterative loop, in which four European institutes are embarking on cooperative fundamental research under the coordination of IRCAM, France.

Italy's Univerona will begin by developing a series of interchangeable building blocks in the form of sound synthesis algorithms for incorporation into physically-based interactive sonic models and sounding objects. Initially based on a repository available from earlier research, the algorithms will be refined and augmented as the initiative progresses. A main goal will be to reproduce naturalistic acoustic settings.

Special prototype appliances will then be constructed at HGKZ, Switzerland, to reflect physical, interactive and sonic features relevant to selected real-life cases and scenarios. These artefacts will serve as the test-beds for trials with human volunteer subjects. They will be equipped with microelectronic circuitry capable of transmitting computer-generated sounds sent wirelessly from a PC, as well as detectors (such as cameras, position sensors and accelerometers) for real-time monitoring of users' reactions.

Psychological experimentation by IRCAM will determine the qualitative aspects of sounds at the perceptual, cognitive and emotional level. A novel goal for the methods developed here will be to investigate the relationship between identity patterns, based on functional analysis, and the corresponding emotional dimensions, in terms such as arousal, pleasure and dominance.

Germany's NIPG will define the most suitable measuring strategy, employing an array of techniques including post-Fourier analysis, computational auditory-scene analysis and unsupervised clustering to achieve an adequate representation of the sound patterns synthesised for the building blocks. Subsequently, classification and prediction systems will be developed for automatic capture and measurement of the emotional and functional-aesthetic attributes identified by the psychological experiments. The closeness of match between predictions and experimental results will provide proof of quality for the methods.

Continuous feedback around this loop throughout the three-year project (visit www.closed.ircam.fr) will permit progressive reshaping of the sonic 'appearance' of the prototypes in response to the partners' discoveries. In the long-term, CLOSED could form the foundation for a whole new user-centred acoustic design methodology, connecting beauty and function via a state-of-the-art combination of phenomenology, system modelling, mathematics and psychology.

AT A GLANCE

Official Title
Closing the Loop of Sound Evaluation and Design

Coordinator
Institut de Recherche et de Coordination Acoustique/Musique (France)

Partners
- Università di Verona – Vision, Image Processing, and Sound Laboratory (Italy)
- Hochschule für Gestaltung und Kunst Zürich (Switzerland)
- Berlin University of Technology – Neural Information Processing Group (Germany)

Further Information
Dr Patrick Susini
Institut de Recherche et de Coordination Acoustique/Musique
IRCAM/Scientific Department/Sound Design Team
1 Place Igor Stravinsky
75004 Paris
France
email: susini@ircam.fr
fax: +331 44 78 15 40

Project cost
€ 1 791 712

EU funding
€ 1 417 402

Project reference
Contract No 029285 (NEST)

Function, aesthetic, and emotion guide the interaction with an object.

The sounds of everyday products are indeed able to elicit emotional responses. Designing sound often leads to the design of an emotional response that should be elicited from the listener. One of the aims of the project is to imagine the tools necessary to make such designs successful.

NEST
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SCIENCE REVEALING THE MYSTERIES OF BODY LANGUAGE

COBOL

Without words being exchanged, a person's body language can attract or repel, signal welcome or create fear. It is a powerful mode of communication that is hardly understood in objective scientific terms. The COBOL consortium's proposal to develop a new theory for measuring the components of body language could form the basis of more reliable tools for detecting criminals, deterring terrorists and studying degenerative diseases.

Body language is a powerful source of information about human emotions and intentions. In daily encounters between people, it constitutes a very important non-verbal means of communication and triggers immediate responses in us and in the observer, which are automatic and often out of our control. Despite its importance, there has been little scientific research to support the intuitive feeling that emotional body language (EBL) is perceived and understood effortlessly.

Practical pay-offs

It is generally agreed that body language plays a key role in successful negotiations and in achieving consensus in cultural, commercial, political and business transactions. But while hundreds of studies have been conducted in face recognition, almost no research has been done on EBL. This is perhaps surprising because better understanding of body language would not only be scientifically rewarding but also have many practical uses.

It would, for instance, launch an innovative line of research on emotional disabilities such as autism, and on motor disorders in Parkinson's and Huntington's diseases. It may even contribute to the development of improved computer graphics and human-computer interfaces.

Furthermore, since EBL can deliberately be manipulated for the purposes of deceit or personal gain, accurate identification and measurement of the traits would permit the preparation of more reliable guidelines and countermeasures for investigators and security personnel.

The basic steps in understanding EBL are: perceiving the emotion; perceiving the biological movement; and recognising the intended action. These three elements are encountered at two distinct levels. At the primitive biological level, EBL is automatic, expressing emotions such as pain, fear and disgust. At the perceptual-cognitive level,

"Everyone is exposed to an increasing variety of facial and bodily expressions of people from different races and cultures."

it is used intentionally and in a controlled fashion to steer, mislead or stimulate the observer.

Cultural differences

An important consideration is that of inter-cultural variability in EBL. For example, there are major differences between eastern and western cultures concerning displays of anger but so far our understanding of this is mainly based on anecdotes.

With populations becoming increasingly international, everyone is exposed to an increasing variety of facial and bodily expressions of people from different races and cultures. Aside from occasional observations, these differences have not yet been investigated, and their role in social interaction and emotional communication has rarely been explored. Such cultural differences may occur at different stages of body language and may be related to perceptual differences and to cognitive factors.

There is evidence that people are generally more accurate at judging emotions expressed by members of their own cultural group than by those from a different group. However, most of this work relates to facial expressions. Extending it to the whole area of EBL would certainly be of value to professionals in sales, teaching, medicine and law enforcement.

Besides developing a framework for understanding cultural variability, COBOL's intention is to develop measurement tools for EBL and to apply them interactively in order to validate their quantitative and qualitative accuracy. Detection and analysis of gestures and body movements has so far been based on the statistical analysis of videos or simple trajectory images, from which it is often difficult or impossible to obtain an accurate measurement.

COBOL aims to achieve a much deeper understanding and more precise modelling of the underlying structural components of EBL with the aid of novel mathematical and computational measurement tools.

Methods from kinematic and dynamic analysis will be combined with machine-learning and techniques for the spatial and temporal segmentation of complex action streams. Using this combination, the consortium will derive building blocks and determine the 'grammar' of the components.

This will permit the measurement and evaluation of even complex or ambiguous actions and sequences. In addition, it will, for the first time, provide a more detailed analysis of the individual components of EBL that are critical for eliciting emotional response.

The COBOL team will also blend its own original methods with neurobiological tools to study the potential association of EBL with self-awareness mechanisms. Certain kinds of EBL of a more social nature are intriguingly linked with acute situations of enhanced self-awareness, such as stage fright or embarrassment.

Recent studies have begun to uncover a fundamental organisation of human brain areas into corresponding internally- and externally-targeted processes. COBOL will examine the potential relationship of the two categories of EBL with the newly emerging cortical organisation. The result? Possibly a profound change in the way we understand and collaborate with one another.

AT A GLANCE

Official Title
Communication with Emotional Body Language

Coordinator
Tilburg University (The Netherlands)

Partners
- Collège de France (France)
- Universität Tübingen (Germany)
- Weizmann Institute of Science (Israel)
- Eidgenössische Technische Hochschule Zürich (Switzerland)

Further Information
Prof Beatrice de Gelder
Tilburg University
Stichting Katholieke Universiteit Brabant
Faculty of Social and Behavioural Sciences
Warandelaan 2-90153
5000 Tilburg
The Netherlands
email: degelder@uvt.nl
fax: +31 13 4662370

Project cost
€ 2 139 929

EU funding
€ 1 799 431

Project reference
Contract No 043403 (NEST)

We respond to gestures… in accordance with an elaborate and secret code that is written nowhere, known by none and understood by all.
(Sapir, 1927)

NEST Pathfinder

HOW TO LIE WITHOUT TRYING

EYEWITMEM

Eyewitness testimony has sent a lot of people to prison. Even when they mean to tell the truth, however, eyewitnesses can be surprisingly unreliable. EYEWITMEM aims to reduce injustice by bringing a more scientific approach to evaluating eyewitness testimony. Experts in memory, forensic psychology, neuroscience, artificial intelligence and the law plan to come up with a versatile toolkit that will help police officers and judges evaluate the likely reliability of individual witnesses.

The verdict in a criminal court case is sometimes driven by incontrovertible physical evidence, such as DNA left at a crime scene. More often, though, there is no 'smoking gun' and the outcome depends heavily on eyewitness testimony. Unfortunately, this testimony is often unreliable. Studies of past cases show that a significant proportion of people convicted on the basis of eyewitness testimony were probably innocent, as revealed by the retrospective use of DNA evidence.

The EYEWITMEM project aims to improve the way we assess the accuracy of witnesses' memories. This is a challenging task, but the project partners believe that it is possible thanks to recent advances in experimental memory research, forensic psychology, neuroscience and artificial intelligence. The project will use a mixture of experiments and literature analysis to link these disciplines and develop recommended techniques for assessing the reliability of what witnesses think they saw.

It's not a question of lying

Scientists have already had some success in discovering when witnesses are deliberately lying. But the question of whether people who want to tell the truth are recalling memories accurately has been much less studied, despite plenty of evidence for 'false memory'. At the moment, say the EYEWITMEM partners, police officers, judges and jurors assess the accuracy of memories using intuition and simplistic theories that have themselves been shown to be unreliable.

