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Time patterns of emotional communication in children

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The aim of this study was to analyze the communication of emotions in preschool children, focusing on the development of competence in regulating emotional expression in an interactive context. The work developed through the discovery of temporal patterns, in accordance with the assumption that human behavior is a system characterized by sequential structures that cannot be identified by simple observation and are not detected by standard statistical analysis.

On a theoretical level, the study was influenced by dynamic systems theory [1], which focuses on the dynamic nature of behavior, and by situationist social psychology, founded by Kourt Lewin. According to the latter, behavior can be accurately explained and predicted as part of a situation embedded in a dynamic tension system [2]. Any behavior, including facial expression, should be explained in terms of the situation in which it is observed. Empirical support for the tension-system approach to facial expression comes from various sources, including studies of the development and regulation of the non-verbal expression of emotion [3,4,5,6,7].

Our general objective was to collate the results emerging from previous studies of non-verbal expression and communication of emotions among pre-school infants [3,8,9] by using an analytical method that allows the temporal dimension of behavior to be calculated. The Theme software enabled us to record and describe the temporal and sequential structure of a set of data by operating T-pattern detection in a process analysis [10]. The analysis was conducted using filmed sequences of the behavior of children (aged 3-5 years) observed in a laboratory situation under two different experimental conditions:

- success in a game against the experimenter (stranger)
- failure in a game against the experimenter (stranger)

The analysis was conducted over an interval of 30-120 s, during which time the children communicated their emotions to the experimenter. These were mapped onto a behavior grid according to FACS [11].

Our results show that there is a large number of temporal patterns under both sets of conditions. The number and frequency of these patterns demonstrate that emotional communication is highly synchronized: some patterns are repeated cyclically during the communication process. The age of the subjects and the hedonic connotation of the context emerge as significant factors in data variation: children regulate their behavior according to social context features.

The careful, empirical description of non-verbal behavior in emotional communication reveals a remarkable variety of behavioral units, variously combined to produce patterns. This finding suggests that true 'expressions' of emotion are the output of complex tension systems, according to the Lewinian standpoint. During periods of emotion, actual behavior is a complex and rapid succession of both gestures and facial, head and eye movements.

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A three-dimensional reconstruction and analysis system for mapping behavior-related gene expression in the brain

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Present concepts of the neural basis of behavior are based on ideas of concerted activity from many brain regions. Therefore, techniques for mapping the functional activity of the whole brain have become increasingly important in recent years. Patterns of inducible transcription factor expression and 2deoxyglucose utilization can provide rich information about alterations of neural activity during animal behavior and learning. Whilst such studies allow localization of even subtle behavior-induced changes, they have yielded primarily two-dimensional (2-D) results, showing patterns of activity within individual brain sections. Because of the complexity of brain topology, however, it is often impossible to evaluate activity patterns and the spatial relationship between different activated structures from a set of separate brain sections. Therefore, we have developed a computer-based system aimed at 3-D reconstruction of functional brain activity, as revealed by in situ hybridization neuromapping techniques, and its alignment to brain neuroanatomy. This system allows for several types of analysis, including: (1) comparison of functional activity patterns in several different brains or groups of brains; (2) comparison of 3-D brain activity patterns obtained by different mapping techniques; and (3) correlation of variations in animal behavior with activated brain structure patterns.

The software consists of: (1) a module for semi-automatic alignment of consecutive sections, creating a 3-D model from 2-D planes and thereby restoring the original shape and orientation of the brain prior to sectioning; (2) a graphic editor module, creating electronic 3-D brain atlases from standard animal brain histological sections; (3) a module for warping the 3-D reconstruction of mapped experimental data into the geometry of a standard 3-D brain atlas, with corrections for brain size, plane of sectioning, fixation and shrinkage artifacts; (4) a volume visualization module for rotating and viewing mapped data, either in different planar cuts with the 3-D model, or as semi-transparent images using volume-rendering techniques; (5) an image analysis module for quantifying 3-D patterns of brain activity. The entire activated neuronal population can thus be seen in a single image, and measurements made for particular brain areas. Via 3-D reconstructions, brain regions can be viewed from different angles and rotated on the computer screen, allowing insights into the pattern of behavior-activated brain structures, which is difficult to detect in series of individual brain sections.

The "mouse fitness centre": motor function analysis as part of the general health assessment for mice

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An assessment of the animals' general health status should precede any behavioral testing of transgenic or knockout mice. Using a series of test systems, we routinely perform a pre-screening on gross behavioral abnormalities. Such behavioral deficits must be detected to allow an interpretation of test results obtained with e.g. cognition tests. Only healthy animals will be able to meet the physical requirements of many standard behavioral tests. If they prove unable to meet these requirements, special cognition tasks must be selected which do not depend upon the compromised sensory and/or motor functions.

One of the first general health assessment routines (Irwin 1968) evaluated the response of mice to psychoactive drugs. It can also be used to assess the general health of mice and includes, among others, body positon, bizarre behaviors, transfer arousal, locomotor activity and respiration rate. Another test battery, the SHIRPA protocol, is subdivided into three levels of observation. This protocol consists of preliminary observations, such as sensory and muscle functions, autonomic functions, lower motor neuron functions, exploratory behavior, histology, biochemistry and physiological measurements. Taken together, these tests provide a very detailed picture of the animals' general health status.

To allow a quick and simple assessment of one important general health factor, namely motor functions, we developed a multi-task testing apparatus called the "mouse fitness centre". Intact motor functions are a prerequisite for the execution of more complex behaviors. Therefore, the motor abilities of mutant animals should be measured before additional, more sophisticated tests are performed. The fitness centre consists of eight tests (vertical pole, placing response, footprint pattern, horizontal wire, gimp, grip strength, inclined grid and upside-down grid), allowing checks for several gross behavioral dysfunctions. The test apparatus is installed on the so-called 'basis', allowing the mice to perform all motor tests in a row. In this way, testing is less time-consuming and less stressful for the animals. Furthermore, all necessary adaptations of the apparatus for the next test are guided by the basis and defined in a standard protocol, which must be strictly applied. The tests are run in close succession: modifications of the test apparatus mean that pauses between tests are reduced to a minimum. This system has been developed to help realise the idea of a standardized testing system.

Automatic recognition of different cognitive strategies in the Morris water maze

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The Morris water maze (MWM) is the most frequently used apparatus in behavioral neuroscience. In rodents, its application ranges from learning and memory studies to molecular, genetic and focal lesion studies, often combined with each other. Despite its widespread use, we still lack a methodology to analyse rodents' cognitive performance in the MWM. Until now, in fact, the great majority of behavioral analyses relied on escape latency as the main indicator of a complex spatial strategy. Although latency correlates with an improved performance in the MWM, it is not an accurate measure of cognitive performance because the same escape latency could result from very different spatial strategies.

In the last decade, technological advances have allowed us to track rodents' swim paths and record their spatial and temporal coordinates. Many quantitative variables and different parameters can now be extracted to describe the complex MWM behavior more accurately than latency does, but because they oversimplify the animal's strategy, they do not represent the complexity of the actual behavior. More recently, a new computing approach has shown that complex behaviors are better described by using many parameters at the same time. This method involves a factor analysis of different quantitative variables. It allows hypothetical variables (so-called 'factors') associated with characteristic swim paths to be identified, such as thigmotaxis, extended or restricted search. However, being mainly a descriptive tool, even this 'bottom-up' method has a limited discrimination power among the numerous behaviors observed in the MWM.

To overcome these limitations, we implemented a 'top-down' method to categorize rodents' swim paths by combining a tracking system (EthoVision) with the statistical method of Discriminant Analysis. We defined the following regions of interest (ROIs): a circular zone around the platform ('critical zone'), an outer annulus ('periphery'), and the total arena. All the measures included in the analysis were related to these ROIs. According to the above definitions, we first classified 1,061 swim paths, performed by 37 rats in the same MWM paradigm, into eight distinct categories: thigmotaxis, peripheral-circular search strategy, peripheral-jagged search strategy, extended or brief-extended search strategies, first-orientation-then-reach search strategy, approach targeting, and direct finding of

the platform. We then extracted 28 dependent variables and performed a Discriminant Analysis to obtain a Classification Function (CF). By means of the CF, we obtained 97.7% correct automatic recognition. Furthermore, when the Discriminant Analysis was restricted to only two categories at a time, we reached 100% correct classification, no matter which categories were analysed. The CF also allowed us to classify newly recorded paths with the same statistical efficacy.

Naturally, the eight categories codified are not the only ones required to classify a complex MWM behavior – but this system is flexible enough to recognize any *a priori* defined swimming behavior, regardless of the starting point and platform position. In conclusion, this new methodology produces an automatic 'gestaltic' evaluation of different explorative searching strategies. A new genesis has begun in the study of cognitive strategies of rodents in the Morris water maze.

Replicability issues in the analysis of open field behavior of inbred mouse strains over three laboratories

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Conventional tests used for behavioral phenotyping frequently have difficulties differentiating certain genotypes and replicating these differences in other laboratories. We argue that some inter-laboratory differences are unavoidable, and that this should be reflected in the statistical analysis of results from such experiments by using mixed models, rather than the conventional fixed factors ANOVA. Further limitations should be imposed on the interpretation of analytical results by controlling the False Discovery Rate (FDR) – a new approach to the problem of multiple comparisons.

We demonstrate this double-headed strategy in the multiple endpoint analysis of open field behavior of inbred mouse strains over three laboratories using SEE (Software for the Exploration of Exploration). Strain differences are evident, even though taking the mixed models approach and addressing multiplicity present higher demands on the discriminatory power. These higher demands greatly enhance the replicability of the strain differences discovered.

A behavioral assay for endocrine disrupting compounds (EDCs) based on avian calling patterns

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A number of environmental chemicals are estrogenic or androgenic, acting through synergistic interaction with the steroid-receptor complex. Until now, assays for these environmental signals have been based largely on transgenic expression systems, such as the yeast estrogen system. Here, we investigate the possibility that synergistic low dose exposure to environmental chemicals interfering with steroid-associated responses may be detectable by transient activational effects on steroid-dependent calling behavior during early development in the precocial avian model.

Dietary and systemic applications of a number of steroids reorganize the synaptic connectivities of neurons within the intercollicular area in galliform birds. These neurons seem to control the expression of at least two distinct types of calls: one isolation-induced juvenile calling pattern (distress calls), and one typically adult and male expression (crowing). After hatching, exposure of chicks to androgenic steroids leads to a sonographically clear transition from distress-calling to crowing within hours. The change in the time-frequency pattern of single calls becomes associated with a modified pattern of inter-call intervals – that is, there are previously undetected modifications in the temporal evolution of single events.

Here, we show how to register the temporal pattern of single calls by extracting event-tuning curves from real-time sonographic records. Changes in the timeresolved calling patterns, available from the evolution of call-tuning curves, seem to be highly sensitive to the onset of steroid-dependent reorganization of callcontrol areas. In fact, this type of time-resolved vocal analysis can signal effects that are below 'threshold' for time-frequency changes of single calls, and may be suitable for assaying the long-term action of low dose combinations of certain environmental chemicals. At the scale of behavioral motoric expressions, the present methods reflect similar aspects that have been found by introducing temporal aspects into the study of neural coding principles at the scale of single brain cell activities.

The visual interface for the NITE workbench: a tool for annotating natural interactivity and multimodal data

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NITE (Natural Interactivity Tools Engineering) is a European HLT (Human Language Technologies) project which aims to develop a workbench, or an integrated toolset, for annotating and analysing natural interactive communicative behavior between humans, as well as between humans and machines (systems). NITE began its work in April 2001 and has a duration of two years. The NITE project partners are: NISLab (Odense, Denmark), DFE (Barcelona, Spain), DFKI (Saarbrücken, Germany), HCRC (Edinburgh, UK), ILC (Pisa, Italy), IMS (Stuttgart, Germany) and Noldus (Wageningen, The Netherlands).

The vision of natural interactivity is that of enabling systems to exchange information with humans in the same ways in which humans exchange information with one another, i.e. through speech, facial expression (including lip movements and gaze), hand and arm gesture, bodily posture and (to a limited extent) touch. Moreover, extending their use of gesture, humans exchange information through creating and manipulating objects, including objects which themselves represent information, such as images or written text. The natural interactivity vision comes with two claims: (1) that the ease and intuitiveness of human-human-system interaction could be improved tremendously through natural interaction, and (2) that pursuing natural interactivity will lead to completely new families of applications which cannot be realised through traditional graphical user interfaces with a screen, mouse and keyboard.

This talk will present the NITE consortium's analysis of present user needs for a natural interactivity coding tool, and then proceed to present and illustrate the state of ongoing work on the tool's user interface for standard users. The work is based on the following high-level interface specification. The tool should:

- support working with annotation projects, including meta-data handling;
- enable flexible control of raw data files (audio and/or video);
- support annotation of natural interactive communication at any analytical level and across levels/modalities through an existing or new coding scheme;
- enable users to specify new coding schemes, either by editing existing coding schemes or by adding one from scratch;
- enable information extraction and analysis of annotated data.

Phenotypic characterization of transgenic mice: choosing the right test battery

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The serotonin (5-HT)1A receptor is associated with a wide range of behavioral and physiological effects, including anxiety-related behavior, 5-HT syndrome, depression, aggression, thermoregulation and food intake. Additionally, learning and memory might also be regulated by this receptor. Knockout studies have confirmed the significance of the 5-HT1A receptor for anxiety-related behavior and depression. To further elucidate the role of this receptor subtype, an inverse approach has been used by generating transgenic mice overexpressing the 5-HT1A receptor.

To study the phenotype of these mice, we chose a test battery that allowed us to assess the main physiological and behavioral paradigms. To evaluate general health, we measured weight gain, body temperature and food intake of homozygous, heterozygous and wildtype mice. Motor functions and exploratory behavior were investigated using the open field and hole board. In addition, home cage activity was controlled. The Morris water maze task was used to assess learning and memory abilities, and the elevated plus maze to investigate emotional behavior.

The homozygous mice differed from the wildtype mice in many of the conducted tests and physiological paradigms. They gained more weight with a simultaneously lower food intake, and showed a lower body temperature. There were no differences in locomomotor activity investigated in a new environment (i.e. the open field and hole board), but in the home cage transgenic mice showed reduced activity. Learning and memory ability were impaired in homozygous mice compared to wildtype mice. Finally, in the elevated plus maze test, homozygous mice demonstrated a decreased level of anxiety-related behavior.

Overall, mice overexpressing the 5-HT1A receptor show behavioral and physiological changes, highlighting the involvement of 5-HT1A receptors in a number of CNS-dependent functions. Furthermore, our data endorse the view that a battery of observational tests and physiological measurements is capable of distinguishing subtle variations in the phenotype of transgenic mice.

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Captive bred cheetah behavior: a study of an ex-situ conservation program

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Cheetahs are well known as the most difficult felid to breed in captivity. There are three theories to explain the cheetah's breeding problem: (1) cheetah populations have gone through a bottleneck period; (2) most sperm are non-functional; (3) captive animals are unable to display the full range of behavior seen in the wild. This project aimed to investigate the behavior of captive cheetahs and evaluate management quality by studying their enclosure, the distance between playing cubs and their mother, vocalisations, behavioral patterns and similarities to in-situ behavior, to determine how to improve the captive population's status.

In 1999, one year after cheetah husbandry was re-established, eight cubs were born at Marwell Zoo (England) to a female born in 1992 and a male born in 1990. The female's enclosure was classified into eight zones, according to the microhabitats available, while the male's was simply divided on a geometrical basis. Between 08:00-17:30, we made ad libitum observations of both the female and her cubs at three-minute intervals, using instantaneous sampling for the female and one-zero sampling for the cubs (see [1]), for a total of 84 h. Using focal sampling, the male was observed twice per day (11:30-12:30 and 15:00-17:00) for a total of 35 h. Ad libitum sampling is seldom used, but it was the only method that allowed us to record a complete pattern of behaviors during the day. Night observations were conducted to study the use of available dens.

During the observation period, the cubs were still being nursed by their mother, but they also made their first contact with solid food (mostly during play). The cubs played among themselves and with their mother, and were observed to use tools while playing -a previously unrecorded phenomenon. The complex structure of their enclosure ensured that their use of it was satisfactory, and there was no indication of any stress caused by zoo visitors. Mobbing (a behavior typically displayed between wild cheetahs and their prey, but never before seen in captivity) was often recorded late in the evening between the cheetahs and their neighbours, sable antelopes, which presumably represented a source of behavioral enrichment. Conversely, the behavior of the male (which was located in a temporary enclosure) appeared to be of a poorer quality, characterised by signs of distress and incomplete use of the enclosure.

The new management plan adopted by Marwell Zoo is an adaptation of the 'six steps' husbandry developed in the U.S.A. It is rarely applied in European zoos, but at Marwell it has already led to the birth of a record number of cubs and markedly improved the behavior of these animals, and at minimal economic cost.

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The modified hole board as a large-scale screen for cognitive alterations

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To understand the influence of a genetic or pharmacological interference on a complex organism, reliable phenotyping methods are of great importance. Therefore, it is necessary to develop dependable behavioral tests that enable us to obtain a differential, and thus a reliable image of the phenotype of an animal.

The modified hole board (mHb) represents a large-scale screening method that allows the reliable investigation and differentiation of a wide variety of behavioral dimensions (e.g. anxiety, arousal, social affinity, exploration and activity) and their interaction in one test. As previous studies have shown, the mHb reveals a realistic and complex overall view of an animal's behavioral phenotype, thus representing a highly useful tool in screening for novel animal models. Since many psychiatric disorders are accompanied by cognitive dysfunctions, it would also be valuable to be able to identify cognitive alterations in the mHb.

Hence, we integrated an object recognition test into the experimental set-up. The object recognition task is mediated primarily by the perirhinal cortex, and it is known that patients suffering from Alzheimer's disease or amnesia are impaired in recognizing objects when compared to controls. To investigate the reliability of the assessment of cognitive performance in the mHb, three mouse strains (C57BL/6, DBA/2 and C3H) were first phenotyped using the mHb test and then tested in a standardized object recognition test in a novel home cage. Next, we tested the same mouse strains in a complex visuo-spatial version of the mHb to evaluate cognitive processes, such as working memory and declarative memory, which differ from those displayed in the object recognition task.

Our results with these three strains of mice showed that the cognitive diversities in recognizing objects observed in the phenotyping screen were reproduced in the selective object recognition test, but that no matching outcomes could be found in the visuo-spatial task. In summary, we show that the mHb could well be used as a reliable large-scale screen for specific cognitive alterations.

Measuring stress in the mental activity of shiftworkers

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The purpose of this study was to reveal the peculiarities of subjective and objective measurements of stress in the mental activity of shiftworkers. The study subjects were electricity distribution network controllers, whose work is characterised by having to deal with many unpredictable situations that may affect their ability to provide a continuous supply of electricity for consumers.

In total, 17 controllers were examined, all of whom worked 12-hour shifts under a two-day shift rotation. Over a three-week period, the following variables were measured in controllers at two-hour intervals during their working shifts: systolic and diastolic blood pressure, and heart rate. A total of 1,224 subject observations was acquired. Haemodynamic parameters, including age and anthropometric data, were calculated for each observation [1,2], and measurements of short-term memory [3] and attention [4] were acquired at the beginning and end of each shift. At the end of every shift, subjects were asked to estimate the level of stress they perceived that they had experienced over that shift using a 5-point scale, where 1 represented very low stress and 5 very high stress.

All parameters studied were recalculated as a percentage of the overall mean, owing to the individual nature of the data. ANOVA and MANOVA were performed, and Pillai's criterion was used to test the significance of any effect of stress on the parameters studied. Diastolic blood pressure and attention were shown to be the most sensitive to stress. The effect of stress on cognitive performance and the cardiovascular system was most pronounced during the first day shift, and less pronounced during the first night shift. It was suppressed during the second consecutive shift. It was also shown that subjective stress evaluation does not accurately reflect the psychophysiological body response, and hence should not be treated as a sufficient measure of stress on its own.

In conclusion, this complex approach to measuring stress can be recommended, using both subjective scores and psychophysiological measurements, as well as accompanying information (e.g. the type of shift) and complex computer-based data processing.

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Observational measurement and sequential analysis of the effects of naltrexone on the social mediation of self-injurious behavior

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Most research on drug treatment of human behavioral disorders involves only measurement of changes in behavioral rate or severity. The outcomes of analyses based solely on these changes do not permit an analysis of the actions of drugs on the environmental variables that may be exerting control on the target behavior of interest. Thus, little is known about the behavioral mechanisms of actions of psychotropic drugs. Accumulated evidence suggests that biological (e.g. opioid peptides) and environmental (e.g. social interaction) variables influence selfinjurious behavior (SIB), a common form of behavioral disorder in persons with neurodevelopmental disorders. To date, however, no studies have examined directly whether pharmacological treatment alters the environmental mediation of self-injury.

In this study, the sequential dependency between staff behavior and self-injury was examined during naltrexone and placebo treatment conditions in a sample of 10 adults with severe self-injury secondary to neurodevelopmental disorders. For all subjects, naltrexone effects were examined in the context of an ABAB placebo, double-blind design. During each phase, we directly observed each subject two to three times per day in fifteen-minute sessions for a mean total of 136 fifteen-minute sessions per subject (range: 130-142), or approximately 34 hours per subject (range: 33.0-35.5). Direct observational data were collected in real time by trained observers using hand-held microcomputers (Psion HC3As). The Observer and MOOSES software packages were used for downloading and analysing data on a Dell PC.

Subject and staff behavioral data were analyzed for frequency and duration, interobserver agreement and sequential dependencies. For sequential analysis, sequential dependencies were analyzed as either event- or time-based. The sequential analysis option on MOOSES is designed to calculate sequential dependencies between identified antecedent and target events. The analysis allows the counting of occurrences of a single or combined behavior code, designated as the target, within a time window or event lag from another selected code (i.e. the 'given' or antecedent). The event-based method counts the number of times codes follow other codes at discrete event steps or lags. The time-based method tallies the frequency with which codes follow other codes within designated intervals of time. In general, this analysis procedure determines whether the probability that one event or behavior leads to another is significantly different from that expected by chance. Conditional probabilities, Allison-Liker Z scores and Yule's Q were computed for the resulting frequency tables for each analysis.

Naltrexone-related reductions (>33%) in the daily rate of SIB were observed for 50% of the subjects. For the subjects who displayed a positive response to naltrexone, the magnitude of the sequential dependency between staff behavior and subject self-injury was significantly greater during treatment with naltrexone than during placebo. These results are discussed in relation to the utility of observational research methods for determining potential behavioral mechanisms of action-regulating medication effects for behavioral disorders.

On the use of video-microscopy for the analysis of protist feeding behavior

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High-resolution video-microscopy was used to investigate the feeding, digestion and selection behavior of different heterotrophic protists (single-cell eukaryotic organisms). Behavioral observations in protists are complicated for two reasons: their small size (5-100 microns) and the lack of comparative data sets. A high resolution video-microscope system was used for observation (Figure 2). This allows the study of interactions between bacteria and protists. However, the method is limited when studying fast moving organisms. As no expedient comparable data sets are available, the feeding process was divided into feeding phases based on typical behavioral elements (e.g. flagella movements, formation of food vacuoles, etc.; Figure 1).

The mechanisms of food selection were the focus of the study. Food selectivity of heterotrophic nanoflagellates can be subdivided into: (1) passive food selection (contact probability and morphological properties of the feeding structures are responsible for a particle-specific response); and (2) active food selection (flagellates may actively select food during food uptake). These experiments revealed a high variability between species, and also high intraspecific variability. Advantages and disadvantages of the technique will be discussed. These include photochemical effects, experimental artifacts and the general suitability of the method for investigating behavioral patterns in microbial populations.



Figure 1. Feeding steps of a flagellate.



Figure 2. Experimental set-up and observation chamber.

Using electronic musical instrument design techniques for measuring behavior

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Introduction

Musical instruments have a long history of development as the most sensitive artefacts for human expression. Electronic musical instruments, developed in the last century, are no exception. In the field of the electronic arts, examples can be found of human interfaces that are extremely sensitive and precise, enabling the artist to have profound and intimate control over the complex processes inside the computer. These instruments and interaction technologies can be used for measuring human behaviour in fields other than the electronic arts. To measure human behaviour, there are three broad categories of relevant machine factors:

- *Machine input or sensing technologies:* sensors are the sense organs of the machine, and are necessary for any measurement in the real world. In electronic musical instruments, very sensitive sensors can be applied with many parallel and multiple degrees of freedom.
- Software processing, interpretation and logging of the machine input, and response preparation and generation: the timing criteria for psychometric experiments are similar to real-time composition and music generation software, such as the Max/MSP programming environment. This is a visual language that is very easy to learn and understand, yet is vast in its possibilities and has built-in functionality for the generation of audio and video.
- Machine output, particularly haptic feedback technologies: it is a central issue for the electronic arts to use computers to generate sounds and (moving) images. However, considerable research has also been conducted on tactile and force feedback, after it was realised that this important element of information the haptic articulatory feedback present in mechanical artefacts was missing in electronic instruments.

In this presentation, I will give some examples ranging from interactive architecture to electronic musical instruments I have developed with pioneers in the field, such as Laetitia Sonami ("The Lady's Glove"; Figure 1), Michel Waisvisz ("The Hands"; Figure 2) and Sensorband's "Soundnet" (Figure 3). I will also describe the structured design approach, as applied in a recent project to produce an instrument for the live performance of audio and visual material ("The Video-Organ").

Crossover

During the talk, some examples will be given of how technologies and techniques from the electronic arts field may be used in psychometric experiments:

Investigating the parallel use of the sense of touch in multimodal human-computer interaction: a research project I carried out at the UCL and Birkbeck Colleges of the University of London. An experiment was designed and performed using (in addition to standard loudspeakers and screens): purpose built switch units, a tactile feedback device, and the Max/MSP software (to generate the auditory, visual and haptic stimuli, in random and structured order, as well as measuring and logging the response times).

The occurrence of a central processing bottleneck in human cognition when carrying out a multimodal task was investigated through the measurement of the PRP-effect (Psychological Refractory Period, referring to the measurable slowing of responses under certain conditions). The set-up allowed for programming all the conditions, and was used to reproduce a classic experiment involving auditory and visual stimuli (with manual responses required), to test the precision and reliability of the set up. It was then used to carry out a new experiment, involving a dual task consisting of haptic and visual stimuli (and manual responses).

Threshold levels of tactual sensitivity of motion-impaired computer users: research I carried out at the Engineering Design Centre and the Computer Laboratory at the University of Cambridge. In these experiments, purpose-built tactile feedback devices were used to enhance the input device (a computer mouse); the threshold levels of tactile perception of the subjects were inferred from their responses. The Max/MSP software was used to generate the stimuli, and to log the responses. The experiments were carried out as a step towards the design of virtual textures, investigating what the design parameters of these textures would be.

The physical instrument design space: a research project I started at the Philips Research Labs and the Institute for Perception Research (IPO) in Eindhoven, and further developed at Cambridge University. The model is still under development at the Metronom Electronic Arts Studio in Barcelona. It describes computer interfaces at the level of physical interaction, based on the following:

- description of both input and output (the haptic feedback), using the interface as a two way device
- breaking up the functions of the device into separate sensors and actuators
- describing each of these elements along the dimensions of the design space
- the design space consists of degrees of freedom, range and precision

Conclusion

The general point made in this presentation is to emphasize the importance of cross-disciplinary communication through the mutual exchange of knowledge and resources. Some examples are given on the level of technology and physical interaction aspects, and there are also cases involving cognitive issues. For instance, when investigating human behaviour in multi-tasking situations, there are several studies involving musicians carrying out tasks in other modalities while playing their instruments.

The field of electronic performance arts uses knowledge, techniques and technologies from many other disciplines, such as virtual reality research, the games industry, and indeed the field of measuring human behaviour. By the same token, the field of measuring behaviour can benefit from findings in the field of interface development in the electronic arts. The purpose of this presentation is to further facilitate and encourage this discourse between the disciplines by providing mutual inspiration. See also our company web site: www.cycling74.com

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Figure 1 (top left). Laetitia Sonami's "Lady's Glove" (1994). Figure 2 (top right). One of Michel Waisvisz's "Hands" (1991). Figure 3 (bottom). The Sensorband on the "Soundnet" (1998).

Using telemetry to measure stress-induced hyperthermia in metabotropic glutamate receptor 5 knockout mice

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Stress-induced hyperthermia (SIH) in mice is sensitive to anxiolytic properties of drugs. In this paradigm, stress causes a mild increase in body temperature that can be blocked by anxiolytic drugs [1]. Recently, the selective and systemically active antagonist for the metabotropic glutamate receptor 5 (mGluR5), MPEP (2-methyl-6-(phenylethynyl)pyridine), was reported to produce anxiolytic-like activity in a number of rodent models of anxiety, including stress-induced hyperthermia in mice [2]. It is often suggested that genetically modified mice lacking a particular receptor may provide a useful tool for predicting the effects of compounds that act at that receptor.

We tested this hypothesis for the mGluR5 receptor by examining mice genetically modified to lack the mGluR5 receptor (mGlur5-KO) in several variations of the SIH procedure. We employed classical SIH, using rectal measurement of body temperature, and radiotelemetric measurement of body temperature, in response to saline injection or the introduction of an intruder into the home cage (Data Sciences International mouse temperature and physical activity telemetry units model #TA10TA-F20, Dataquest A.R.T.; St. Paul, MN). The mGluR5-KO mice displayed a significant attenuation of the hyperthermic response to stress compared to wild-type (WT) controls.

That the mGluR5-KO mice displayed this anxiolytic-like phenotype suggests that mGluR5 antagonists may be useful in the treatment of anxiety. Furthermore, these findings parallel the effects of MPEP on SIH and add support to the notion that knockout animals may be useful tools for predicting the effects of antagonists.

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Analysis of rodent ultrasonic vocalizations using the TDT system II

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While the analysis of human speech and birdsong is very advanced, that of rodent ultrasonic vocalizations (UVs) is more primitive because researchers cannot detect ultrasound without specialized equipment. The ultrasonic vocalizations emitted by rodents are signals in which the primary frequency lies above the audible range of humans (typically between 20 and 130 kHz). Bat detectors have been used to visualize and count UVs, but a more advanced system is required for analyzing rodent UVs into 'syllables', 'words' and 'phrases'.

We have developed a system that uses the Tucker-Davis Technologies (TDT) System II for recording, storing and analyzing ultrasonic vocalizations. Ultrasounds emitted by mice and rats are detected and transduced to electronic signals by an ultrasonic microphone. A 20 kHz high-pass filter is used to remove frequencies below 20 kHz. The filtered signals are converted to a digital signal using a TDT Analog-to-Digital module. The digitized signal is recorded to a computer hard drive and Fast Fourier Transforms are performed on each pulse by the System 2 to provide frequency data. The recorded data is analyzed in LabVIEW to determine pulse length, pulse frequency, and the number of vocalizations within a 1-5 minute test period. Means, medians and standard deviations are calculated for both the vocalization length in ms and the frequency in kHz.

The recording process is controlled using software written in Visual C++. Using this system, each ultrasound is counted, categorized by frequency and stored. The signals can then be edited and played back using a TDT digital-to-analog module. We can examine the ultrasonic vocalizations of rodents and compare the effects of age, sex, species and experimental treatment on different parameters of UVs, and then play them to other animals to determine their responses to whole and edited vocalizations. This system will allow us to advance the study of rodent ultrasonic vocalizations in new ways that are not possible using bat detectors.

Evaluating three versions of the Barnes maze for mice: some problems in developing a test of spatial learning

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The Barnes circular maze was designed to test spatial learning in rats, but has been adapted for mice [1]. There are strain differences in the speed at which mice learn this maze, and many mice do not seem to learn a spatial strategy for finding the escape hole. Because this maze has a wall, facilitating thigmotaxic behavior, mice appear to use a serial search strategy. We examined the behavior of mice in the Pompl design and in two other designs of the Barnes maze: a Barnes design, with no circular wall around the perimeter, and a divided design, with a circular wall and dividers between each escape hole. The behavior of male CD-1 albino mice was examined in each maze during acquisition trials, reversal learning trials and a probe trial.

Very few mice used a spatial strategy in any of the mazes. In the Pompl design, mice began with a random search strategy and then switched to a serial search strategy in over 70% of trials. Spatial search was used in less than 10% of trials. In the Barnes design, a random search strategy was replaced by serial search patterns, but spatial searches were used in only about 20% of the trials. In the divided design, random search patterns were used throughout, with very few serial or spatial search patterns.

These results indicate that the design of the Barnes maze influences the learning strategy used by mice, and suggest that many mice do not develop a spatial learning strategy. We discuss possible solutions to this problem.

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Deflecting eels from water intakes with light

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Fish migrating downstream suffer mortality by passing through the turbines of hydroelectric power stations. There is currently high concern for the European eel *Anguilla anguilla*, a migratory catadromous species, because of the large decline in its population over recent decades. In Europe, mortality rates of migrating silver eels at hydropower stations may reach 40%. Eels are particularly sensitive to damage due to their large length. Other factors contributing to their mortality are the flow rate and the type of turbine.

In order to reduce this mortality substantially, KEMA has developed behavioral deflection methods based on light, to guide the eels through a safe bypass [1,2,3]. With respect to the development of a suitable light deflection method at water intakes, two behavioral characteristics of eel are very important. First, eels are negatively phototactic. They are nocturnal predators, and prefer to burrow in bottom sediment during the day. The downstream migration of silver eels takes place almost completely during the night [4]. Second, eels are strongly attracted to water currents. The preference of migrating eels for areas with the highest current might be a tactic to save energy, since the amount of active swimming is reduced and a shorter migration period is required to reach the sea [5].

During recent years, KEMA has performed a variety of laboratory and field experiments with light systems. Several light sources (incandescent, mercury, fluorescent and strobe lights) with different spectra heve been tested. Eels showed a clear avoidance reaction to light in laboratory flume experiments, and in field experiments at different locations. Deflection rates of up to 74% were reached at water intakes of thermal and hydropower stations. An essential feature to the efficiency of a light deflection system is a bypass facility with optimal attraction flow. Laboratory experiments indicated that eels are strongly attracted towards higher water velocities.