To improve on this, the project will first explore the factors determining the accuracy of memory, and use these insights to develop diagnostic tools that can predict witnesses' reliability. Next, these tools will be tested against one another and refined to create a set of techniques recommended for legal purposes.

The empirical phase of the project has four strands, the first of which will study the difference between quantity and quality in

"Memories of real events are likely to contain more ancillary detail, such as sounds, smells and feelings, than false memories do."

memory. Until recently, researchers have favoured the 'storehouse' model of memory, which emphasises the amount of information people can recall. In a courtroom, however, detailed memories are useless – and even damaging – if they are inaccurate. This part of the project will carry out experiments involving quantity-accuracy profiles (QAPs), which examine how people assess the reliability of what they think they remember, and how these assessments affect the amount and accuracy of the information they recount. The work will be carried out by researchers from the University of Haifa, Israel, which is coordinating the project.

From AI to brain scans

The QAP approach, though valuable, is more like a traditional list-based memory test than the free narrative that is often important in a courtroom. A second sub-project will therefore study the correspondence between free-narrative memory reports and the events they describe. To do this, the researchers will adapt an artificial intelligence (AI) system currently being used with considerable success to grade law-school essays -- COmputer aided Document Analysis System (CODAS). This software was developed by another of the project partners: Erasmus University in the Netherlands. By comparing different written accounts of the same sequence of events, the adapted CODAS system will be able to judge the faithfulness of individual reports.

Researchers at the University of Bielefeld, in Germany, will investigate the link between brain structure and memory. Previous work using techniques such as functional magnetic resonance imaging (fMRI) has looked at the regions of the brain that are activated as emotion-laden memories are recalled. There is already some evidence that memories describing a true sequence of events are associated with activity in different brain regions than those involved in 'false memories'. This part of the project will use neuro-psychological testing and an adapt the QAP and CODAS methods for use with fMRI to shed new light on the physical basis of true and false memory.

A fourth element is the contribution of forensic expertise from the University of Aberdeen, Scotland. The accuracy of eyewitness reports depends on a host of factors, some of which (such as the amount of time elapsed and the emotional state of the witness) are outside the court's control. Others, such as the form of the interview used to extract the information, can be controlled.

This part of the project will analyse appropriate literature to find out which factors are most likely to produce accurate or inaccurate memories. It will also examine the theory that memories of real events are likely to contain more ancillary detail, such as sounds, smells and feelings, than false memories do. Finally, the project will adapt an existing technique known as criteria-based content analysis, which is already used to tell when witnesses are lying, so that it can be used to distinguish real from false memories.

When the various strands of the study come together in the second phase of the project, the result should be a practical toolkit that significantly improves our ability to assess the reliability of individual eyewitnesses.

AT A GLANCE

Official Title
The Assessment of Eyewitness Memory: a Multi-Componential Correspondence-Oriented Approach

Coordinator
University of Haifa (Israel)

Partners
- Erasmus University (The Netherlands)
- University of Bielefeld (Germany)
- Juelich Research Center (Germany)
- University of Aberdeen (United Kingdom)

Further Information
Prof Asher Koriat
University of Haifa
Institute of Information Processing and Decision Making
University of Haifa, Mt Carmel
31905 Haifa
Israel
email: akoriat@research.haifa.ac.il
fax: +972 4 8249431

Project cost
€ 1 698 800

EU funding
€ 1 698 800

Project reference
Contract No 043460 (NEST)

NEST
Pathfinder

HOW DEEP IS EMOTION?

FEEL EUROPE

Emotion is the basis of our response to the physical world. Feeling represents the subjective experience aroused by that emotion – from joy to despair, security to fear. Such reactions differ from person to person, but they influence many aspects of human decision-making, even down to basic purchasing choices. In FEEL EUROPE, experts from numerous disciplines will pool their resources to determine how these seemingly intangible phenomena can be measured. Their findings could have a profound impact on both industry and society.

Feelings arise from human perception and experience. Each individual has different experiences and perceives impressions subjectively. A given event may, therefore, cause different feelings and emotions in any two people, even if both receive the same stimulus.

If such phenomena were able to be measured objectively, the results could be used in a variety of beneficial ways – such as, adapting working environments and conditions, improving the domestic landscape, making tools more user-friendly and the treatment of diseases more sympathetic – and, in doing so, enhance the quality of life for all EU citizens.

The overall objective of FEEL EUROPE is to stimulate interdisciplinary research to identify investigative methods that will underpin advances in measurement techniques for future application. A consortium of two organisations – Germany's Fraunhofer Society Institute for Biomedical Engineering and the medical faculty of Spain's Miguel Hernandez University – will bring together over thirty of Europe's leading minds to participate in an open platform and explore this unconventional challenge.

Lean management, broad ambition

Because measuring human feelings and emotions is intrinsically multidimensional, the international group will comprise: scientists in medicine, biology, psychology, philosophy, neurology and materials science; engineers in biomedicine, architecture, telecommunications and acoustics; as well as designers and experts from the automobile, textiles, lighting, sports and consulting sectors. Their aim will be to promote the formation of new partnerships by pooling the creative potential of researchers drawn from an even wider range of fields.

To prepare the groundwork, the partners will produce a 'vision' paper presenting the state of the art with new hypotheses and questions, and proposing a series of topics for discussion.

"Artists and philosophers have offered us their musings on emotions in paintings, performance and literature throughout history."

An expert workshop will then be organised, within which it will be possible to explore the whole gamut of human feelings and reactions. This will not only allow participants to discuss the scientific and technical possibilities for measuring feelings and emotions, but will also enable them to consider aspects relating to issues such as ethics and gender.

As a first step towards developing measurement theories, the targeted emotions will need to be identified and characterised. In this regard, ideas and theories abound.

Artists and philosophers have offered us their musings on emotions in paintings, performance and literature throughout history. Physiologists and other natural scientists have provided no shortage of possibilities on the origins, development and mechanics of emotions. Likewise, psychologists, anthropologists and sociologists have contributed their perspective on the impact emotions have on the individual and society. FEEL EUROPE boldly proposes to bring all these threads together.

Long-term rewards

Since breakthroughs in this area could generate substantial returns in the future, efforts will focus on the recognition of new opportunities, research advances and methodologies that could impact on the overall project and might be incorporated into it.

At the same time, through continuous open dialogue with experts from all the related fields, careful attention will be paid to the possible risks incurred when measuring the feelings and emotions that form an integral part of daily human life.

A final paper will offer general guidelines on the possibilities for future development, as well as represent a culmination of FEEL EUROPE's results. On completion of the project, the document will be disseminated to national and international politicians, policy-makers, project investors, researchers and developers. A shorter version will also be published online to familiarise the general public with the project's results.

FEEL EUROPE will help to define and develop novel kinds of technical cognitive systems, with the ability to understand human behaviour and provide a basis for the development of improved human-machine interfaces.

The initiative will serve as a potential source of new thematic ideas for research and development programmes embracing novel technologies, such as (bio-) sensors, non-invasive techniques and miniaturisation. It will also provide new insights in the field of neural sciences, design and ethics – and, eventually, of patentable innovations capable of market development by European enterprises.

AT A GLANCE

Official Title
European Expert Platform for Measuring Human Feelings and Emotions

Coordinator
Fraunhofer Society – Institute for Biomedical Engineering (Germany)

Partner
- Universidad Miguel Hernandez, Facultad de Medicina (Spain)

Further Information
Dr Klaus-Peter Hoffmann
Fraunhofer Society
Institute for Biomedical Engineering
Hansastr. 27C
8007 Munich
Germany
email: klaus.hoffmann@ibmt.fraunhofer.de
fax: +49 6894 980 408

Project cost
€ 237 141

EU funding
€ 195 359

Project reference
Contract No 043357 (NEST)

Communication and emotion.

Motion and emotion.

NEST
Pathfinder

TIME TO MEASURE GAMES APPEAL

FUGA

Although video and computer game players certainly appreciate the fun, developers and scientists cannot currently measure the games experience as relatively little research has ever been carried out in this area.
FUGA is focusing on creating novel measurement techniques to quantify the complex and dynamic experience of enjoyment derived from such games.
It will also develop an emotionally adaptive gaming prototype.
The results will improve European products and support those concerned with the potentially adverse effects of gaming.

Computer and video gaming is now one of the most popular forms of mass entertainment worldwide. Digital games are also playing a growing role in therapy, education and training. But what makes a game good and why? And just how do you measure the effect of such a dynamic and continuous interaction? The FUGA project will establish innovative comprehensive measurement methods to help designers and media psychologists answer these questions and to improve computer and video gaming.

Digital gaming attracts millions of players worldwide and is forecast to grow substantially, making it a major new area of information and communications technology. Yet, despite the intense enjoyment derived by most gamers, surprisingly little is known scientifically about the fun involved. Despite enormous resources invested in creating new computer and video games, developers make little use of psychological research to create better and more appealing products tailored to the enjoyment of individual users.

Multidimensional environment

The computer games experience is a multi-dimensional phenomenon that involves both emotions and cognitions. FUGA will combine expertise in neuroscience, psychology, physiology, communications, computer science and vision research that will improve existing approaches and create novel methods to assess the different emotional and thought processes involved in the highly dynamic games experience.

Innovative psychophysiological techniques linking the way psychological activities produce physiological responses will be used to measure the experience. Recordings will be made of reactions using facial electromyography, electro-encephalography, electrocardiography, electrodermal activity and respiration.
And FUGA will employ functional magnetic resonance imaging (fMRI), eye-movement recording, the online implicit association test (IAT) and tracking of behavioural indicators for emotion and motivation.

"Interactive games are a major business generating high quality jobs in development and marketing."

FUGA's objectives include establishing the validity and reliability of such techniques and seeing how they can predict game playing in the long term. The project will also develop a prototype of an emotionally adaptive game that changes its behaviour dynamically in real-time based on psychophysiological measurements that index the players' emotions.

Use of psychophysiological recordings offers several advantages, not least the ability to perform high resolution measurements continuously and to provide information on emotional and attention responses. Such an approach has been used in media studies to examine responses to television, radio and textual messages but little use has been made of this technique in examining the dynamic interaction involved in games play.

Mobile psychophysiological recording will form an important element as many games are portable and the gaming environment plays a role in the experience. New algorithms will be developed to extract relevant parameters from the measurements being made to determine which specific elements of a game result in a particular response.

Emotional enjoyment will be determined using a combination of physiological recordings, facial expression observation and fMRI with high resolution real-time content analyses. A major challenge will lie in the application of fMRI in a real game, requiring innovations in imaging procedures.

Another innovation will be the use of an approach based on the IAT that makes possible the assessment of thought processes in computer games play. IAT uses response latencies to identify and sort implicit associations in the mind, particularly those associated with self-esteem – for example, 'I'm winning/not winning' – and the player's role in the game. The aim is the development of new methodology providing reliable, valid and time-sensitive data on game users' implicit thought processes.

Boost to European gaming industry

Interactive games are a major business, generating high quality jobs in development and marketing. Much of this business is currently concentrated in Japan and the United States. FUGA will significantly advance the methodology of European games research, helping guide design choices when pre-testing products. It will have a practical effect on games design, enabling designers to maximise pleasure and attention. And it will help in the development of new types of games, overcoming the need for designers simply to copy successful existing formats.

The results of FUGA will help Europe boost its gaming industry, creating jobs and gaining global impact in the entertainment sector. FUGA will also help improve the design of non-leisure software such as games for therapeutic and educational purposes, allowing the development of games that engage students in knowledge discovery and skill acquisitions without distracting from educational content.

The work involved in FUGA will also be applicable to tackling the effects of violent video games by providing a valid method to examine emotional and thought processes while they are being played. In addition, FUGA could well help in improving the understanding of how addiction to gaming arises and how it can be prevented or treated.

AT A GLANCE

Official Title
The Fun of Gaming: Measuring the Human Experience of Media Enjoyment

Coordinator
Helsingin kauppakorkeakoulu (Finland)

Partners
- Teknillinen korkeakoulu (Finland)
- Högskolan på Gotland (Sweden)
- Hannover University of Music and Drama (Germany)
- University of Aachen (Germany)
- Eindhoven University of Technology (The Netherlands)

Further Information
Dr Niklas Ravaja
Helsingin kauppakorkeakoulu
Center of Knowlegde and Innovation Research
PO Box 1210 (Fredrikinkatu 48A, 9th floor)
FIN-00101 Helsinki
Finland
email: ravaja@hse.fi
fax: +358 9 431 38391

Project cost
€ 2M

EU funding
€ 2M

Project reference
Contract No 028765 (NEST)

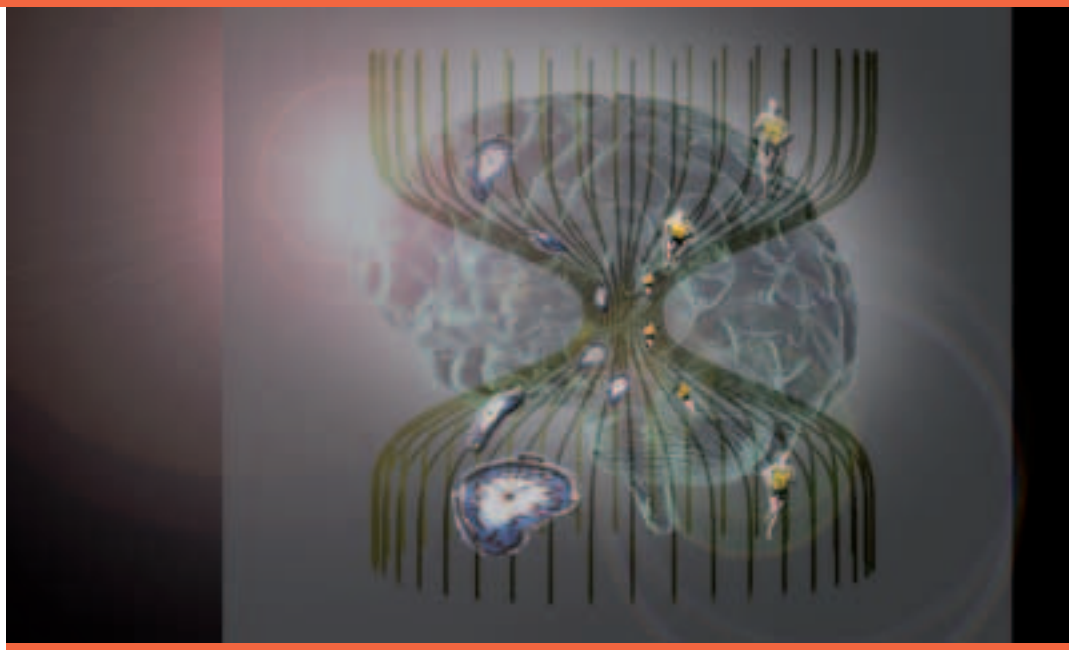
City of Bruma in Elder Scrolls IV: Oblivion. © Bethesda Softworks

EMG electrodes in place.

NEST
Pathfinder

WHAT MAKES HOLES IN TIME?

MEMORY



When we view the world around us, we observe a stable image, despite frequent rapid body and eye movements. How the brain accomplishes this interpretation remains only partially understood, although it is known to involve short-lived perceptual distortions of space and time. The aim of MEMORY is to explore this complex mechanism and to reproduce it on a distributed computer system. The findings could lead to improved man/machine interfacing, and more sophisticated robots. MEMORY may additionally shed light on our understanding of the neuronal mechanisms, leading to the development of possible aids for diseases related to misperception of external space, such as in Alzheimer's and Neglect patients.

Watching a badly filmed video sequence shot with a camera that weaves, pans and zooms in a haphazard manner, can be an almost nauseating experience. Yet, although our own eyes roam about in much the same way when looking at everyday scenes, the brain automatically compensates for the shifting viewpoint and focus. We see a stable image, and can make valid judgments about the spatial relationships between the objects we see.

In observing the world, frequent small and jerky involuntary eye movements known as 'saccades' constantly change the images falling on the retina. Psychophysical studies by members of the MEMORY consortium and others, have shown that perceptual thresholds (particularly for motion) are raised during saccades, which implies a damping of the visual pathway at these times.

In addition, there is a transient distortion – by shifting or compression – of the objects in view. For example, locations may be spatially offset in the direction of the saccade target, and objects parallel to the path of the saccade appear squashed. The MEMORY team hypothesises that the effects are probably part of the process of neuronal integration of successive image captures.

More intriguingly, a phenomenon revealed by recent work is that time perception is also distorted in a similar fashion. A simple test of this fact is to look at your own eyes in a mirror, switching the gaze repeatedly between the left and right eye reflections. Each eye movement can take tens of milliseconds; although an observer can see the movements, you never will. What happens during the apparent gaps in time?

Cerebral relativity

The premise under investigation is that the distortions are relativistic – like consequences of the rapid remapping of neurones to compensate for the changes in retinal position produced by eye movement.

"An integrated environment that combines real-life perceptual information with the virtual cyberworld."

Experiments conducted on macaque monkeys reveal that the receptive fields of some neurones in the lateral intraparietal area (LIP) of the brain change position before each saccadic eye movement, effectively anticipating its consequences. Subsequently, the same LIP neurons have been strongly implicated in encoding time when the monkeys are performing cognitive tasks. This remapping is surprisingly fast compared with neural transmission time, but not instantaneous. The postulated relativistic effects may occur when the speed of remapping approaches the physical limit of neural information transfer.

In a parallel to Einstein's landmark theory of physics, it appears that the brain treats space and time as strongly interdependent, and that the neural coding of time may vary with spatial location. Confirming the responsible mechanisms is crucial in understanding how visual stability is achieved.

MEMORY brings together four partner institutes representing Italy, Germany and Switzerland. Italy's Libera Università 'Vita Salute S.Raffaele' (UHSR) and Philipps-University in Germany specialise in neuroscience, while the University of Applied Sciences of Southern Switzerland and the Italian National Research Council specialise in Information and Communication Technology. Under the coordination of UHSR, they will collaborate by performing direct psychophysical and electrophysiological measurements on monkeys and humans, and then carry out computer modelling of the findings on networked control systems (NCSs).