These results encourage the installation of light-induced deflection systems at hydropower stations to reduce eel mortality.

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Figure 1. Light barrier at hydropower water intake.

Mapping murine loci for physical dependence on ethanol

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The lifetime prevalence of alcohol abuse and alcoholism is 5-10% for men and 3-5% for women among U.S. and European adults. It is evident that there is a substantial genetic component to alcoholism predisposition, and that multiple genes, as well as environmental factors, influence this disease. In addition to the initial effects of ethanol, other factors that come into play with continued ethanol use can profoundly affect the pattern of use and the likelihood that it will, for some individuals, progress from casual use to alcoholism. Among these is the capacity of ethanol to produce physical dependence. When ethanol is eliminated, and as its depressant effects disappear, characteristic symptoms of hyperexcitability first wax and then wane. These include tremors, autonomic nervous system overactivity and, in extreme cases, convulsions. These withdrawal symptoms define a pre-existing state of physical dependence on the drug.

No animal model exactly duplicates clinically defined alcoholism, but many animal models for specific factors, such as the withdrawal syndrome, have been developed. Alcohol withdrawal convulsions occur in all species studied, including humans, and provide a quantitative index of the severity of withdrawal in mice. The well-documented difference in susceptibility to withdrawal after chronic ethanol exposure between the C57BL/6J and DBA/2J mouse strains provides an excellent starting point for dissecting genetic influences involved in physical dependence on ethanol. A quantitative trait locus (QTL) identifies the genomic location of a gene(s) affecting a trait of interest. Genome-wide QTL mapping studies have been carried out to dissect the multifactorial nature of withdrawal after chronic ethanol exposure, using recombinant inbred strains and F2 mice derived from the C57BL/6J and DBA/2J progenitor strains.

To induce physical dependence, we used a standard paradigm in which mice were exposed to ethanol vapor for 72 hours. The mice were then tested hourly for handling-induced convulsions (HICs) for 10 hours, and at hours 24 and 25. Ethanol withdrawal severity was first computed as the area under the 25-hour HIC curve. Separate regression residuals were then calculated to correct for individual differences in blood ethanol concentration at the time of withdrawal and baseline HIC severity (i.e. before ethanol exposure). Statistical mapping yielded significant evidence (P < 0.00005) for QTLs on chromosomes 19 and distal 1 which account for 45% of the genetic variance in ethanol withdrawal severity.

The results also provide supporting evidence for a sex-limited QTL on chromosome 13, and a QTL on proximal chromosome 1, which may account for an additional 30% of the genetic variance. The distal chromosome 1 QTL is a locus of major effect, and experiments using chromosome 1 congenic strains mapped this QTL more precisely. The QTLs map near candidate genes involved in neurosteroid biosynthesis and signal transduction. Syntenic homology between human and mouse chromosomes suggests that genes related to physical dependence on ethanol may localize to human chromosome regions 10q23-q26, 1q31-q43, 2q11-q32 and 5p15/5q14-q21.

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The Observer Video-Pro: a versatile tool for the collection and analysis of multimodal behavioral data

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The Observer is a professional tool for the collection, management, analysis and presentation of observational data. The user can record activities, postures, movements, positions, social interactions or any other aspect of behavior. The Observer can be used either for live scoring, or for scoring from analog or digital video material. With The Observer's generic configuration utility, detailed coding schemes can be designed for observing hand gestures, body postures, and facial expression.

Recently, we have noticed an increasing interest from researchers in the area of multimodality and speech annotation. We are in the process of extending our software to cater for the specific demands of researchers in this field, through our active collaboration in the EU-funded NITE project (Natural Interactivity Tools Engineering, http://nite.nis.sdu.dk/). At present, speech transcription involves free-format comments with time stamps. We are currently looking into options for XML export, and for allowing more structure for speech annotation.

The Observer 4.1, the latest release, will be demonstrated using a video of a group discussion. This video will be annotated for speech, gestures and facial expressions. Compared to previous editions, version 4.1 features improved usability, especially regarding the design of the coding scheme. Data selection has been completely redesigned to allow for complex filtering of annotation results. The Observer 4.1 has an intuitive new layout, showing projects and their content in a tree view.

Segmentation and behavioral classification of mice using digital video

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We present results for the automated classification of three types of mouse behavior on typical bedding material using digital video (30 frames per second). The uniformly coloured brown mouse we use has a smooth texture on this bedding material, so we perform texture segmentation [1] to distinguish the mouse from the background. The segmentation process involves convolution with a texture filter, followed by thresholding. Several steps of erosion are performed to remove the tail from the body, and then several iterative dilations are used to expand the segment to approximate its original contour. The tail is found using a line detection algorithm [2]. In Figure 1, we display a typical image of the mouse with its contour and tail superimposed.

We then perform a straightforward motion analysis to determine when the mouse is active or inactive. To identify grooming, we examine the contour's power spectrum to look for oscillatory activity. The power spectrum is based on a twosecond time interval and includes data from one second before and one second after the frame in question. If there is a peak in the power spectrum in the range of 5-10 Hz, the mouse is not elongated, and if the mouse is not active, then the behavior is classified as grooming.

We tested the algorithms on 564 seconds of data from a single mouse (roughly 17,000 images). Both the raters and algorithms classified each second of data into the three following categories: activity, inactivity and grooming. There was 87% agreement between the algorithms and the raters, and 93% agreement between the two human raters. We discuss the computational complexity of the algorithms have in finding the tail and the body under specific circumstances, and other possible behaviors that can be determined visually.

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Figure 1. A typical image with body contour and tail localized.

The impact of dolphin-watching boats on resident bottlenose dolphins *Tursiops truncatus* in the Sado Estuary, Portugal

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The bottlenose dolphins *Tursiops truncatus* resident in the Sado Estuary, Portugal, comprise a very small, declining population. Increasing levels of dolphin-watching activity in this area may be placing this population at high risk. To investigate the response of these dolphins to boats, this study monitored the respiration and behavior of dolphins in the presence and absence of boats from August to September 2000, during the peak season for dolphin-watching. Land-based observations were made using the focal group sampling method. A high number of recreational boats were observed near the dolphins, but tourist boats spent longer periods of time around them. Boat-dolphin encounters occurred mostly during weekends.

Using respiration parameters, our results indicate that, in the presence of boats, the dolphins spent significantly less time at the surface, made fewer exhalant blows, had shorter inter-blow intervals and made longer dives. Using behavioral parameters, the increase in tailslaps, alteration of activity, changes of orientation and changes within the group were also significant in the presence of boats. Interblow interval, dive duration and tailslapping were all significantly correlated with the number of boats.

These results suggest that this population seems to show avoidance behavior towards boats. The creation of specific regulations for tour boat operations in the Sado Estuary is thus indispensable for the conservation of these dolphins.
Developing a quantitative method for objectively evaluating the behavior of laying hens in furnished cages

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Next to production, physiology and health, behavior is an important characteristic to consider with respect to animal welfare when evaluating novel housing systems. Behavioral characteristics are usually measured by visual observation, which is time consuming and prone to human error. Automated surveillance, by means of cameras and image-processing techniques, has the ability to generate data providing an objective measure of behavior, without disturbing the animals.

The general purpose of this study is to develop an image-processing technique to quantify the behavior of laying hens. At present, the imaging system under development is able to identify three different postures (standing, laying and pecking), by analyzing contour plots of hens and then classifying these plots.

In a series of experiments, 642 images of a single hen in a furnished cage were analysed. A model-based segmentation technique (GVF Snake's) was used to calculate the contour of the laying hen automatically. A Fourier descriptor was used to represent the contour, which was visualized by Multi Dimensional Scaling techniques in a 2-D space. The postures of the laying hen (standing, laying and pecking) formed three clearly separate clusters, with an appropriate Kruskal stress of less than 0.1 in all cases. Using these techniques, it was possible to successfully cluster the 642 images in the database according to the hen's posture.

Relationships between novelty- versus d-amphetamineinduced behavior and brain c-fos expression in two inbred mouse strains: a functional systems analysis

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By comparing the neuronal bases of behavior between different inbred strains of mice, we can address the role of genes in development, neuroanatomy and the organization of complex behavioral functional systems. To start developing tools for such an integrative approach, we employed a relatively simple model in the present study. We compared behavior patterns and the distribution of c-Fos brain expression in C57Bl/6 and BALB/C mice in response to either amphetamine injection or a novel environment. Mouse activity was recorded in home cages with a video tracking system (VideoMot 2, TSE, Germany), and c-Fos expression was detected by immunohistochemistry on brain sections. For a novely session, mice were transferred into a new cage with transparent walls and new bedding.

Analysis of the distance travelled by mice revealed a significant increase in locomotor activity in both strains when compared to saline control groups. Amphetamine increased the distance travelled significantly more in C57Bl than in BALB/C mice. A significant difference between novelty and amphetamine groups was observed in C57Bl, but not in BALB/C mice. Analyses of the natural structure and pattern of mouse tracks, using existing approaches [1,2] and methods developed in our laboratory [3], revealed significant differences in locomotor behavior between novelty and amphetamine groups in both strains of mice. Studying c-Fos expression revealed significantly larger number of c-Fospositive cells in the secondary motor cortex of C57Bl mice injected with amphetamine than in BALB/C mice. Novelty produced a significant increase in c-Fos expression in BALB/C, but not in C57Bl mice. Analyses of correlations between patterns of behavior and c-Fos expression will be presented.

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Non-verbal communication of emotions: analysis of behavioral patterns in children

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The question of whether gestures and body movements are indicative of the quality of emotions, as well as the quantity (intensity), is a matter of debate. This study represents an attempt to shed some light on the importance of gestures, body movements and posture in communicating four specific emotions: happiness, sadness, shame and anger. It consists of observations of 80 children (40 males and 40 females), 7-10 years old, during a task in which they have to communicate emotions using non-verbal channels.

On a theoretical level, our study arises from the behavioral ecology perspective [1,2], which underlines the communicative function of emotional expression, and from the development of emotional competence theory [3]. On an empirical level, this research is a tentative attempt to overcome some of the methodological limitations of previous studies concerning the non-verbal expression of emotion in adults. Most of these have studied facial expressions alone [4], because body movements were considered only to provide information regarding the intensity of emotions. Moreover, the main approach was the decoding method [5,6,7], applied only to adult subjects [8,9]. To avoid such problems, we decided to use a 'scenario approach' [9,10,11,12] in which subjects are provided with vignettes or short scenarios describing an emotion-eliciting situation. They are instructed to imagine these scenarios and then act as if they were in such a situation.

Our general objective is to check the existence of patterns of body movements and gestures related to the four emotions considered in the present study. This objective has been prompted using the software Theme, a program that allows the temporal dimensions of behavior to be calculated [13]. During the experiment, every child read stories conferring different emotions. Their attempts to communicate these emotions using only non-verbal channels were recorded. All recordings were analysed using a movements and gestures grid, according to behavioral units based on other studies [9,14,15,16].

Our results show that children use a variety of T-patterns to communicate their emotions. Moreover, these T-patterns confirm outcomes obtained with adult subjects. Thus, this work allows us to go beyond paradigms describing the face as

the preferential channel for communicating emotions, and promotes the observation of interactions between facial expression and body movements.

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Understanding and supporting design team practice

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There is a large gap between the academic theory of design team activity and the reality of design team behavior in the work place. Theories propose that there should be systematic processes, structured (and even formal) representations, and well-specified techniques [1]. In real life, however, the design community has shown that crafts and creativity are needed just as much as academic knowledge.

Until recently, the authors of this paper were on the academic side, developing a design approach (DUTCH) that proposes a theory, methods, techniques and tools, all based on solid scientific backgrounds [3]. At present, the main goal is to make DUTCH appropriate for the practice of design teams in real life. To fulfil this goal, we applied two research approaches towards the practical behavior of design teams. The first involved learning about the practices used by teams, using ethnographical methods. The second involved evaluating DUTCH by applying it.

This paper discusses the results of applying both research approaches to a leading IT firm. We were invited to collaborate with the User Interface Design team, and began our work as ethnographers inside the team, which was working on a complex design project. Another researcher acted as an external consultant. We used a variety of ethnographical techniques, such as participant observation, diaries, audio and video recording analysis, and in situ interviews [2]. In addition, we used the Teach-back method [4] to externalize the team's mental models about the design process. This investigation produced a set of data about design practice, including the difficulties related with it.

After two weeks, due to the many problems the design team encountered in using their own official design method, we were asked to introduce DUTCH. This gave us the chance to evaluate how DUTCH performs in a complex, real life situation.

The results of our research illustrate the problems existing in real life design practice (e.g. the need for, and lack of, actual knowledge and its availability for designers in industry). They also highlight the advantages and problems of using DUTCH in practice. Another important finding regards the consequences for team behavior of the research approaches we used (e.g. the dependent relationship that developed between the design team and the ethnographers).

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Predicting current glycemia by training subjects to use subjective feelings before feeding

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Objective

To train adults to recognize symptoms of glycemia using emerging feelings of depletion (i.e. bearable hunger). Design: within-individual verification of the learned ability.

Setting

University Hospital, tertiary care.

Subjects

60 healthy adults (24 males and 36 females, aged 15-60), all of whom had functional complaints or were overweight, were prepared by primary or secondary care before the experiment began.

Methods

Rather than preventing and ignoring energy depletion, the subjects in this experiment waited for feelings of depletion to emerge and then measured their level of glycemia, thereby training them to recognize the association between the two. By repeating this process at the same blood glucose level, most learned how to make the association within two weeks. Thereafter, they took meals whenever they recognized the onset of feelings associated with this level of glycemia. Moreover, they were able to adapt their meal intake to provoke the emergence of the same depletion feelings at the desired meal time for 80% of meals. This was made possible by matching dietary intake with presumed inter-meal expenditure, and by consuming copious amounts of fruit and vegetables.

Two months later, at a verification session in the hospital laboratory after an overnight fast, subjects declared whether or not they perceived depletion feelings. They also predicted their current blood glucose level. A venous blood sample was taken for analysis, using the hexokinase method and hospital autoanalyzer. Subjects were also asked whether they thought they could continue the programme in the long term.

Results

66 of 71 eligible subjects came to the verification session after two months. Six of these were excluded due to illness. Of the remaining 60 subjects, 25 were at that

moment perceiving depletion feelings and had glycemia levels measuring an average of 3.98 mmol/l (range: 3.75-4.21, \pm 2SD). Those who did not perceive depletion feelings at that moment (35 subjects) had significantly higher levels of glycemia, measuring an average of 4.90 mmol/l (4.74-5.06, \pm 2SD).

Under 'normal' circumstances (i.e. ignoring their individual condition), the levels of glycemia recorded (range: 3.1-5.7mmol/l) would have allowed ad libitum intake in the entire group of 60 subjects. Instead, by waiting for feelings of depletion, the subjects in this experiment ensured that they ate only at the lower end of the range of preprandial glycaemia. Moreover, 80% of subjects thought that they would easily be able to continue to use this intake method in the very long term.

Conclusion

Feelings of depletion emerge as a highly reliable threshold for predicting glycemia between 4.6 mmol/l and 3.1 mmol/l in trained adults, thereby indicating the latest time at which a meal should be consumed to prevent overeating.

Automatic speech recognition and speaker identification of animal vocalizations

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There have been many studies on the relationship between animal behavior and auditory communication. Many of these show that there is a strong correlation between the animal's vocalizations and the action(s) it is performing at the time. Others have shown that this correlation varies, depending on the individual. For instance, tamarins have been known to vary their calls depending on what foods they prefer, and elephants have different vocalizations for greeting other elephants and for showing aggression. While research has shown correlations between vocalizations and behavior, there has been little effort to build automatic classifiers to categorise vocalizations or determine which animal made them.

There has also been much research on human speech processing. Two tasks receiving great attention are speech recognition and speaker recognition. Well-founded techniques, such as Hidden Markov Models (HMMs), can translate spoken utterances to written language (speech recognition), and others, such as Gaussian Mixture Models (GMMs), can identify the speaker of a given utterance (speaker identification). These two tasks correspond directly to what many researchers in the animal behavior field are attempting to do with animal vocalizations. The present research aims to adapt these 'human' techniques for use with animals, to perform speaker identification and speech recognition.

This project aims to create a framework in which animal vocalization classifiers can be built to perform the tasks of speaker identification and speech recognition. Elephants, tamarins and aquatic mammals will be the first species explored. The initial step is to identify the features of vocal utterances carrying the most information. In human speech, spectral characteristics have proven to be the most effective, but animal behavior research shows that temporal characteristics are also important. Numerous statistical measures, including autocorrelation and mutual information, can indicate the importance of specific features.

The second part of the framework will involve identifying the model for the classifier. Currently, two of the most popular models in human speech research are HMMs for speech recognition and GMMs for speaker identification. However, it is expected that simpler models, such as Dynamic Time Warping (DTW), will also prove effective for animal vocalizations.

The development of a framework from which to build these animal vocalization classifiers will have a profound impact on animal behavior research. By using an automated algorithm to understand what animals are trying to say, software or devices could be made to provide a human language transcription of animal vocalizations. The ability to identify individual animals could even lead to the development of an animal tracking system, whereby animals could be tracked in the wild using microphones, instead of implanted devices.

Anxiolytic activity of E-5842, a potential atypical antipsychotic, in the isolation-induced ultrasonic vocalizations of rat pups

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Rationale

Ultrasonic vocalization (USV) in rat pups is a well-accepted model with which to identify anxiolytic drugs, representing a measure that is relatively independent of additional behavioral and physiological variables. Anxiolytic drugs, such as benzodiazepine receptor agonists or $5\text{-}HT_{1A}$ agonists, are active in this model – but so too are the mixed antidepressant/anxiolytic drugs, including the selective serotonin re-uptake inhibitors, fluoxetine and paroxetine. The potential atypical antipsychotic E-5842 has been shown to possess anxiolytic properties in different animal models. The present study was undertaken to compare the activity of E-5842 to that of several typical and atypical antipsychotics, using diazepam as a reference compound.

Methods

Each rat pup (\sim 14 days old, either male or female) was separated from the dam. Its body temperature was taken and negative geotaxis evaluated. The pup was then isolated in a glass tube, and the number of USVs it produced were recorded using the UltraVox software system.

Results

As expected, diazepam reduced USV. E-5842 also reduced USV at concentrations of 1.5, 3.0 and 0.6 mg/kg. The antipsychotics, haloperidol and clozapine, did not reduce USV, but olanzapine, risperidone and chlorpromazine did. These results do not allow us to distinguish the typical from the atypical antipsychotics, though the anxiolytic-like activity has been postulated to be a distinction between them. Their effects on body temperature and negative geotaxis will also be reported, reflecting no relationship between them and USV.

Conclusions

E-5842 is active in the USV model of anxiety, reducing the number of calls in a dose-dependent manner. Its effects on USV do not seem to be related to changes in body temperature or motor impairment. These data may support the idea that the USV-reducing effect is a specific property of drugs with anxiolytic capabilities, highlighting the anxiolytic-like properties of E-5842.

Action unit recognition in spontaneous facial behavior

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Over the past decade, significant efforts have been made towards automatic recognition of human facial expressions using computer vision. Several such systems have recognized a small set of emotion-specified expressions under controlled conditions, such as joy and anger. Others have achieved some success in the more difficult task of recognizing action units, i.e. the smallest visible change in facial expression.

Our interdisciplinary group of psychologists and computer scientists has developed a system that recognizes 18 of the *c*. 30 action units that have a known anatomic basis and occur frequently in emotion expression and non-verbal communication. These action units are recognized whether they occur alone, or in additive or non-additive combinations. One limitation of this (and related) research into automatic facial expression recognition is that it is limited to deliberate facial expressions, recorded under controlled conditions, which omit significant head motion and other factors that may confound feature extraction.

Automatic recognition of facial action units in spontaneously occurring behavior presents several technical challenges. These include: rigid head motion, non-frontal pose, occlusion from head motion, spectacles, gestures, talking, low intensity action units and rapid facial motion. Version 3 of our Face Analysis System (FAS) addresses these challenges. The system recovers full head motion, stabilizes facial regions, extracts motion and appearance information, and recognizes important facial actions (e.g. eye blinking).

The precision of recovered full head motion was evaluated with ground-truthed data, obtained by a precise position and orientation measurement device, and found to be highly consistent. The full system was tested using video data from a spontaneous two-person interview. Eye blinking was chosen for analysis because of its importance in psychology and neurology and its applied importance in detecting deception. Eye blinking occurred with relatively high frequency (167 occurrences in 10 subjects of diverse ethnic background), and was reliably coded by human facial expression experts for comparison with FAS.

Figure 1 depicts an overview of FAS. A digitized image sequence is input to the system. The face region is delimited in the initial frame. Full head motion is

recovered automatically, using dynamic templates and a cylindrical face model. Using the recovered motion parameters, the face region is stabilized. An example of system output is shown in Figure 2. Luminance values in the eye region are used for blink recognition (see Figure 3). The system recognized blinks with 98% accuracy in spontaneous facial behavior. Reliable and precise compensation of head motion was critical to action unit recognition.



Figure 1. An overview of the face analysis system.







Figure 3. Examples of luminance curves for blink (left) and non-blink (right).

Subjective duration assessment: an implicit probe for software usability

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A classic problem in software usability engineering is that direct assessment of satisfaction is frequently confounded by an inherent positive bias [1]. We describe a new procedure for gauging users' difficulties with tasks, interfaces and situations, which we refer to as subjective duration assessment. The method centres on the use of time estimation to characterize performance. We introduce relative subjective duration (RSD), a measure that captures the difficulty that users have with performing tasks, without directly asking them. Although there are several applications of RSD, we focus on using it to probe users' experiences with software. RSD is based on earlier psychological studies on time estimation, which demonstrated that when engaging tasks are interrupted, participants tend to overestimate how long those tasks take when compared to the actual task times. Conversely, tasks that are completed tend to be underestimated in terms of the overall task times [2,3]. We explored the value of time estimation as a measure for evaluating task performance in human-computer interaction (HCI). Our hypothesis was that participants would overestimate the duration of tasks they were not able to complete on their own. In contrast, they would underestimate the duration of tasks completed successfully.

To explore this idea, we performed a standard usability study as an iterative test of the usability of an Internet browser. We included seventeen typical browsing tasks, such as account maintenance, playing videos and songs, searching, sending instant messages, reviewing and composing e-mail, and performing calendar activities on the web. Dependent measures included task success rates with and without experimenter intervention, completion times, participants' estimates of how long each task took, and overall user satisfaction ratings.

We found that, despite the fact that success rates without experimenter intervention were quite low (<60%), satisfaction ratings were very high. In fact, 17 out of the 19 questionnaire items were rated above average. Clearly, user satisfaction and performance were not well correlated. In contrast, users' estimated task times tracked their performance quite well. Participants reliably underestimated tasks with high success rates, and reliably overestimated the lengths of tasks that had lower success rates. A summary of the relationship between the actual versus estimated task time findings is shown in Figure 1.

We believe that RSD is an interesting implicit measure for usability that can be used to probe user satisfaction versus frustration with tasks. As participants do not necessarily know ahead of time what the experimenter expects from the time estimates, they are less likely to bias their time estimates toward a positive response.

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Figure 1. Over- and underestimation of task times by task success rate (negative y-values are underestimates; positive y-values are overestimates).

Welfare in farmed fish: aggression and formation of feeding hierarchies

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Short- and long-term restrictions in feeding rations are commonly used in farmed fish, but the relationships between reduced feeding and social interactions in groups of fish are not fully understood.

In order to monitor food intake, aggression and the formation of hierarchies, 30 groups of Arctic charr, *Salvelinus alpinus*, were observed before, during and after a 14-day period of feed restriction. During the experimental period, each group of fish (weight range: 100-200 g, n = 6) was fed either 125%, 100%, 75%, 50%, 25% or 0% of the calculated food ration. Individual food intake was measured using radiography. The fish were individually tagged, and video recordings during the feeding period enabled a behavioral scanning of aggressive acts, such as nips, chases, attacks and displacements. Using The Observer Video-Pro and MatMan, a behavioral analysis of the conflict matrix within each group was conducted.

The study revealed a large variation in aggression. After the formation of hierarchies, the highest ranked fish took most of the food and achieved the highest growth rate, even if total food for the group was in surplus. Maturation was the most important factor explaining which fish become dominant – initial fish size did not affect dominance. Aggression clearly affected the level of plasma cortisol, and dominant fish had a significantly lower cortisol level compared with subordinate fish. After a period of reduced feeding, the fish on a restricted ration increased their food intake and aggression in order to compensate for the period with a low food intake.

In conclusion, the study demonstrated that aggression in farmed fish was affected by several factors, including short-term compensation and long-term life history traits.

The effect of suddenness and novelty on psychophysiological parameters in sheep

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Emotions are crucial for animal welfare, yet our understanding of emotions in farm animals is still sparse. To characterise the range of their emotions, we followed a strategy derived from cognitive psychology, in which emotions experienced by an individual result from its evaluation of the situation according to a set of criteria (novelty, suddenness, pleasantness, expectancy and controllability). We placed three-month-old lambs in experimental situations where the evaluation was oriented to only one criterion, and used a psychophysiological approach to identify the behavioral and physiological responses specific to that criterion.

Using video cameras positioned at various angles, we recorded fine movements (such as head posture and ear movements) made by the lambs in response to the suddenness or novelty of a visual stimulus. The behavioral response of each lamb was recorded by focal sampling on a computer using the event recorder software, The Observer Video-Pro. To record the startle response, an accelerometer was fixed on the back of the lamb. We also recorded cardiac and respiratory activities, along with skin temperature. Since these measures had to be made in a short time interval on freely behaving lambs, without any interference or manipulation, the animals were equipped with a non-invasive instrumentation pack.

For cardiac monitoring, two Ag/AgCl adhesives and pre-gelled electrodes were used. A pneumograph (PneumoTrace, model 1132, UFI) placed around the abdomen was used to record respiratory activity. Finally, the temperature was recorded with two thermal sensors: one on the head (attached with an elasticised strap) and one on the thigh (attached by a Velcro patch, with one side glued onto the animal). These four types of psychophysiological signals were transmitted via radio telemetry: the four transmitters were fitted on an elasticised girth strap (model Lombogib Gibortho, Gibaud S.A., France), which also secured the cardiac electrodes. In total, the pack weighed 1.04 kg (4% of the weight of a three-month-old lamb).

The cardiac and respiratory transmitters used for the startle response were part of monitoring units with analog transmission (Life Scope 6 model OEC-6301K, Nihon Kodhen, Japan). The temperature transmitter was part of a multi-channel

monitoring unit with an analog-digital converter (model Modem Radio R4MT, HTS Electronique & CEM, France). All of the monitoring unit receptors were connected to an Apple Power PC equipped with Chart Software (version 3.6.8) via a PowerLab (both ADInstruments, Australia).

Our initial results show that it is possible to record all these parameters concurrently. Most of the parameters vary when the animals are placed in a stressful situation, but the pattern of responses varies according to the situation.

3-D representation of the landing approach of *Libellula depressa* in a study of navigation mechanisms in natural surroundings

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Introduction

As a swift flyer and an extremely successful hunter [1], the dragonfly requires high-performance eyes for visual orientation in space. Environmental structures must be detected and information concerning them processed at lightning speed to make it possible for appropriate flight manoeuvres, such as landing on a preferred perch, to be initiated at the right time. In such acts of precision navigation, image expansion, retinal image displacement through translational movement, and binocular target fixation could all represent optical stimuli that trigger specific landing reactions. Systems that analyse such motion information and image expansion could, as components of an autopilot, serve to correct course deviations and prevent collisions [2].

Rather than investigating the neuronal background of this highly complex system, this project examines the structure of the eye as a stimulus detector, together with the stimulus patterns involved in triggering specific components of the landing approach under conditions close to those found in nature.

Materials and Methods

Libellula depressa was chosen for the experiments. The male of this dragonfly is particularly suitable for such studies, due to its bright blue coloration and perching hunting strategy. An artificial perch was placed near a garden pond, and insulation tape was used to mark the perch at defined intervals to provide a scale (Figure 1). Two analogue video cameras, positioned 2 m from the perch and oriented at 90° to one another, were used to record the last 50 cm of each landing approach. External time codes were also recorded by both cameras. A special program was developed for the analysis (see Figure 2), which made it possible to extract three-dimensional landing data from the two-dimensional data provided by the two cameras. The output of this Borland Delphi program consists of CSV files, which can be processed by any current spreadsheet program.

With the aid of these data, angles can be calculated which, in conjunction with optical and morphological parameters (monocular and binocular visual field,

interommatidial angle, facet size and interocular distance) make it possible to reconstruct the image flow of the perch in the eye of *Libellula depressa* during the last 50 cm of the landing approach (Figure 3).

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Figure 1. Libellula depressa approaching the target.



Figure 2. Computer program interface.



Figure 3. Landing data, plotted in MATLAB.

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Correlating brain metabolism with stereotypic and locomotor behavior

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While many labs have quantified behavior in rodents and determined rates of metabolic activity in brain regions, few have attempted to relate the two measures statistically. The work reported here is the correlation of locomotor activity (determined using a photobeam box) and stereotypic behavior (determined from videotapes, using Noldus software) with rates of glucose metabolism in components of the nigro-striatal and mesolimbic systems (determined using the quantified deoxyglucose method).

The subjects were given cocaine during a critical period of brain development and then challenged with a selective D1 dopamine agonist, SKF 82958, while their behavior and brain metabolism were determined. Rates of metabolism were correlated with stereotypic and locomotor behaviors using Pearson Product Moment Correlations. The analysis revealed that, under saline challenge conditions in control rats, rates of metabolism in mesolimbic regions were significantly coupled to rates of locomotor activity. In cocaine-treated rats, however, these correlations tended to be negative. Following SKF challenge, a different pattern was seen: locomotor activity was negatively correlated with mesolimbic metabolism in controls, but positively correlated with it in cocainetreated rats. Similarly, stereotypic behavior was negatively correlated with nigrostriatal metabolism in controls, but positively correlated in cocaine-treated rats.

In summary, stereotypic and locomotor behavior can certainly be correlated with regional brain metabolism, and these correlations can be both positive and negative in controls. Furthermore, the coupling of metabolism and behavior can be disrupted by developmental exposure to psychostimulants.

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Using Theme to analyze interaction structure and strategy

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This research proceeds from the perspective that various types of face-to-face interaction are convention-based or rule-governed. This approach to interaction research follows a two-step process. First, once actions are transcribed using Theme coder software, exploratory analyses of these actions are designed to yield hypotheses concerning one or more conventions being used by participants in an interaction. These empirically based hypotheses, termed *structures*, include among other things: (a) a set of appropriate actions, termed *elements*, for each participant in the interaction; and (b) a set of rules, describing the sequences in which these actions may appropriately occur. By identifying patterned sequences of transcribed actions, Theme provides invaluable information relevant to the formulation of structures; the information most directly relevant to hypothesizing structures will be reviewed. In this phase of the research, Theme patterns are not in themselves the results; rather, these patterns provide information necessary for the formulation of structures.

Second, once these structures – that is, the 'rules of the game' – have been hypothesized, it becomes possible to examine *interaction strategy*: the way in which the participants jointly construct specific instances of interaction, within the constraints provided by the rules. Obvious examples of structure and strategy would be chess or basketball, in which many different games and game outcomes (strategy) may occur within the constraints of a constant set of rules (structure). It is clear that productive analyses of strategy in these games is dependent on prior knowledge of their rules – particularly those points at which participants choose between various rule-defined options. Similarly, the analysis of interaction strategy only becomes meaningful once the structures describing the elements and rules relevant to the interaction have been hypothesized.

In part, interaction strategy can be described as sequences of elements, performed by the respective participants, at those points in the interaction at which the structure provides choices between alternative elements. These choices are a major constituent of the joint construction of an interaction by the participants. Theme can be used to analyze sequences of elements, uncovering patterns of choice. In addition to these choice patterns, analyses of interaction strategy can be used to examine, for example: (a) the degree of influence of each participant upon the other as the interaction proceeds; and (b) whether a choice of action at a specific point can be described as a Markov process, or as something more complex. Thus, the Markovian nature of this process is treated as an empirical issue.

This presentation will include examples of interaction structures and accompanying results, showing the degree of fit of these structures to the transcribed data. Based on these structures, examples of strategy analyses, derived from Theme analysis of element sequences, will be presented. These will illustrate the fluctuating influence of each participant upon the other's choice of elements as the interaction proceeds, and evaluate this influence as a Markov process.

Measuring the metabolic cost of spinning silk: developing a method for investigating a silk-spinning insect

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Webspinners (Order Embiidina), silk-spinning insects, are unique in their ability to spin silk by stepping against the substrate with their front feet while multiple silk strands issue forth. Webspinners construct silken dwellings that house mothers with their young, sometimes in large colonies. The use of silk within the order varies from extensive structures covering tree trunks to scant amounts applied as an adhesive for materials gathered to form dwelling walls. In the laboratory, we investigated the question "how costly is it to spin silk?" as the first part of our study examining how the costs and benefits of silk production affect the evolution of primitive social behavior in these insects.

To determine the relationship between metabolic rate and behavioral activity, including silk-spinning, we developed a method that employs simultaneous event recording (using The Observer) and metabolic rate recording (using a Qubit Systems carbon dioxide analyzer). We quantified the activity of individuals placed in a respiratory chamber for 30 minutes. Subsequent analysis of behavioral repertoires allowed us to identify three distinct female categories, based on overall activity: resters, wanderers and spinners. Compared to their resting state, webspinners produced carbon dioxide at twice the rate when when they were spinning. However, the apparent metabolic costs of locomotion and of spinning silk were not significantly different, suggesting that spinning is as energetically costly as walking and climbing.

Our method of coordinating behavioral and metabolic recordings appears efficacious, and should provide a method for an extensive comparative study as we investigate the range of silk-spinning strategies within the order.

Circadian rhythmicity in cardiac stress reactivity: using the VU-AMS in a constant routine protocol

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Buijs *et al.* [1] have provided anatomical and functional evidence that the biological clock has direct regulatory control over the activity of the hypothalamic-pituitary-adrenocortical (HPA) axis. Because a substantial functional relationship between HPA and sympathoadrenal responses has been established, it seems logical to suggest that the biological clock may also influence autonomic (i.e. sympathetic and parasympathetic) reactivity to stress. The present study, therefore, aims to investigate the circadian rhythmicity of autonomic reactivity to stress in healthy subjects.

To examine this, a constant routine protocol was used (see also [2]). This procedure aims to control for the masking effects of sleep, posture and physical activity changes by requiring subjects to remain awake in a semi-recumbent position for a period of >24 hours. The environment in which the subjects resided during this routine was closed off from the external world, and lighting, temperature and food intake conditions were kept constant. For 19 subjects (group 1), the experiment started at 09:00 hours, whereas for 15 more subjects (group 2), it started twelve hours later, at 21:00 hours. This prevented the circadian phase being confounded by time, possibly associated with accumulating stress and/or sleepiness over the course of the experiment.

The stressor task battery – composed of four cognitive computer tasks and a cold pressor test – started at 11:00 (or 23:00) hours, and was repeated every three hours throughout the experiment. The duration of this task battery was approximately 45 minutes. Sympathetic and parasympathetic cardiac reactivities to the tasks were estimated by continuously monitoring the pre-ejection period (PEP) and respiratory sinus arithmia (RSA) using the VU-AMS device. This device was attached to the subject throughout the experiment.

Data analyses were then performed. Only time frames corresponding with the tasks were analysed. These data were analysed in segments representing 32 seconds, using the PTFAP software V2.10 [3]. This software was used for artefact pre-processing, and for computing mean heart periods and high-frequency heart period power values to estimate RSA (i.e. 0.125-0.5 Hz, using discrete Wavelet transformations). The B-points were determined manually for each ensemble-

averaged ICG segment (i.e. 30 s) to obtain PEP values. Finally, repeated measures ANOVAs were used to explore the effects of time of day and time-on task on autonomic stress reactivity.

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Measuring physician-patient communication using The Observer and sequential analysis

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Introduction

The aim of this study was to describe the communication process during consultations between cancer patients and oncologists.

Methods

The sample consisted of thirty-six audiotaped consultations with different patients, administered at an oncology outpatient clinic. The tapes were digitised to the computer's hard disk by means of Broadway software, and then copied onto CD. The consultations were then coded with the most frequently used interaction analysis system in medicine: The Roter Method of Interaction Process Analysis (RIAS). The Observer Video-Pro was applied in the coding process.

The data were then transferred from The Observer to GSEQ for Windows 4.0 (Bakeman and Quera 1995) by means of the OTS-program. The interraterreliability was measured using Cohen's Kappa, and the global sequential association between physician and patient behaviors at several lags was tested with GSEQ.

Results

Results from the interrater-reliability testing and the sequential analysis of the data regarding the characteristics of physician and patient interaction will be presented.

Using databases in behavioral research: a practical approach

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Increasing demand for data security means that new strategies for planning, collecting and storing experimental data from computer-controlled, in vivo test models are needed. In traditional file-based test systems, the experimenter is required to export and keep track of several files from each experiment, and to manage and analyze data in separate programs. Such systems require very strict safety procedures to maintain a reasonable level of data security, especially when the data are stored on a shared network drive with multiple users. Furthermore, most behavioral test models are controlled by very different types of software, such that experimenters often require insight into several different user-interfaces and data sampling procedures.

To improve data security and user friendliness in computer-controlled behavioral test models, the test model ES-Applications, based on a relational database (ES-LabBASE), has been developed. Together, ES-Applications and ES-LabBASE constitute a complete and unique system for running in vivo test models and saving data in a secure shared database, with a distinct security level for each user. This system is a solution to the problem of data housekeeping in a paperless, modern behavioral laboratory, where a number of technicians and researchers routinely use the same test models. Taking advantage of database technology, it is possible to link the data collected to information on system set-up, animals, test protocols, drug treatment, experiment configuration and user comments made during the experiment. All actions and changes are logged for documentation. This makes data safety very high, and ensures that data flow is much easier to track and describe when compared to file-based packages.

During each experiment, data are collected and saved on the local PC hard drive. Subsequently, the PC is connected to a network and the local database is synchronized with a client-server database on that network. User-specified data processing (e.g. group means) and statistical analyses can then be performed by standard SQL-calls to the network database.

The ES-LabBASE has been applied to more than 20 test models used routinely for in vivo pharmacology testing, e.g. active avoidance, ultrasonic vocalization, acoustic startle, locomotor activity, black and white box test and food consumption. All these applications have a common user interface and similar rules for data flow, maximizing user friendliness and data security.

In summary, the software programs based on the relational database, ES-LabBASE, have a number of advantages over file-based software programs:

- There is a similar user interface for all test models.
- The data flow is very easy to track from protocol to final results.
- All changes are logged.
- No raw data files are kept on shared network drives.
- There are separate security levels for each user.

The use of relational databases in behavioral research represents an important step towards a more reliable documentation of derived data, and reduced vulnerability of stored data, especially when multiple users can access the data.

Algorithmic analysis of rat behavior in a radial water maze

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A number of authors have shown that the direction taken by rats searching lateral platforms in radial mazes is not always random [1]. In some cases, a clear preference is observed for a platform in a certain corner (e.g. one at 45°, 90° or 135°). The consecutive passage of channels (corner 45°) is designated as '1', passage through one channel (90°) corner as '2', and so on (see Figure 1).

In the present work, we analysed the search algorithms of lateral platforms made by two groups of rats in an 8-arm radial water maze (RWM). One group of rats contained intact controls, but the other comprised those with disturbed spatial memory, following unilateral and bilateral lesion of their amygdala by kainic acid.

Most intact animals preferred algorithms '1' and '2', though pairs of algorithms (e.g. '4,3') and complex combinations (e.g. '3,2,1') were also found. In contrast, rats with unilateral amygdala lesions preferred algorithm '2', while those with bilateral lesions preferred algorithm '3' (corner 135"). No complex algorithms were recorded in these experimental rats.

Thus, rats with amygdalal lesions made fewer consecutive passes through channels, and were not observed to construct any complex algorithms.

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A - "1" (corner 450); B - "2" (corner 900); C - "3" (corner1350); D - "4-3". From Foreman, Ermakova,1997

Figure 1. Algorithms in 8-arm radial maze.

The simultaneous acquisition of video, kinematics data and electro-physiological signals

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In behavioral and motion research, pieces of equipment for measuring electrophysiological signals, kinematics and video are generally used separately. For motion analysis, various types of equipment for recording kinematics and physiological signals in concert are available from several manufacturers. In our department, the combined recording and analysis of video and physiological data for behavioral research has been used since the mid-1980s.

Researchers in the fields of movement sciences and developmental neurology have long wished to merge motion and behavioral analysis with physiological data. The electrical activity of trunk and limb muscles, respiration, heart action, eye movements and the electrical activity of the brain have all been mentioned as valuable in behavior and motion analyses. These electro-physiological signals represent the neural drive and control of the behavioral system. For maximum flexibility, two options have been implemented for recording physiological data: (i) stationary recording, by means of a fibre optic data-link between the front-end acquisition and the data-recording computer; and (ii) an ambulant system, which records the data at the front-end. The temporal relationships between the signals should, of course, be preserved.

This system allows data input from three sources, each with its own specific data rate: (1) video, at 25 (30) or 50 (60) frames per second (fps); (2) kinematics, from six cameras measuring multiple (up to 24) sets of coordinates at either 50 (60) or 100 (120) per second (cps); and (3) up to 128 channels of physiological data, at a sampling rate of 200 to 2000 Hz. A sync generator synchronizes the digital video camera and the kinematics cameras (which are in essence also video cameras). The digital video camera is connected to the data-recording computer by means of an i-link, which converts video frame number data into a time-code signal. Transmitting this time-code signal from the recording computer to the front-end by means of a radio link synchronizes the data at the front-end. The time-code data is sampled as an extra data channel at the front-end, and either sent over the fibre link with the physiological data (in the stationary mode) or recorded at the front-end (in the ambulant mode). The kinematics data, time-code and (if recording stationary measurements) the physiological data are then transported to the main computer over a 100 MHz Local Area Network.

Quantifying complex human behavior during system usability testing

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Traditional usability testing is conducted in an ad hoc manner, essentially yielding observer opinions about usability problems that exist in the product being tested. In this way, a test user is observed interacting with the software product or prototype. As the test user encounters difficulties, the observer takes notes about where the trouble occurred and then suggests what usability problem is creating or contributing to the user's difficulties. The observers (generally usability professionals) record the data in a narrative or list format, and then report it to the product developers as an accurate view of human interactions with the system [1,2].

Recent studies indicate that different usability test professionals cannot replicate each other's results: each identifies different usability problems in the product being tested, with little overlap between them [3,4]. In addition to this replication issue, traditional usability testing and data recording fail to generate quantitative data, avoid specific behavioral data, and do not test users of different levels in ways that can be compared with one another.

The author has developed a quantitative approach to usability testing: the Optimal Path Test Method. This method creates a distinction between user errors (i.e. observable events that occur during testing) and usability problems (i.e. underlying design issues that contribute to the occurrence of user errors). Expanding on a traditional doctrine that different tests should be conducted for novice users as opposed to expert users, the Optimal Path Test Method has been applied to three levels of users performing exactly the same task, thereby generating data suitable for comparison across levels. Analyzing statistical contrasts by group level and by test element revealed not only where usability problems existed, but also provided empirical underpinnings for determining the type of usability problem present.

Replacing traditional usability testing with the structured Optimal Path Test Method, and testing and comparing users of varying experience, renders a data set that supports multiple levels of analysis of human behavior during usability testing. It also makes connections between the behavior and the actual problems that exist in the product under test. Moreover, the Optimal Path Test Method provides results that are repeatable and consistent across testers.

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Using hand-held game consoles for animal monitoring

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Introduction

Experimental set-ups for monitoring and analysing animal movement and behavior typically require a personal computer equipped with frame grabber and video camera. Many experiments can, however, be performed using hand-held consoles, allowing for a much simpler and more portable set-up.

Method

A Nintendo GameboyTM, together with the Gameboy CameraTM, has been modified to capture and analyse video. The console has a working resolution of 128 x 123 pixels in 256 shades of grey and operates in the order of 1 frame per second, depending on the operation.

Operation

Five modes of operation are currently implemented: Distribution, Motion, Activity, Zones and Event Logger. 'Distribution' generates a two-dimensional map, indicating the amount of time spent in a given area. 'Motion' generates a similar map, indicating the amount of motion in a given area. 'Activity' logs the activity in the camera's field of view. 'Zones' generates an event record of activity in user-defined zones. Finally, 'Event Logger' generates an event record of up to eight different user-defined events, which are linked to keys on the console for manual monitoring without the camera.

Application

Suggested applications for the system included generating simple time budgets, analysing animals' use of space, and counting and registering diurnal activity. Besides the five modes of operation described here, others could also be implemented to increase the field of application.

Continuous objective measurement of pain indicators in children: a feasibility study

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Newborn children hospitalised in an Intensive Care Unit frequently experience pain as a result of medical interventions. This makes adequate pain treatment very important. Assessing the level of pain in these very young children (0-1 years), however, is difficult. Although many assessment scales have been developed over the years, they are generally subjective, time consuming and discontinuous. Recent developments in long-term ambulatory monitoring [1,2] may, however, also be useful for objective pain assessment in young children.

The aim of this study was therefore to examine the feasibility of a so-called 'Continuous Pain Monitor', based on continuous, ambulatory and objective measurement of pain indicators. First, the most relevant indicators of pain were selected on the basis of existing pain assessment scales, the literature [3,4] and experts' opinions. Facial expressions, movement patterns of the extremities, muscle tension in the extremities and heart rate were all considered to be relevant and measurable parameters.

Second, based on explorative measurements in eight children during the postoperative period, a sensor configuration and analysis program was developed. EMG, accelerometry and ECG were monitored during these measurements.

Subsequently, the most appropriate configuration and analysis program was tested in six children to determine whether it was possible to continuously and objectively measure post-operative pain. The preliminary results show that signal variability and frequency content are both important signal characteristics. Validation measurements have been performed, and data will be presented.

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Using The Observer to analyze exploration in virtual worlds

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In reality, we learn about new environments with a fixed frame of reference by moving within them. The frame of reference aids orientation and navigation [1]. In contrast, a Virtual Environment representing the Solar System (VESS) on a computer screen has no stable frame of reference. Imagine 'flying' through the solar system, moving with the planets as they revolve in orbit around the sun. Imagine controlling your visual journey through the solar system, deciding what to see and from which viewpoint. These learning experiences, and much more, form part of VESS: a unique interactive virtual environment [2].

How can we identify and describe systematically the ways by which students explore VESS? How can we represent the navigation processes that take place in a VE with a dynamic frame of reference?

To address these questions, we used The Observer to analyze exploration processes in VESS. The interactions of ten 10th grade high school students with VESS were videotaped. A qualitative method for analysis was developed – SEE (Systematic Exploration of Exploration) – based on the ideas of Marshall [3] and the work of Golani & Drai [4]. The Observer served to convert the videos into meaningful data, allowing us to investigate at the level of observable actions, and at the level of interpretation. Each action and verbal expression made by the students was coded with a one-second resolution, producing a 'thick' description of the exploration process. Two basic types of behavior were identified:

- 'On the move' mode the student interacts with the dynamic VESS
- 'Freeze' mode the student interacts with the static VESS (Figure 1)

'Freeze' mode emerges after several minutes of exploring in 'on the move' mode. The student is cognitively active, organizing the data collected, making categorizations, and so on. This pattern of 'freezing' VESS after exploring it in dynamic mode occurred several times during the spontaneous exploration task.

Within 'on the move' mode, three different exploration patterns were found: the 'butterfly', 'bee' and 'eagle' patterns. Each pattern differs according to the pace and duration of object exploration, the way the space is manipulated, and the visual and symbolic data collected (Figure 2).

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Figure 1. A "freeze" screen from the VESS.



Figure 2. VESS video analysis.

Behavior and fertility in different types of budgerigars

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Artificial selection in show-type budgerigars (*Melopsittacus undulates*) has led to heavier and larger birds compared to wild-type budgerigars. In particular, breeders who exhibit their budgerigars at shows want large birds with long feathers on the head, partially covering the eyes, and large black dots on the throat feathers. In this study, we wanted to know whether (reproductive) behavior differed between morphological types of budgerigars, and if so whether it influenced their fertility. 24 pairs of budgerigars in breeding boxes were videotaped about three weeks before egg-laying, and the tapes were analysed using The Observer Video-Pro.

Males paired to females that later laid eggs flew from perch to perch significantly more often than males whose females did not go on to lay eggs. The frequency of flying in males was negatively correlated with the desired characters: the heavier the male, and the larger the throat dots, the lower the frequency of flying. Males with large throat dots showed more courtship behavioral acts than males with smaller throat dots. The number of courtship behavioral acts was positively correlated with the fertility rate of the future eggs. There were no correlations between the courtship of the male and morphological traits of the female, or morphological differences within the pair.

This study is an example of integrating morphological traits and the measurement of behavior to address the question of how morphology – and especially artificial selection of morphological traits in companion animals – might affect their reproduction.

Fear conditioning: automated detection of immobility, and the need to do more!

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Fear conditioning (FC) allows the dissociation of hippocampal and nonhippocampal behavioral function in rodents, and has become a diagnostic tool in transgenic mouse research to investigate mutation-induced changes in brain function. Although the procedural details of the paradigm have been established, quantification of the behavioral output – freezing – remains problematic in mice. Observation-based techniques are time consuming and may be subject to bias, while movement detection with photocells is imprecise. Here, we describe an alternative method for movement detection based on an electronic force transducer system, which allows the quantification of acceleration forces generated by a moving subject.

We compare the behavior of two inbred strains of mice (C57BL/6 and DBA/2) whose performance is known to differ in hippocampal tasks, including FC. The comparison is made using multiple techniques: the force transducer approach, and three observation-based methods: a computer-aided event-recording approach, a traditional time sampling paper/pencil method, and a subjective impression-based scoring system. In addition, we investigate the correlation structures of behavioral elements quantified by event recording, using Principal Component Analyses.

We conclude that fear may manifest itself in multiple forms, and in a stimulusand genotype-dependent manner. We suggest that the force transducer system provides precise quantification of freezing in an automated manner, and will allow high throughput screening for mutation and drug effects in mice. However, we also argue that fear responses can be complex, and freezing behavior may not be the only measure of fear or fear-associated memory.

Welcome and introduction to the VU-AMS

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This second VU-AMS User Meeting introduces participants to the acquisition and analysis of ambulatory data recorded with the Vrije Universiteit – Ambulatory Monitoring System (VU-AMS). The VU-AMS can be used to measure behavioral and physiological variables in real-life settings. In this introduction, a global overview of the practical use and theoretical framework of the VU-AMS will be presented.

Physiological variables assessed with the VU-AMS device are heart rate, heart rate variability, respiration rate, respiratory sinus arrhythmia, galvanic skin response, pre-ejection period, left ventricular ejection time, Heather index, stroke volume and cardiac output. From these variables, sympathetic and parasympathetic nervous system activity can be derived. The VU-AMS also assesses motility information, which can be used (in conjunction with diary information) to control for the effects of physical activity and posture on the physiological variables.

Measurement and analysis of eye movement and heart rate as markers of visual attention in babies

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The full richness of the visual world becomes available to the infant at birth. Development of the visual system is very important, as the baby is hardly able to actively explore the environment in other ways. During the first five months of life, maturation of the cortical areas related to the control of eye movements and the processing of visual information leads to a major gain in the functionality of the visual system, in interaction with visual input from the environment [1]. For example, between four and eight weeks of age, infants cannot easily disengage their gaze from an interesting stimulus they have fixated: a phenomenon called 'sticky fixation'.

Visual attention, presumably controlled by posterior parietal areas in the brain, is essential to cognitive, motor and social development. Stable fixation of foveated objects and changes in the environment, and the selection of targets of interest in the peripheral world, are the main functions controlled by visual attention. The latter may lead to eye movement and the fixation of a new location. Thus, eye movements reflect attentional processes. Changes in heart rate and heart rate variability have been reported in both adults and infants in tasks requiring different levels of effort, and to stimuli that draw attention. These changes have generally been interpreted as an autonomic response to attention, and may serve as an independent marker of attention in the infant during visual attention tasks.

We studied the longitudinal development of visual attention and heart rate responses to visual stimuli in infants from six weeks to six months of age at fourweek intervals. Infants were positioned in a semi-reclined position in a maxi cosy, 35 cm from a 21-inch monitor. Stimuli were presented in a central position and at 16 degrees to the left or right. Real time video records of the mother's smiling face and abstract dynamic video streams were used as stimuli. Eye movements were recorded on video and with an ASL eye tracker system (only 50% successful recordings). Heart rate and stimulus events were recorded separately. Data recording was synchronised between the systems. Video analysis (The Observer) of the frequency and latency of shifting gaze to a peripheral stimulus was performed at 20 ms resolution. These data were compared with the eye tracker data to enhance their accuracy. Longitudinal data will be presented regarding the development of visual attention, involving both heart rate data and gaze shifts. Problems of measurement and integrated analysis of these varied data sources will be discussed.

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Regulation of cardiac rhythm in fish under metabolic depression: a calorimetric and radio-telemetric study

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In nature, under adverse conditions like low oxygen or low environmental temperatures, some fish species can slow down their metabolism ('metabolic depression') in a manner comparable with hibernation or aestivation. This strategy may be applied to slow down ATP flux, save energy stores and diminish end product (e.g. lactic acid) accumulation. It has been suggested that metabolic rate and metabolic depression are controlled by a combination of blood perfusing the organs and the factors carried in that blood, e.g. oxygen and substrates.

In this study, two techniques were combined to investigate these issues: direct heat measurements of cold-blooded animals via calorimetry, to measure overall metabolic rate; and radio-telemetry, using small implanted transmitters (weighing 3 g: TA10ETA-F20-L20, Data Science International, St. Paul, MN, U.S.A.) to gather information about cardiovascular properties (heart frequency).

At hypoxic levels of 40%, 20%, 10% and 3%, the metabolic rate of goldfish (*Carassius auratus*) dropped to 94%, 84%, 61% and 55% of its normoxic level, respectively. This implies that metabolic depression is flexible, depending on the supply of oxygen. Heart frequency at normoxia (100% oxygen) was 34 beats per minute, but this too fell under the conditions of hypoxia listed above, to 26, 22, 14 and 9 beats per minute, respectively.

To explain the close coupling between the metabolic demand of the tissues, respiratory gas exchange and cardiac activity, nonlinear regression techniques were performed. This statistical analysis indicated that the level of metabolic depression was determined more by heart frequency than by environmental oxygen concentration or oxygen consumption. This suggests that, to a large extent, these animals determine their level of metabolic depression by regulating their heart frequency.

Investigating the foraging behavior of a pupal parasitoid of stemborers in an intercrop situation

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Molasses grass (*Melinis minutiflora*), a non-host plant to stemborers, is reported to produce volatiles that attract stemborer parasitoids [1]. The foraging behavior of the stemborer pupal parasitoid (*Dentichasmias busseolae*) was investigated in a maize monocrop and in an intercrop of maize and molasses grass. These studies were conducted to determine whether the presence of the non-host plant would interfere with the location of infested host plants by the wasp.

Individual female parasitoids were given the opportunity to sample the two crop arrangements under semi-field conditions. Two classes of behavioral elements – the behavior and position of the parasitoid – were continuously recorded using The Observer 3.0 software. The following wasp behaviors were observed and recorded, along with whether they occurred on the test plants or elsewhere: fly, walk, stand, groom, antennate, window-bite and enter hole.

Analyses were performed to test for differences in foraging behavior between the monocrop and the intercrop. In both cropping systems, infested plants were visited more often and for longer periods. There was no significant difference between the total time spent on uninfested plants and non-host plants. While on infested plants, wasps spent most time engaged in activities related to host location.

These investigations show that the presence of the non-host plant did not significantly interfere with the ability of *D. busseolae* to locate herbivore-infested plants in an intercrop, even though it took slightly longer for wasps to find the infested plant in the intercrop than in the monocrop. Hence, at least over short distances, the parasitoid seems able to distinguish the odours of its host plant.

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Phenotyping mouse locomotor behavior in ten strains and across three laboratories using SEE (Strategy for the Exploration of Exploration)

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A key goal in behavioral phenotyping is the development of behavioral measures (endpoints) that are both discriminative across genetic strains and replicable across laboratories. Such endpoints are of crucial importance to the field of behavioral genetics, since those that are easily affected by slight environmental changes (and are therefore not replicable across laboratories) cannot be related to genomic data. Replicable endpoints are also of great importance in ethology, where innate behavior patterns are expected to be stable across a wide range of environments. Despite great efforts to standardize test and housing protocols, it has recently been shown that currently used behavioral phenotyping paradigms yield results that are often idiosyncratic to particular laboratories [1].

SEE (a software-supported Strategy for the Exploration of Exploration [2,3]) was developed to facilitate the generation of discriminative and replicable endpoints of open field locomotor behavior in different mouse strains. Key features of this strategy are: (i) simultaneous testing in multiple laboratories; (ii) large arena (2.5 m diameter), long session (30 min) and high tracking rate (30 Hz), providing high resolution in space and time; (iii) robust smoothing algorithms that reduce tracking noise; (iv) algorithmic identification of ethologically relevant behavior patterns; and only then (v) computation of a large number of measures for each separate pattern. In a study performed in three laboratories on ten of the most commonly used mouse strains, this strategy yielded replicable differences between strains in many behavioral endpoints. The results of this study will be presented.

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A behavioral theory of operator activity

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Based on the theories of systems and functional systems, a theory of operator activity has been developed to quantitatively describe the working processes of a man-operator (MO) in a man-machine system (SMM). It also considers the functional efficiency of the whole system from a human factors (HF) perspective.

The theory contains primary and secondary concepts, axiomatic statements and logical consequences, allowing the operator's psychophysiological parameters to be selected and assessed. Algorithms can be created to calculate the numerical values of behavioral characteristics, such as the operator's biological condition and the emotional and motivational components of his behavior. With the help of these components, and by determining the successful functioning of an SMM, it has been possible to quantify such psychophysiological criteria as difficulty, MO work intensity and SMM reliability, using HF positions.

The basic structures underlying this theory have been validated in both laboratory investigations (modelling the conditions of processing increasing volumes of visual information into control actions under time pressure) and in flight experiments. The levels of pilot difficulty experienced during different stages of the flight can be related to data regarding the psychophysiological tension of the pilot during his performance. There is an exponential relationship between the probability of HF-induced flight incidents and the level of pilot difficulty experienced during the flight (Figure 1). This highlights the potentially dangerous effect of the pilot's psychophysiological condition on flight safety.

These results give us the confidence to apply this relationship when developing new "ANONOV" planes. We can now take into account the optimality of technical decisions based on psychophysiological measurement, in addition to the professional standard of the pilot and degree of flight safety, from an HF perspective. This applies at all stages of the process, from research training, through flight test preparation, to flights themselves.



Figure 1. Dependence between the probability of a flight incident due to human factors (HF) and the psychophysiological tension of the pilot.

A mirror task to assess emotional reactivity and temperament in non-human primates

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At a very young age, monkeys respond to their mirror image. When confronted with a mirror, monkeys react as if their reflection is another monkey. They display behaviors corresponding to their species' typical social behavior repertoire, including submission, aggression, affiliation and play [1]. These behavioral responses persist over time, but are usually more frequent during the first exposure and decline thereafter [1]. Short and repetitive mirror image stimulation (MIS), rather than continuous exposition, is the most efficient way to induce a persistent behavioral response [2]. The unique features of MIS as a social stimulus present good opportunities for the study of socio-emotional behavior in primates. MIS is very pertinent because of its capacities to mimic a social encounter, and is unique in the sense that the animal has control over, and is instrumental in, producing stimulus change.

Goal

The goal of the present experiment was to design and pilot a new task using MIS to assess emotional reactivity in infant rhesus macaques.

Subjects

Eight 3-month-old male and female infant rhesus macaques (Macaca mulatta) were used.

Apparatus

A test-cage was designed specifically for this mirror task, consisting of an opaque rear wall, two wire-mesh sidewalls, and a white Plexiglas front wall containing a window closed with a one-way mirror. A guillotine door was used to expose the subject to the mirror. One video camera was affixed behind the mirror to record the monkey's facial expressions and behaviors. Another video camera was placed on one side of the cage to record the subject's location.

Procedure

The subject was introduced to the cage with the mirror masked and left for a 5minute acclimation period. Then, a series of ten 1-minute trials was given with the mirror exposed; each trial was separated by a 15-second inter-trial interval (ITI) with the mirror hidden. Afterwards, the subject was left in the cage for a 5-minute recuperation period.

Behavioral observations and analysis

A detailed ethogram (involving a total of 50 behaviors) was defined and used to code the behavioral responses of each subject. Different categories of behaviors were coded: mirror directed behaviors, activity, location, looking behaviors, facial expressions, social behaviors, non-social behaviors, vocalizations, and self-directed behaviors.

The behavioral reactions were coded using The Observer Video-Pro. The durations and/or frequencies of each behavior were analyzed with the statistics program SPSS.

Preliminary results and conclusions

Preliminary results indicate that the first reactions of infants towards their mirror image differed strikingly between subjects. However, these reactions changed progressively, probably because the 'other monkey' displayed the same behavior as the subject. Three types of emotional reactivity to the mirror image emerged: (1) threatening becoming avoidant; (2) fearful becoming affiliative; and (3) affiliative becoming more affiliative.

More analysis is required, but this new task seems, a priori, to be effective for assessing emotional reactivity and extracting temperamental differences in young rhesus monkeys. This mirror task could thus be very useful for assessing the effects of brain lesions on emotional reactivity in primates.

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Novel application of the Noldus UltraVox system for automated recording of maternal separation-induced audible distress vocalizations in the guinea pig

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Separating guinea pig pups from their dams and placing them in a novel environment elicits audible distress vocalizations. This maternal separation paradigm is used as a model of anxiety/stress, and is sensitive to the effects of anxiolytics and anti-depressants [1]. Historically, the duration and frequency of vocalizations were recorded manually, using direct observation or tape recordings. We have significantly increased the accuracy and throughput of the maternal separation test by automating the data acquisition and quantification processes.

Automation was achieved using UltraVox, which measures ultrasonic vocalizations. Audible sound capture was achieved using a standard condensing microphone (100-10,000 Hz) suspended 7.5 inches above the test chamber floor. The standard microphone line feed was too weak to register in the Ultravox system. Therefore, the microphone was connected to a small cassette recorder that provided necessary pre-amplification of the signal and recorded each session's data. The UltraVox system gain was set at 8.0 to record sound greater than 65 dB. Brief extraneous noise was eliminated through the minimum duration filter, a time delay control within UltraVox, which was set to record sound with a minimum duration of 60 ms. A secondary output was available for real time listening. Additional filtering could be applied, if needed, by using a graphic equalizer that provided multi-band width filtering from 16 Hz to 32,000 Hz.

We tested the effects of an anxiolytic (alprazolam) on maternal separationinduced distress vocalizations using the automated system. At 14 days of age, pups were administered alprazolam (0.3, 1 and 3 mg/kg) an hour prior to testing. Pups were then placed individually in a cage (10w x 10d x 16h inches) inside a lit (470 lux) sound attenuation chamber. The amount of vocalization was recorded for 30 min. Our results show that alprazolam significantly inhibited vocalization at doses of 1 mg/kg (68%, p < 0.05) and 3 mg/kg (81%, p < 0.01). Studies are ongoing to further characterize the maternal separation assay in guinea pigs.

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A technician's view on the future of the VU-AMS

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Several new techniques in digital technology make it possible to improve the specifications of the current VU-AMS device. By using high capacity memory cards and high resolution digital-to-analog converters, it will be possible to record raw ICG and ECG signals with increased accuracy and higher sampling rates. In this way, on-line signal processing and averaging can be postponed and performed in more sophisticated off-line data analysis applications. During this presentation, an outline of the new design and its implications will be discussed.

Shape versus size analysis of Fitts' aimed-movement paradigm

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A Fitts task requires people to move their hand, or some pointer, along one dimension to reach, as quickly and accurately as possible, a target of width W placed at a distance D [1]. What are the degrees of freedom available in this experimental paradigm? The usual answer is D and W. We suggest that this factorial description of the paradigm is flawed, and will introduce an alternative and (we believe) a more satisfactory description.

The major discovery permitted by Fitts' paradigm is Fitts' law:

 $MT = k_1 * f(D/W) + k_2$

where MT represents movement time (the paradigm's key dependent measure), f is some (linear, logarithmic or power) function, k_1 and k_2 are empirically adjustable coefficients, and f(D/W) is the index of difficulty (*ID*).

If the ratio D/W substantially influences the dependent measure (Fitts' law says it does), then D and W can no longer be regarded as independent variables, because no separate manipulation of a ratio's numerator or denominator is possible without altering the ratio itself. For example, increasing D at a constant level of W amounts to increasing both the *absolute* and the *relative* amplitude of the movement (i.e. both D and D/W), thereby confounding the two effects. The effects of D or W could be evaluated separately only if their inextricable correlate, the ratio D/W (and hence the ID), could be safely ignored – but we know by Fitts' law that this ratio is quite influential.

This confounding factor seems to have been overlooked so far in Fitts' law research, which typically has had recourse to orthogonal $D \ge W$ experimental designs. We will show that this traditional design has led to measurement errors (e.g. biased estimates of Fitts' law coefficients) and given rise to some conceptual muddles (e.g. the intractable problem of isolating the effect of D).

We will introduce an alternative *shape* versus *size* analysis. Suppose we want to measure the effects of the shape and size of a set of rectangles on some dependent measure, e.g. an aesthetic rating. These two effects can be evaluated

separately. Not only are a rectangle's aspect ratio and diagonal length orthogonal to each other, but our description is also exhaustive – there is no hidden correlated variable. In contrast, one cannot separate the effects of width and height on the aesthetic rating of rectangles because of the inextricable co-variation of the aspect ratio – a third variable that the width versus height analysis leaves aside. Likewise, we will argue that factorizing Fitts' paradigm in terms of (1) the ratio D/W (task shape) and (2) either D or $(D^2 + W^2)^{0.5}$ (task size) allows us to capture all the paradigm's variability, without any confounding effects.

This revised description of Fitts' paradigm, which we will illustrate with some fresh data, sets the stage for confound-free experimental designs that disentangle the effect of the ratio D/W (the determinant of the *ID*) from that of movement amplitude. Moreover, it opens interesting new avenues for research on human target-directed movement in the new context of multi-scale electronic worlds [2].

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SYBAR: an integrated system for gait analysis in clinical rehabilitation

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In the context of rehabilitation medicine, human movement analysis is best suited to an integration of observational techniques and measurements of physiological signals. For this purpose, the SYBAR system was developed. SYBAR is based on a combination of an intelligent data acquisition controller, a video digitizer and SYBAR software, to integrate the synchronized data streams and allow userdomain specific visualization.

The Syntech IDAC (Intelligent Data Acquisition Controller) combines a 16channel data acquisition system with independent and fully softwareprogrammable input amplifiers in a single instrument. For each of the 16 channels, the DC offset, gain, band pass and notch (50/60 Hz) filter and sampling rate (1-50 kHz) can be programmed individually. Each channel is provided with its own 16 bit D/A converter, the outputs of which are digitally multiplexed for transfer to the PC via the USB port. Data communication via the USB port also programs all gains and digital filter settings per channel. The software takes care of real-time on-screen presentation of all signals before and during recording, and monitors the effects of the amplifier settings. Stored data can be manually or automatically post-processed and exported. In SYBAR, the IDAC is configured to record bipolar surface EMG via 8 channels, while six other channels connect to a force plate measuring ground reaction force. The trigger from a synchronization generator is also recorded.