Visual perception is considered to be a distributed function, rather than under the control of a central bodily clock. The use of NCSs for modelling is therefore particularly appropriate since these, too, are distributed systems operating in real time with interacting sensors, actuators and controllers connected by wired or wireless networks.

Strong analogies with human perceptive errors can be seen in such systems, because transmission and processing speed limitations result in time-dependent aberrations, such as delays, jitter and information losses. The sophisticated and modern methods used in this field could thus prove equally useful in investigating the basis of visual stability.

Time perception over fine scales is fundamental to many aspects of our lives, including speech recognition and production, motion perception, sound localisation and motor coordination. A common framework of measurement techniques for the neurosciences, pervasive computing, communications and robotics would also be adaptable to the study of these and other multidimensional phenomena, which are mediated by human interpretation and perception. It has further relevance to the understanding of attention and memory.

Merging the real- and cyber-worlds

Ultimately, the goal is to define an integrated environment that combines real-life perceptual information with the virtual cyberworld. It could then become possible to devise models that compensate for human decisional errors in virtual support environments. Conversely, computerised analysis of the neural processes may provide ideas for innovative communication protocols, leading to more human-like machines and robots.

AT A GLANCE

Official Title
Measuring and Modelling Relativistic-Like Effects in Brain and NCSs

Coordinator
Libera Università 'Vita Salute S.Raffaele' (Italy)

Partners
- Philipps-University (Germany)
- University of Applied Science (Switzerland)
- IIT CNR (Italy)

Further Information
Prof Maria Concetta Morrone
Libera Università 'Vita Salute S.Raffaele'
Faculty of Psychology-Vision Laboratory
Via Olgettina
20132 Milan
Italy
email: concetta.morrone@hsr.it
fax: +39 02 2643 4892

Project cost
€ 1 453 000

EU funding
€ 1 281 000

Project reference
Contract No 043236 (NEST)

Einstein showed that for physical systems moving near the maximum speed of information transmission, space-time becomes distorted. Recent studies show that similar effects may occur in the brain: when neural representations are moved near the maximal speed of neural information transfer, space-time in the brain becomes distorted, manifested in weird perceptual effects.

NEST
Pathfinder

CONSCIOUSNESS UNRAVELLED AT LAST

MINDBRIDGE

How can the human brain transcend its physical structure to create conscious experiences and a sense of self-awareness? The MindBridge partners believe they are ready to answer the question that has so far defeated all comers. They believe that by pursuing the challenge on all fronts – including subjective accounts and behavioural studies of learning and memory, as well as brain scanning – they will be able to crack one of science's last great problems: what are the causes and mechanisms of consciousness?

Understanding consciousness is a key objective of scientists who study the human mind and brain. Something in the structure of the brain creates consciousness, but despite a large amount of research we still do not know how it happens. The MindBridge project aims to close the gap between the subjective experience we call consciousness – perceptions, judgments, feelings and desires – and the objective, third-person accounts produced by the cognitive neuro-sciences.

Six institutes are working together to develop a toolbox for studying different levels of consciousness, as well as the relationships between conscious and unconscious processing in the brain. The novelty of MindBridge is that it is multidisciplinary and more integrated than previous research, bringing together subjective reports, behavioural studies and functional neuroimaging.

Their ultimate goal is to produce an empirical theory of consciousness. Practical results could include an understanding of the mental state of people who are unable to communicate, and new insight into conditions such as schizophrenia. The results are also expected to generate new rehabilitation methods for patients with moderate and severe brain injury.

Mapping objective to subjective

In recent years, several tools have become available for studying the physical state of the brain and, in particular, the way it changes during different thought processes. These tools include electroencephalography (EEG), magnetoencephalography (MEG), positron emission tomography (PET) and functional magnetic resonance imaging (fMRI). The results of these investigations are known as the neural correlates of consciousness (NCC), and they have a high priority as tools in research into consciousness.

"Consciousness is one of the most important unsolved problems in science."

Despite much research effort, though, we so far have no adequate models of how consciousness arises or relates to brain state. In the words of one researcher, "No-one has produced any plausible explanation as to how the experience of the redness of red could arise from the action of the brain." But to a capable, multidisciplinary team with the right resources, the MindBridge researchers believe reaching this understanding is only a matter of time.

The project will analyse both qualitative and quantitative characteristics of conscious and unconscious processing. The researchers will examine different cognitive functions, such as perception, attention, memory, learning and language. They will work with a wide range of subjects, including people who are awake, asleep, or in altered states of consciousness (such as those with pathological conditions such as minimally conscious, comatose or vegetative states).

The consortium's first task is to develop measures of consciousness based on subjective reports and behavioural measures. Next, they will compare this measured consciousness with the corresponding brain states as defined through structural and functional neuroimaging. A key factor here will be the use of computerised pattern-recognition techniques to decode the data produced by fMRI and MEG, a task previously thought to be impossible but which now seems within reach. Measurements over short timescales, as with MEG, and multivariate analysis are already producing impressive results.

The ability to see how the activity of neurons in the brain varies with different states of consciousness will help to solve the 'binding problem', one of the biggest unresolved issues in the search for neural mechanisms of consciousness. The binding problem addresses how networks of neurons in different parts of the brain can act together to produce specific mental states. The answer may lie in the timing of the neurons' firing, specifically that sets of neurons become locked into an oscillatory pattern with a frequency of 30 Hz or greater.

Self-consciousness and schizophrenia

Self-consciousness is one of the mental functions to which MindBridge will pay particular attention. Self-consciousness is important not least because social functioning depends on being able to distinguish one's own mental state from those of others, and many experts believe that it is likely to be 'hard-wired' into the brain. The researchers plan to develop an experimental platform for characterising self-consciousness, and ultimately to explore the 'neural signatur' that may give rise to this state.

Existing studies of consciousness draw few conclusions that are useful in the diagnosis or treatment of mental problems, the MindBridge researchers say. They, in contrast, plan to develop practical new tools for assessing patients with conditions such as brain injury, schizophrenia and autism.

The ultimate goal is to produce an empirical theory of consciousness to supplement existing theories, which are based largely on philosophical reasoning about how consciousness ought to work. Consciousness is one of the most important unsolved problems in science, so this is certainly an ambitious project whose implications reach well beyond what will be possible in the three-year timescale.

AT A GLANCE

Official Title
Measuring Consciousness: Bridging the Mind-Brain Gap

Coordinator
Hammel Neurocenter Research Unit (Denmark)

Partners
- Cognitive Science Research Unit, Université Libre de Bruxelles (Belgium)
- University Medical Centre Hamburg-Eppendorf (Germany)
- Institute of Cognitive Neuroscience, University College London (United Kingdom)
- Cyclotron Research Centre, University of Liège (Belgium)
- Department of Psychiatry, University of Cologne (Germany)

Further Information
Dr Morten Overgaard
Hammel Neurocenter Research Unit
Voldbyvej 15
8450 Hammel
Denmark
email: neumov@sc.aaa.dk
fax: +45 87 62 33 05

Project cost
€ 2 140 958

EU funding
€ 2 140 958

Project reference
Contract No 043457 (NEST)

NEST
Pathfinder

MEASUREMENT IS THE FIRST STEP TO IMPROVEMENT

MINET

Seeking to provide a reproducible basis for qualifying and quantifying what are essentially 'soft' measurements (subject to human perception and interpretation) is a particularly challenging scientific endeavour. Individual projects in the NEST Pathfinder Measuring the Impossible (MtI) programme are addressing various aspects of this problem. The MINET project aims to maximise their outcomes by promoting synergy and information exchange, with the longer-term goal of building a broad Europe-wide MtI community.

Measuring the Impossible deals with the application of objective metrology to holistic quantities and qualities which are perceived and interpreted by the human brain and mind.

Providing a means for reproducible measurement of parameters such as pleasure and pain has important implications in evaluating all kinds of products, services and conditions. In the commercial world, choice is influenced by a host of factors – from naturalness, aesthetics and comfort to security, service and price. Is the smell of a new car appealing? Does this fabric have a luxurious feel? By being able to predict user perceptions and reactions through modelling, companies may be able to save time and resources by meeting the expectations of their customers, without the need for extensive testing.

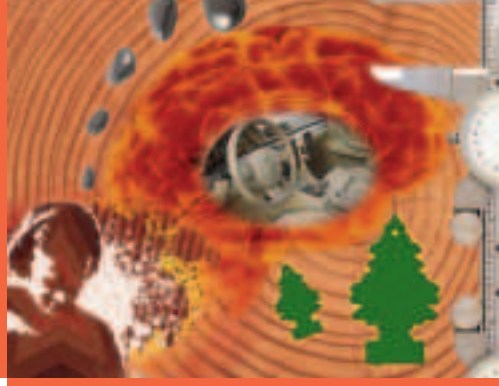
As its name implies, Measuring the Impossible is a highly challenging field. On the one hand, it requires the cross-linking of related (but hitherto uncoordinated) developments across a variety of disciplines, embracing the physical, biological, psychological and social sciences. On the other hand, it faces an ever-increasing demand for valid measurement as the basis for decision-making. Moreover, the resultant measuring systems must be comprehensible to human senses that are difficult to model or match using current manufactured sensor systems.