Videos are digitized using either commercially available digitalization or the SYBAR software. In the first case, a synchronization pulse is inserted visually into the video stream. Digitizing by means of the SYBAR software provides the option of reading the VITC (vertical interval time code) from the video stream itself. In this way, synchronization with physiological signals can be achieved either automatically or manually (using the visually inserted synchro-pulse).

After importing files from IDAC, SYBAR can customize the visualization of the various signals. This includes video overlay ('enhanced reality') of the ground reaction force vector. Thus, meaningful representations of the recorded signals are obtained (i.e. relevant to the user group). The user interface of this domain-specific application is kept straightforward, and can be tailored to groups of users.

A PC system for measuring driver behavior

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This paper describes a low cost PC platform, including a driving simulation, that is designed to provide orientation, subject record keeping, training, performance measurement and evaluation of driver behavior. The system is based on standard PC technology, and can be run on laptop or desktop computers. At the heart of the platform is a driving simulator system that includes an easily programmable scenario definition language for designing driving courses and providing performance measurement.

The driving simulation and its application have been described at previous conferences. The simulator has now been added to a platform that allows for login and record keeping of subject data, the presentation of orientation and tutorial material, the training and measurement of driving behavior, and the assessment of driving performance. The orientation and tutorial material can be prepared and presented with Microsoft PowerPoint, giving the user a great deal of flexibility in presenting a variety of visual and auditory effects, including narration. Given appropriately designed driving scenarios, the simulator component of the platform can present cognitively complex situations involving hazards, pedestrians, traffic and signals. These scenarios require critical driving skills, including situation awareness, hazard perception, risk assessment and decision-making under time pressure.

The platform is designed to permit psychomotor and cognitive skills to be taught to novice drivers, and to provide a driving skill evaluation tool for more experienced drivers. Performance measurements include assessments of vehicle motions, driver control responses and relative motions with respect to other vehicles and pedestrians. Typical measures include accidents, violations, speed and lane deviations, time to collision, use of turn indicators, reaction time, etc.

The paper will include a description of the training and evaluation platform, and a summary of two current applications: one involving training novice driver skills, and the second concerning the evaluation of older driver skills.

Telemetry and animal welfare: practical refinements

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Telemetry and data logging can be used to refine both experimental procedures and animal housing and husbandry. The primary advantage of these techniques is that interference with 'normal' behavior and physiology can be greatly reduced, thereby improving animal welfare and enabling more valid, reproducible and relevant data to be obtained. Other potential benefits include reducing the number of animals used in individual projects, and the ability to use telemetry data to monitor animal wellbeing more effectively, thereby assisting with the definition and implementation of humane endpoints.

However, implantation surgery and the presence of a telemetry device still have the potential to impair animal wellbeing [1]. It is thus essential that any impact on animals is minimised, while maximising the potential benefits associated with the use of telemetry. The BVA(AWF)¹, FRAME², RSPCA³ and UFAW⁴ Joint Working Group on Refinement is currently producing a report on refinements in telemetry that aims to help achieve this by setting out current best practice in:

- Selecting a device
- External attachment or implantation
- Anaesthesia and surgery
- Post-operative pain management
- Monitoring animal wellbeing
- Housing and care of animals on telemetry studies
- Conducting field studies using wild animals
- Removing devices and rehoming or releasing animals
- Guidelines for ethics committees when assessing projects involving telemetry

Our poster provides an overview of the Working Group's main findings and recommendations. A list of resources to assist with refinement is also available.

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Predicting suicide risk from patients' and therapists' facial expressions

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60 patients admitted to the Geneva University Hospitals after a suicide attempt were video-recorded during an interview with a psychiatrist. After each interview, the therapist was asked to assess the patient's suicide risk on a 4-point scale. During follow-up appointments two years later, we identified 11 patients who had made subsequent suicide attempts ('repeaters'). These patients were matched with 11 'non-repeaters' from the original sample with respect to gender, age and number of previous suicide attempts. To code the therapist's facial behavior during the original interviews, we used Ekman and Friesen's 'Facial Action Coding System' (FACS) and analyzed the ways in which her behavior differed between repeaters and non-repeaters.

Using traditional statistical analysis, we found significant differences between the two groups that allowed 82-91% of the patients to be correctly classified as either repeaters or non-repeaters. In particular, there were differences in the average activation of some coded units, such as peri-ocular activation, and in the duration of the therapist's gaze straight at the patient. By contrast, the therapist's written prediction was erroneous: only 23% of the patients were correctly classified.

These findings reflect the therapist's accurate perception of risk without her being aware of it. In the future, after replication, these findings may lead us to new methods for assessing suicide risk. New analyses with Theme should help us to better understand the interaction between therapist and patient, and may reveal which cues made the therapist able to distinguish between repeaters and non-repeaters – albeit non-verbally and subconsciously.

Querying multimodal corpora represented in XML

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In this presentation, we describe a language developed within the framework of the NITE project (a collaborative European project in the IST framework) for querying and retrieving data from multimodal corpora. The corpora are represented in XML and are annotated with respect to several modalities – typically, at different levels of description for a given modality. Although XQuery may seem to be an obvious candidate for the query module, a new, dedicated query language has been developed instead. In our presentation, we explain this choice, describe the language we have developed, and compare it with XQuery. We conclude with remarks on its ongoing implementation.

Evolving understanding: using video records in Interaction Analysis

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It is not uncommon to find people who think that being present when a behavior of interest takes place provides adequate information for an analyst to understand that behavior. For example, many developers of computer systems feel that watching people using computer applications is the ultimate engagement with users. However, because human activity usually proceeds more quickly than our analytical understanding of it, a single encounter cannot provide a basis for deep understanding. Also, memory limitations will not permit us to recall all that happens in even a short spate of activity, and notes cannot be made fast enough to record observations. Furthermore, any notes taken are made using some analytical perspective; such perspectives can comprehend only a part of what was understood at the time of recording, and even less of what might be understood upon reflection.

Consequently, ethnographers use videotape to capture a record of activity. Such records, though limited in physical and temporal scope, provide a record of activity that is not filtered through a human's perspective and understanding of the activity. These 'unprocessed' records provide a more neutral basis for analysis of the recorded activity. Furthermore, videotape records can be viewed repeatedly, providing multiple exposures to the activity. They may also be viewed at different speeds (slow and stop-action for dense activity; fast to obtain patterns). As a result, a much richer analysis of activity can be achieved. This analysis can then be used to identify other events in the activity that the analysis should account for. The analysis can be checked against the events for correspondence to the predictions of the analysis. Such validation, usually again entailing repeated viewing, is a second mode of viewing the videotape records.

Any analysis is obtained under a perspective that the analyst brings to it. This raises the concern that the analyst's perspective may significantly affect the outcome. There are at least two ways to address this concern. First, other analysts can be invited to view the videotape records and asked to either critique the analysis in hand or produce their own analyses for comparison. Such communal viewing and group analyses are at the heart of the Interactions Analysis Laboratory (IAL) analytical method. Second, the videotape records may be viewed in a third viewing mode: evaluating the videotape records to determine where the proposed analysis does not account for all the material filmed. Such unexplained activity can suggest ways in which the perspective used to create the analysis is limited or flawed, and may lead to proposals of alternative perspectives from which to analyze the tape.

Either of these methods for improving analytical perspective can lead to a further round of analysis, validation and evaluation. This analytical cycle is called Interaction Analysis (IA). This talk illustrates these ideas with a videotape (made in 1981) of people making copies with a Xerox copier. It shows how successive rounds of analysis/evaluation work lead to successively better understandings of the activity, and raises questions about convergence and completeness.

Discontinuities in the development of mother-infant relationships: applying a two-piece linear model to a study of the relationship between outcomes and underlying processes

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It is a well-established principle that behavior and social relationships change over time, and that these changes tend to be more dramatic during the early stages of ontogeny. A major challenge for developmental behavioral scientists is to find mathematical functions that capture the nature of these changes, and that allow tests of hypotheses regarding the possible effect of a number of variables:

- on the shape of the individuals' developmental trajectories
- on the observed variation in inter-individual developmental pathways
- on the relationship between age-dependent patterns of behavioral or relationship change and their underlying processes

The application of multi-level hierarchical models to study patterns of change in mother-infant relationships has shown that they can deal successfully with the first and second issues. Here, we use a two-piece linear model to explore its utility in analysing the third issue. Behavioral data from 23 mother-infant pairs of hamadryas baboons at Madrid Zoo were collected for 25 two-week periods over the first year of life, using focal animal and time sampling methods. We present results from the analysis of one of the 28 behavioral units considered: the percentage of time that the infant spent within 50 cm of its mother. We explore the effect of three variables known to influence spatial relationships between infants and mothers in primates: the infant's sex, and the mother's age and reproductive experience.

Our findings demonstrate a curvilinear relationship between time spent together and age, i.e. the multi-level hierarchical model was able to detect a 'discontinuity' in the behavioral outcome. Application of the two-piece linear model was then able to show that the association between the mother's age and the developmental course of this spatial unit changed when the two periods (i.e. before and after the occurrence of the discontinuity) were analysed separately. This suggests that the observed discontinuity in the behavioral outcome may be driven by a discontinuity in underlying processes linked to the mother's age. We conclude that multi-level hierarchical models in general, and piecewise linear models in particular, can be very helpful in unravelling the principles of behavioral development.

Vocality of the sound of coughing

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This research positively evaluated the vocality of the cough sound by estimating the average cough fundamental frequency or pitch. The fundamental frequency was determined by autocorrelation analysis on both the rough time signal and the linear predicted time signal [1]. An experimental cough database was recorded using a standard multi-media microphone (20 Hz - 20 kHz frequency response) and a sound card (16-bit) in a free acoustical field, using both male and female subjects. These included three ailing and nine healthy, non-smoking human subjects, along with two infected and two healthy Belgian Landrace piglets.

The healthy human subjects coughed voluntarily, whereas those suffering from a respiratory ailment coughed in an acute, productive way (i.e. sputum was cleared from their airways). Piglet coughing was either elicited by chemicals (in healthy animals) or was of a chronic, non-productive nature for subjects deliberately infected with bronchopneumonia. Accordingly, a total of 36 'voluntary', 48 'acute', 119 'chemical' and 1,883 'chronic' cough-sounds were studied.

Overall, 55% of 'voluntary', 75% of 'acute', 87% of 'chemical' and 73% of 'chronic' cough sounds were characterised by periodicity expressed by a global fundamental frequency. Generally, as in [2,3], the pitch of coughs originating from healthy subjects was higher than that of 'spontaneous' coughs resulting from ailment or infection. For both species, differences in pitch between healthy and infected subjects indicated the existence of acoustically different cough classes, in accordance with different causes or physical conditions of the respiratory system.

Pitch was also shown to vary during a single 'spontaneous' cough, so further research into the pitch-contour characterisation of the cough sound may be useful, as well as investigations into its production. The simplicity of free field sound recording and the objective, non-invasive nature of sound analysis offer great opportunities for implementating on-line follow-up work, and for applying this work as a diagnostic tool. The discovery of vocality represents an important and physically meaningful feature for advanced sound-recognition, consisting firstly of 'cough' versus 'no cough' recognition and secondly of whether a cough originates from a subject in 'pathological' versus 'normal' respiratory health.

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Computer-aided examination of schoolchildren's postural faults

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The alarmingly poor posture of our schoolchildren calls for action! Our studies showed that more than 80% of Styrian schoolchildren aged between six and eight suffer from severe postural problems.

The method employed in this examination was the so-called 'video screening of the spine' - a technique developed in Graz, in which the children's spinal processes are marked with small reflective stickers without putting a strain on the children themselves. The children are then videotaped from behind and from the side while walking and taking various positions, e.g. standing upright, or bending forward or to the side. With the help of the reflective stickers, the structure of the children's spinal columns can be easily analysed (Figure 1). Tests of coordination skills and muscle function, as well as an orthopaedic check-up, complete the examination.

To carry out many comprehensive examinations in a row, a software program for analysing, storing and documenting the postural faults had to be developed. Today, the 'Spine Analysis System' makes it possible to transmit selected frames of standardised positions via digital video directly to the computer (Figure 2). The doctors or therapists who analyse the data collected are given a context menu for each frame, from which they select the desired parameters. For essential parameters (such as scoliosis, hollow back, round shoulders, etc.), a frame database of deformities of different degrees in various positions is available. By videotaping standardised positions, the structure of the spinal processes can be palpated automatically, using virtual tools like protractors or plumb lines.

After each evaluation is complete, a suitable exercise programme is selected. According to the postural faults of each child, the program 'WIRBEL-MED' suggests a set of focal and alternative exercises from a range of more than one hundred. The doctor or therapist composes the final programme and prints it out for the children, together with all the relevant instructions. This software has proven to be of great help for doctors and therapists in the standardised analysis of postural faults.



Figure 1. Videotaping a subject whose spinal processes have been marked with reflective stickers.



Figure 2. Tailoring an individual exercise programme with the Spine Analysis System.

Information synchronization through post-processing utilising the PRN code

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Some of the synchronization problems encountered when recording data with different systems are presented, with a focus on the simultaneous measurement of video and digital data, followed by off-line synchronization of the information streams. Research in the context of the Visual Lab project [1] has led to the development of the Pseudo Random Noise (PRN) code approach, which combines excellent synchronization accuracy with a relatively simple set-up and a low synchronization information data-rate.

Every post-processing synchronization method relies on the overlap of information between different simultaneous measurements. The main difference between the methods is the amount of data used to record the overlap. At the two extremes, one can record an (absolute) time source for each measurement, or simply rely on the overlap of information channels in different measurements. An example of the latter is the similarity of eye-blinks measured with a camera system (e.g. eye-tracker) and eye-blinks detected through the measurement of the vertical EOG. All possible approaches have been implemented in the NLR 'Human factors Evaluations, data Analysis and Reduction Techniques' (HEART [2]) data analysis program, to determine the best option.

This program concluded that the required overlap of information could best be provided by a special binary code, called PRN [3]. The PRN code possesses some interesting characteristics, which make it suitable for recording on diverse media (digitally, or within audio and video streams), without the requirement for specialised and/or complex converters. It also allows the retrieval of time-differences with a high resolution (in the order of 5 ms for a PRN chip-rate of 2 Hz and a measurement length exceeding 100 chips, i.e. 100/2 = 50 seconds). The PRN code tested is also used by the Global Positioning System (GPS, a satellite position determination system), which determines time-differences between a transmitter and a receiver with extreme accuracy (in the order of nanoseconds).

The development of the PRN synchronization technique is not finalised. Several enhancements and refinements to the technique are still possible. However, the current implementation already demonstrates extremely high precision without many system constraints, and therefore seems to be a practical way to allow multiple recordings with diverse media (audio, video and digital information).

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Long-term neurocognitive deficit, cardiopulmonary bypass and microsphere injection in the rat

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Different mechanisms may be responsible for neurocognitive deficit (NCD) following cardiac surgery, including immune activation due to cardiopulmonary bypass (CPB) and cerebral embolization. Short-term NCD following CPB was recently reported in a rat model [1]. We hypothesized that long-term NCD would occur in a similar set-up, and would be exacerbated by the injection of microspheres to simulate atheromatous embolization.

Methods and results

Male Wistar rats (c. 450g) were anaesthetized and subjected to one hour of CPB (n = 12) or sham-operated (n = 9). Twelve weeks after recovery, they were neurocognitively tested in the Morris Water Maze. Analysis using EthoVision showed no difference in the learning curve (decreasing search time or distance) between groups.

In a second experiment, either $30\mu m$ diameter microspheres (n = 12) [2] or vehicle (n = 4) was injected into the right internal carotid artery of similar rats. Again, the learning curves did not differ.

Using a new method to achieve bilateral distribution [3] in pilot experiments, there was a tendency for the injected animals (n = 5) to perform less well than control or sham-operated animals (n = 7).

Discussion

Injury due to CPB in the rat is either too minor to be detected, or the NCD does not persist beyond the short term. The plasticity of the rat brain may allow recovery from unilateral embolic damage, but bilateral damage appears to cause a lasting deficit. We intend to use this model to test possible pharmacological protective measures against surgery-induced NCD.

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VU-AMS derived differential contribution of cardiac vagal tone, central respiratory drive and respiratory parameters to RSA during mental stress and physical exercise

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Changes in Respiratory Sinus Arrhythmia (RSA) may result from changes in Tonic Vagal modulation of heart rate (VT), central respiratory drive, respiratory depth or respiratory frequency. The differential contribution of these parameters to RSA during different stressors is not clear, hampering the interpretation of reduced RSA found in high risk or patient groups. Using the VU-AMS device, this study tested the contributions of these determinants of RSA in a within-subject design.

Twenty-two healthy participants were submitted to mental stress, relaxation and mild physical exercise during three different breathing conditions: normal breathing, breathing compressed room air, and breathing compressed 5% CO₂-enriched air. The CO₂-enriched air was used to manipulate central respiratory drive, which was estimated with the end-tidal partial pressure of CO₂ (PetCO₂). RSA was estimated as High Frequency (HF) heart period variability power. Respiratory depth and frequency were derived from the thoracic impedance signal. The Pre-Ejection Period (PEP) was measured to obtain an indication of changes in the Tonic Sympathetic modulation of heart rate (ST), and used in combination with changes in heart rate to estimate changes in VT.

Path-analysis demonstrated that changes in VT, PetCO₂, respiratory depth and respiratory frequency each had an independent contribution to changes in HF power. Reductions in HF power were enhanced by increases in respiratory frequency and reduced by increases in PetCO₂ and respiratory depth. The relative contributions of these determinants were different under conditions of mental stress and physical exercise. To index within-subject changes in VT, changes in RSA should be corrected for changes in central respiratory drive, respiratory depth and respiratory frequency.

Automated infrared thermographic tracking as a non-invasive tool for measuring long-term temperature effects of social stress

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Non-invasive automated infrared thermography is a useful new tool for tracking immediate stress-induced skin and tail temperature changes (comparable to Stress Induced Hyperthermia) in free-moving animals. Previously, we have found indications that the latency and amplitude of these autonomously-mediated temperature responses differ between enriched- and standard-housed rats.

Here, we use a social-stress paradigm to test the hypothesis that the normal course of the skin-temperature response to a stressor is altered in rats with reduced wellbeing. The paradigm consists of a social defeat followed by social isolation. The combination of both is known to be a powerful stressor with many long- and short-term effects on behavior and physiology, for which reason it is often regarded as a model for human depression and for reduced animal welfare.

We compared defeated (n = 8) and control rats (n = 8) in several tests over time. The control rats differed in none of the behavioral variables considered, which was unexpected. In contrast, the defeated rats showed a more pronounced skinand tail-temperature response to various stressors. For instance, four weeks after the defeat, the rats were placed in a novel cage. All rats responded with an immediate decrease in tail temperature, but the two groups differed significantly in the speed of subsequent increase to normal levels (mean \pm se for defeated rats: 0.26 ± 0.03 °C/min; for controls: 0.37 ± 0.06 °C/min; Mann-Whitney U-test: U = 10, p < 0.05). In general, the tail temperature of the defeated rats stayed at a low level for longer periods. This effect was found on several occasions, from four weeks after the defeat onwards. See Figures 1 and 2.

These results are in line with other studies indicating that physiological measures are often more sensitive than behavioral measures. An interesting finding was that tail temperature increased sharply approximately 9 min after the stress-induced decrease. There are some indications that the onset of this increase is related to the intensity of the stressor, as perceived by the animal. These data show the potency of automated infrared thermography as a tool for detecting a physiological indicator of reduced welfare. The potential uses of this non-invasive method for monitoring welfare in other species will be discussed.



Figure 1. A thermographic image of a rat.



Figure 2. Another image of the same rat, taken two minutes later, after a novel object.

Linking individual behavior and population dynamics: using electronic tags to measure fish migration

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Detailed studies of the migratory movements of marine animals are still hindered by the difficulty in obtaining repeated and frequent estimates of their geographical location over appropriate seasonal time-scales. Many marine animals do not surface with sufficient frequency to be tracked using satellite-based telemetry, and are often too small to bear satellite tags. Furthermore, the use of ambient light records to estimate geoposition from data loggers is not possible for many marine fish, particularly in relatively turbid shelf seas like the North Sea. However, the unsustainable levels of exploitation currently being experienced by fish stocks makes an understanding of their behavior paramount to the implementation of effective conservation measures.

Towards this end, we have successfully used small electronic data storage tags (DST), which measure ambient depth (from water pressure) and seawater temperature, on North Sea plaice, cod and rays. These tags can record and store data for many months, providing information over seasonal time-scales appropriate to the understanding of annual migratory movements. Tidal data (times of high water and tidal ranges), recorded when fish remain motionless on the seabed, have been used to estimate geoposition with a degree of accuracy unattainable using light-based geolocation. Our results have provided detailed information on fish spatial dynamics, encompassing individual vertical activity patterns to population sub-structures (see following abstract).

In terms of fish stock conservation, our data provide a fundamental method by which accurate predictions can be made regarding the occupancy and transition times of fish in defined areas. With fisheries exclusion zones increasingly being employed as a measure to regulate fishing intensity, the incorporation of fish behavior data into biologically-based predictive models of spatial dynamics has an important potential role to play in the formulation of stock recovery plans.

Subdivision of the North Sea plaice population: evidence from electronic tags

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Between December 1993 and September 1999, 752 mature female plaice were tagged with electronic data storage tags (DST; see preceding abstract) and released at eight North Sea locations. Tidal data recorded by returned DSTs were used to reconstruct the movements of 145 free-ranging plaice for periods of up to 512 days, with a total behavioral record of 20,403 days of data.

The results revealed a seasonal subdivision of the population sampled into three geographically distinct sub-units. Between May and October, these sub-units were centred on Amrum Ground to the east, Ekofisk Field to the north, and between the north coast of East Anglia and Dogger Bank to the west. During the spawning period (December-April), individuals from both the eastern and northern sub-units were found simultaneously on the German Bight spawning grounds, while individuals from all three sub-units visited spawning grounds in the Southern Bight.

The only fish in the current study to leave the North Sea were a sub-set of the western sub-unit that visited spawning grounds in the eastern English Channel. The western and eastern sub-groups recorded a seasonal rise and fall in ambient temperature, whereas the northern sub-group spent the summer in deep, cold, thermally-stratified water.

Reliability of selected performance analysis systems in football and rugby

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It has been suggested that 70% of 72 behavioral analysis research papers examined did not report any reliability and, of those that did, most used inappropriate statistical techniques [1]. The purpose of this study was to assess, in terms of reliability, the analysis procedures for two invasion games, football and rugby. Both games involve many behaviors that are subtly different and can cause confusion for the untrained observer. In football, for example, a tackle may be deemed unsuccessful when the ball goes to another opposition player, but since the ball carrier was deprived of the ball, some form of success was achieved. This can result in confusion, and hence observational errors, unless the behavioral definition for the tackle is very specifically worded.

In this study, operational definitions of behaviors were formulated and configurations set up using The Observer. Once the two configurations were complete, matches were coded. The adaptability of The Observer meant that configurations and operational definitions could be amended match by match, as the need arose. This took eight matches for rugby, where 38 anomalies occurred (79% were operational definitions, 13% configuration changes and 8% remained irresolvable), but only two matches for football, where all 9 changes involved the configuration. This difference was largely due to the rugby configuration being used to provide weekly feedback to a professional team, whereas the football configuration was used solely for research purposes. Hence, there was more time pressure to complete the rugby configuration, resulting in less robust operational definitions than for the football. The unique difficulties in observing behaviors in each sport would have also contributed to other errors, however.

Intra- and inter-operator reliabilities were calculated using the percentage error for each variable [1], producing a powerful image of the error for each variable (Figures 1 & 2). Two trained analysts (with >100 h of system experience) recorded low errors (<8.5%) for all variables in both trials, but two less experienced observers made far more errors on some variables (15-20% in rugby, 11-44% in football). They either failed to label behaviors correctly (52.1% of errors in rugby; 49.6% in football), or failed to record the behavior altogether.

This study implies that operators must be trained sufficiently in linking the recording process with operational definitions, and that their skill levels must be

tested using methods similar to these. High motivation is required to minimise lapses in concentration that result in certain behaviors being missed. Individual behaviors vary in terms of associated error, but all are within acceptable limits.

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Figure 1. Errors for each behavior in the rugby analysis.

⊽ tackle

⊲ penalty O pass

🛇 scrum



Figure 2. Errors for each behavior in the football analysis.

behaviour O player

△ pass
 ▽ pass outcome
 ▷ pass type
 ⊲ area of pitch

🗆 gain possession

🗘 tackle

Reliability analysis on continuously measured behavioral data

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Background

Reliability analysis theory has been developed for assessing, on a nominal scale, a series of cases by two independent raters. For each case, the assessment results are tallied in a *confusion matrix*: a contingency table in which agreements and disagreements in the classifications of both raters are presented (Figure 1). Reliability statistics, such as percentage of agreement, Cohen's *kappa* (agreement corrected for chance agreement) and Pearson's correlation coefficient *rho*, can be computed from the confusion table.

Reliability analysis and continuously recorded behavioral data

In behavioral research, reliability analysis must deal with two sets of timestructured data ('observations'). This is not a problem if the two observations compared involve behaviors sampled at fixed intervals, since each sample then corresponds with a case. But if they involve behaviors that have been recorded continuously, such that the start and end of each case are measured subjectively, the following problems arise in finding a basis for comparing the data sets:

- The number of cases must be assessed subjectively, since one does not know how many behaviors have occurred (Figure 2).
- Assigning nominal values (behavioral records) to cases is difficult, since a rater may not make an assessment for each case (e.g. the rater may have overlooked a behavior).
- Overlap of cases: making a simple choice between 'agreement' and 'disagreement' for each case, and tallying the results in the contingency table, may not be appropriate, since cases may overlap only partially in time. Using the *duration* of overlap as the result of each comparison, instead of the choice between agreement and disagreement, produces a contingency table that better reflects the actual agreement.

Reliability analysis using The Observer software

The Observer 4.1 offers a new set of reliability functions capable of taking the time-structured nature of the data into account. Reliability analyses are based on four different methods of comparing continuously recorded data sets, which differ in the way the three problems mentioned earlier are dealt with:

- Cases and corresponding values are either identified through an algorithm that takes into account the overlap of behaviors in time and sequences of behaviors, or not identified at all.
- The results of comparisons for each case can either be presented as 'duration of overlap' or 'agreement/disagreement'.

Furthermore, The Observer presents outcomes at different levels:

- A list of coupled behaviors and their assessment (agreement or disagreement), for a detailed analysis of reliability per case (not applicable to duration-based and frequency-based comparison; Figure 3).
- A confusion matrix of behaviors (Figure 4).
- An overview of reliability statistics, including percentage agreement, index of concordance, Cohen's *kappa* and Pearson's *rho* (Figure 5).

		Rater 2		
Rater 1	Nominal value	А	В	С
	А	2	3	0
	В	0	4	1
	С	1	1	3

Figure 1	Example	f a contingency	table in which	agroomonts and	disagroomonts	have been t	tallind
riguie i.	Example o	y a contingency	uole in which	agreements and	uisagreemenis	nave been i	annea.

	Observat	ion 1	Observat	ion 2
Case	Behavior	time	Behavior	Time
1	Walk	0	Walk	0
2	Jog	5	-	
3	-		Run	7
4	Hold	12	Hold	11

	Observat	ion 1	Observat	ion 2
Case	Behavior	time	Behavior	Time
1	Walk	0	Walk	0
2	Jog	5	Run	7
3	Hold	12	Hold	11

Figure 2. Example showing the difficulty of objectively determining the number and type of cases.

Result of	Indoor grou	IP (Outdoo	or group
Comparisons	Time	Record	Time	Record
Agreement	14-5-2002 01:00:09.20 Dere	k None	14-5-2002 01:00:09.20	Derek None
Agreement	14-5-2002 01:00:09:20 Dere	k Watch Object	14-5-2002 01:00:09:20	Derek Watch Object
Agreement	14-5-2002 01:00:09 20 Sean	None	14-5-2002 01:00:09.20	Sean None
Agreement	14-5-2002 01:00:09.20 Sean	Nul	14-5-2002 01:00:09:20	Sean Null
Agreement	14-5-2002 01:00:09.20 Roge	r None	14-5-2002 01:00:09.20	Roger None
Agreement	14-5-2002 01:00:09 20 Roge	r Null	14-5-2002 01:00:09:20	Roger Null
Agreement	14-5-2002 01:00:09.20 Jerry	None	14-5-2002 01:00:09.20	Jerry None
Agreement	14-5-2002 01:00:09.20 Jerry	Nul	14-5-2002 01:00:09:20	Jerry Null
Agreement	14-5-2002 01:00:13.16 Dere	k Telk	14-5-2002 01:00:13:00	Derek Talk
Agreement	14-5-2002 01:00:15.88 Dere	k None	14-5-2002 01:00:15:70	Derek None
Agreement	14-5-2002 01:00:19.32 Dere	k VisualCo Child	14-5-2002 01:00:19.40	Derek VisualCo Child
Agreement	14-5-2002 01:00:19.56 Dere	k Watch Object	14-5-2002 01:00:19.46	Derek Watch Object
Agreement	14-5-2002 01:00:19.88 Dere	k Talk	14-5-2002 01:00:20.92	Derek Talk
Agreement	14-5-2002 01:00:22.52 Dere	k None	14-5-2002 01:00:21.82	Derek None
Agreement	14-5-2002 01:00:31.48 Dere	k Talk	14-5-2002 01:00:29.34	Derek Talk
Disagreement	14-5-2002 01:00:31.96 Dere	k VisualCo Child	14-5-2002 01:00:31.96	Derek VisualCo Adult
Agreement	14-5-2002 01:00:32:40 Dere	k Watch Object	14-5-2002 01:00:32.48	Derek Watch Object
Agreement	14-5-2002 01:00:33.64 Dere	k VisualCo Child	14-5-2002 01:00:34.06	Derek VisualCo Child
Agreement	14-5-2002 01:00:34.00 Dere	k Watch Adult	14-5-2002 01:00:35.08	Derek Watch Adult
Agreement	14-5-2002 01:00:35.84 Dere	k Watch Object	14-5-2002 01:00:36.10	Derek Watch Object
Agreement	14-5-2002 01:00:36.76 Dere	k VisualCo Child	14-5-2002 01:00 36.66	Derek VisualCo Child

Figure 3. Example of a case-by-case comparison in The Observer 4.1.

																Indoor gro	ıp	
					Derek							Jerry						
							Activit	y		Mouth activity			Activity Mouth a			uth activity	ivity Activ	
				v	Natch		Visu	alCo	<no record=""></no>	Talk	lk None	one <no record=""></no>	Null	<no record=""></no>	None	<no record=""></no>	Null <	<no f<="" th=""></no>
				Object	Adult	Child	Child	Adult							1			
Т	Т		Object	6	0	0	0	0	1	0	0	0	0	0	0	0	0	
		Watch	Adult	0	1	0	0	0	0	0	0	0	0	0	0	0	0	-
	€l		Child	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
¥	히	10	Child	0	0	1	3	0	0	0	0	0	0	0	0	0	0	
ale	٩	visualco	Adult	0	0	0	1	0	0	0	0	0	0	0	0	0	0	
5	1	<no record=""></no>	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	≩Ì	Talk		0	0	0	0	0	0	4	0	1	0	0	0	0	0	1
	ŝ	None		0	0	0	0	0	0	0	3	0	0	0	0	0	0	
	륑	<no record=""></no>		0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Т	٤Ĩ	Null		0	0	0	0	0	0	0	0	0	1	1	0	0	0	
≥	B	<no record=""></no>		0	0	0	0	0	0	0	0	0	0	0	0	0	0	
şΓ	١ <u>ظ</u>	None		0	0	0	0	0	0	0	0	0	0	0	1	1	0	
	ŝ	<no record=""></no>		0	0	0	0	0	0	0	0	0	0	0	0	0	0	
ſ	٤Ĩ	Null		0	0	0	0	0	0	0	0	0	0	0	0	0	1	
a.	5	<no record=""></no>	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
21	텛	None		0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	5	<no record=""></no>		0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Т	٤l	Null		0	0	0	0	0	0	0	0	0	0	0	0	0	0	
=	5	<no record=""></no>	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Figure 4. Example of a confusion matrix in The Observer 4.1.

Indoor group vs Outd	oor group	
Measure	Value	
Number of Agreements:	23	
Number of Disagreements:	10	
Percentage of Agreements:	69.70	
Index of Concordance:	0.70	
Pearson's Rho:	0.88	
Cohen's Kappa:	0.67	

Figure 5. Example of reliability measures in The Observer 4.1.

Measuring social interactions in colour-marked rats adapted to a reversed daylight cycle: ultraviolet lighting and fluorescent markers help avoid problems with colour distinction in dim light

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The symptoms of schizophrenia can be divided into positive, negative and cognitive. Positive symptoms are characteristics added to the normal state, including hallucinations, delusions and thought disorders. Negative symptoms refer to lost functions, and comprise social withdrawal, flattened affect and apathy. Classic neuroleptics are effective in relieving positive symptoms, but affect negative or cognitive symptoms to a lesser extent. Furthermore, these drugs have serious extrapyramidal side effects. There are a few atypical antipsychotic drugs that alleviate a broader spectrum of symptoms, but there is still an urgent need for more effective drugs with fewer side effects.

Hypoglutamatergia in rodents, induced by the non-competitive NMDA receptor antagonist MK-801, results in a characteristic behavioral pattern that serves as a powerful model for schizophrenia. The aspect of behavior most widely studied in this context is hyperactivity, which is believed to model positive symptoms. Increased computer power and refined methods for behavioral studies have made it feasible and cost-effective to measure a large number of other aspects of behavior, such as stereotypies and social behavior, through automated video tracking [1]. Hypoglutamatergia-induced social withdrawal in rats is believed to serve as a model for negative symptoms.