Action at three levels

In a series of Specific Targeted Research Projects (STREPs) funded by the European Union under the NEST Pathfinder programme, researchers are joining forces to explore issues ranging from the emotions aroused by viewing pictures, to the functional/aesthetic qualities of sound.

Specific Support Actions (SSAs) assist these individual efforts by mapping and developing more detailed definitions of the fields in question, assessing development prospects and identifying future trends.

"The barriers are beginning to tumble, and MINET will accelerate the process."



As a Coordination Action (CA), MINET goes still further in the bid to achieve long-term integration, whereby the whole science of MtI can become established as a cohesive entity, supporting hard science metrology.

A consortium of 22 partners has been formed for this purpose. Nine of the members are 'operational partners', involved directly in the development, organisation and management of the CA. The remaining members are coordinators of projects in the field, who will additionally contribute strongly to, and participate in, the scientific development and information exchanges.

Barriers tumbling

A significant hurdle to be overcome is that MtI still suffers from the historical division that arose between physicists and psychologists in the middle of the 20th century. The two sides disagreed strongly on the meaning of measurement and the possibility of 'measuring' sensory events. This led to parallel developments in measurement science within the two separate camps. Both went on to generate remarkable results, but the lack of communication between them prevented coherent and interactive progress. Often, the same methods were reinvented and promoted under different names, or in slightly different versions.

Today, the barriers are beginning to tumble, and MINET will accelerate the process.
At current estimates, almost 1 000 high-profile scientists worldwide are active in the field of soft measurement. Those who are developing the most innovative methods tend to be either specialised basic researchers in particular disciplines, or dedicated particularly to specific areas of application. MINET will bring this disparate group together in a European arena, because the individual national contexts are simply too narrow to feasibly support such an activity.

Initially, the CA will provide a mechanism that enables NEST project members to cooperate and interact with each other. In a key move to raise their productivity, MINET will set up an online core human network (c-Minet), as part of a dedicated MINET website. Building on this foundation, the partners will go on to initiate a wider sharing of knowledge amongst all interested stakeholders across the EU, as well as actively promote the spread of MtI awareness among decision-makers and the population at large.

The c-Minet site will later be expanded to involve the evolving European community, stimulate interactive dialogue with the national metrology institutes, and launch a medium for wider scientific communication within what will become a unified 'e-Minet' web presence.

MINET will be a European booster of soft measurement science, through academic and application-driven workshops and stimulating sessions at conferences targeting MtI topics.

Progressive interdisciplinary development of scientific knowledge and science communication will be ensured in creative think-tanks, study visits and training courses for senior researchers. Material produced will include an external Expert Group Report, newsletters and a scientific book on soft measurement and its terminology.

The goal is to have a viable European MtI community in place by 2009.

AT A GLANCE

Official Title
Measuring the Impossible Network

Coordinator
Stockholm University (Sweden)

Partners
- National Physical Laboratory (United Kingdom)
- Unilever R&D (United Kingdom)
- University of Genova – DIMEC (Italy)
- Biometris, Wageningen University and Research Center (The Netherlands)
- Center for Usability Research & Engineering (Austria)
- Helsinki School of Economics (Finland)
- Laboratorio di scienze della cittadinanza (Italy)
- University of Ljubljana (Slovenia)
- SP Swedish National Testing & Research Institute (Sweden)
- Technical University of Berlin (Germany)
- University of Mannheim (Germany)
- Centre National de la Recherche Scientifique (France)
- University of Haifa (Israel)
- Profactor Produktionsforschungs GmbH (Austria)
- Stichting Katholieke Universiteit Brabant – Tilburg University (The Netherlands)
- Fraunhofer – IBMT Institut für Biomedizinische Technik (Germany)
- Technische Universitaet Dresden (Germany)
- University of Helsinki (Finland)
- Hammel Neurocenter (Denmark)
- Universitá Vita-Salute San Raffaele (Italy)
- Institut de Recherche et de Coordination Acoustique | Musique (France)

Further Information
Prof Birgitta Berglund
Stockholm University
Department of Psychology
SE-106 91 Stockholm
Sweden
email: Birgitta.Berglund@ki.se
fax: +46 8 16 55 22

Project cost € 1 807 026.46
EU funding € 1 498 339

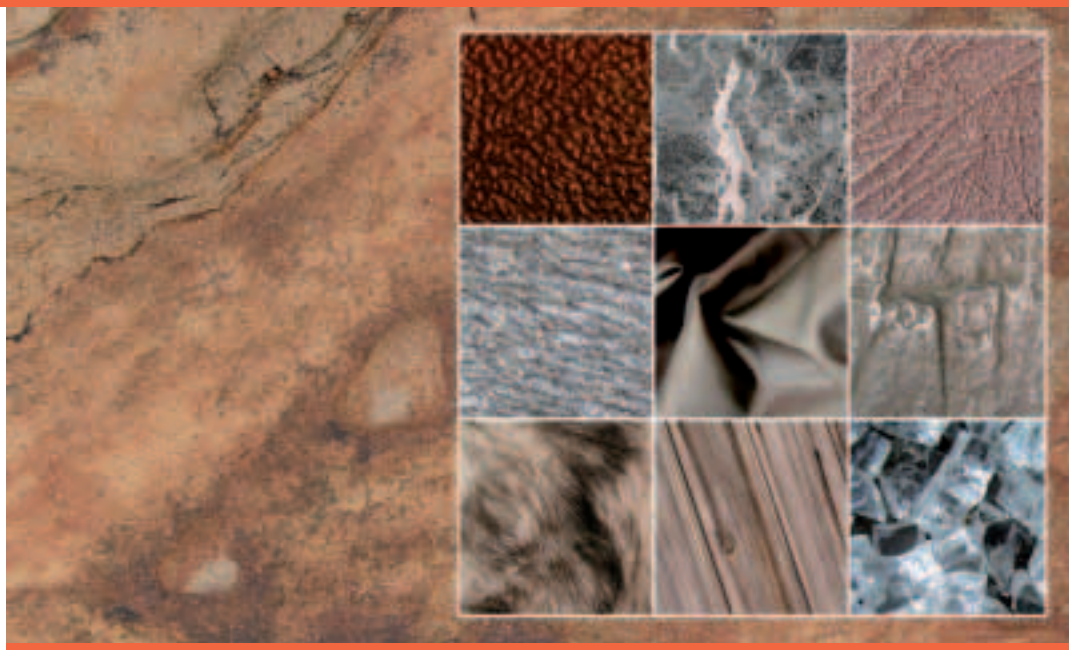
Project reference
Contract No 043297 (NEST)

The measurment of odour quality is at the head of brain-mind affairs.
This project will be the European booster of 'soft' metrology.

NEST
Pathfinder

REPRODUCING NATURE'S LOOK AND FEEL

MONAT



From cotton to cashmere and from oak to walnut, many natural materials have an innate beauty that is hard to emulate in synthetic products. On the other hand, artificial materials are often cheaper, more durable and less scarce than their natural counterparts. By exploring how we decide whether or not materials are natural, the MONAT project will help manufacturers create artificial materials that are more like 'the real thing', making luxury more affordable and saving precious natural resources.

There is nothing quite like crisp cotton or luxurious cashmere, glossy leather, solid oak, and richly-patterned walnut. So what makes these natural materials special? After all, many of the plastics and synthetic fibres we meet in everyday life have remarkable properties too.

Much of the answer, according to the MONAT project team, lies in our ability to distinguish subtle differences in the appearance and feel of different materials. Of the five senses we use to explore the properties of materials, sight and touch are the most important, not least because they sometimes give conflicting information: artificial silk can look realistic enough, but it just doesn't feel right. If a synthetic material looks like the real thing and feels like it too, we're likely to be convinced.

The processes involved in deciding whether the look and feel of a material distinguish it as natural are complex and not well understood. Our senses of sight and touch are only the starting point. The brain's interpretation of sensory information, which depends on factors such as memory and emotional state, is just as important as the raw information transmitted by the nerve cells in our eyes and skin.

By studying this sensory chain, the MONAT researchers plan to learn the secrets of what makes materials seem natural. Apart from its intrinsic scientific interest in increasing our understanding of how the brain processes sensory information, this will help scientists and engineers design synthetic materials that closely mimic their natural counterparts. This could help create everyday items, furniture and clothes that are more desirable than those made from current synthetics, yet cheaper and more durable than those made from natural materials. For materials like ivory, high-quality synthetic substitutes could even help to protect threatened animals and plants.

"They plan to create an artificial fingertip that can match the sensitivity of a real finger."

From properties to prediction

Difficult though it will be to discover how our brains decide whether or not something is natural, the MONAT researchers start with one advantage: 'naturalness' seems to be fairly objective. Concepts such as beauty are hard to study because they are highly subjective, and depend on outside factors such as culture. People's assessment of naturalness, in contrast, is more consistent and reproducible.

Most existing research in the area of perception is confined to individual fields of science. Taking the view that understanding such a complex process will require a wider view, MONAT is a multidisciplinary project that includes researchers specialising in physical measurement, cognitive neuroscience, psychology and mathematical modelling.

The project partners aim to understand how the brain decides whether a given material is natural, and how this depends on the physical properties of the material. By modelling the relationships between physical properties, the nerve stimuli these properties create, and how the brain interprets these stimuli, their ultimate goal is to be able to use the physical properties of a new material to predict how natural it will seem.