To meet our needs for a more complete model for schizophrenia, we have extended our use of EthoVision to measuring social interactions between two rats. The rats are videotaped from above, and the animals' movements are tracked by computer analysis. EthoVision offers two different means of identifying animals tracked in the same arena: by surface area or by colour. In our system, identifying rats by measuring surface area results in errors that must be corrected manually. Thus, we decided to use colour marking for identification. Since we keep the animals in a reversed light/dark cycle and perform the experiments in dim light conditions during the rats' active phase, detecting colour becomes a problem. Therefore, we mark the rats with fluorescent dyes (Net-Tex Agricultural Ltd.) and illuminate the arenas with UV-light (350-400 nm, 2 x 1.2 W). The fluorescent spots on the rats appear as patches of different colour against a dark

background. The software can then effectively separate the two animals. The resulting tracks form the basis for a vast number of parameters describing many aspects of behavior. EthoVision is capable of calculating most parameters, but additional and modified parameters may be calculated using other software, such as MatLab (The MathWorks, Inc.).

In conclusion, behavioral studies in rats serve as a powerful tool to evaluate putative pharmacological treatments for schizophrenia. Novel drug candidates are compared in this model with existing classic and newer antipsychotic drugs, with respect to their capacity to alleviate both positive and negative symptoms.

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Mobilising for mass release of guard bees in Apis dorsata

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The South Asian Giant Honeybee *Apis dorsata* builds single-combed nests in the open, attached to branches, rocks or buildings. The bees themselves cover the comb in several living layers, forming a so-called *bee curtain*. The nests are exposed to the weather and to predators feeding on bees. The pressures of predation, particularly by birds and wasps, have induced the evolution of defence strategies [1]. Responding to predatory wasps, members of the outer layer display so-called *shimmering behavior* [2]. Stronger stimuli, e.g. from birds, may provoke a mass attack [3]: within a fraction of a second, hundreds of bees take flight to attack the enemy and pursue it over a large distance. The current study examines how a colony mobilizes itself to provide such a sudden defence response.

In our experiments, we disturbed *Apis dorsata* nests by throwing small twigs towards the centre of the nest. The nest surface was monitored by infrared camera (Thermacam SC1000), so that changes in the temperature of single individuals as a response to stimuli could be assessed by image analysis. After the stimulus, guard bees were recruited in the disturbed area of the nest. On one hand, formerly quiescent surface bees started warming up their thoracic muscles; on the other, nest-warmed bees with an overall body temperature of 37°C emerged from inside the nest (Figure 1, lower curve). These individuals may be called *soldier bees*, as they were not previously members of the surface layer and were specially recruited for defence.

The group of hot bees assembled at the nest surface was uniquely responsive. Consecutive stimuli triggered the immediate release of some of the recruited bees. Seconds after the stimulus, the nest started to increase in size (Figure 1, upper curve). Two responses can be distinguished here: initially, the bee curtain became vertically longer, reflecting movement only in the vertical mesh component of the bee curtain. This can be seen as an active response of bees in the mesh of the curtain layers, which stretch their legs to make room for bees emerging from inside the nest. In a second step, the emerging bees force the mesh of the curtain to disperse in a horizontal direction.

The response latency of any particular zone of the nest surface (measured as the time interval between the moment of disturbance and the onset of soldier bee emergence) depends on its distance and angle from the stimulation site. Arousal spreads faster diagonally than it does horizontally or vertically (Figure 2). We

assume that the three pairs of legs of the curtain bees form the network for signalling arousal state, as individuals are 'connected' to each other via their foreand midlegs [4].

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Figure 1. Changes in nest size and the number of hot bees following stimulation.



Figure 2. The relationship between response latency and relative angle from the site of stimulation.

Face expression detection and synthesis using statistical models of appearance

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Face expression change has been recognized as a major source of variation in face modelling. It can significantly change the appearance of a face and degrade the performance of face recognition systems. Statistical models of appearance, which explicitly represent variation in the shape and texture of face images, can be used to encode a face in a compact set of parameters. In this paper, we describe a method of analysing face expressions using such a facial appearance model.

Statistical models of appearance have been widely used for the recognition, tracking and synthesis of many different objects. They contain a statistical model of the shape and grey-level appearance of the object of interest, and are capable of 'explaining' almost any valid example in terms of a compact set of model parameters. The strength of such models has been shown by their effective performance in modelling face variations and synthesizing photo-realistic reconstructions [1,2,3].

Using simple linear regression on a suitable training set of static images, we first learned the relationship between different expressions and the model parameters. We considered five typical face expressions: neutral, smile, frown, surprise and winking. Given a new face image, the model produced a new set of parameters, and the degrees of each of the represented facial expressions were computed using the relationships learned previously. Preliminary results have shown that this method can effectively separate each face expression, and can therefore potentially be used for measuring face behavior.

A facial appearance model has been built from a face image database containing multiple images of 100 people, including a variety of posed expressions (e.g. smiles, frowns and looks of surprise). The analysis has led to a parameterised model with 349 modes controlling facial appearance. The first three modes are displayed in Figure 1. We used linear regression to learn the various relationships, and then built four expression estimators. Figure 2 shows expressions synthesised using the relationships learned.

Using these expression estimators as classifiers, the facial expression on a new image can be detected. Table 1 shows the test result obtained using a training data set. The threshold was set at 0.5. A false rejection means that one of the

expressions was recognized as neutral, whereas a false acceptance means that a neutral face was recognized as one of the expressions. In this table, for example, 62 smiling faces were tested and 5 of them were detected as neutral.

These results demonstrate that simple linear relationships can provide a good model of expression change, and can be used for both expression synthesis and recognition. We hope to extend the approach to image sequences, which we anticipate will give more reliable results.



Figure 1. The first three modes of the face appearance model.



Figure 2. Expression estimator values vary between four standard expressions.

Estimator	Error Rate	
	false reject	false accept
Smile	5/62	5/62
Frown	7/62	7/62
Surprise	9/60	8/60
Wink	0/34	4/34

Table 1. Test results obtained using a training data set.

Observing and recording the defence strategies of giant honeybees (*Apis dorsata*)

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This film focuses on the social structure of the South Asian Giant Honeybee *Apis dorsata* (Figure 1), and demonstrates that the bees' ferocity reflects their potent defence capacity. With a unique set of defence strategies, this bee is adapted to cope with many predators. The film explains how thousands of individuals within a bee community can cooperate to defend themselves against predators. The whole repertoire of a colony's defence strategies is displayed, in the context of natural predation and under controlled experimental conditions. The following behavioral aspects are shown, as visualised by infrared camera (Figure 2):

- Wasps are prevented from effectively fixing their eyes on individual bees by wave patterns, which involve thousands of bees in the outermost layer of the 'bee curtain'. This process is pheromonally linked, via Nasonov scenting [1].
- When a wasp comes into contact with a nest, the worker bees form a ball around it and increase the temperature until the wasp dies.
- Larger predators cause the colony to produce massive waves, with all bees stretching their bodies upward, activating their flight muscles and acoustically mimicking feral mammals. This causes the nest to thicken and enlarge.
- Thousands of bees can counterattack birds and humans in a split second. This is illustrated using bee-eaters, which have a unique hunting strategy [2].
- Colonies that are not directly threatened can participate in the defence response of those that are.
- Only colonies able to respond rapidly are prepared for mass defence. Infrared recording demonstrates how an undisturbed colony mobilises its defence strategies. If disturbed, nest-warm bees emerge from deeper layers to the nest surface within one minute (Figure 3); these are referred to as 'soldier bees'. A single disturbing stimulus is sufficient to make these bees attack.
- Colonies can memorize previous disturbances and keep soldier bees on 'stand-by'. While the mobilisation of mass defence can be observed directly, the readiness of a colony to attack cannot be assessed without knowledge of its past history.

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Figure 1. Aggregation of giant honeybee nests.



Figure 2. Infrared image of a giant honeybee (25-37°C).



Figure 3. Stimulation experiment.

Facial expression during trauma exposition

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New studies on trauma suggest that most patients suffering from post traumatic stress disorder can benefit from using a new therapeutic strategy named EMDR ('eye movement desensitization and reprocessing'). However, our theoretical understanding of the properties and indications of EMDR remain unexplained and controversial.

Using a multi-channel behavioral approach, involving EMFACS (EMotional Facial Action Coding System), gaze analysis and interaction analysis, our work examines the conscious and unconscious processes affecting the regulation of interactions between therapists and patients during initial therapy sessions. We also record facial expression as an indicator of cognitive and affective information processing during trauma exposition with EMDR.

The clinical hypotheses of trauma therapists will be discussed, along with presumed indicators of improvement. We will also present some initial results from our analysis of facial expression.

A toolset to support logfile examinations

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In the scientific community, well-documented evaluation methods are primarily those in which experts make the system assessments. Many of these describe methods such as thinking aloud or interviews with test-users. In contrast, methods based on recording logfile data, or observing interactions between test subjects and the system, are hardly ever documented. Despite this, such tests are frequently conducted, because the data they produce are reliable and many longterm effects can only be proven in this way. The toolset we have developed is designed to act as a guideline, by providing a set of tools for those steps of the evaluation that occur systematically, i.e. recording and analysing data.

Logfiles show snapshots of system states. To assess user behavior, it is necessary to examine all of the interaction data. This work could be simplified by structuring the data in advance. Developing prototypes of technical systems is often restricted by limiting conditions (e.g. platform, development surroundings). Therefore, it is not possible to give developers instructions concerning the concrete realization of their system. To use our toolset, only the structure of the logfiles produced must be variable; the toolset is not designed to replace professional tools for statistically evaluating the data (e.g. SPSS, Excel). Between these two steps (i.e. developing the system and performing statistical calculations) lies the *real* problem for the tester, where (s)he must view, structure, complete and summarize the data. To achieve this, (s)he often uses specific new macros, scripts or self-made tools, which must be adapted for every new question. Our toolset fundamentally simplifies and structures this work.

As already explained, the structure of the produced logfiles within the system must be variable. However, one firm requirement is that the data must be saved as XML files. To achieve this, we have designed an XML-DTD. Despite having a simple structure that can be easily created by the system, it is also powerful and flexible enough to handle every imaginable type of logfile data. The use of XML made it possible to develop a general tool for browsing logfiles. As well as representating all entries in tabular form, it is also possible to switch different filters on or off within this table.

By improving the browser to an editor in this way, new information (e.g. names of conditions and events, identification of hierarchical levels) can be entered and saved in the logfile. It is also possible to record details regarding the knowledge of the evaluator about process content and application events within the logfile. An Application Knowledge Base (AKB) can be built, eventually making it possible to perform an automated evaluation. The tester must deal only with those sections in the logfile that have not already been taken into account by the AKB. The application of the AKB is illustrated in Figure 1.



Figure 1. Use of the editor and the AKB.

Cat odour exposure increases the expression of wolframin gene in the amygdaloid area of rat

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The aim of the present study was to identify which genes are expressed in the amygdaloid area of rats after exposure to cat odour. A cloth containing cat odour was used to induce the ethologically relevant fear reaction in male rats. Video recording was performed so that all 12 animals belonging to each group of rats were visible. Videotaped behavioral responses were analysed by an observer who was unaware of the manipulations performed. At one-minute intervals, the videotape was paused, and the number of animals sniffing the cloth, in the proximity of the cloth, or touching the cloth was recorded. We also evaluated the number of animals grooming in each group. These behavioral measures have been shown to reflect avoidance and fear towards unpleasant objects.

The differential expression of genes was analysed using cDNA Representational Difference Analysis (cDNA RDA). The differentially expressed clones were identified by sequencing and database searching. RT-PCR (Reverse Transcription Polymerase Chain Reaction) was applied to confirm the differences found by the RDA. Exposing rats to cat odour induced avoidance behavior and suppressed the exploratory activity of these animals. During the cat odour exposure, several genes with various functions were activated in the amygdaloid area of the rats. Among these genes, we identified the activation of wolframin gene. RT-PCR confirmed quantitative elevation in the levels of wolframin transcripts in the amygdaloid area. Thus, this study supports the role of wolframin in the regulation of emotional behavior.

Body language and mate choice: an empirical ethological study

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The field of human mate choice and attractiveness is one of intensive study. Despite the enormous amount of data collected, human mate choice is still not fully understood. This is due to the huge number of ways in which mate choice can be influenced. So far, research has dealt predominantly with the assessment of attractiveness from photographs, body and face symmetry, analysis of non-verbal communication, and sexual signals during courtship and flirting. In contrast, human body movement has not been of great research interest. Although early attempts at methodologically objective research were undertaken during the 1920s [1], this aspect of mate choice was of very low interest to researchers, mainly because of the lack of available technology.

In many other aspects, it has been shown that body movements are used, both deliberately and indeliberately, to support communication. To date, however, there has been a lack of research concerning how people are influenced by body movement when considering attractiveness [2]. Therefore, our work focuses on studying how people judge others when movement is the only criterion. We wish to investigate the following hypotheses:

- There is a significant difference between male and female judgement regarding the attractiveness of body movement.
- Male and female observers do not judge sex and age significantly differently.
- The attractiveness of the opposite sex is rated significantly differently to that of the same sex.
- Self-assessment of attractiveness differs significantly from that of an observer.

To examine these hypotheses, the following methods will be applied. A pool of stimulus subjects will be filmed in front of a neutral background so as to gain maximum contrast and detail. They will be filmed in three different situations: greeting, self-presentation and walking. Prior to filming each stimulus subject, a questionnaire will record demographic data, personality and self-assessment, as well as mate choice behavior.

The recorded material will be cut and edited. With the help of the Ludwig-Boltzmann-Institute, Vienna, a special software package will analyse the films to assess the intensity and duration of body movements. Next, the material will be digitally modified with a 'quantized-display' technique [3] to match a mosaic structure. This step is necessary to neutralize possible influences of mimic, skin texture, voice and sound, such that raters receive only the movement information. These modified films will be presented to a rater group, who will judge the subjects on the basis of attractiveness, vitality, aesthetics etc. The results of this research will be available later this summer.

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The use of radio-telemetry in small laboratory animals: recent advances

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Radio-telemetry provides an alternative means of obtaining physiological measurements from conscious, freely moving laboratory animals, without introducing stress artefacts. For researchers, especially in the fields of pharmacology and toxicology, the technique may provide a valuable tool for predicting the effectiveness and safety of new compounds in humans.

Traditionally, a variety of techniques has been employed to obtain physiological measurements in the laboratory. With the exception of studies on anaesthetics and certain other types of experiments, it is generally assumed that the quality of such measurements are superior when collected from conscious animals, since they best represent the normal state of the animal and are most predictive of the results that would be achieved in humans. When monitoring conscious animals, it is possible to use invasive methods (e.g. sensors, electrodes) or non-invasive methods (e.g. surface electrodes for monitoring an electrocardiogram, tail cuffs for monitoring blood pressure). Indwelling sensors for monitoring flow and pressure are usually more accurate and more reliable than non-invasive methods. When using indwelling catheters, sensors or electrodes, there are several options for accessing the information from the sensor and forwarding it to a recording system. The advantages and disadvantages of each of these will be summarized.

Although wireless radio-telemetry technology for monitoring laboratory animals has existed for some time, it has only been in the last ten years that affordable, reliable and easy-to-use commercial products have been readily available for monitoring a variety of signals. This has resulted in a significant increase in the use of implantable radio-telemetry in biomedical research. The advantages of implantable wireless telemetry transmitters include: (1) providing a humane method for monitoring conscious, freely moving laboratory animals; (2) eliminating stress related to the use of restraints, which can alleviate a potential source of experimental artefact and inter-animal variability; (3) reducing animal use by 70% in single studies, and by more than 90% in multiple studies; and (4) allowing 24-hour data collection via computer, for days, weeks or months, without any special animal care.

However, the weight and volume of the implanted intra-abdominal transmitter may cause discomfort, and it was recently found that the wellbeing of mice is compromised during the first week following an intraperitoneal transmitter implantation. Despite this, when body weight has been normalized after fourteen days, the mice seem to have recovered completely and cope very well with the weight of the implanted transmitter. Long-term measurements of physiological parameters (e.g. electrocardiogram, heart rate, body temperature, blood pressure) in freely moving laboratory animals with radio-telemetry techniques are nowadays a valuable tool in our university, and are used in a range of pharmacological, toxicological, physiological and behavioral studies. The application possibilities and benefits of long-term measurements of physiological parameters in small laboratory animals will be presented, based on recent results.

Behavior registration and analysis for driver training on simulators

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Registration of driver operations is essential for feedback systems, and for modelling the behavior of intelligent agents.

Virtual Observer

During *Measuring Behavior '98*, we presented "Virtual Observer" [1]: an application that automatically registers user actions and other events in a virtual environment and stores them in a log file. The stored data and corresponding video information can then be analyzed with The Observer [2]. One of the target markets for Virtual Observer is skills training with simulators based upon virtual reality technology. Green Dino is now researching new applications in cooperation with Wageningen University & Research Center and Twente University.

Driver training

Driving schools all over the world are interested in training with interactive simulators. Driving lessons become more and more expensive, and research shows that the performance of a normal driving lesson is three times less effective than a lesson on a simulator. In 1999, Green Dino began developing a driving simulator called INTRASIM (Intelligent Training Simulator; Figures 1 & 2). A major feature of this process involved using behavioral observation and registration to provide feedback for the virtual instructor, and for the agent system that calculates the behavior of the other traffic. Recording behavioral information is necessary for both direct and indirect feedback systems.

Virtual Instructor

Most driving simulators offer a simple feedback system for instruction, based upon negative comments as a result of broken rules. We have built a new feedback system that registers behavior over a longer period in a log file. The software uses this information to give positive feedback. For example, the negative system will automatically give negative feedback on a fault action. The positive system relates this fault to the action history, and then decides if a response is necessary. The positive system can also compliment the driver when (s)he shows improvements. The virtual instructor uses the registered information for performance overviews and gives advice for future lessons. With The Observer, the registered data can be analysed quantitatively, together with the corresponding video information. This can be useful for researching the effect of the virtual instructor's comments on the driver's performance in the simulator.

Virtual Agents

In any driving lesson, other traffic is essential for driver training. The behaviors of the other vehicles must be interactive and respond to each other, and to the operator. Therefore, it is necessary to register the behaviors of all traffic members and send this information to the other members, and to the instruction system. Based upon this information, the agent system calculates new behavior for each traffic member. For behavioral calculations, we have developed a system with agents that have emotions. A new method will involve the use of live-recorded data; research shows that it is relatively simple to use live action data as input for traffic agents. Using The Observer, the live-recorded data will be translated into behavioral patterns, and a neural network will be trained in how to react to all kinds of traffic patterns. This neural network will be used by the agent to decide how to react to the behavior of other agents. Green Dino has entered into an exclusive partnership with the Parlevink group of Twente University to research the performance of this artificial intelligence system.

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Figure 1. INTRASIM from an external perspective.



Figure 2. INTRASIM from the driver's perspective.

Measuring the behavioral effects of antidepressant drugs on rhesus monkeys (*Macaca mulatta*)

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Rhesus monkeys are regarded as suitable animals in which to investigate the behavioral problems of humans. The subjects for this study were social colonies of healthy adult monkeys aged 3-5 years, weighing 4-6 kg. Each colony comprised one male and seven females housed in 20' x 12' x 8' cages. The monkeys were kept under controlled conditions of temperature ($22 \pm 5^{\circ}$ C), humidity (55-60%), ventilation (10-15 air changes per hour) and light (300 lux intensity) in a 12-h light/dark cycle, to maintain their physiological rhythm. A balanced diet was provided in the morning and evening, and water was available ad libitum.

The animals were allowed 4-6 weeks to habituate to their new surroundings. During this habituation period, they were caught and removed from the cage once a week and administered saline, either intramuscularly or orally. Behavioral observations took place prior to and after drug or vehicle treatment, producing a baseline control. The checklist of social and solitary behavioral responses used was a modified version (Palit *et al.* 1997) of the parameters described by Schlemmer & Davis (1983). Behavior was observed via a video monitor placed in an adjacent room, with two 180° rotating video cameras with zoom lenses fixed in the behavioral chamber. All behavioral responses were recorded for analysis.

On any one day, only one animal from each group was injected with an antidepressant drug. All monkeys were injected on a rotational basis, and scores of their normal behavior were compared with that observed after treatment. After drugging, the subject's behavior was observed for 1 min at 10-min intervals over 2 h. Behavioral scores from these twelve 1-min intervals were summed, with the total representing the day's score for that monkey. Monkeys were also observed at 4, 6, 8 and 24 h post-treatment, to check for any significant alteration in behavior. At least 10 days passed before each monkey was reused.

Imipramine (16 mg/kg) produced mild changes in social and solitary behavior in these monkeys. Locomotion and vigilance decreased significantly, and a high degree of piloerection was observed. Fluoxetine (20 mg/kg) produced a marked decrease in social and solitary behavioral responses. Centpropazine (40 mg/kg), a new antidepressant, produced a mild decrease in social and solitary behavior. It may be concluded that imipramine and fluoxetine showed similar sedative effects, which were not observed with centpropazine.

HyperTrack: a software package designed specifically for neuromuscular and motor control research in humans

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HyperTrack presents a tracking task in which a test subject attempts to control a response object so as to track a target object on a computer screen. The subject's input may be through a joystick or a large variety of other transducers or signals, which are captured through a Biopac data acquisition system (see Figures 1-3).

While this sounds very simple, HyperTrack contains a number of sophisticated features to support detailed testing of non-trivial motor control models:

- data acquisition of both tracking and incidental signals
- flexible control of task presentation details, including multiple tasks in multiple modes
- versatile specification of the task model, including signal tranformations and non-linear filtering
- professional task presentation on another display or computer
- easy data exchange with Matlab for data analysis

HyperTrack will be of interest to researchers investigating:

- any detailed analysis of tracking performance
- adaptation by subjects to dynamically changing tasks
- adaptation by subjects to non-linear tasks
- tracking with inputs other than hand control (e.g. EMG)
- correlation of physiological parameters (e.g. EEG) during task tracking

As for system requirements, HyperTrack runs under Windows 98 or Windows 2000, and requires MP100WSW (Biopac).

HyperTrack was developed in collaboration with Prof. Peter Neilson, Associate Professor in Systems & Control, The University of New South Wales, Australia.

eral Presentation Objects Target File Targ	get Data Analog in Input Filters Outputs Options Results
Tasks	Display Location
Task 1 Mode: Pursuit Task 1 Format: 2-Dimensional	Run display on: ROGER2 (this computer)
F Enable Task 2	Use monitor: 2 Select
Task 2 Mode: Pursuit	Resolution: 800 x 600 @ 75
Duration	Use central square only Border colour:
Run tracking for: 20 👻 seconds	

Figure 1. HyperTrack's main control panel.



Figure 2. HyperTrack's transform editor.


Figure 3. HyperTrack's filter editor.

Remote web usability testing

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Remote usability testing allows researchers to evaluate the usability of web sites by gathering information from remote users [1]. In this paper, we describe a software package, called OpenWebSurvey, capable of recording, storing, sharing and processing data for web usability analysis. An alpha release of the software is being tested at Turin University, Department of Information Technology, to investigate the usability of web sites for children.

Problems in usability testing

Although it is common to run usability tests in research laboratories, there are some situations in which this is not possible, because it is difficult to find a sufficient number of users willing (or able) to participate. In these situations, it can be useful to record user behavior remotely. Moreover, instead of simply supplying a survey to collect information about the perceived usability of a site, it is also useful to have quantitative data about user behavior while surfing. OpenWebSurvey allows you to do this without needing to install any software or hardware components, either in the client computer or on the web site server.

Testing model

OpenWebSurvey is a web-based survey software package. This means that the user connects to the OpenWebSurvey server, surfs a site under investigation and answers some questions. The testing interface is a double-framed browser window (Figure 1): the upper frame contains the survey questions and input fields to be completed, while the lower frame contains the site under investigation, modified to allow surfing data to be recorded.

Although users do not perceive any differences when surfing the site under investigation, OpenWebSurvey monitors their web navigation and stores data about the pages visited (load times, client side actions), the entire user session (pages visited, total visit time, page visit time, general information about the user system) and the survey answers. On the server side, it tracks and saves user navigation data; on the client side, it tries to capture every step of user interaction with the system (i.e. mouse movements and actions).

Survey questions and answers and other collected data are stored in XML format [2], and functions are provided to easily import and export them.

In the analysis stage, researchers can make assumptions about site usability and infer psychological motivations that may have induced certain actions, using the data collected on survey answers and user behavior.

The usefulness of OpenWebSurvey is maximised if it is used with survey questions that involve performing tasks, such as looking for an answer in a web site. In this way, it is possible to analyse not only the answer found by the user, but also how (s)he discovered it.

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Figure 1. OpenWebSurvey's testing interface.

An online user study investigating interactions between auditory and visual user interface feedback

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This paper presents an online user survey technique that was used to examine the interaction between auditory and visual modalities in providing navigational cues for a user of a multimodal interface. The online application used in the study went beyond a standard online questionnaire. It included video scenarios that demonstrated interaction with certain functionality of the user interface, where the sound in question appeared as an auditory interface feedback. The study investigated the following question: how does the visual interface representation influence the semantic interpretation of the interface feedback conveyed via the auditory modality? The necessity of providing the user with navigational cues is especially important when the interface is intended to be used in hands-and-eyes free situations, with speech control. In this case, it is crucial to give the user sufficient feedback for navigating the interface.

Before tackling the area of hands-and-eyes free usage, however, we set up an experiment addressing the audio-visual interaction in a hands-and-eyes busy situation. The Internet Audio Jukebox multimodal application was used as a platform for conducting the experiment. This application gives access to large collections of musical content via a number of interaction techniques, such as voice commands, touch input and query-by-humming. The Jukebox provides the user with visual and auditory non-speech feedback and can be operated hands-and-eyes free. The feedback sounds used in the Jukebox are melodic 'earcons', each conveying a certain message to the user.

In total, six Jukebox sounds were evaluated in the experiment, and a video scenario was made for each sound. The sounds were evaluated by the respondents in three experimental conditions: together with the 'correct' scenario, together with the 'wrong' scenario, and with just the sounds on their own. In each experimental condition, the subjects were asked two open questions: one addressing the meaning of the sound, and another addressing the appropriateness of the sound to convey this meaning. To prevent order effects in the first two visual conditions, the 'correct' and 'wrong' contexts were counterbalanced between the subjects. Consequently, half of the respondents received scenarios with sounds in the 'correct' visual condition first, while the other half received the 'wrong' visual condition first.

The results of the study indicate that the visual interface representation had a strong impact on the interpretation of the message conveyed by the interface via the auditory modality. In spite of this influence, the experimental sounds were judged by the subjects as significantly more appropriate to the visual interface representation for which they were intended, rather then for the 'wrong' visual representation. The experiment also demonstrated a higher recognition rate of the sounds in combination with the visual, rather than in that without it.

A dynamical disease model of stereotyped movement disorder: measuring complexity and regularity in motor behavior

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In a dynamical disease model, illness can be characterized by strikingly periodic or predictable dynamics in relevant physiological systems. Healthy systems, however, are complex, variable and difficult to predict. We have sought to apply a dynamical disease model to motor and behavioral systems in individuals with developmental disorders. Our target has been abnormal repetitive behavior, typical of individuals with autism and severe mental retardation. In testing the utility of this model, we have employed both automated and observational methods, coupled with data analysis strategies designed to provide an index of complexity or regularity.

We have assessed repetitive behavior (stereotyped body rocking) by live coding using standard observational methods, as well as kinematic analysis of videotaped body rocking motions. We have also assessed body rocking using a force platform, which measures forces and moments using a 100 Hz sampling rate. We have also measured aspects of other motor behavior in individuals with stereotyped body rocking, including spontaneous eye blink rate, as well as the dynamics of postural control involved in standing and sitting. Blink rate was assessed using standard observational techniques, whereas the dynamics of standing and sitting were assessed on the force platform.

Combining repeated measurements of behavior over time with non-linear dynamical analyses (approximate entropy, or ApEn) has yielded several findings. First, kinematic and force platform analyses of body rocking both showed that this behavior, although highly periodic, is in fact less regular or more variable than body rocking exhibited by healthy volunteers (higher ApEn). Second, compared to matched controls, individuals who engaged in stereotyped body rocking exhibited significantly lower rates of spontaneous blinking with less variable inter-blink intervals. Third, compared to matched controls, individuals who engaged in stereotyped body rocking displayed postural control deficits when standing on the force platform. These differences included significantly increased amplitude and velocity of postural sway, as well as markedly reduced complexity (lower ApEn) in the distribution of forces around a centre of

pressure. Viewed as a time series, these moment-to-moment forces were highly periodic compared to control series. Finally, compared to healthy volunteers, individuals who engaged in stereotyped behavior exhibited less complexity in the dynamics of sitting (lower ApEn).

These findings suggest that the notion of dynamical diseases might be extended to behavioral disorders which, as a consequence of CNS insult, represent the loss of variability or complexity in behavior, and their replacement by highly repetitive, periodic actions. Evidence of a shift from complexity to regularity can be observed not only in the target behavior (i.e. stereotypy), but also in other motor behaviors.

Transponder-based in-cage learning and activity monitoring system for 8-16 mice per cage: INTELLICAGE and TRAFFICAGE for high-throughput screening

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Behavioral assessment of mice is a sensitive tool for discovering early effects of neurodegeneration, targeted gene deletions or chronic exposure to toxic agents or drugs. On the other hand, it is time consuming and the results are often biased by behavioral peculiarities of mice, such as unstable performance, limited cognitive abilities, handling artefacts and inappropriate choice of test paradigms. Based on more than 20 years of studying mouse behavior in the laboratory, and five years of studying cognitive abilities in naturalistic settings, we have developed a transponder-based technology that allows the learning behavior and circadian activity of group-caged mice to be monitored over weeks and months.

INTELLICAGE houses 8-16 mice (preferably both experimental subjects and controls). Male mice must have been raised together, or they may require insertable separators. One cage contains four test chambers, accessible to only one mouse at a time (Figure 1). Each chamber contains a two-choice bottle system with computer-controlled delivery of liquids. Animal identities are checked by reading numbers from subcutaneously implanted commercial transponders, such as TROVAN. Within a chamber, mice can be tested for operant visual discrimination learning, conditioned taste aversion and various forms of conditioning schedules. Punishment can also be delivered. Mice can be tested for patrolling different locations (working memory), temporal patrolling schedules and spatial avoidance learning. Activity of mice and devices from up to 8 cages is controlled by a microcomputer. Off-line data analysis and downloading new program modules is done via the Internet from an application server in Zurich; the experimenter simply collects the daily results from a web site.

TRAFFICAGE is a downscaled version of INTELLICAGE that records only the circadian activity of transponder-tagged mice (Figure 2). Due to the complexity of brain systems regulating circadian activity, many cerebral alterations are likely to be detected. The system runs as a stand-alone system controlled by a local computer, but for more thorough analysis data can also be sent to an application server. For further information, visit http://www.newbehavior.com

Supported by Swiss National Science Foundation and the NCCR 'Neural Plasticity and Repair'.



Figure 1. INTELLICAGE.



Figure 2. TRAFFICAGE for in-cage assessment of activity.

New tools for ecological and orientation research: E-NEST and MICRO-GPS pathlogger

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E-NEST is a plate equipped with transponder antennae capable of reading codes from nestling and adult birds equipped with transponder foot rings (Figure 1). It records nestling activity and parental visits, and stores them on a nearby datalogger. The datalogger can be read wirelessly by palm computers, or can communicate with a remote computer through a wireless modem. The system is currently being used to monitor kestrels and owls at ecologically different sites.

MICRO-GPS is a second-generation system of the GPS datalogger first presented at *Measuring Behavior 2000*. It contains a μ -blox GPS chip mounted on a custom board and is capable of logging between 40-100,000 data points, in either continuous mode (readings 1 Hz) or user-selectable intervals. It is used routinely on homing pigeons, dogs, albatrosses and other sea birds, including species that dive. The smallest version (for pigeons) weighs 24 g and runs on rechargeable flexible batteries, allowing flight paths up to 200 km to be recorded in continuous mode (Figure 2). The resolution of paths is good enough to discriminate leading pigeons in a flock. For further information, visit www.newbehavior.com

Supported by Swiss National Science Foundation and the NCCR 'Neural Plasticity and Repair'.



Figure 1. E-NEST.



Figure 2. MICRO-GPS.

Using two distinct testing environments to assess decision-making skills in rhesus monkeys (*Macaca mulatta*) after selective amygdala, hippocampal or orbital frontal cortex lesions

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For both human [2] and non-human primates [1,3], the amygdala and orbital frontal cortex appear to be integral parts of a neural network responsible for advantageous decision-making. However, conclusions drawn from studies of human lesion patients are tenuous, due to the non-specific nature of their lesions. Furthermore, the role of the amygdala and orbital frontal cortex in non-human primate decision-making has never been assessed in a semi-naturalistic setting. Therefore, we compared the decision-making skills of sham-operated monkeys (SHAM, n = 6) to those of monkeys with selective lesions of either the amygdala (AMYG-ibotenic, n = 6), orbital frontal cortex (ORB-aspiration, n = 3, and ORB-ibotenic, n = 3) or hippocampal formation (HIPP-ibotenic, n = 6).

To measure decision-making skills, we examined baseline preference for foods and non-foods, as well as subjects' abilities to alter choice strategy when a highly preferred food is suddenly made less rewarding (via satiation). These variables were measured in two different experimental paradigms: (1) a two-alternative free choice task (TAFC), conducted in a Wisconsin General Testing Apparatus; and (2) a semi-naturalistic free foraging task (FF), conducted in a large rectangular enclosure. Preferences for food and non-food items were measured in each task, both pre- and post-surgery.

While none of the lesions altered subjects' preference for foods in the TAFC task, AMYG showed higher preference for foods post-surgery in the FF task, specifically for those that were least preferred by all animals prior to surgery (lemon, garlic and standard monkey chow; p < 0.05). Selection of non-food items was unaltered in SHAM and ORB, whereas HIPP and AMYG selected more non-food items after surgery (p < 0.05) in the TAFC task, though only HIPP showed this trend in the FF task (p = 0.06).

These results indicate that the amygdala and hippocampus are important for inhibiting the selection of items that normal animals typically avoid (non-foods and less palatable foods), regardless of context. To examine how amygdala, hippocampal and orbital frontal cortex lesions impact on subjects' abilities to flexibly alter choice strategies, we determined each animal's favourite food and allowed them to eat from a surplus of this food until they refused. Subjects were then retested in both TAFC and FF tasks. In both the TAFC and FF tasks, SHAM, AMYG and HIPP showed a decrease in their selection frequency for the satiated item (p values < 0.05), but ORB did not. Therefore, the orbital frontal cortex appears to modulate choice strategy when reward contingencies change, regardless of context.

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Regional cerebral 2-deoxyglucose uptake during open-field exposure in mice: metabolic patterns of habituation and exploratory activity

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Analysis of open-field behavior is widely used to assess spontaneous activity and emotionality in rats and mice. Some studies have suggested a differential involvement of right and left cerebral hemispheres in the modulation of this behavior, as well as in other paradigms of emotionally motivated behavior. Accordingly, we have previously reported a higher metabolic activation of the right cerebral cortex in two strains of mice after exposure to an open-field. However, little is known about the relative contribution of the different neural circuits to such a complex behavioral output.

In the present study, we analysed the individual correlations between the regional cerebral uptake of 2-deoxyglucose (2DGU) and open-field behavior in a sample of C57BL/6 male mice (n = 10) and in hybrid C6xI/LnJ mice with callosal agenesis (n = 9). Because absence of the corpus callosum is expected to boost functional hemispheric asymmetries, we also analysed correlations between 2DGU asymmetries and open-field behavior. Mice were injected with a solution of [14C]-2-deoxy-D-glucose, and immediately released into the middle of a large (150 cm x 80 cm), previously unexplored, dimly illuminated (6 lux) arena. The locomotor path of each mouse was recorded for 45 min and then analysed in six blocks, each lasting 7.5 min.

Off-line analysis of the paths was done by means of WINTRACKTM, by extracting the following variables: *path length, wall distance* and *habituation*. This last parameter was calculated as the difference in path length between the beginning (min 0-7.5) and the end (min 37.5-45) of the open-field session. Thereafter, the mice were withdrawn from the arena, immediately killed by cervical dislocation, and their brains processed using autoradiography. Relative 2DGU was measured in eight cortical fields and six forebrain regions. Correlations between 2DGU rates and behavioral variables were assessed with a parametric test (Fisher's r) and confirmed by a non-parametric procedure (Spearman's rank).

A highly significant negative correlation was found between habituation and the bilateral 2DGU in the lateral nuclei of the amygdala (r = -0.73, p < 0.001): higher 2DGU was associated with more sustained activity throughout the 45-min

session, irrespective of the total locomotor activity. This correlation was confirmed when the two groups were considered separately, suggesting that this observation did not depend on strain differences. The lateralized 2DGU in the cerebral cortex was found to correlate with the average distance the mice kept from the walls (Figure 1). More activity in the center of the field was associated with higher 2DGU in the right perirhinal, cingulate, parietal, frontal and infrarhinal cortex (0.63 > r > 0.51, 0.003). The correlations between cortical asymmetries and activity in the center of the field were mostly due to the large behavioral variability of the acallosal mice.

These data indicate that the lateral amygdaloid complex is involved in the modulation of locomotor activity in an open-field, and suggest a preferential activation of the right hemisphere during exploration of a novel environment.



Figure 1. Locomotor tracks and corresponding 2DGU of two mice.

T-patterns in behavior and DNA: detection and analysis with Theme and GeneTheme

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As pointed out elsewhere (e.g. [1,2]), analogies exist between the real-time structure of behavior and the structure of DNA molecules and proteins. One such analogy concerns the existence of t-patterns. These are repeated patterns of elements occurring in a fixed order, with distances between consecutive elements being significantly similar each time the whole pattern occurs. They are also characterized by a hierarchical/recursive structure, i.e. there are typically patterns of patterns of the same kind [1]. The behavioral data referred to are time-based records, i.e. real-time streams of various event-types, where any (large) number of types and instances may occur, both sequentially and/or concurrently. Because the quality of data for detecting t-patterns in such records must be controlled, a new measure – called 't-kappa' – has been developed, and will be illustrated.

Vast amounts of genetic (molecular) data are becoming available, most of which are strictly sequential strings of symbols. There are typically four different symbols (bases) in DNA, but twenty (amino acids) in proteins. DNA (genomes) may, however, be transcribed in terms of 'codons': base triplets that may correspond to amino acids. The number of symbols may vary from hundreds or thousands (proteins) to millions (DNA, genomes). In a collaborative study between this laboratory, www.patternvision.com and www.decode.com, behavioral t-pattern methodology is now being adapted to molecular analysis in a specialized version of Theme, called GeneTheme, as will be briefly shown.

In both the behavioral and molecular cases, the search for t-patterns requires the setting of two search parameters: (a) the significance level of each critical interval relationship, and (b) the minimum number of occurrences of a pattern for it to be retained (other parameters are optional). A new automatic procedure for the objective setting of these search parameters for individual behavioral records has now been developed, allowing more optimal detection of patterns. It also allows better comparisons between the structure of behavioral streams (data, records) of varying length, which may be essential for detecting the effects of independent (experimental) variables. Some new illustrative results will be presented.

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Anaesthetists at work: analysing the operational composition of action sequences

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Anaesthesia may be characterised as a paradigmatic field of activity in complex work environments. In our research, however, we shift the focus away from identifying performance deficiencies or classifying errors in how complexity is handled by the anaesthetists. Instead, our main focus is to investigate the operational structure of action sequences in a clinical setting.

Methods

Previous studies have faced the methodological problem of recording and interpreting simultaneous operations. This study, however, aims to counter this problem by applying a new observational method, sensitive to overlapping operations in action sequences. Due to the fact that (referring to the theoretical framework of activity theory) only operations are directly observable, our observation is located at the level of operations that constitute action sequences. Superimposed concepts, structuring a set of 41 observation codes (each of them representing a single operation), are monitoring, manual tasks, communication, documentation and additional operations outside the main remit of anaesthetists.

A computer-based recording technique, called 'FIT-System', provided us with a means to record overlapping operations online. To analyse the data, we conducted case studies focusing on the operational composition of action sequences. In order to quantify the relative amount of overlapping operations in a given time frame, measures of action density were calculated.

Results

The results of this study support the descriptive validity of action density as an indicator of the occurrence of overlapping operations. First, the results show that a reasonable amount of overlap is neglected by conventional observation methods. Second, action density due to overlapping operations shows a characteristic distribution, corresponding to different phases of anaesthesia. For example, periods characterised by increased action density include the induction of and the emergence from anaesthesia. Moreover, overlapping operations seem to have a central position when dealing with the various requirements related to the occurrence of unexpected events.

Discussion

Overlapping operations in action sequences may be interpreted as an indicator of coping with varying complexity during an anaesthesia case. These results fit very well with research on workload during the administration of anaesthesia. As this was an initial, exploratory investigation into the operational composition of action sequences, many areas of further study may be identified (e.g. differences between the action sequences of experts and novices, especially in cases of varying conditions). Moreover, we did not intend to analyse co-operational aspects in action sequences. This important aspect of clinical practice will be included in future research.

None of the material presented here should be interpreted as an argument for restricting the analysis of professional practice to the level of operations. Rather, we emphasise the need to integrate different levels of analysis. The integrative use of methods at various levels will provide a balanced system for investigating the anaesthetist's activity, taking into account specific occupational aspects. This will be crucial to assure patient safety in an increasingly complex health care system.

Measuring cooperations between modalities in human multimodal behavior

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When communicating with someone else, we use several different modalities in a cooperative way, such as speech, gestures, facial expression and posture. The mechanisms underlying this multimodality are not completely identified or understood. Similarly, we do not fully understand the behavior a subject might display when faced with a system that allows him or her to use different modalities. The study of such multimodality is currently driving collaborative research by LREC and IST-ISLE.

Following previous work on the manual annotation of human multimodal behavior, we have developed two tools :

- grammar for describing annotations of multimodal behavior
- software for computing behavioral metrics from annotations

According to our grammar (an XML DTD), these annotations are composed of several sections. The first section describes the features of the objects referred to by the subject in the corpus (Figure 1). Each of the following sections contains the annotation of a multimodal segment, itself composed of several sub-sections (one for each modality).

A software package has been developed to parse these annotations and compute multimodal behavioral metrics (e.g. rates of complementarity, redundancy and equivalence). It follows these steps:

- Parse the annotation and build an internal representation of the corresponding tree
- Assign a 'salience' value to each (object, reference) couple, according to rules such as 'if the reference contains the fully specified name of the object, assign value 1.0 to the salience value'
- Assign a priori fixed values to weights for each modality
- Compute the average salience value in each single multimodal segment across all modalities
- Compute the average salience value for each object across all modalities
- Compute behavioral metrics

40 samples taken in several corpora have been manually annotated and parsed by our software. In the near future, we intend to improve the annotation by using a tool such as Anvil. This will allow us to annotate larger corpora, and to integrate the grammar and metrics in a methodology for analysing multimodal behavior across different applications.

IST-ISLE http://isle.nis.sdu.dk/

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Figure 1. Frame of a multimodal corpus.

Measuring eye movements and mouse-pointing patterns using thumbnail images

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A two-dimensional arrangement of small images is used to display a number of pictorial data on a computer screen, which is limited in area. These small images, sometimes called thumbnail images, are frequently used in graphical user interfaces like e-commerce web sites and digital photo viewers. The behavioral patterns of users searching thumbnail images, however, have not yet been analysed for comparison with those produced by users searching pull-down menu items [1]. Thus, this paper reports an experiment recording users' search patterns of thumbnail images.

Experiment

An experiment was conducted to compare the search patterns of two types of thumbnail images: random setting and group setting. In the random setting, thumbnail images of 36 home appliances were selected and arranged in a random order in a 6 x 6 grid (Figure 1a). In the group setting, the same 36 images were categorized and arranged into four 3 x 3 sub-areas within the 6 x 6 grid (Figure 1b). The experimental task was to search for and click on a target image. Data on the subjects' eye-tracking and mouse-pointing were recorded to obtain a general behavioral pattern of their searching technique.

The point of gaze was recorded using an EMR-HM8 head-mounted eye-tracking device (NAC Image Technology, Inc.; Figure 2). The datalogger of this device connects to the RS232C serial port of a PC, transmitting all recorded data for analysis. Initial analysis was made with our original software, coded in Microsoft Visual Basic. This software records the user's mouse movements and eye-tracking data every 10 ms. In addition, it calculates fixation points from the eye-tracking data. A threshold level for fixation was assigned as 120 ms.

Results

The recorded data show three general patterns. First, the path of the subject's mouse movement is corrected near the target image. This path of mouse movement correction has two patterns: (1) over movement and (2) under movement (Figure 3). Second, the user starts moving the mouse after finding the target image. This pattern is similar to the result of Smith *et al.* [2]. Finally, in the group setting, users fixate on points in all four sub-areas to the same extent.

Conclusion

Our software successfully coordinated eye-tracking data and mouse movement data for analysis. The data showed three patterns of visual searching of thumbnail images. This finding is a first step towards developing a general theory of searching thumbnail images for graphical user interfaces.

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Figure 1. Screenshots showing the two settings of thumbnail images.



Figure 2. Eye tracking device by NAC Image Technology, Inc.



Figure 3. Mouse correction patterns.

Effects of test experience in a mouse behavioral test battery

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Test battery approaches have been developed for the initial assessment of phenotypic behavioral differences of transgenic, knockout and inbred strains of mice. The standard test battery, originally developed by Paylor *et al.*, includes: open field activity, light-dark exploration, rotarod, prepulse inhibition (PPI), acoustic startle habituation, conditioned fear, Morris water maze and hot plate. Tests are conducted in the order listed (least invasive to most invasive), to minimise carry-over effects from prior testing experience. Two studies will be discussed, investigating (1) whether differences exist between naïve mice and mice that have undergone testing on different tasks, and (2) whether the order of the tests within a battery affects how an animal performs on subsequent tasks.

In the first experiment, C57BL/6J male mice were evaluated on all of the tests described above and compared with gender- and age-matched naive mice. The results indicate that, on some tests, the behavior of the 'test battery' mice was significantly different to that of naive mice, while on other tests there were no differences. Experiments for the second study used an abbreviated test battery with 129S6/SvEvTac and C57BL/6J male mice at ten weeks of age. The results suggested that certain test variables were sensitive to test order, while others were resistant.

These two studies demonstrate that some behavioral tests appear to be sensitive to previous testing experience, while others are immune. Studies evaluating the feasibility of a high throughput test battery and its use in biotechnology will also be discussed.

Behavioral responses and heart rates of stereotyping and non-stereotyping geldings to four stimuli

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The short-term causality of stable vices has received much less attention than that of long-term factors. To what extent do frequently occurring stimuli in daily management influence the frequency of stereotypy? Are there differences between crib-biting and weaving?

Methods

Fifteen geldings, aged between 5 and 17 years, were stabled in individual boxes and had visual contact with neighbouring horses. Ten behaviors were observed using a Psion LZ64 configured with The Observer 3.0, and heart rates were measured using the Polar Horse Trainer SW 3.0. The five crib-biters and the five weavers had all been heavily stereotyping for at least three years. Five normal horses were included as controls.

Each horse was exposed once during four consecutive stimuli, using a Latin Square design with one extra period:

- 1. the observer alone
- 2. a second person entering the stable and rubbing the horse's neck with ethermoistened cotton wool
- 3. the same person leading a neighbouring horse away
- 4. the same person letting the horse eat carrots, but subsequently withdrawing the bag within the horse's vision

Each stimulus was presented during the first two minutes of a 10-min observation period. It was technically impossible to record behavior without the horse perceiving the observer. Data were analysed using a repeated measures ANOVA or Kruskal-Wallis test, depending on the results of a normality test and variance check. Newman-Keuls test was used as a post-hoc test.

The main results

Crib-biting decreased significantly after stimulus 2 but increased after stimulus 4 (F = 30.296, p < 0.001). Stimulus 2 induced an increase in nibbling (mainly bedding), whereas stimulus 4 caused a decrease. Weaving was not significantly influenced by any stimulus. Weavers and crib-biters nibbled significantly less than

controls after stimuli 1 (F = 21.659, p < 0.001), 3 (F = 4.769, p = 0.043) and 4 (F = 4.531, p = 0.048).

Control horses remained significantly more immobile than both types of stereotypers after stimulus 2 (F = 11.089, p = 0.005). All three groups differed significantly after stimulus 1, weavers being more immobile than controls, and controls being more immobile than crib-biters (F = 22.659, p < 0.001). Crib-biters had significantly lower heart rates than weavers and control horses during stimulus 1 (H = 10.349, p = 0.006) and stimulus 3 (F = 41.794, p < 0.001). Controls had significantly lower heart rates than weavers after stimulus 3. Leading a horse away during the initial two minutes induced a strong increase in heart rate in controls and weavers, but not in crib-biters.

These results suggest that weavers and crib-biters react differently, depending on the type of stimulus. They also confirm previous data concerning the de-arousing effect of crib-biting. Weaving does not seem to have the same effect – at least not on heart rate.

Methodology and tools based on video observation and eye-tracking to analyze facial expression recognition

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Our project concerns coaching activities that require the supervisor to visualize the face(s) of their partner(s) [1]. Applied examples of such situations are remote assistance, remote teaching and video conferences. Our goal is to find software solutions to help supervisors with their task, by providing them with information about the emotional state of their partner(s). We study how a supervisor proceeds to classify an emotion, and which parts/areas of the face (e.g. lips, eyes) are most important for identifying emotions [2,3,4].

The first step of this project was to acquire some raw material. We did this by videotaping students working on three different, attention-demanding tasks: one pleasant, one neutral and one unpleasant. The videotaping was done via a hidden camera, and a total of 44 students was filmed. The second step involved asking observers to view these videotapes and identify the emotions they recognized. For each emotion recognized, the observer had to click on the corresponding inerface button (Figure 1). Using this method avoided any interruption of the videotape. Data were collected from 240 observers. The third step was to objectively analyze the eye movement strategies of the observers (n = 80). We used an eye-tracker and specially developed software to monitor and record eye movements and analyze the results. The analysis of eye movement patterns provided information about which facial areas held the observers' focus of attention, along with some spatial and temporal metrics.

The software displays the scan path, superimposed over the videotape. Two different visualization modes have been implemented:

- raw measurement points (Figure 2), where each little circle represents the localization of the eye on the current page (30 positions per second)
- fixation points (Figure 3), represented by circles whose diameter is proportional to the duration of the fixation

The software can also define regions of interest on the video (Figure 4) and make calculations relating to each region, e.g. the number and duration of fixations.

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Figure 1. Interface for emotion recognition.



Figure 2. Raw measurement points.



Figure 3. Fixation points.



Figure 4. Regions of interest.

Ontology as ethogram: knowledge representation for behavior

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Artificial Intelligence has, over the past 20 years, developed several approaches to representing knowledge about the common-sense world. The term 'ontology' has been applied to numerous knowledge representation schemes, ranging from controlled vocabularies to more powerful logic-based systems. Several ontologies have already been developed for molecular biology (e.g. EcoCyc [1]) and genomics (e.g. Gene Ontology [2]).

Frame-based ontologies, which were used in this study, represent an intermediate level of representation power. Such ontologies can explicitly represent concepts (e.g. behavior types), individuals (e.g. events) and relations (e.g. type hierarchies or temporal sequencing). An ontology partially defines concepts in relation to existing concepts, providing flexility and reducing the tendency to "pigeon-hole" novel exemplars. Explicit definitions of relationships and their properties can unmask assumptions and may provide a basis for describing evolutionary change.

This study explores ontology-based representations as an alternative to conventional ethograms, using Protege-2000, currently one of the most popular ontology editors. The "frame" paradigm used by Protege-2000 provides an intermediate representation power with a relatively friendly user interface. Protege-2000 also directly supports the use of the ontology as a scheme for a database of events that support the descriptive representation. These events generally link or refer to digitized media.

I will present ontologies developed for a comparative study of courtship in a clade of *Habronattus* jumping spiders, as well as an earlier ontology based on a published ethogram of loggerhead seaturtle *Caretta caretta* nesting. Extensions to the Protege-2000 tool, to improve editing and checking of behavioral data, will also be described.

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Analysing animal path trajectories in terms of individual behavioral acts

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Standard approaches to the analysis of movement trajectories with video-tracking systems (e.g. EthoVision [1]), using such measurements as track length or time in zones of interest, provide useful information about animal behavior in tests like the open field or Morris water maze. However, such cumulative characteristics are related only indirectly to the complex organization of an animal's motivated behavior and learning. On the other hand, coding systems (e.g. The Observer [2]) are able to supply data on the units and structure of behavior, but lack detailed spatial information. The objective of the present study, therefore, was to develop an approach for isolating and analyzing individual acts within the behavioral continuum, using path trajectories from BVision video-tracking software [3].

To perform such an analysis, we first divide a continuous movement trajectory into individual behavioral acts, each of which is defined as a component of the behavioral continuum from the result of one goal-directed activity to another [4]. The points of separation between behavioral acts are chosen as points of minimal activity, i.e. the moments of drastic decrease in speed of movement [5]. Functional affiliation of these acts is achieved using a coding system, and the ensuing pattern is analyzed to reveal the structure of exploratory behavior or performance strategies within different learning tasks. In this way, the behavioral trajectory of an animal in an experimental session can be described, making it possible to find differences in behavior between different groups of animals, or to study the evolution of behavioral patterns of animals within the same group. We have developed corresponding software for the functional analysis of rat and mouse path trajectories.

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Measuring daily activity patterns in dairy cows

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The daily activity pattern of dairy cows is likely to be a crucial parameter for the assessment of housing conditions, as changes in activity can reflect stress reactions. Reliable estimates of activity patterns can only be achieved via automated 24-hour recording. For this purpose, we validated a new manageable system, the Actiwatch Activity Monitoring System (AMS), which has previously been used in human research (e.g. sleep analysis).

The AMS is a very compact accelerometer $(27 \times 26 \times 9 \text{ mm}, 34 \text{ g})$ which stores activity counts in intervals from 2 s to 15 min for long time periods (e.g. 45 days at a sample interval of 1 min), until they can be read out through an interface. To validate the system for its use with cattle, we attached AMS devices to the hind leg (distal to the metatarsal joint) of 12 dairy cows. After habituation, we measured the cows' activity at intervals of one minute for 10 days. Simultaneous video observation was conducted for five days (24-h time-lapse mode) to relate the recordings of the AMS to particular behavioral patterns. All 12 cows accepted the AMS devices without any signs of disturbance.

In particular, we will present results on:

- the effects of attaching the device to different legs
- the consistency between different devices, tested by attaching two devices to the same leg and comparing AMS recordings with video recordings
- whether and which specific behavioral activities can be distinguished by the AMS (e.g. resting, locomotion)

At the very least, the AMS can provide valuable information about the temporal organisation of activity patterns at the individual level (e.g. the periodicity and duration of general activities).

Ultrasonic vocalizations as a versatile index of emotionality

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Ultrasonic vocalizations (UVs) are a useful and highly sensitive assessment tool for the study of numerous rodent models of teratology, toxicology and emotionality. While collecting UV data is a relatively straightforward task, analyzing it presents some challenges. These include defining the parameters for what constitutes a vocalization, the age of subject, and creating a situation in which the rats are likely to vocalize.

In this study, an automated system to detect and analyze UVs was developed for both pups and adult rats. The compressed 20-200 kHz output of an S-25 Bat Detector was digitally recorded (1000 Hz for adults, 5000 Hz for pups) and analyzed to detect UV start time, duration and relative intensity. Test sessions lasted 30 min for adults and 6 min for pups. With adults, UVs were initiated by an acoustic startle stimulus, and the study focused on UVs that were > 190 ms long, with > 120 ms between calls. With pups, UVs were initiated by maternal separation, and calls of interest were > 150 ms long, with > 60 ms between calls.

This technique has proven valuable in detecting subtle teratologic effects of ultrawide band radiofrequency radiation, genetic, gender and age variations in emotionality, and the effects of repeated handling.

The views, opinions and/or findings contained in this poster are those of the authors and should not be construed as official Department of the Air Force, Department of Defense or U.S. Government position, policy or decision, unless so designated by other documentation.
Play behavior and disorganised attachment in children suspected of having psychiatric disorders

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Most children with pervasive developmental disorders (like autism) already present their symptoms and signs in the first year of life. Despite these early signs, few children are currently diagnosed before the age of three years. In the SOSO project, children suspected of having psychiatric disorders are observed in their behavior at the age of 16 months and followed until the age of 42 months.

According to the literature, playing is one of the behaviors that can differentiate between children with and without autism. Children with autism tend to play in a more stereotyped way, and the level of their play behavior tends to be lower compared to other children. During this project, we are able to observe these behaviors at a very young age, so we can investigate whether these differences are also visible at this young age, or whether they appear after receiving a specific level of play behavior. Therefore, we observe children who are suspected of having psychiatric disorders via two settings, in which we provoke play behavior. To analyse differences in play behavior we have developed ethograms, which we analyse using The Observer Video-Pro 4.0. Different observers use these ethograms to analyse child behaviors once their reliability exceeds 80%. The elements of these ethograms will be discussed during the presentation.

Another factor that might influence play behavior is the quality of attachment. The parents of a securely attached child can provide comfort and serve as a safe base for exploration and play; so, when observing child behavior, it might be important to consider their attachment. Trained observers judge the form of attachment of the children to their primary caretaker. Disorganisation of attachment is considered to be a major risk factor in the development of child psychopathology. It is not thought that disorganised attachment originates from physical problems of the child. Neurological abnormalities, however, may lead to pseudo-disorganised behavior, e.g. in children with autism. This may influence the behavior of the child. Using regression analyses, we try to get more insight into which factors influence play behavior in children suspected of being autistic.

To analyse whether differences in attachment and play behavior are a matter of different coping strategies, we also analyse cortisol levels (from saliva samples) and attachment classifications of these children. Many children have already participated in this project, and data will be presented for over 60 subjects.

Foraging behavior in horses: measuring bite dimensions

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The grazing behavior of large herbivores is influenced by many factors. However, the processes of voluntary intake during grazing events are important in the management of pastures and for maintaining an adequate supply of energy and protein. Surprisingly little is known about the processes controlling voluntary intake of herbage by horses, especially regarding the dimensions of the bite. Bite dimensions (depth, area and volume) have been measured in cattle, sheep and other grazing ruminants, but little research has been performed with horses. This paper examines a novel method of measuring the bite dimensions of horses offered herbage cut to four grazing planes.

Method

Laca *et al.* [1] developed a method to investigate bite dimensions by heifers offered swards of known tiller density. However, swards were constructed for their study by growing and presenting individual grass plants arranged in a discrete area and pattern. In the present experiment, the method used relied on the production of swards on an artificial growth medium. Perennial rye grass swards were established and grown on artificial media (40 x 90 cm) for a period of five months before the grazing experiment. The swards developed a tiller density of 3000/m². The four grazing planes cut were 3, 8, 15 and 19 cm mean sward height. Eight horses (2 to 4 years of age; mean body weight 512 kg, s.e. 24.7 kg) were each offered individual swards for a period of time and allowed to take six bites. The swards were then removed and bite dimensions were measured. The bite dimensions recorded were depth, area, weight and volume. During the measurement period, the horses' behavior was recorded using a monochrome CCTV camera, and the films were analysed using time lapse editing.

Results and Discussion

The mean dimensions of bite are presented in Table 1. The dimensions of bite depth were not fixed in relation to sward height, suggesting that the horses perceived differences in sward height and adjusted their ingestive behavior by modifying their grazing process. Similar behavior has been observed in sheep and cattle [1,2]. However, the mechanisms associated with the modification of grazing are poorly understood. The horses also showed a degree of objectivity during grazing. By analysing the CCTV films, the time taken for six bites, overlap and single bites were recorded (Table 2). The median time needed to take six bites of herbage varied little between horses, but the range of time taken was greater at

either very short swards (3 cm) or very tall swards (19 cm). Overlap of bites increased with sward height, suggesting a reduction in selectivity.

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Sward height (cm)	Depth (cm)	Weight (g) DM	Volume (cm³)	Area (cm²)
3	1.7 (0.2)	0,20	46.2 (9.8)	26.9 (4.6)
8	5.0 (0.5)	0,15	227.6 (21.8)	46.1 (7.5)
15	9.9 (0.6)	1,16	642.7 (113.2)	64.9 (10.5)
19	12.6 (1.1)	2,08	1280.4 (279.1)	103.9 (31.1)

Table 1. Dimensions of bite (s.d.).

Sward height	Overlap	Single bites	Time (median; sec)	Range (sec)
(cm)	(proportion)	(proportion)		
3	0.71	0.29	8.0	3-119
8	0.67	0.33	5.5	3-13
15	0.79	0.21	5.5	3-7
19	0.83	0.17	6.0	4-131

Table 2. Objectivity and time for six bites.

Do female rats actually like sex?

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Measuring sexual behavior has become a prominent feature in behavioral pharmacology. The reason for this is not only an increasing focus on sexual health and wellbeing. The emergence of increasingly specific psychopharmacological drugs has opened the door to far more direct studies of the neurobiological mechanisms underlying the expression of sexual behavior.

Most of the present knowledge on this topic has been obtained from studying male subjects. Implicitly, researchers have assumed equality between the sexes with regard to biological mechanisms, as well as to the interpretation of the parameters of sexual behavior. However, growing evidence points to the possibility that sexual drive in the female rat differs from that of the male.

Different methods have been applied in the quest to elucidate female rat sexual behavior, the relevance of which will be discussed. For example, what are we actually measuring when we quantify the degree of lordosis shown by the female rat upon mounting or intromission by the male? What is the connection between lordosis behavior and the inner state of sexual excitement?

The discussion will focus on the need to change the way we interpret female rat sexual behavior. Furthermore, suggestions will be put forward in an attempt to revise the current paradigm in sexual behavioral research.

Risk assessment behavior of rats in the elevated plus maze: methodological aspects and effects of typical and novel drugs

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Risk assessment (RA) consists of rodents' defense behaviors displayed towards aversive stimuli, and is enhanced by anxiogenic drugs and reduced by anxiolytics. Although scoring of RA has been proposed to improve the sensitivity of the elevated plus maze (EPM) test to drugs that modulate anxiety [1], the lack of methodological standardization means that RA has limited use as a reliable parameter to be analyzed alongside the conventional measures of time and entries in open and closed arms of the EPM. To try to show the importance of a deeper investigation into RA measurement for enhancing EPM sensitivity, rats were tested under the effect of four drugs: two related to the benzodiazepine-GABA neurotransmitter system; and two which act on NK-1 receptors, but have as yet no established effect on human anxiety.

Naïve male Wistar rats received intra-peritoneal injections of either the anxiolytic diazepam, the anxiogenic pentylenetetrazol, the NK-1 agonist (substance P, or [Sar₉Met(O₂₋₁₁]-substance P), the NK-1 antagonist (GR82334, given alone or with substance P), or a control vehicle. After a fixed amount of time, each animal was allowed to freely explore the EPM for 5 min. During this period, conventional measures of time and number of entries, as well as distance moved in the EPM zones (open and closed arms, center zone, and open arm ends), were automatically recorded by the EthoVision video-tracking tool. At the same time, RA (postures with stretched body, flat back and elongation of the head) was observed and scored with the EthoVision manual event recorder tool, in terms of absolute duration and frequency in each zone. These were then converted into percentage measures, % RA time and % RA frequency, calculated as factors of the time spent in each zone and of the total number of occurrences displayed over the whole session, respectively.

Rats that received diazepam (0.3, 1 and 3 mg/kg) displayed significantly less RA than controls, but no dose was able to significantly change conventional measures. Pentylenetetrazol (1, 3, 10 and 20 mg/kg) enhanced RA, but only the highest dose increased time spent in the closed arms. The NK-1 agonists (50 μ g/kg) enhanced time and distance moved in the open arms, but each drug changed different RA parameters. Both open activity-enhancing and RA-reducing actions of substance P (considered to be anxiolytic effects) were abolished by pre-

treatment with GR82334. The most sensitive RA parameters were % RA time in the open arms and in the open arm ends.

These results provide evidence that measuring the RA of rats in the EPM is advantageous to achieving an appropriate sensitivity to both typical and novel drugs. It can also be practical and reliable, especially when combined with a tracking tool that provides spatio-temporal measures.

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Spikes on the air: radio-telemetric transmission of multiple single-neuron signals from behaving animals

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The most direct approach to bridging the gap between brain activity and behavior is to record the electrical activity of single cells in conscious, behaving animals. Physical restraint of animal subjects is generally inherent to technically demanding electrophysiological studies. For some experiments with highly mobile animals such as birds, however, it would be extremely desirable to have the animal free from the encumbrance and restriction of connecting wires. In these cases, the use of telemetry could be very advantageous and might enable a new perspective for combined behavioral/electrophysiological approaches.

Compared to the transmission of 'slow' bioelectric potentials, like electrocardiograms, electromyograms or electroencephalograms, telemetry systems designed to broadcast the activity of single nerve cells must meet specific demands. Action potentials are fast (ϵ . 1 ms) and exhibit small amplitudes in the range of 100µV when recorded extracellularly. Continuous improvements in electronic components and the application of highly-integrated circuits nowadays offers the possibility for easy construction of high-quality, miniature systems with more than one transmission channel.

In this study, a new miniature FM-stereo radio transmitter (Figure 1) was designed to permit multiple single-unit recordings from two electrodes simultaneously [1]. Input from two independent channels was multiplexed to form a stereo composite signal, which modulates a radio frequency carrier. The high quality of the extracellular signals broadcast enabled the separation of single units based on differences in spike waveforms. This device has been used successfully to record from behaving barn owls [2-4].

Recording several single cells from different electrodes offers three distinct advantages. First, data collection is faster, as two channels instead of one can transmit at a time. Thus, the probability of maintaining a stable recording in at least one of the two electrodes increases. Second, so-called 'stereotrodes' [5] - two closely spaced electrodes, whose signals are compared for spike separation - can be used to enable reliable spike separation in certain brain regions. Third, it offers the possibility to investigate correlations between small, distributed neuronal ensembles. Multi-channel radio-telemetry that meets the demands of modern electrophysiology might therefore open a new perspective for combined behavioral/neurophysiological approaches in freely behaving animals.

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Figure 1. Miniature stereo radio-transmitter.

Measuring visceral pain in conscious animals

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The International Association for the Study of Pain has defined pain in the following way: "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" [1]. The problem, however, is that pain cannot be measured directly in animals, but can only be estimated by examining their responses to nociceptive stimuli. Most models of nociception are based on behavioral responses to pain, ranging from the most elementary motor reflexes to far more integrated behaviors (e.g. escape, avoidance).

Distention of the viscera is a natural occurring noxious stimulus in clinical visceral pain, and has been used as a noxious mechanical stimulus in several animal studies. It produces avoidance behavior, as well as abdominal muscle contractions (visceromotor response), increased mean arterial pressure (MAP) and tachycardia (pseudoaffective response) in the conscious rat. These abdominal cramps can be recorded by electromyography (EMG). Several research groups have measured this parameter in the conscious or lightly anaesthetised rat by inserting electrode wires into the abdominal musculature. These were exteriorized on the back of the animal, from where they could be connected to an ink-writer or computer for EMG analysis.

Our group was interested in developing a new technique to measure EMGs, MAP and body activity simultaneously in the conscious, freely moving rat during duodenal distention. Therefore, a telemetry transmitter, consisting of a bipolar electrode pair and a blood catheter, was chronically implanted into the abdominal cavity of the rat. The tips of the electrodes were sutured into the abdominal muscle for EMG measurements, and the blood catheter was placed into the abdominal aorta to register MAP. A balloon catheter was also chronically implanted into the duodenum and tunnelled subcutaneously to the skull, where it was fixed to a connector. During the experiment, a fluid-filled long-line connected to a syringe was attached to the balloon catheter, so that variable volume distention could be delivered from outside the home cage. Body activity was measured by detecting changes in signal strength from the transmitter as the animal moved about its cage.