Stone blocks and artificial fingers

One of the project's first tasks will be to create a set of reference materials whose appearance and feel spans the range from completely natural to completely synthetic. The types of material may include natural and synthetic fabrics and leather; building materials such as stone and concrete; as well as wood – both real and simulated – for furniture and flooring. The plan is to build up a library of materials, each with several measurable properties that differ from one sample to the next. The properties to be measured will include colour, texture, reflectivity, compressibility, roughness and thermal diffusivity.

The researchers will also adapt existing measuring techniques and develop new ones to match the particular characteristics of human vision and sense of touch. As part of this work they plan to create an artificial fingertip that can match the sensitivity of a real finger and be used to help distinguish what properties of a material make it seem natural to the touch.

Alongside this, the consortium will run experimental work on volunteers to find out how their nerves and brains react to the sight and touch of different types of materials. Techniques used here will include functional magnetic resonance imaging, which shows which regions of the brain are involved in processing different types of stimuli, and psychological experiments designed to explore how people perceive naturalness.

The information will be used to help develop mathematical models that link the physical properties of a material with its perceived naturalness. With enough data, the models should eventually be able to predict the 'naturalness' of any given combination of physical properties.

Understanding how we get from physical properties to a sensation of naturalness is a challenging task. Given the premium our society places on natural materials, the MONAT research will be of great commercial as well as scientific importance.

AT A GLANCE

Official Title
Measurement of Naturalness

Coordinator
National Physical Laboratory (United Kingdom)

Partners
- Unilever Research Port Sunlight Laboratory (United Kingdom)
- The Provost Fellows and Scholars of the College of the Holy and Undivided Trinity of Queen Elizabeth, Dublin University (Ireland)
- Parc Científic de Barcelona, Universitat de Barcelona (Spain)
- Laboratoire de Physique Statistique, Centre National de la Recherche Scientifique (France)
- Laboratoire d'Electronique et Technologie de l'Information, Commissariat à l'Energie Atomique (France)
- Biometris, Wageningen University and Research Centre (The Netherlands)

Further Information
Ms Teresa Goodman
National Physical Laboratory
Optical Radiation Team
Hampton Road
TW11 OLW Teddington
United Kingdom
email: teresa.goodman@npl.co.uk
fax: +44 208943 6283

Project cost
€ 2 493 915.36

EU funding
€ 1.5M

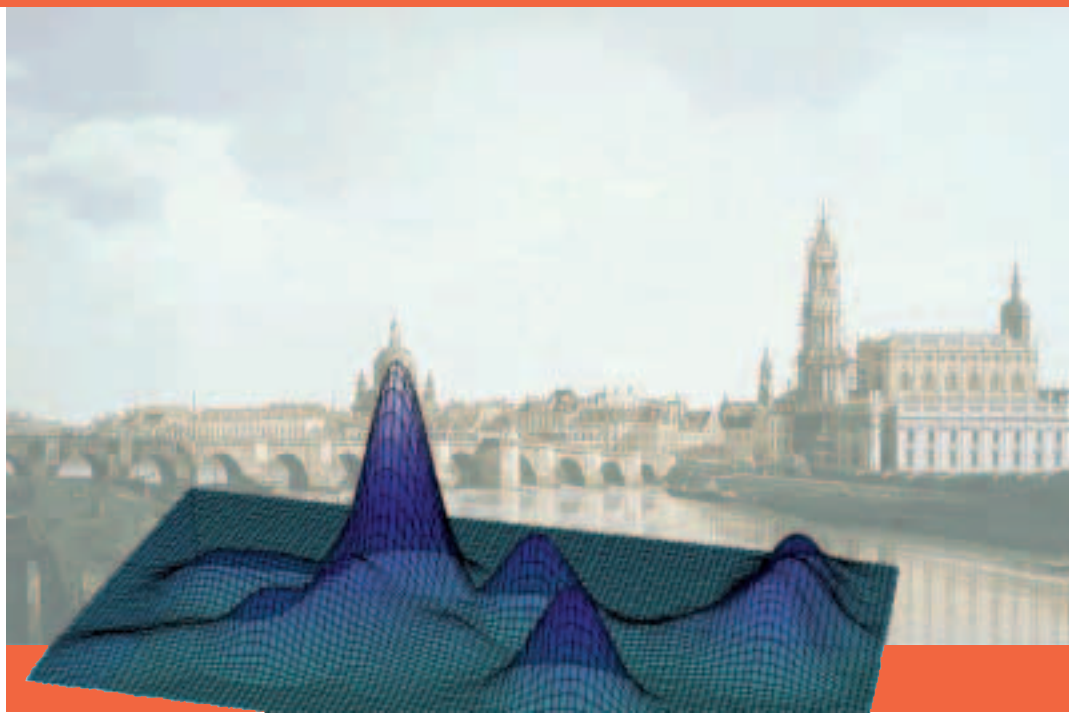
Project reference
Contract No 029000 (NEST)

The MONAT project seeks to understand the complex relationships between the physical properties of a material and our human sensory systems, and how our senses interact to generate a perception of whether or not the material is natural.

NEST
Pathfinder

IN THE EYE OF THE BEHOLDER

PERCEPT



When we view a visual image – be it an artwork, a chest x-ray or a street scene – much about our innermost feelings, competencies and interests can be revealed. Where do our eyes focus? How long do they dwell? And what pattern of brain activity accompanies our perceptions and actions? The objective of the PERCEPT project is to map this information into a quantifiable and comprehensible form that could provide a basis for clearer communication and more effective education.

The impressions we obtain from looking at pictures vary greatly from person to person. An art curator's feelings about a masterpiece will differ from those of a casual observer. Likewise, a medical student confronted for the first time with a patient's x-ray will find it more difficult to comprehend than an experienced surgeon who can rapidly identify the important features and ignore the rest. However, even in the case of an expert this interpretation is always subjective; that is, potentially mistaken.

If it were possible to analyse these processes with an objective measurement system, valuable information could be extracted that is unavailable at present. This would provide a window onto hidden perceptual impressions and emotions, allowing them to be shared with others through entirely new ways of communicating and collaborating.

In PERCEPT, eight universities are cooperating to pursue an approach grounded in the work of Professor Boris Velichkovsky and his colleagues at the Technical University of Dresden.

Can emotion be mapped?

The aim is to develop Interpretation Maps (IM) of pictorial objects, relating observers' emotional and attentional states to their viewing patterns. The principal objects of study during the project will be European artworks, but the partners expect the system to be equally suitable for analysis of people's interpretation of technical and scientific images.

A first step in this direction was the attempt to elucidate interpretations of ambiguous paintings by rendering them into Fixation Maps (FM), highlighting areas that are the prime focus of visual fixations. This approach was subsequently deemed to be an over-simplification since fixation content may not actually be registered consciously (as in the case of a motorist who sits gazing at a traffic light but fails to notice the change to green until the following driver sounds his horn).

It is necessary to replace FM with more sophisticated Attention Maps (AM), which take account of different modes of visual processing associated respectively with the dorsal and ventral parts of the posterior cortex.

"The impact could continue to be felt over the next two decades and beyond."

Forging new ground

True attentive fixations have been tentatively identified by Professor Velichkovsky and his group as ventrally mediated, but confirmation of this fact requires simultaneous measurement of eye movements and brain responses during free visual exploration of a scene. This is one of the goals of PERCEPT. New techniques known as Eye-Fixation Related Potentials (EFRP) and Fixation-Based Event-Related analysis (FIBER) will enable the responsible teams to record eye movements with a temporal resolution down to 100-200 ms, permitting reliable attribution of the corresponding cerebral activity.

Another problem in progressing from FM to AM is that focal attention fixes on complete objects; a whole animal, rather than just the areas on its pelt that are directly fixated, as would have been suggested by FM. The partners hope to resolve this issue by means of a texture expansion and filling-in modelling process, which they expect to be able to perform automatically in real-time by the latter stages of the project.

The elucidation of perceptual consciousness also depends upon the development of Emotional Maps (EM), ascribing affective values, or valences, to the objects in a scene. Despite extensive study over a long period, few options have yet emerged to answer this need. Subjective evaluations are potentially unreliable; the mere fact of focusing on an experience changes the emotional state. Data for mapping will, therefore, be gathered using a combination of neurophysiological measurement techniques such as functional magnetic resonance imaging with behavioural methods that include the analysis of facial expressions and speech.

The proposed facial recognition method, the Amsterdam system, already deciphered the enigmatic smile of Leonardo da Vinci's *Mona Lisa* as 83% happiness, 9% disgust, 6% fear and 2% anger.

IMs will be derived by a three-stage integration of the work on AM and EM. The first phase will determine how data on focal attention and emotional values can be rendered onto the original scene. Next, input from the behavioural measurements of attention and emotion will be added, and the visualisations reviewed. Finally, the behavioural measures will be validated and, if necessary, corrected. The refined version of the visualisation will then be tested for its reliability in various scenarios; for example, the aesthetic evaluation of art material (Beauty Maps) and the diagnosis of scientific, technical, educational and medical images (Relevance Maps).

With further advances in areas such as unobtrusive remote signal detection and the use of wearable sensors, the impact of PERCEPT's concepts and innovative methodology in reinforcing European science and technology could continue to be felt over the next two decades and beyond. The major practical impact can be expected in fields such as education, medicine, geosciences, human-machine interfacing, industrial design, market research and product evaluation.