The advantage of this telemetry system is that behavioral, autonomic and visceromotor responses can be measured at the same time without additional

handling procedures or external connection lines. We will discuss how EMGs and cardiovascular parameters can provide us with valuable information about the degree of visceral pain perception in the conscious animal.

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Predator avoidance in Protaphorura armata (Collembola)

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Blind, soil-living springtails such as *Protaphorura armata* must use either chemical or mechanical cues to recognise potential predators. Chemical information may come directly from the predator or indirectly, e.g. from an injured conspecific or heterospecific. We used a video-computer system to record the movement of individuals in an arena, and EthoVision software to analyse their movement patterns.

Springtails did not avoid areas where predatory mites *Hypoaspis aculeifer* had been moving around or where heterospecifics *Folsomia candida* had been killed, but areas where dead conspecifics had been laid repelled them. Springtails could also sense that live conspecifics had moved around in an area, and were attracted to it. Both repellent and attractant chemicals resulted in a changed movement pattern. Springtails were more active and took a straighter route when exposed to repellent odours; the latter effect was also seen when they were exposed to attractive chemicals. This may be a consequence of individuals moving directly towards an attractant or away from a repellent.

Assessing cognition-enhancing properties of antipsychotic agents by movement pattern analysis in mice

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Cognitive dysfunction plays an important role in mental disorders like schizophrenia, autism and ADHD, and may involve inadequate glutamatergic signalling in different regions of the brain, mediated by e.g. glutamatergic Nmethyl-D-aspartate (NMDA) receptors. In rodents, NMDA receptor antagonists often increase motor activity; in addition, they induce a more primitive and undifferentiated behavioral pattern, which we believe may correspond to some of the cognitive defects seen in schizophrenia, childhood autism and ADHD.

In the present study, the movement pattern of mice treated with the uncompetitive NMDA receptor antagonist MK-801 was characterised and quantified, in conjunction with currently used or potential antipsychotic agents (some of which have reported clinical effects on cognition). The video-tracking software EthoVision 1.95 was used for this purpose. After 30 minutes of drug pre-treatment, mice were individually introduced into a diffusely illuminated open field arena and videotaped from above for 30 minutes. The videotapes were then analysed using EthoVision. Variables calculated included: distance moved, number of stops, rearing frequency, spatial movements and variation in body area. Data were evaluated with Partial Least Square (PLS) Discriminant Analysis.

In accordance with previous observations, MK-801 was found to induce a primitive and monotonous behavioral pattern, dominated by forward locomotion: spatial movements, switches between the moving and stationary states, and rearing frequency were all reduced compared to controls. Most test substances reduced MK-801-induced hyperactivity, but differed in their ability to restore behavioral diversity. A striking similarity in movement pattern was seen between hypoglutamatergic mice treated with the alpha-amino-3-hydroxy-5-methyl-isoxazole-4-propionic acid (AMPA) receptor potentiator, CX516, and hypoglutamatergic mice receiving the 5HT2A-antagonist, M100907.

In both preclinical and clinical studies, CX516 has been observed to improve a number of cognitive functions: for instance, in schizophrenic patients, CX516 improved attention and memory. The similarity in movement pattern produced by the AMPA receptor potentiator CX516, with observed positive effects on cognition, and the 5HT2A-antagonist M100907, might indicate that 5HT2A-

receptor blockade is beneficial for some aspects of cognitive functions. In line with this theory, the combined dopamine D2/5HT2A-antagonist risperidone has been reported to have favourable effects on working memory, executive functioning and attention in schizophrenia.

Using driving simulation to predict road speed choice by young male drivers

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Speeding is one of the major factors associated with road accidents, and is linked to many other risky driving behaviors, especially in young males. Although young males are at higher risk, only a small proportion actually engages in these behaviors or has accidents. Driving simulation has been proposed as a means to identify those at high-risk for speeding because of its high ecological validity, though it has rarely been used for this purpose. The use of questionnaires, a more common method for the prediction of risky driving behaviors, has been criticized because of its susceptibility to response bias. This study aimed to evaluate (1) whether road speed choice is predicted by speed choice on a simulator, and (2) whether simulation provides a significantly better prediction of road speed choice, relative to a questionnaire of risky driving behavior.

Road site speed (RSS) of a group of 19-year-old male drivers was measured and compared with: (i) simulator mean speed (SMS) and simulator site speed (SSS); and (ii) a questionnaire that measures risky driving behaviors: *Analyse des Comportements Routiers* [Road Behavior Analysis] (RBA) [1]. It was hypothesized that all of these variables would be positively correlated, the strongest relationship being between measures collected on the road and on the simulator. If the first hypothesis was supported, a further analysis would evaluate how much additional variance in speed on the road could be explained by the addition of speed measures on the simulator to scores from the questionnaire.

RSS was correlated with SMS ($r_{18} = 0.66$, p < 0.001), SSS ($r_{18} = 0.68$, p < 0.001) and the RBA ($r_{18} = 0.44$, p < 0.05). Hierarchical regression, with RBA and SSS entered, revealed that SSS explained 36% (p < 0.01) of the variance of speed on the road, over and above the 20% (p < 0.05) already explained by the RBA.

Thus, simulation is a viable tool to predict speed choice on the road of high-risk young male drivers. It may provide additional predictive power compared with questionnaires. The feasibility of simulation for this purpose needs to be balanced against the lower cost of questionnaires and the limited availability of simulators.

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Facial gesture recognition from static dual view face images

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The research presented here pertains to the problem of automatic facial gesture analysis. Our major impulse to investigate this problem comes from the significance of the information that the face provides about human behavior. Facial gestures (i.e. facial muscle activity underlying a facial expression) regulate our social interactions: they clarify whether our current focus of attention (a person, an object or what has been said) is important, funny or unpleasant to us. They are our most direct, naturally preeminent means of communicating emotions. Automatic analysis of subtle facial changes, therefore, seems to have a natural place in various vision systems, including the automated tools for psychological research, lip reading, bimodal speech analysis, affective computing, video-conferencing, face and visual speech synthesis, and human-behavior-aware next-generation interfaces.

We first investigated whether and to what extent human facial gestures could be recognised automatically from a static face image. We developed an automatic system to analyse subtle changes in facial expressions, based on both fiducial points of the contours of the permanent facial features (eyes, mouth, etc.) and fiducial points of the face-profile contour in a static dual view (i.e. frontal and profile) of the face. Figure 1 outlines the system developed.

A hybrid approach to facial feature localisation has been proposed for spatial sampling of the profile contour and the contours of the permanent facial features. This hybrid facial-feature detector employs various image processing techniques, such as active contours, fuzzy edge detection and artificial neural networks. From the extracted contours of the facial features, we extract 10 profile-contour fiducial points and 19 fiducial points of the contours of the permanent facial features (Figure 2).

By comparing the examined facial expression with a neutral facial expression of the currently observed subject, subtle changes in the examined facial expression are measured. Motivated by the facial action units (AUs) of the facial action coding system (FACS), these changes are represented as a set of mid-level feature parameters describing the state and motion of the fiducial points and the shapes formed between certain fiducial points. We define six mid-level feature parameters in total: two describing the motion of the fiducial points, two describing their state, and two describing shapes formed between certain fiducial points. The definitions of these parameters are given in Figure 3.

Based on these feature parameters, a fuzzy-rule-based algorithm interprets the extracted facial information in terms of 32 AUs (from a total of 44 possible AUs), occurring alone or in a combination. With each scored AU, the utilised algorithm associates a factor denoting the certainty with which the pertinent AU has been scored. Our AU-encoder demonstrates rather high concurrent validity with manual FACS coding of test images, achieving a correct recognition rate of 85%.



Figure 1. Outline of the dual-view-based AU recognition.



Figure 2. Fiducial points.

Fiducial points motion				
up/down (P) = ypheword - ypewrone	in/out(P) = Xineused - X pourrene			
If $up/down(P) \le 0$, P moves up.	If <i>in/out(P)</i> > 0, P moves outward.			
Fiducial points state				
If P9 equals P7, absent(P9).	increase/decrease(AB) = AB _{reword} -			
If there is no maximum of f"	ABcurrents where			
between P5 and P7, absent(P6).	$AB = \sqrt{\{(x_A - x_B)^2 + (y_A - y_B)^2\}}$			
Similarly for P7', P7" and P8	If increase/decrease(AB) < 0, distance			
(see Fig. 2).	AB increases.			
Shapes formed by fiducial points				
The physic meanings of <i>angular(P6P8) = true</i> and				
increased curvature(P5P6) are shown below.				



Figure 3. Mid-level feature parameters for AU recognition.

The influence of different management conditions and preweaning handling methods on foal/mare ethograms

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The horse is a social animal whose management influences its manageability and reduces its fear reactions [1]. We compiled daytime ethograms for mares and foals to define the influence of management on the animals' behavior, emotional reaction, learning ability and manageability. We defined the ethograms using focal sampling in different stabling conditions. Data were analysed using The Observer Video-Pro. The ethogram included the timings of upright resting, recumbent resting (with the foal in either sternal or lateral recumbency), feeding and playing. It also included vocalizations, details of aggressive and submissive behaviors, numbers and times of suckling, and the distance between mare and foal.

We recommend behavior shaping and natural communication in horse management, because the handling strategy during the preweaning period alleviates the emotional reactivity of horses to novel stimuli and increases their manageability; it also enhances their later learning ability [2,3,4]. The handling of foals and young horses should reduce their fear reaction and increase confidence during contact with humans. Behavioral and emotional reactions of horses are of great importance during their use and daily care, especially if they are handled horses used in therapeutic riding programs. Contact with humans is an important factor influencing the behavioral and emotional characteristics of young animals. For this reason, we advocate handling foals to create 'family ties' between horse and trainer. Applying more efficient training procedures should produce animals better suited to training, and permit a more natural, 'soft' approach to the horse and its world [5,6].

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A microwave radar device for monitoring locomotor behavior in insects

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Modified radar devices for alarm systems, based on the Doppler effect, have already been employed in monitoring the general locomotor activity of mice [1,3]. These devices can detect movements of subjects in the home cage, thereby avoiding undesirable handling – but the size of the experimental subjects is critical. The apparatus can detect mice very well, but it is not reliable for studying smaller subjects, e.g. cockroaches. This problem arises from the wavelength of the radar emission. The radar employed in alarm systems uses a wavelength of 3 cm, and moving objects smaller than the wavelength are detected only under accurately set levels of sensitivity.

To solve this problem, we used a Lince MW12 microwave sensor on X band (9.9 GHz). In commercial devices, the sensitivity is controlled by a trimmer with only a narrow range of variation, which is therefore not suitable for a fine regulation of sensitivity. The changes we made in the electronics included: (a) substituting the original 22K trimmer with one of 100K, producing a finer resistance scale and greater sensitivity control; (b) zeroing the time constant, to obtain instantaneous responses to each movement; and (c) installing a pulse former in the output for a constant relay-on time, compatible with the reading time of the digital I/O board in the computer.

This modified device was tested on the circadian activity of cockroaches *Periplaneta americana.* 17 males were housed in individual 15 x 15 x 10 cm Plexiglass cages, with a radar placed above. The animals' activity was monitored for three days at 18°C and subsequently for three days at 28°C in constant darkness, with food and water provided ad libitum. For each animal, we recorded the number of movements every 10 minutes. Each time series was smoothed, the linear trend removed, and the power spectrum computed by a Discrete Fourier Transform. In all spectra, power peaks with values higher than 2.81 standard deviations above the mean (p < 0.001) [2] were considered significant. A chi-square periodogram (Wintau, code by Refinetti) was used to determine the period during the time intervals 1-8 hrs and 20-26 hrs.

The Q10 values and the circadian free-running period derived both agreed with the data reported by other authors [4,5], thus supporting the reliability of the

apparatus. Moreover, the spectral analysis and periodogram revealed the presence of ultradian rhythmicity during the 1-8 hr range.

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WebRemUSINE: a tool for usability evaluation of web applications

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Creating a web site allows millions of potential users with various goals and knowledge levels to access the information it contains. For this reason, interest in usability evaluation of web sites is rapidly increasing.

We have developed a method and an associated tool to detect usability problems in web interfaces through a remote evaluation. Our approach combines two techniques that are usually applied separately: empirical testing and model-based evaluation. The reason for this integration is that models can be useful to detect usability problems, but their use is much more effective if they can be related to the actual use of a system. Our tool is able to analyse the possible inconsistency between actual user interactions and the task model of the web site, which describes how its concrete design assumes activities should be performed. To support remote evaluation, we have developed a technique that allows user actions to be recorded during a site visit. The analysis of the logged data is based on comparing the traces of actions performed with the structure of the task model. This analysis provides evaluators with a number of results related to the tasks that users intend to perform, the web pages and their mutual relationships.

In our case, we follow a hybrid approach because our environment is able to analyse data relative to user interactions and then compare them to the task model corresponding to the design of the web site. The solution adopted to identify user intentions in WebRemUSINE is to display the high-level tasks supported by the web site and ask the user to indicate explicitly which task they want to perform. WebRemUSINE compares the logs with the task model and provides results regarding both the tasks and the web pages, thereby supporting an analysis from both viewpoints.

The method is composed of three phases: *preparation*, which consists of creating the task model of the web site, collecting the logged data and defining the association between logged actions and basic tasks; *automatic analysis*, where WebRemUSINE examines the logged data with the support of the task model and provides a number of results concerning the performed tasks, errors, loading time, etc.; and *evaluation*, where the information generated is analysed by the evaluators to identify usability problems and possible interface improvements.

The environment is composed mainly of three modules: the ConcurTaskTrees Editor (CTTE, publicly available at http://giove.cnuce.cnr.it/ctte.html); the logging tool, which has been implemented by a combination of Javascript and Java applet to record user interactions; and WebRemUSINE, a Java tool capable of performing an analysis of the files generated by the logging tool, using the task model created with the CTTE tool.

Actimetry for marmosets

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Assessment of spontaneous activity in laboratory species is an important feature of preclinical behavioral screening. The available methodologies for monitoring such activity are diverse in terms of their complexity and level of sophistication.

Activity monitoring in human subjects by means of wrist-worn devices is widely used in clinical research and patient care. Superficially positioned piezoelectric accelerometers have previously been developed in this laboratory to assess the effects of cholinesterase inhibitors on spontaneous activity in marmosets [1].

More recently, studies have been carried out to evaluate technology devised for humans in the marmoset. Thus, 24-h recordings over up to 21 days were made using 'Mini-Actiwatch' devices (Cambridge Neurotechnology Ltd.), worn as a pendant attached to a standard collar. Figure 1 shows a typical activity profile.

Hitherto, technical limitations have necessitated the use of time-consuming video analysis as an adjunct to single channel EEG recording for characterising sleep patterns in marmosets. Assessment of actimetry data suggests a good correlation (<3% chance of there being a disagreement between the video and the Mini-Actiwatch) to aid differentiation between REM sleep and waking states. We believe that this approach offers considerable potential for monitoring the circadian patterns of spontaneous activity in laboratory species.

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Figure 1. A typical 24-hour activity pattern for a marmoset.

Complex neurological and behavioral characterization of ENU mouse mutants

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In the field of neurobiology and behavior, screening of ENU mutagenized mice will yield novel disease-relevant genes and pathways, as well as therapeutic and diagnostic targets for neurological and psychiatric disorders. Ingenium employs one of the largest recessive mutagenesis programs worldwide, in which all genetic variants are thoroughly characterized by a high throughput screen battery, including neurological and behavioral tasks. To screen for mouse models of psychiatric disorders, tests for anxiety-, schizophrenia-, depression- and cognition-related behaviors are implemented into the screen. Established test systems, like the Dark-Light Box, Elevated-Plus-Maze and Open-Field, are performed using fully automated video tracking for the detection of abnormal, anxious or explorative behavior. The Prepulse Inhibition of the Acoustic Startle Reflex has been assessed as a measure of sensorimotor gating, which is defective in schizophrenia patients. Depression-like symptoms are screened by the Tail Suspension and Porsolt Forced Swim tasks. Finally, cognition is tested using Fear Conditioning and Passive Avoidance, the most straightforward assays to study learning and memory deficits.

Beside the behavioral paradigms, the screen includes a broad set of neurological tasks, testing motor coordination, muscular functions and sensory functions, including assessment of hypo- and hyperalgesia. As pieces of the diagnostic puzzle, all major clinical chemistry parameters, blood cell counts and a broad variety of immunological parameters are generated for every mouse in the primary screen.

Secondary assays consist of measurement of activity, circadian activity patterns and cognition tests. Thorough neuropathological analyses of the CNS, PNS and muscular system are also indispensable as a secondary assay. Our comprehensive screen, determined by repeated and secondary analyses, confirms recessive neurological or behavioral phenotypes in about 5% of the investigated animals. More than 50% are immediately genetically confirmed by the presence of at least two phenotypically identical animals per pedigree. Several mouse lines will be detailed in the areas of anxiety-, hyperactivity- and schizophrenia-related disorders.

Using an electronic diary with the VU-AMS

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Combining behavioral entries from a paper-and-pencil diary with physiological measurements from the VU-AMS is time-consuming, and alternatives may be preferable. We used a Palm handheld device to assess several questions about stress-related behavior on an hourly basis. The questions were converted into electronic questions with Pendragon Forms 3.1, a program used to design question forms and manage collected data. Advantages and limitations of this method will be discussed.

Towards an experimental timing standards laboratory

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The timing of events in studies of human performance increasingly relies on the use of software tools running within complex hardware and software environments. With the advent of graphical multitasking operating systems and associated software for designing and running studies, it is hard for the researcher to be confident of the accuracy of the timing of stimulus and response events. Thus, the reliability of timing is subject to a wide range of influences.

It is common for chronometric studies performed by psychologists or human factors engineers to treat differences between conditions of ten milliseconds or less as behaviorally significant, yet inaccuracies resulting from hardware and software for individual events may typically be considerably larger than this. Whilst repeated sampling can overcome random variation, it cannot counter systematic bias which might be correlated with different experimental conditions.

Accuracy claims made by commercial software developers are seldom supported by hard evidence, and in any case may refer to specific ideal operating conditions, which users may not be able to follow. Moreover, rapid changes in hardware, operating systems and associated software mean that the same product may not perform in the same way in different laboratories, or following an upgrade.

Careful and technologically sophisticated users may well take steps to ensure the validity and reliability of their measuring instruments. However, the ubiquitous penetration of experiment generators into research and teaching laboratories raises serious concerns over the possibilities of flawed data collection and inappropriate training in research methodology for students.

With national research council backing, we have established the Experimental Timing Standards Laboratory and formulated recognised benchmarks for testing the timing characteristics of most tools used by behavioral scientists for chronometric studies. This has required the development of appropriate testing criteria, benchmark standards and testing methodologies, the collection of timing data from commonly-used tools, the dissemination of information concerning good practice, and the establishment of a continuing testing service. In this paper, we outline these benchmarks and discuss our findings in relation to some commonly used packages. See also http://www.psychology.ltsn.ac.uk/ETSL

Benchmarking precision in the real world

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There is little doubt that the majority of today's high-speed, high-specification hardware and operating systems are capable of real-time data collection [1,4]. The caveat is the word 'capable'. As many researchers have noted, the dominance of multitasking operating systems makes the picture murky at best [2,3].

To date, research has concentrated on the raw performance of platforms and operating systems. Many studies have investigated suitability for high-precision timing by using programs that examine the performance of repeating a simple operation within a tight timing loop (e.g. [4]). The effect of stressing the operating system with a background task is a widely accepted variable. Such research, whilst providing a solid baseline, leaves researchers in the field with the fundamental question: 'How does my own paradigm perform in the real world?'.

Until now, this has been a question that has remained extremely difficult to answer. Complete real-world paradigms can often be extremely complex, making use of both visual and auditory stimuli and requiring complex patterns of responses from subjects, with the more being done, the greater the likelihood of lower timing resolution. It is acknowledged that the hardware running the experiment will also play a large factor. What is needed, then, is a rig that can test the majority of paradigms in situ and without modification.

To this end, we have developed a generic rig which can be used to control and time a second machine that is being used for presentation – that is, a machine running the experimental paradigm under test (Figure 1). The results of testing can be used to inform a researcher how well their hardware, experimental software and paradigm have performed as a cohesive unit.

In this paper, we report on the test rig we have developed and how this was used to test a working psycho-acoustical paradigm in situ. Within this real world paradigm, we assessed (with sub-millisecond precision): visual presentation onset and duration accuracy; synchrony between audio tones and visual stimuli; tone duration; and the accuracy of response registration. This enabled us to compare actual events with those programmed in to, and recorded by, the experiment generator used (in this case, PsyScope running on a Mac Performa 630). This study has been conducted under a funded project called the Experimental Timing Standards Laboratory (ETSL). See http://www.psychology.ltsn.ac.uk/ETSL/

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- A Control and Timing PC (CAT)
- B Breakout box
- C Presentation PC running software under test (PRES)
- D Mouse
- E Keyboard
- F Button box
- G Microphone or voice key
- H Speakers

Figure 1. An overview of the ETSL benchmarking rig.

- I Lines attached to mouse buttons
- J Lines attached to up to six keys
- K Lines attached to button box keys
- L Lines attached to parallel or serial ports
- M Fibre optodetectors
- N ETSL voice key
- O ETSL tone generator

Evaluating and studying the Internet: a challenge for client-side tracking of user behavior and automatic capturing of content

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In recent years, we have witnessed a large increase in usability-related Internet activities, and there are now many questionnaires that can be used for (rapid) usability testing. However, a successful web usability engineering process [1] requires more than just understanding user attitudes: namely, it involves testing the effectiveness and efficiency of user behavior. Performing a suitable user test is not a simple task, and it can also be very expensive. Similar problems can be found in the area of experimental research, so we now have 'web laboratory' portals, representing an attempt to transfer experimental investigations into the world of the web. Such experiments [2] use Internet technology in a lab to investigate user behavior. Using Internet technology in this way involves both browsing the web with a standard browser and scripting for data collection, as well as controlling the experiment and the variation of the experimental material.

Our experience suggests that, for most purposes, a combination of lab-based experimentation and covert automatic interaction tracking on the web is preferable to web-based user tests, in which an anonymous sample of users is attracted via 'web laboratory' portals [3,4]. The inconsistency between the methodological requirements of usability testing and experimental research, allied with the economic requirements (i.e. the rapid implementation of investigations with low costs and small resources), led us to the broadening of web-supported experimentation.

In the sense of 'cause-tools' (Computer Aided Usability Software Engineering [5]), we developed a toolkit called UBI-ACT (Usability Benchmarking, Inspection and Automatic Capture Toolkit). This system is a combination of client-side interaction-tracking (events of micro-navigation, e.g. mouse-click, mouse-over, scroll), including many system properties (e.g. the content of a clicked link), page or site statistics gathering (e.g. links per page, content length, system response time), and a collaborative research management platform, allowing assembly of modular usability tools and coordination of the usability engineering work flow.

In our contribution, we will demonstrate the usefulness of UBI-ACT in two different areas: (a) the rapid and efficient development of an experiment with

user-tracking; and (b) the use of annotations when capturing content and site statistics to perform a heuristic evaluation [5], without needing to change the source code of a known web site.

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Neurobiological factors in aggressive and antisocial juveniles

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In this study, various biological markers will be studied to observe the biological characteristics of antisocial and aggressive behavior in juveniles, as well as biological predispositions for such behavior. A total of 300 first offenders (males aged 12-13, all of whom participate in a diversion project) and 50 controls will be included in the study. Demographic, psychological and psychiatric data will be obtained from the subjects, and from their parents and teachers, by standard questionnaires and a structured psychiatric interview. The biological markers to be studied are: heart rate, skin conductance, cortisol and testosterone.

During one test session, the subjects will perform a preservation task (card play task), a passive avoidance task (go/no-go discrimination task) and a frustration task (tira task). During this session, heart rate and skin conductance will be registered using a VU-AMS device. Spread over the day and during the session, cortisol and testosterone levels will be measured from saliva samples.

Over a two-year follow-up period, developmental characteristics will be studied, focusing on aggression, antisocial behavior and any habitual relapse into crime. A pilot study began in Amsterdam in February 2002, and the first results are expected in July 2002. During our presentation, we will focus on the hypotheses, methods, first results and experiences using the VU-AMS device for measuring heart rate and skin conductance.

Encoding pilot-controller communications using the aviation topics/speech acts taxonomy

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The Aviation Topics/Speech Acts Taxonomy (ATSAT) is a tool for categorizing pilot/controller communications according to their purpose. What makes the ATSAT different from other communications taxonomies is that FAA Air Traffic Control Order 7110.65 served to guide its development. We have used the ATSAT to identify, classify and code communications made by controllers and pilots from field tapes representative of day to day operations. The ATSAT is a hierarchical order of communication elements, which combine to form messages transmitted over voice radio or data link communications systems.

The communication element is conceptualized as a fundamental unit of meaningful verbal language [1]. In the ATSAT, communication elements are arranged by their functionality: that is, their purpose, operation or action. A commonly referenced communication element is the speech act [2,3]. The speech act is defined as an utterance, either spoken or written, which describes one discourse function. Aviation topics are the subject matter of the speech act [4]. They place a constraint on communication elements by imposing restrictions on the identified speech act category (who, what).

As shown in Table 1, the speech act categories include Address, Courtesy, Instruction, Advisory, Request and Non-Codable. The Address is the 'who' of the transmission. It refers either to an aircraft or to the air traffic control facility position/sector. In addition to showing a level of respect, a Courtesy often signals the end of a dialogue between the air traffic controller and the pilot, in much the same way that a 'goodbye' signals the end of a telephone conversation. The Instruction, Advisory and Request speech act categories represent what the communication element in the message is about - the action to be undertaken. They represent the 'do something', 'tell something' and 'ask something' of an utterance. For example, there are only two types of aviation topics listed in the Address speech act category.

There can be only one speaker and one receiver of a transmission. The types of aviation topics listed in the Instruction, Advisory and Request speech act categories are not exhaustive, but represent the most frequently uttered messages heard from the field tapes. Using transcripts from pilot/controller communications, the process of parsing and encoding transmissions into communication elements, speech acts and aviation topics will be demonstrated.

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TABLE 1. Aviation Topics/Speech Acts Taxonomy				
Speech Act Category	Aviation Topics			
Address/Addressee	Speaker, Receiver			
Courtesy	Thanks, Greetings, Apology			
Instruction/ClearanceReadback/Acknowledgment	Heading, Heading Modification, Altitude, Altitude Restriction, Speed, Approach/Departure, Frequency Hold- ing, Route/Position, Transponder Code, General Acknowledgment			
Advisory/RemarkReadback/Acknowledgment	Heading, Heading Modification, Altitude, Altitude Restriction, Speed, Approach/Departure, Route/Position, NGTAM, ATIS, Weather, Sighting, Traffic, General Acknowledgment			
RequestReadback/Acknowledgment	Heading, Altitude, Speed, Approach/Departure, Route/Position, Type, NOTAM, Traffic, Weather, Say Again, General Acknowledgment			
Non-Codable Remarks	Equipment, Delivery, Other			

Table 1. Aviation Topics/Speech Acts Taxonomy.

Monitoring stress calls of domestic pigs using linear prediction coding analysis and a self-organising neuronal network

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In recent years, sound analysis has become an increasingly important tool for interpreting animal behavior, health condition and wellbeing. Additionally, vocalisation may provide an objective, non-invasive and useful tool for evaluating the emotional state of animals under natural or captive conditions.

A sound analysis procedure based on linear prediction coding (LPC) and a selforganising neural network is presented, and its capacities are demonstrated using various stress calls of domestic pigs. Using LPC, an extremely compact, shorttime representation of the call was obtained, comprising only a few features (LPC-coefficients). A neural network was trained such that topological relations of the neurons represent the input vector space of the determined LPCcoefficients. Hence, the resulting feature map allows conclusions to be drawn concerning the structure of the input data.

Early results demonstrate that the procedure is able to distinguish stress calls from any other calls or noise. It is also possible to discriminate individuals on the basis of their calls, and to differentiate between stress-related calls caused by a variety of sources (e.g. normal handling versus castration of young piglets).

This procedure may be used as a methodological approach to solve different analysis and classification tasks in animal vocalisation. Under the assumption that the observed animals vocalise when stressed, the procedure can be executed in pseudo real-time on commercial laptops, to allow automatic monitoring of the vocal behavior of pigs in various stressful situations (e.g. housing and transport).

Illumination-dependent variations of behavior and physiological indices in cultivated salmon (Oncorhynchus mykiss)

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In fish, the pineal organ (PO) is the main centre for the circadian and seasonal photoneurohormonal regulation of physiological status and behavioral pattern rhythmicity. This is achieved by the conversion of environmental photosignals into neurohormonal output in PO photoreceptor cells. The function of this organ directly links the physiological profile of the organism with its environment through hormonal attenuation and behavior. Pineal melatonin production is high during the night and low during the day, and is extremely sensitive to ambient radiation.

The role of the PO in circadian organization has received most attention, because it is involved in piloting numerous rhythmic functions and is tightly connected with behavioral strategy choice. The PO is one of the main structures determining the degree and individual characteristics of physiological plasticity and environmental adaptogenesis in lower vertebrates. By applying various types of radiation, it is possible to artificially shift pineal function, thereby achieving functional regulation of various indices.

Over the last seven years, experiments have been undertaken at a trout farm in the Crimean Mountain Reservation. These have demonstrated the efficiency of pineal regulation for piloting spawning, smolts, growth rates, food consumption efficiency and the development of behavioral patterns in rainbow trout. As a species lacking an inner 'pacemaker', the salmon is an especially convenient subject for assessing the performance of light dependent functions, because incoming photosignals cause direct neurohormonal effects in its brain, as well as corresponding shifts in physiological indices.

In this study, two sets of experiments were conducted under different illumination regimes: dim light (L:D = 0:24, 10-500 lux) and constant light (L:D = 24:0, 10,000-15,000 lux). Both sets consisted of three experimental groups, each containing 25 specimens. The regime for the control group (20 specimens) was L:D = 12:12, 5,000-7,000 lux. The regime L:D = 0:24 caused growth rates to increase by 7-12% and mortality to decrease by 75-100%, and led to the normalization of feeding behavior. The L:D = 24:0 regime resulted in gonadal maturation increasing by 3-5% but immune status decreasing, as

demonstrated by increased numbers of infected specimens and changes in blood cell composition. Schooling and the ability to withstand the current were also shown to depend on the melatonin-piloting illumination regime applied. Considered independently, these changes might not be treated as having a systematic link – but occurring in parallel, they seem far more likely to reflect inner hormonal shifts.

Overall, the entire life cycle of these fish seems to be extremely light sensitive. The physiology of the PO, and pineal regulation of organism activity as a whole, have both been studied extensively – but mainly in higher vertebrates. This study helps to show that they may be more important in lower vertebrates with active locomotion and migratory ethology (e.g. fish). Understanding the neurohormonal structure of the PO is of supreme importance for explaining how behavioral and endocrine strategies are coupled in fish.
Fit for market: understanding work patterns to design solutions for professionals at work

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Practitioners need to understand work patterns in order to design solutions for professionals at work. Understanding work flow, task flow and event flow is essential for designing the structure and interaction of user-interfaces so that they work. In this contribution, a method is presented for capturing work patterns in practice. The key to the method is the notion that professionals have goals, roles and responsibilities. These form the basis for analysing the professional's work patterns. The method is illustrated with several examples.

Facial expression analysis for assisted technology

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Augmentative and alternative communication (AAC) systems are methods providing enhanced communication possibilities. A major goal of AAC is to provide access to technology for those without the fine motor control necessary to use standard interfaces, e.g. keyboard and mouse. It is generally accepted that users can 'adapt' their response to suit the interface device. A more appropriate solution would allow the system to adapt to the user, thereby increasing AAC flexibility [1]. Analysing facial expression may thus be a useful mechanism for AAC. One application for rehabilitation is visual speaker identification, whereby the system recognises the speaker and provides personalised rehabilitation.

Research into speech reading has shown that, by dynamically tracking a small number of visual features from the face, a small number of words can be recognized with high accuracy [2]. Figure 1 summarizes the processing steps in this study. The Discrete Cosine Transform (DCT) was employed, with the highest energy coefficients used as the feature vector for classification.

In addition to the transform coefficient features, temporal difference information (or delta features) between image frames are also calculated. Given frame k, delta features are computed between frame n and n-k, where N is the number of frames per utterance and k = 1, N/3, N/2, N*2/3, N*5/6, N-1 (Figure 2). The audio-visual database employed in this study consisted of 10 speakers, each uttering the same 78 words [3]. A classification topology was constructed with 10 whole word left-to-right HMM models (representing the 10 speakers), each with five states and one Gaussian mixture per state.

The outcome of this small study is that visual recognition was maximized at k = N/6 for all repetitions, and was seen to increase with the number of repetitions included in the training data. The study shows that geometric details of the mouth region, as well as its dynamic movements, are required to better identify a speaker. This provides a mechanism by which persons unable to vocalize may be able to control systems through articulation movement. Research has also shown that these dynamic features can be used as a form of person identification.

Current research is concerned with developing on-line tremor suppression algorithms. An expression recogniser is being developed to allow recognition of user-specific facial expressions. This would allow the system to be trained to an individual's needs. The research outlined provides the possibility to assess humancomputer interaction, and allow experimentation to improve the quality of AAC.

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Figure 1. The visual subsystem.



Figure 2. Visual memory features.

Influence of sequential photothrombotic cortical lesions on forelimb use in rats

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There are many indications that the contralateral hemisphere contributes to recovery from cortical lesions in rats. Here, we examine how a second contralateral cortical lesion, inflicted after the first, affects the functional recovery.

A focal brain lesion with a diameter of about 2 mm was induced by means of a photothrombosis in the forelimb area (FL-SMC). A second lesion was induced in the contralateral FL-SMC, either simultaneously or 2, 7 or 10 days after the first lesion. Functional recovery was tested in two ways: (1) by rearing rats in a glass cylinder and counting the number of forelimb movements along the wall; and (2) by counting 'foot faults' while the rats were walking on a grid. In both cases, we scored the number of steps in the impaired limb compared to controls.