AT A GLANCE

Official Title
Perceptual Consciousness Explication and Testing

Coordinator
Technische Universität Dresden (Germany)

Partners
- Johann Wolfgang Goethe Universität Frankfurt am Main (Germany)
- Rijksuniversiteit Groningen (The Netherlands)
- Universiteit van Amsterdam (The Netherlands)
- Danmarks Tekniske Universitet (Denmark)
- Eötvös Loránd Tudományegyetem (Hungary)
- Université de Nice Sophia Antipolis (France)

Further Information
Prof Boris Velichkovsky
Technische Universität Dresden
Chair of Engineering Psychology and Cognitive Ergonomics
Helmholtzstrasse 10
1069 Dresden
Germany
email: velich@psychomail.tu-dresden.de
fax: +49 0351 463 37741

Project cost
€ 1 900 274

EU funding
€ 1 799 906

Project reference
Contract No 043261 (NEST)

'View of Dresden' by Canaletto (1749) and the Attentional Landscape resulting from the perception of one observer.

A participant inspecting Canaletto's 'View of Dresden', while eye movements are recorded with the EyeLink eye tracker.

NEST
Pathfinder

UNDERSTANDING WHAT YOUR SKIN IS SAYING

SOMAPS

There is much more to our sensations of touch, temperature and pain than the simple responses created by single receptors on the surface of the body. The SOMAPS project will study how complex stimulation patterns on the skin are processed by the central nervous system and, just as importantly, how memories and emotions can affect the resulting perceptions. This enormously challenging research will have practical applications in psychology, medicine, virtual reality and the design of everyday products.

How are bodily sensations generated? Receptors in the skin are activated by a wide range of events, including contact with an external object and exposure to heat. The resulting signals are transmitted to neurons in the spinal cord and the brain, which process and integrate them, finally creating sensations such as touch, pressure, tickling and pain. Furthermore, what we sense of our body is often accompanied by an emotional overlay, which is influenced by memory and situational factors. Examples include fear, which may accompany pain when the source of the sensation is unfamiliar, and pleasure or relaxation at the touch of a loved one.

The triangle that links physical stimulus, brain activation and subjective experience is the target of SOMAPS. The project takes its name from the field of somaesthetics, which deals with sensations such as touch, temperature and pain. These are sensations that can be experienced over every part of the body's surface, as opposed to being localised in a sense organ, such as the eye. By developing models to link the corners of the triangle, the researchers hope to understand the three phenomena better than has previously been possible. Ultimately, they say, it should be viable to predict properties of the subjective experience directly from the applied stimulus.

Practical applications for the SOMAPS work could include: the design of user interfaces, feedback devices and virtual reality systems using touch or pain to supplement sound and vision; design of products; systems and training programmes to promote safe working conditions in hazardous environments; and the diagnosis and treatment of people with neurophysiological and neuropsychological problems. Both the equipment (stimulators) and the models that result from the project will be useful for these applications, and will form a strong platform for future research.

From body surface to brain…

SOMAPS comprises six partners from Germany, Denmark, the Netherlands and Spain. The team is made up of cognitive neuroscientists and

"People who have had a limb amputated may feel 'phantom' pain at a site that does not physically exist."

psychologists, physicists, computer scientists and engineers. As well as mathematical models, the project will develop novel measuring methods and laboratory devices for stimulating the body surface.

Brain imaging techniques, such as electroencephalography (EEG), magnetoencephalography, positron emission tomography and functional magnetic resonance imaging (fMRI), have revealed a lot about how the brain processes sensory input, especially vision. Much less advanced, however, are models that take into account touch and pain, as well as stimuli that vary with space and time; and furthermore, their relationship with memory and emotion, and how these aspects transfer to multidimensional, subjective space. SOMAPS will tackle all these issues.

The first task is to create machines to stimulate the receptors of the skin in spatial patterns that can also be varied in time. The project will work on multi-stimulus arrays (MSAs), including a mechanical device, a laser array powerful enough to produce pain, and a system that uses electric currents to stimulate nerves. The researchers will also develop a procedure for mapping the body surface using a three-dimensional scanner. They will then test the MSAs on real people, recording how they experience specific patterns of stimulation in terms of perception.

Next, the researchers will use fMRI and EEG to study the brain activity that results from somatic stimuli. This will require the development of experimental protocols for the use of the previously-developed MSAs, together with brain scanning techniques. The experiments, divided into four main tasks, will involve stimuli that vary in both space and time.

…and from brain activation to perception

At this point, the SOMAPS team will build mathematical models that can predict perceptions from spatio-temporal patterns of stimuli. They admit that this seems impossible, given the current state of knowledge, but believe that it can be achieved within the lifetime of the project. Even partial success will provide important advances in science and technology. The models will be built with artificial neural networks and tested using the experimental data acquired in the previous part of the project.

Other objectives of SOMAPS are the study of interactions between somatic and visual information, and of how memory as well as state of mind can alter perception. Memory and emotion are particularly important in the perception of pain, even to the extent that people who have had a limb amputated may feel 'phantom' pain at a site that does not physically exist.

The researchers plan to distinguish low-level physiological reactions (related directly to the stimulus) from high-level responses (influenced by state of mind and past experiences). Armed with this knowledge, medical scientists may be able to eliminate phantom pain and help people with nerve damage or disturbances in relation to body perception and body image. Feedback devices based on touch, and the design of anything that needs to be handled or sat on, are other practical applications. In fact, after SOMAPS, nothing is ever going to feel quite the same again.

AT A GLANCE

Official Title
Multilevel Systems Analysis and Modelling of Somatosensory, Memory, and Affective Maps of Body and Objects in Multidimensional Subjective Space

Coordinator
University of Mannheim,
Otto-Selz Institute (Germany)

Partners
- University of Mannheim, Otto-Selz Institute (Germany)
- University of Mannheim, Institute for Computational Medicine (Germany)
- University of Aalborg (Denmark)
- University of Twente (The Netherlands)
- Universidad Nacional de Educación a Distancia (Spain)
- Central Institute of Mental Health, Mannheim (Germany)

Further Information
Prof Rupert Hölzl
University of Mannheim
Laboratory for Clinical Psychophysiology Schools
68131 Mannheim
Germany
email: hoelzl@psychologie.uni-mannheim.de
fax: +49 621 181 2107

Project cost
€ 2 320 720

EU funding
€ 2 037 220

Project reference
Contract No 043432 (NEST)

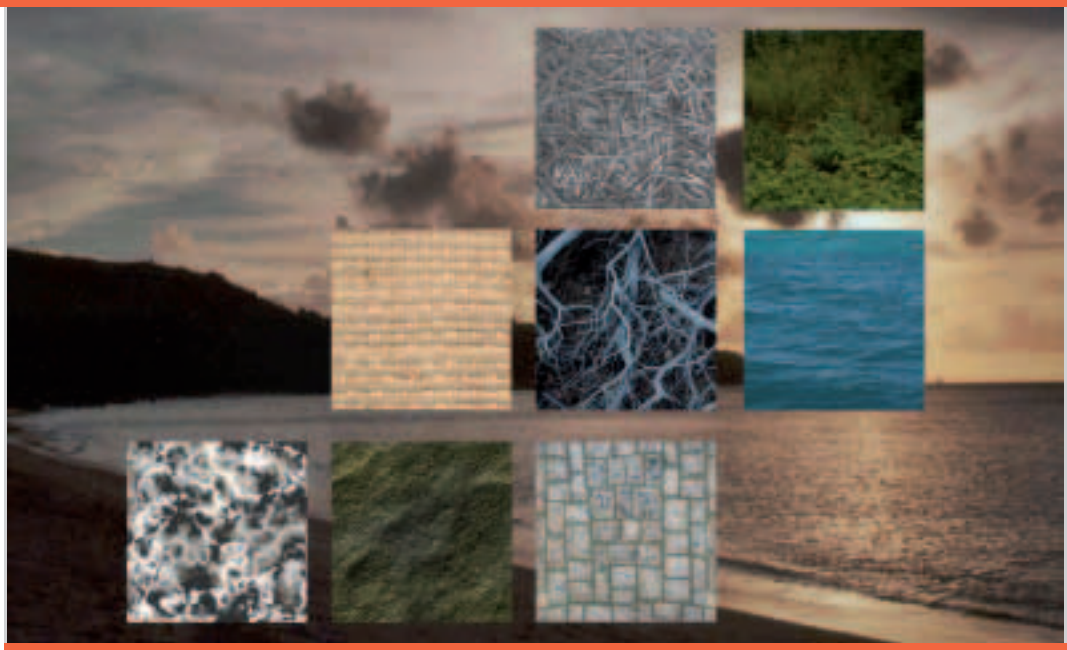
Physical domain: haptic objects and textures.

Cerebral maps by functional MR imaging.

NEST
Pathfinder

THE EMOTIONS OF TEXTURE

SYNTEX



We all know that stepping carelessly onto a wet marble floor might cause us to slip. The same way we know that running on grass in the park is safe; even if we fall we're unlikely to get hurt. Although we may not be aware of it, texture provides us with information that triggers certain emotional qualities and expectations. Knowing how to measure and control these would result in an untapped source of information.
One creative team of researchers dared to ask what this source might actually look like.

Texture is a part of our daily life – it's in nature and the designs all around us. It provides us with clues about the safety of our surroundings or the strength and quality of certain objects. We are able to recognise the texture of an object's surface simply by looking at it. This makes texture a significant part of the sensory input that we receive each day.

And it evokes emotional responses within us, just as a particular score of music might. Much of the research conducted in the past has focussed on the relationship of emotions to music, smell, colour and taste. We have since learned to use these to achieve certain effects, such as employing particular colours for therapeutic aims or tailored sound design for the use in cars.

Surprisingly, however, little research has ever been conducted on the emotional qualities and expectations associated with specific textures. In fact, SYNTAX is the only project to have ever attempted to measure, model and predict the psychological effects induced by texture.

Its proposed outcome will open the gates to a new tool at the disposal of any adventurous mind. Applying the information could, for example, alter the design of surfaces on and in buildings, consumer products and even the interfaces of software and web pages in the virtual world.

Beyond the surface

The ability to understand and, ultimately, control the sensory inputs we receive through texture requires the collaboration, headed by Austria's Profactor GmbH, of a diverse group. The SYNTAX consortium, headed by Austria's Profactor GmbH, is represented by experts within the fields of psychology, neurophysiology, mathematics, machine vision and product design.

"If design is one way Europe distinguishes itself from its competitors, SYNTAX offers a technique in which to maintain its edge."

Since texture is used in different contexts, the consortium has confined the definition of texture to: visual, the colour pattern that we see when we look at a surface; and haptic, the 3-dimensional surface topography we recognise when we touch a surface.

The project is structured around three cycles of psychological and neurophysical experiments and the concurrent development of a computational model. Each cycle addresses specific steps in the modelling process: basic design, refinement and variation.

Using a model based on existing knowledge of texture perception, the consortium will identify the key mathematical gaps (instead of the gaps in psychological understanding) and create experiments to fill these gaps.

A tangible outcome

Generating a biologically plausible, computational model of the processes taking place when sensory input of textures is interpreted by humans is a challenging task. Two contradictory aspects need to be considered: achieving a more precise model of how the human brain works in this context, while keeping the model sufficiently simple to obtain a computational algorithm.

The modelling will use a new, mathematical approach and will need to incorporate fuzzy logic to accommodate the inherent fuzziness of emotions. When complete, it will be able to measure the extent to which a particular emotion is linked with a given texture in a particular subject.

A set of algorithms, associated with a prescribed set of emotions, will be produced to enable the synthesizing of artificial texture. Additionally, a set of 24 artificially-generated textures will be designed to bias the experience of 12 emotions (such as happiness, safety and aversion). And since texture perception differs between men and women, the project will also consider gender issues, as well as other contextual aspects.

Affective engineering

The project's objective to develop a new investigative method to assess human interpretation of textures will be able to be applied in subsequent research areas of human sensory and emotional processing.

In achieving its aims, SYNTAX will also contribute to the new and growing discipline of affective engineering, the study of relationships between physical features and their effects on people.

And, if design is one way Europe distinguishes itself from its competitors, SYNTAX offers a technique in which to maintain its edge. After all, the ability to understand and control the impact that texture has on our thinking, feeling and emotion can have an immeasurable effect on the way we design products in the most general sense in the future.

AT A GLANCE

Official Title
Measuring Feelings and Expectations Associated with Texture

Coordinator
Profactor GmbH (Austria)

Partners
- Rijksuniversiteit Groningen (The Netherlands)
- University of Leeds (United Kingdom)
- Fundación Prodintec (Spain)
- Johannes Kepler Universität Linz (Austria)
- University of Amsterdam (The Netherlands)
- Fundermax GmbH (Austria)

Further Information
Dr Christian Eitzinger
Profactor GmbH
Im Stadtgut A2
4407 Steyr-Gleink
Austria
email: christian.eitzinger@profactor.at
fax: +43 7252 885 101

Project cost
€ 2 416 643

EU funding
€ 1.8M

Project reference
Contract No 043157 (NEST)

Visual and haptic textures are all around us. They influence our feelings, expectations and emotions.

Functional magnetic resonance imaging is used to create a cognitive model of texture processing.

NEST
Pathfinder

IMPROVING INDOOR AIR AND QUALITY OF LIFE

SYSPAQ

The development of a fully integrated electronic system, able to determine human acceptability of air quality, is crucial to improving our living, working and travelling conditions. Improved ventilation and the reduction of complex smells from building and other materials are essential for the improvement of indoor air quality. SYSPAQ combines perception psychology and expertise in sensor and related technologies, to link chemical measurement directly to sensory perception. This will enable building materials suppliers and vehicle manufacturers to reduce odour emission levels at the design stage.

We spend 90% of our time indoors – either at home, at work or commuting between the two. Enhancing indoor air quality is crucial to improving our quality of life, resulting in increased comfort, fewer health problems and higher productivity. But current methods of controlling indoor air pollution are limited, and no viable method has yet been found to predict either the intensity or the quality of smells. There is therefore a strong need for an objective system that relates chemical effects directly to sensory perceptions.

Indoor air pollution is caused by human activities and by emissions from building materials, furnishings and equipment. Reducing the effect of such contamination demands low-polluting materials and more frequent air freshening. Yet the new European Energy Directive calls for substantial energy reductions that may well cut ventilation rates. Consequently, it is essential to develop less polluting materials for homes, offices and transport.

Currently, building and other materials producers only monitor a limited range of chemicals – and not those necessarily most relevant to air quality. Development of an innovative sensory system that measures smells as perceived by humans will be of great value to producers of building materials, furnishings and other equipment. Such a system could also contribute to the establishment of a labelling system for low air pollution products.

The judicious selection of interior materials is equally important for the transport industry; this system would make it possible to create high standards of air quality in cars, trains, boats and planes. And it would even allow for the creation of brand-specific odour impressions.

Sensory response

Three separate methods are used currently to quantify indoor air quality: human perception, chemical measurement and sensors for specific odours. Human perception is still considered better than chemical measurement because of our unmatched sensitivity to the many

"A particular challenge lies in discovering how to mimic the human perception of odours and air quality."

sources of indoor smells, with each source responsible for a range of odorous molecules. The problem lies in relating chemical measurements or sensor signals to our human sensory responses.

The SYSPAQ project is setting out to develop a highly innovative system that will measure indoor air quality as we perceive it, able to provide consistently the same indications as a human test panel. Results will include an indicator and a control device to measure air quality based on human perception modelling, combining sensor measurements and perceived air quality assessments.

SYSPAQ will build upon current knowledge of the perceptual effects of indoor air pollutants, and also on the experience gained from using chemical measurements and sensors for specific odours. It will enhance state-of-the-art sensor systems using nanotechnology and other innovative approaches, as well as develop perception methods and software tools for modelling human response. The elements will be integrated in a single innovative hardware/software system, which can measure perceived indoor air quality using a holistic approach.

The project's major challenges include:

- constructing an odour-perception framework based on different odour references that can be used in characterising perceived air quality of materials and products;
- developing a mathematical method for general odour characterisation and software implementation making use of the new odour framework;
- enhancing sensitivity and discrimination of sensor devices using laboratory tests with building and vehicle materials emissions down to threshold levels; and
- building a unique database to calibrate and prove the innovative measurement system, based on simultaneous assessments of perceived air quality, by both the system and also human panels.

Sharing wide expertise

The complex tasks involved require advanced knowledge in perception psychology, as well as technical excellence in sensor-system design and indoor environment research, knowledge and experience which the project partners will contribute.

This highly complex project involves the expertise of industrial and academic partners across Europe, including:

- sensor manufacturers, to develop an electronic measurement system with software that will analyse the input from hardware sensors;
- leading institutes in the development of test and calibration methods for perceived air quality;
- a psychophysics expert with extensive experience of human air quality perception;
- heating and ventilation companies, able to implement the results of the research in building and control systems;
- a carmaker keen to construct a persistent odour framework for its vehicles; and
- two university departments with long-standing expertise in chemical and perceived air quality measurement.

Taking such an approach will lead to innovative research, providing new insights into the human perception of air quality and brand-specific smells. SYSPAQ will develop a system capable of measuring and monitoring indoor air quality as we perceive it. And it will encourage the supply and demand for materials that improve the quality of our indoor environments, and thus our quality of life.

AT A GLANCE

Official Title
Innovative Sensor System for Measuring Perceived Air Quality and Brand Specific Odours

Coordinator
Technical University of Berlin (Germany)

Partners

- Danish Building Research Institute (Denmark)
- Technical University of Denmark (Denmark)
- Karolinska Institute (Sweden)
- Centre Scientifique et Technique du Bâtiment (France)
- Forschungszentrum Karlsruhe (Germany)
- Federal Institute for Materials Research and Testing (Germany)
- REGIENOV (France)
- Alpha MOS (France)
- Halton (Finland)

Further Information
Dr Birgit Müller
Technical University of Berlin
Institute for Energy Engineering;
Department for Heating and Airconditioning,
Hermann-Rietschel-Institute
Marchstr. 4
10587 Berlin
Germany
email: birgit.mueller@tu-berlin.de
fax: +49 30 314 21141

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