These tests revealed acute functional deficits in the impaired limb after the first lesion was made. One day after surgery, rats preferred the healthy limb for moving along the wall and made many false steps with the impaired limb when walking on the grid. Inflicting a second (contralateral) lesion after a few days caused a functional deficit in both forelimbs. Recovery in these animals was delayed compared to animals with only one lesion. Inflicting a second lesion after longer periods (10 days) revealed a residual deficit of the compensated limb.

This investigation shows that: (i) acute motor deficits can be demonstrated with focal lesions in the sensorimotor cortex; and (ii) a subsequent lesion, induced during the process of recovery, delays the compensation.

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Principal components and curves for describing rodent behavior

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In this project, we investigate the use of low-dimensional, nonlinear models to describe high-dimensional data, such as images or movies. A natural application of such techniques is the observation of animal behavior, which we study in cooperation with Noldus Information Technology.

Traditionally, computer-aided animal studies (performed in e.g. medicine or genomics) involve two steps. First, a video sequence is obtained of an animal in a test situation (i.e. subjected to some physical affliction or stress, or to pharmaceuticals). Next, this video sequence is annotated by a human observer. This is both time-consuming and subjective, as inter-observer variability can be quite high. The goal of this project is to produce a low-dimensional description of the video sequence, facilitating automatic classification of animal behavior.

Our work is based on data obtained from the Eureka project [1], a set of movie files of rodent behavior containing roughly 2,500 frames each. Each frame has been classified manually into one of 9 distinctive modes of behavior (7 of which are illustrated in Figure 1). The approach we take is inspired by adaptive shape models (ASM) [2]. For each frame, we automatically extract and pre-process the contour of the rodent (Figure 2). The resulting set of contours, represented as 50 (x,y) coordinate pairs, can then be viewed as a data set in a 100-dimensional space. Traditional data analysis methods, such as principal component analysis (PCA), can then be used to find significant directions in the data set. Figure 3 shows that, while the components themselves (indicated by 1-5) seem to correspond to major changes in posture, the projected data do not show a clear clustering of behavior types. This could be caused by our automatic contour extraction, unreliable labelling, or by the fact that we use only video sequences shot from a position above the experimental area. These topics will be addressed in further research.

We have also fitted principal curves [3] – nonlinear generalisations of principal components – to these data. Figure 4 shows some initial results. The single curves seem to describe all major body changes, but as yet they do not give a clear separation of behavior types. The three curves correspond to the setting of an important regularisation parameter, r, which controls how curved the data

description can become. This parameter clearly has significant influence on the resulting curve; finding a correct setting is an important goal for further research.

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Figure 1. Prototypical behavior.



Figure 2. The contour extraction process.



Figure 3. Principal components.

- +					— II —					→ +
r = 10 ⁻¹	0	0	0	0	0	0	0	0	$\left(\right)$	$\left(\right)$
r = 10 ⁻³	0	0	0	0	0	0	0	0	$\left(\right)$	Q
r = 10 ⁻⁵	0	0	0	0	0	0	0	0	$\left(\right)$	ß

Figure 4. Principal curves.

The Observer Video-Pro based coding: empirical evidence of value added

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Researchers are increasingly aware of the influence of communication in mediating patient treatment decisions [1]. Patient-physician communication has been examined through a variety of methods [2]. Researchers are moving towards videotape-based analyses, arguing that video is the only medium capable of capturing the full range of behaviors involved in interactions [3].

Most coding systems provide a static view of the interaction, relying on frequency counts and global ratings. As models of health-related interactions among providers and patients become better developed, however, the need for more sophisticated sequential process analysis increases.

The Observer Video-Pro allows researchers to efficiently examine observational data sequentially, offers flexible coding and analysis and reduces error. Advantages of The Observer Video-Pro system seem obvious, yet empirical evidence of the value added has not been clearly documented. Our goal is to demonstrate the benefits of using The Observer system over traditional paper and pencil scoring using a patient-physician communication assessment instrument, the Moffitt Accrual Analysis System (MAAS).

Participants

Participants include 47 patients at H. Lee Moffitt Cancer Center (approximately 25% male, 75% female, average age 58 years) and 12 medical oncologists (2 female, 10 male). Data are based on 47 videotaped physician-patient interactions.

Measure

Moffitt Accrual Analysis System (MAAS [1]). This observational behavior coding system is designed for coding relevant communication behaviors occurring between oncologists and patients during oncology consultations, in which patients are presented with clinical trial treatment options. The MAAS contains a set of global subjective ratings, assessing three dimensions of patient-physician communication behavior, and a behavioral checklist assessing physician legal/informational messages, as well as social support messages.

Procedure

Data have been collected and are currently being coded and analyzed. Videotaped interactions are coded by multiple raters using the MAAS under two conditions: (1) using traditional paper and pencil; and (2) using The Observer Video-Pro computer-based coding.

Analysis

Hypothesis 1:

Intra-class correlations reflecting the degree of agreement between raters will be higher in The Observer condition.

Hypothesis 2:

Confirmatory factor analysis on data from the two methods will yield the same factor structures representing the three MAAS dimensions, but the magnitude of loadings will vary between methods. The Observer data should account for more common variance and less error variance.

In addition to empirical comparisons of the two approaches, The Observer provides the additional value of offering efficient sequential analysis, which has not traditionally been performed. Data from the Behavioral Checklist portion of the MAAS will be used in sequential analysis.

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VU-AMS derived cardiac function measures: validity and field studies

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To acquire and analyse data recorded with the Vrije Universiteit - Ambulatory Monitoring System (VU-AMS), an accompanying software package is available. This presentation will focus on the analysis of impedance cardiogram (ICG) data using the scoring program AMSIMP. This program contains an automatic scoring algorithm for detecting 3 specific points in each ICG complex, which are then used to calculate several physiological variables. The program also allows the user to change these points manually. A new feature of the program allows averaging across multiple complexes and activities prior to scoring, which considerably reduces the scoring time. The validity of this method will be discussed, using comparison data from 3,000 individually scored ICG complexes and the scoring of averaged complexes.

Besides validity, the stability of cardiac function measures is also important. Analysis of two subsequent 24-hr workday registrations has shown high test/retest correlations for absolute PEP values. Test/re-test correlations for various PEP reactivity measures were also highly significant. Additional results for other cardiac function measures, e.g. stroke volume, will also be presented.

Nesting behavior as a phenotypic tool in APP transgenic mice

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Advances in the relationship between molecular genetics and behavioral neuroscience have led to the increased use of behavioral tasks that are sensitive to genotypic alterations. One task that is little used by behavioral neuroscientists is the measurement of rodent nesting behavior. Studies have shown that nesting behavior is dependent upon intact hippocampal function, as hippocampal lesions dramatically reduce the amount of daily nesting behavior seen in rats and gerbils. This relationship between nesting behavior and hippocampal lesioning led us to investigate nesting behavior in transgenic APP mouse models of Alzheimer's disease (AD).

AD-related pathology develops in the hippocampus of APPsw and PSAPP mouse models with age. We found that both APPsw and PSAPP mice demonstrated significantly attenuated nesting behavior when compared to their appropriate genetic controls, across a wide range of ages. This behavioral task is valuable because it possesses (1) high predictive validity and (2) high utility, as it is quite simple to collect data and does not interfere with other behavioral procedures being conducted.

This work suggests that nesting behavior is an effective tool for phenotyping APP transgenic mice, and may be sensitive as a behavioral measure for determining potential therapeutic treatments for AD. Further studies will investigate changes in nesting behavior following therapeutic interventions, and examine the relationship between nesting behavior and hippocampal AD-related pathology.

Image analysis of caterpillar feeding behavior

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Efficiency and researcher bias have always plagued behavioral experiment design. The task at hand is to construct a reliable monitor of animal behavior while eliminating the possibility of researcher bias. Previous studies of caterpillar feeding behavior have relied on long periods of human observation (13+ hours) and visual evaluation of food consumption at critical time points. Our new behavior rig eliminates the need for both human observation and data collection/analysis. Using an array of CCD cameras, individual animals are monitored via computer for the duration of the experiment. Images are obtained at pre-set time intervals using a frame grabber to take still images from the CCD cameras. After the experiment, these images are analyzed using software written in Matlab. This system no longer requires a human observer for data collection and, most importantly, removes the possibility of experimenter bias in data analysis.

SLOT: an experimental platform for studying multimodal communication

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SLOT (Spatial Logistics Planning Task) is an experimental platform designed for studying multimodal communication between human participants [1]. It has been developed to gather data about human-human interaction in the European COMIC (COnversational Multimodal Interaction with Computers) project. At the core of the SLOT paradigm is a computer program that displays a map with several cities, connected to one another by one or more roads. A number of cities are marked as 'targets'. The subjects' task is to negotiate a route through the map, such that all targets are reached at least once, while minimizing the 'costs' associated with the route.

Both subjects have a graphical LCD-tablet in front of them, on which the maps are displayed. They can use a 'pen' and 'eraser' to draw on their tablets, using the tablet as a 'whiteboard' to aid the negotiating process. Subjects' verbal and non-verbal behavior is recorded on video, while the content of the writing pads and the subjects' pen movements are recorded on disk. This paradigm has several advantages for the study of multimodal communication. The main advantages are its high flexibility, in terms of the number of independent variables that can be manipulated, and the presence of an objective measure of the quality of the negotiated solution. Also, due to the spatial nature of the task, the paradigm is highly suitable for eliciting multimodal communicative behavior (e.g. speech, 2-D/3-D gesture, facial expression and gaze behavior).

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Behavior of CCK-B knockout mice in place conditioning tests

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In the brain, cholecystokinin (CCK) has been described as a central neuromodulator peptide involved in such functions as anxiety, stress, food consumption, learning, memory storage and opiate analgesia modulation. From existing evidence, we also know that the CCK system is involved with drug dependence phenomena, and that it is correlated with a putative 'drug-preferring' phenotype within free choice tests. CCK exerts its action on the central nervous system through at least two different, G-protein-coupled, high-affinity receptors: CCK-A and CCK-B. The mouse CCK-B receptor gene has been cloned, and targeted disruption of this gene has been achieved (via CCK-B knockout mice). Animals without CCK-B receptors display learning disabilities, disturbances in the development of gastric mucosa, and changes to the function of the brain's dopaminergic system.

In this study, we found differences in the effects of amphetamine, morphine and naloxone on the behavior of CCK-B knockout mice in comparison with wild-type age- and sex-matched littermates, in both conditioned place preference (CPP) and conditioned place average (CPA) tests. The CPP test is based on the association of a putative reward with a set of neutral environmental cues. When given a choice, wild-type mice spent more time in an environment where they were previously under the influence of a reinforcing drug. Knockout mice did not display such a preference. In the CPA test with naloxone, wild-type animals showed a significant aversion to the drug-paired compartment of the test apparatus, whereas knockout mice did not.

Developing a new video analysis system for the study of animal behavior

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Most modern techniques for quantifying and analysing behavior rely on video analysis of recorded pictures. Earlier methods typically used photoelectric cells, which had weak spatial resolution and gave only a coarse measure of animal activity in very artificial conditions. Compared to these, modern techniques permit much finer analyses of many details of animal behavior, combined with a very high degree of automation.

In this context, we have developed a new integrated platform for recording and analysing behavior, based on the treatment and analysis of video recordings. It can be used for many standard behavioral tests (e.g. Morris water maze, elevated maze, radial maze, zero maze, open field), as well as others tailored to suit the field of experimental interest. Another advantage of this new system is its speed of treatment, which allows different types of movement to be distinguished (e.g. slow and fast movements, stereotypy). Its speed has been optimised by using an improved video card. Another advantage of this system is the level of control it allows during all stages of the test, from beginning to end.

These new techniques do not require any specific regulations, and the system is fully adjustable for working under a variety of conditions (e.g. variable light). The system can also be extended to allow the connection of other image sources (e.g. camcorder or video recorder). It allows users to control and observe behavioral tests being conducted at different sites, using the same equipment with a special multiplexer video unit.

By describing and demonstrating this new system, we aim to broaden its field of applicability and show how it can be used to run an efficient behavioral study, while optimizing all material and software parameters.

Movement synchrony at the beginning of interactions between mixed-sex couples: male initiation, depending on female risk perception

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Human movement has its own rhythms, which can be analyzed as temporal behavior patterns using Theme [1]. Movement synchrony is the synchronization of such rhythms among people, and is one of the hottest topics in the study of non-verbal signals in courtship. Such signals – 'flirtation' – must be subtle and implicit, because of risks underlying the bargain between males and females, so movement synchrony has evolved to suit its purpose.

Previous research has showed that such flirtations are mainly controlled by females, and has reasoned that, because females are at higher risk when communicating their interest in males, they must initiate and manipulate communications subtly. However, we know that females are sometimes sexually accessed by males, even when they have little intention of flirtation. What happens in subtle non-verbal communications when males initiate an approach is poorly known. Thus, the first objective of this research was to investigate cases in which males use movement synchrony to initiate courtship.

Some females experience greater sexual access by males than others. If people generally understand movement synchrony as courtship signals, women who are often accessed may have a tendency to synchronize with the movements of men – even when they have no intention of flirting – and may thus be prone to be misunderstood by men. Thus, the second objective of this research was to test this hypothesis.

We began by analysing movement synchrony in the first and last minutes of 10minute long interactions between 50 unacquainted, mixed-sex couples in a waiting-room situation (Figure 1). Stepwise regression analysis revealed that subjects' interest in the opposite sex influenced the formation of temporal behavior patterns only at the beginning of interactions. Furthermore, there was a sex difference in the influence of subjects' interest. As previous research has suggested [2], indices of temporal behavior patterns show that females who are highly interested in the opposite sex tend to synchronise with male rhythms, while highly interested males tend to produce a variety of temporal patterns. Subjects self-reported the frequency with which they were sexually accessed in public places, and females were divided into two groups: rarely-accessed and highly-accessed. The 50 couples were then divided into two groups on this basis. In the highly-accessed female group, movement synchrony during interactions in the first minute occurred according to females' interest. On the other hand, in the rarely-accessed female group, pattern formation was controlled by males' interest (Table 1).

These results show that movement synchrony, a highly ambiguous mode of nonverbal communication, has an active influence in non-verbal courtship communication, especially at the start of interactions between strangers. In this high-risk situation, it seems that people need to get information about their counterpart very quickly, without being perceived. Male interest influenced pattern formation, but not in the same way as female interest. Females in the highly-accessed group did not synchronize with strangers regardless of their interest; rather, they controlled non-verbal communication and seemed to perceive the high risk of interaction with male strangers, while unconsciously trying to assess them through movement synchrony (Figure 2).

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Figure 1. The floor plan of the waiting room where the experiment took place. A pinhole camera was set up, 130 cm above the floor, to videotape subjects. The subjects' chairs were placed about 120 cm apart.

	Rarely-accessed fem ale group					Highly-accessed fem ale group				
	Female's interest	Male's interest	F(125)	p-value	R ²	Female's interest	Male's interest	F(1 <i>2</i> 1)	<i>p</i> -value	R ²
Datapoints	-	.41*	491	£04	16	.45*	-	525	£03	20
Pattern difference (log)	-	.43*	5.62	۵3	18	-	-	-	-	-
Pattem occerence (bg)	-	A2*	530	۵3	18	A3*	-	470	£04	18
Mean of pattern length	-	-	-	-	-	52*	-	7 57	D1	27
Mean of pattern level	-	38*	439	Ω5	15	54**	-	864	D 1	29
A verage num er of actors	-	-	-	-	-	55**	-	891	D 1	30
Pattem repetition (bg)	-	-	-	-	-	-	-	-	-	-

Table 1. Influence of subjects' interest on temporal pattern formation in the first minute of interaction: standardized coefficients from stepwise regression analysis. The left column shows the list of dependent variables; those not normally distributed were log-transformed. These are indices of temporal behavior patterns. "Average number of actors" describes two subjects involved in making the same patterns, i.e. the degree of movement rhythms of the two were synchronized. Female's interest and male's interest are candidates for predictor variables.* coefficient: p < 0.05, ** coefficient: p < 0.025.



Figure 2. Formation of movement synchrony by highly-interested individuals in the first minute of interaction. Highly-interested males make various patterned movements and act as the time-giver (i.e. control the timing for establishing movement synchrony), especially with rarely-accessed females.

Measuring motion behavior in perceptual-motor development

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In a research programme concerned with the consequences of biological risk factors on neurological and behavioral development in infants and children, the combined use of different motion analysis techniques is a must in order to find satisfactory answers to research questions. These questions focus on three main areas. First, investigating the movement behavior of brain-damaged infants with a high risk of developmental disturbances (e.g. periventricular leukomalacia). Second, identifying developmental transitions in perceptual-motor behavior (e.g. fetal behavior, reaching, grasping, kicking and walking). Third, examining visual information sources used in the control of movements (e.g. catching and road-crossing).

Two problems in data collection must be solved. First, no single system exists to tackle these questions. In isolation, each technique cannot provide answers to these questions. The presentation will illustrate how this problem is overcome by using a combination of different motion analysis techniques (e.g. force-plate, 3-D motion system and video), in combination with each other and with other techniques used in the hospital (e.g. MRI and ultrasonographics). Second, data collection related to infants necessitates special arrangements to allow the (relatively) unobtrusive collection of data with a sufficient level of accuracy. Part of this presentation will focus on how these difficulties are being solved.

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Evaluating the living conditions of free ranging animals by automated chronobiological analysis of behavior

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A biorhythmical method has been developed to assess behavior levels and evaluate the living conditions of free-ranging animals. All kinds of continuous and equidistant long-term recordings of behavior are suitable for this method. Data sets from automatic telemetry systems, such as ETHOSYS, are especially convenient and have been widely used.

Time functions can be analysed both macroscopically (comparison of daily levels) and microscopically (autocorrelation function and power spectral analysis). Harmonic Parts (HP) and Degrees of Functional Coupling (DFCs) can be calculated to identify and evaluate disturbances under usually quasi-natural conditions. Hierarchical frequency tuning of the organism, in the context of complex rhythmic behavioral functions, leads primarily to period lengths which are synchronised with the 24-hr period.

HP analyses calculate the percentage of rhythmic behavior synchronised with the 24-hr period. DFCs are a measure of harmony between internal rhythms and the external 24-hr period. These values are high in well-adapted, healthy and undisturbed individuals, but lower under conditions of adaptation, sickness or social interaction. All procedures have been tested on different species under various conditions. The different methods are available as a Windows-compatible software package.

Viewers viewed: facial expressions while watching TV news

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Because facial expressions naturally accompany an emotional process, they can be valuable, observable indicators of otherwise unobservable processes. Based on an interest in the emotional processes that occur while people watch violent events on TV news, we analysed their facial expressions alongside other emotional components.

Our poster describes the methods and findings of this project: "Violence in TV news – on the cultivation of emotions". The development of a timeline-oriented system to conduct a computer-assisted media analysis (CAMA) is outlined. This allows us to 'sketch out' studies on the presentation of violent events in TV news by describing the formats and content of each news item along the timeline. A content analysis of the main news programmes of both public and commercial television channels in Germany was conducted, using four time samples (1981, 1996, 1998 and 2000).

The results of these media content analyses are used to conduct studies about the facial expressions (EmFACS; Ekman & Friesen 1978, 1982) of viewers to TV news. Investigations combine both sets of timeline data (using a split-screen videomixer) and display a timecode on the recorded video. By means of this technique, we explore the process of media reception. Overall, we find typical patterns of facial expressions, but with a remarkably high proportion of contempt (e.g. spite, scorn, disrespect) and specific action-unit-combinations (i.e. muscular facial behavior patterns which, while not denoting any particular emotion, are repeatedly displayed). Differences can be observed in the emotional process of media reception of violent and non-violent news, and there are differences in facial expression while watching violent and non-violent items. Furthermore, there seems to be a connection between the presentation of violent TV news events and the expressive reaction of the viewer.

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Open-field behavior in fish: correlates of brain lipid peroxidation with lead exposure

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The motor activity behavior of fish (mirror carp) was investigated in an open field test following lead exposure (50 μ g/l) for a period of 30 days. Lead is a highly toxic heavy metal, which affects the nervous system in particular. Exposure to lead has been associated with behavioral disorders (such as movement anomalies), learning impairments, memory loss and cognitive functional damages in humans and experimental animals. Behavioral correlates of oxidative damage in the brain, identified as lipid peroxidation, have been found in a number of neurological and neuropsychiatric disorders.

For these open field behavior tests, the floor of an aquarium was divided into a grid of 1 inch squares, and the side walls were divided horizontally by lines at 3 inch intervals. A fish that moved from one grid square to the next was given a score of one; a fish crossing a horizontal line on the side of the tank scored two; and any fish moving up or down by half its length also received a score of one. These motor behaviors were scored every day at 09:00 for two minutes, taking the mean of all scores from two individual sets of fish.

During the first week of lead exposure, the fish showed jerky behavior and/or quick motor activity behavior. However, the movements of most fish were relatively stable, with no appreciable increase or decrease in their motor activities. Spontaneous increases in the movement behavior of these fish were observed between days 16 and 30 of lead exposure, with a maximum of 129% at the end of the experiment. Lipid peroxidation in their brains had increased by 52% by day 15 and 156% by day 30.

This study indicates that increased levels of lipid peroxidation were found in the brains of fish showing anomalies in motor activity during chronic lead exposure.

3-D musculoskeletal ultrasound as an adjunctive measure to clinical gait analysis

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Gait analysis is used for treatment decision-making and assessment of intervention in cerebral palsy, but its power is limited by the variability in, and interpretation of, results. The clinician needs to distinguish the contributions made by muscular weakness, altered neurology and deformity, but often many conclusions can be drawn on the basis of any one set of data. There is a need for complementary investigations, to improve the specificity of gait analysis; one of these may be musculoskeletal ultrasound imaging.

Ultrasound devices transmit high frequency sound waves. Echoes are received from boundaries between tissues of different acoustic impedance. In this way, bone, blood, myofibrillar and connective tissue can be distinguished within an image. Recently, researchers have begun to investigate muscle architecture (Figure 1) with ultrasound, to assess the effects of immobilisation after cruciate ligament surgery [1] and strengthening regimes [2]. Shortland *et al.* [3] have evaluated the architecture of gastrocnemius in cerebral palsy, with implications for our understanding of muscle contracture in this group. While informative, 2-D studies are limited because the complete muscle morphology cannot be detailed.

Freehand 3-D ultrasound systems can be used to visualize the gross structure of muscles. Generally, such systems consist of a magnetic positional sensor attached to a B-mode ultrasound probe. The video output of the ultrasound scanner, and near-synchronous positional information, are combined to produce a collection of non-uniformly orientated image slices. These can be reconstructed into a regularly spaced three dimensional matrix. Different views of the gross structure of the muscle under study can be obtained by "reslicing" the volume (Figure 2).

3-D ultrasound systems do not require magnetic positional sensors. We have used an optical motion analysis system to track the position of an ultrasound probe and collect images from a scanner on a frame-grabber [4]. With this device, we have measured gastrocnemius muscle belly length in normally-developing adults and children, and in children with spastic diplegia. Derived muscle dimensions may be very useful to the clinician who wishes to assess muscle deformity and mechanical capacity [5] before deciding upon an intervention, such as musculotendinous lengthening, splinting or tendon transfers. What is more, the effect of focal interventions on muscle morphology can be evaluated.

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Figure 1. 2-D ultrasound image of the medial gastrocnemius.



Figure 2. Longitudinal view (20 cm) of a 3-D ultrasound image.

Developing a system for capturing classroom interactions

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We have developed a computerised system that records interactions between teachers and pupils in the primary classroom. Our Classroom Interaction System (CIS) uses The Observer 3.0 software [3] to log the frequency of a number of different 'discourse behaviors' [2]. We used focal sampling with multiple actors. The actors were: a teacher, 4 SEN pupils, 'other' pupils (their peers) and the whole class. We were interested in 7 different sorts of behavior:

- Question (whether open, closed, uptake or repeat)
- Answer
- Explain
- Refocus (get a pupil back on task)
- Read
- Write
- Direct (an instruction to do something)

For ease of data entry, we classified these behaviors as events rather than states. However, we did include one state - stage of lesson. This enabled us to key-in when the lesson had moved between whole class work, group work and a plenary session.

Research [1] suggests that if a pupil is allowed to contribute to the shaping of the verbal agenda in a classroom, the discourse is more effective in helping the pupil to learn. Directive, teacher-dominated discourse is not an effective way to promote higher-order thinking among pupils. Figure 1 shows a typical teacher-initiated discourse profile for a literacy lesson (in England). Ten different behaviors are shown on the x-axis, referring to those bullet-pointed above. This graph shows that closed questions were the most frequent form of discourse behavior (an average of 52 closed questions was asked per hour). The teachers in our sample directed the pupils 29 times per hour and explained 28 times per hour. It is clear that directive behavior is the dominant form of discourse in a literacy lesson.

The CIS is a great improvement upon the paper and pencil techniques traditionally used in the field of education. Data are immediately ready for download and analysis. The system is mobile, easy to internalise and adaptable.

This paper will also discuss some methodological issues we have dealt with when using the system across different projects. These include:

- Suitability of such a system for the fast pace of a primary classroom. This has synergies with the realities of fieldwork, and the validity of the system.
- Methods of data analysis ensuring the system is reliable. Choosing the right kinds of analysis to suit the research question.
- Modifying the system for use in different projects and in different countries.
- Intellectual Property Rights how to protect such a system (which takes time and money to develop) from being exploited, yet ensuring the benefits of the system are realised.

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Figure 1. Discourse profile of a typical literacy lesson.

Measuring the behavior of dairy cows milked by robot: automatically recorded data

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The use of automatic milking systems (AM-systems) is increasing. The main attraction of AM-systems is that they allow farmers to increase productivity and improve their daily job routines. Milking by robot affects all aspects of farm management, and the daily life of the cow. Cows can go voluntarily to the milking station throughout the day and night, with the result that milking frequency and milking interval lengths are variable in time for each cow and between cows, depending on individual cow productivity, temperament, attitude and health, as well as on the traffic system and other managerial and environmental factors. Frequency of milking, milking interval length and the time of day when milking occurs all influence milk yield and composition, and the capacity and productivity of the system. To optimise machine utilisation, farmers often adopt some form of milking frequency stimulation, such as one-way traffic, feeding rewards, playing music, or drinking restrictions along the path. Thus, the willingness and spontaneous behavior of cows milked by robot are partially controlled by farmers' behaviors.

The AM-systems are equipped with sensors and technical solutions to check animals, machine functioning and the milking process. The personal computer managing an AM-system automatically records and processes many readings every day, every milking, and for each udder quarter milked. This enormous amount of data can be useful for investigations into dairy cattle behavior. The data concern animal behavior, animal feeding and milk properties, and thus animal behavior can be related to health conditions and system characteristics.

Behavior-related computer data stored in AM-system databases usually include:

- number of visits to the milking station and number of passages through the selection gate
- time and duration of milking station visits
- number of refusals by the milking station

Feeding data commonly include:

- amount of concentrate administered at each milking by the automatic feeder
- number of accesses to automatic feeders

Data from milk usually include:

- milk yield and flow
- electrical conductivity
- optical properties (transparency, colour)
- temperature

Data from milk make it possible to monitor the udder and overall health of individual cows. Data regarding each udder quarter milking are stored in a database after each milking. AM-systems are equipped with software that analyses the stored data to obtain expected values for each milking, compares them with actual data, and then produces an alarm list.

On our experimental farm, we have been milking fifty Italian Friesian cows by a commercial automatic milking system (VMS, DeLaval) since February 2001. Preliminary results obtained using a database automatically stored by the VMS to study cow behavior will be presented. We will describe trends during the day and the year regarding the number of visits to the milking station, the number of milkings and the number of passages through the selection gate, in relation to parity, lactation stage, milk yield, etc.

The "mouse activity centre": a new method for analysing spontaneous and running wheel activity in mice

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In the field of chronobiology, measurements of spontaneous and running wheel activities are typical methods used to analyse the function of the biological clock in rodents. However, both measurements are rarely performed simultaneously, because signal discrimination is problematic and the two activities are often mistaken for representations of general activity. Passive infrared detectors, for example, are unable to determine whether a signal occurs inside or outside a running wheel, as they cannot distinguish between the two signals. Only by compartmentalizing the observation cage into sections can the signals be separated. Spontaneous or general activity, detected by an infrared sensor, reflects a multitude of behaviors, such as running, rearing, leaning, climbing, feeding and drinking. In contrast, running wheel behavior reflects one form of activity. It has been hypothesised that wheel running represents the search by an animal for potential resources where the goal is not perceivable.

Our primary aim was to develop a data acquisition system that ensures stable performance and allows a high resolution of data acquisition and storage. The system we have developed enables the data acquired to be checked without disturbing the animals or interfering with the data acquisition process.

Short description of the system

Signal detection is based on a passive infrared sensor (PIR), which captures locomotor activity, and a Hall sensor, which registers the running wheel rotations. The PIR sensor is mounted at the top of the cage, while the Hall sensor is placed by the outside of the wheel. An integrated processor facilitates signal processing, transformation, timing coordination and discrimination of the sensor signals. The 'activity centre' enables the simultaneous observation of both spontaneous and running wheel activity in 48 cage units. The data can then analysed with appropriate software.

The system will be presented, and preliminary data collected with it will be shown.

High quality screen capturing: a step forward in usability testing with The Observer

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In recent years, The Observer Video-Pro [1] has found its way into many usability labs as a support tool for collecting, managing, analyzing and presenting usability evaluation data. The integration of video and observational data offers the user major benefits with respect to the validity and reliability of observations. When testing the usability of software or web sites, a scan converter is the de facto standard part of the total solution. This piece of hardware converts the screen display of the participant's computer into an analog video signal, so that it can be recorded, allowing the evaluator to analyze what the participant has been seeing and doing. A drawback of most scan converters is that the recording quality does not enable the tester to actually read what has been recorded. Current screen resolutions are often 1024 x 768 or even higher, whereas the number of TV lines in a video signal is much lower (NTSC: 525; PAL: 625). As a result, information is lost and small characters become illegible. This effect worsens if the video signal is stored in MPEG format (number of lines ranging from 240 with MPEG-1/NTSC to 576 with MPEG-2/PAL). To solve this problem, we have developed an add-on to The Observer Video-Pro, named the Screen Capture Module.

Software-based screen capture

The Screen Capture Module uses an external software application to record the screen of the test PC. In addition to producing a high-resolution recording of the screen without any loss of information, this also renders additional hardware for capturing the screen unnecessary. Figure 1 shows a possible set-up of the total system. The image captured from the test PC can be mixed with a video recording of the participant. This picture is displayed using a standard video overlay board, with no separate mixer required. The recording or encoder PC takes care of capturing and creating media files, including sound. Since these software applications require a considerable amount of capacity, it is advisable to use a separate PC for creating the recordings. Live scoring and analysis is done on another PC where the main and observation modules of The Observer Video-Pro are running. Starting and stopping the screen capture is controlled from within The Observer. In this way, the screen capture process is automatically synchronized with the observational data. The PCs are connected to each other using a data switch, which offers a fast and stable connection.

Creating video highlight clips using combinations of behaviors

One of the standard features of The Observer Video-Pro is the ability to search for actors, events, behaviors, etc. Each time a particular event is found in the Event Log, the associated video episode can be added to a Video Play List (VPL). With the Video Highlights Module (VHM) [2], one can do this automatically: a filter for events of interest is defined, and the program will automatically add all episodes in which those events occur to a Video Play List. A new feature in the VHM is the ability to use so-called 'nesting' when building a VPL. One can build a VPL based on combinations of behaviors, such that the VPL contains episodes in which behaviors occur at the same time (e.g. select all occurrences of the behavior 'use online help' during a specific task in the usability test).

This functionality can also be used in combination with the Screen Capture Module. Although the VHM normally works with MPEG files, the AVI media files created by the Screen Capture Module are also supported. After creating the VPL, this AVI file can be exported to an AVI editor that comes with the Screen Capture Module. This application automatically extracts the selected clips from the video archive and saves them as new media files that can be used outside The Observer Video-Pro, e.g. in a Word document, a PowerPoint presentation or a web page. Since the size of the AVI files is rather large (around 2 GB per 45 minutes), DVD is the most suitable medium for storing the video files.

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Figure 1. Example set-up of a stationary usability lab, including the Screen Capture Module.

Feeding state-dependent and odour-conditioned anemotactic responses of a tiny predatory mite on a newly developed locomotion compensator

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Phytoseiulus persimilis is a small, blind, predatory mite less than 0.5 mm in size. It depends heavily on herbivore-induced plant volatiles (HIPV) as chemical cues for prey location. Previous research has revealed that this mite shows feeding state-dependent and odour-conditioned anemotactic responses towards the complete HIPV blend.

Although locomotion compensators (LC) have been successfully used for studying orientation behavior in insects, none have been suitable for tiny arthropods like mites. This is because it has not been possible to mount a reflecting substance (necessary to track the mite's walking path) on the animal's body without disturbing its natural behavior.

Here, we present the results of orientation behavior experiments on a newly developed, Kramer-type LC by Syntech, which is (to our knowledge) the first suitable apparatus for conducting such studies with small arthropods. The questions we will address are:

- 1. How does *P. persimilis* orientate towards the individual compounds of the HIPV blend (i.e. methyl salicylate, linalool, (3E)-4,8-dimethyl-1,3,7-nonatrien and (3E,7E)-4,8,12-trimethyl-1,3,7,11-tridecatetraen) and green leave volatiles (trans-2-hexen-1-ol and trans-2-hexen-1-al), in comparison with the complete HIPV blend (two-spotted spider mite infested bean leaves) and clean air?
- 2. How will the animal's feeding state, either well-fed or starved, influence its orientation behavior towards these single compounds?
Measuring the host-searching and ovipositional behavior of a parasitoid of the tobacco budworm on tobacco and cotton

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This study was conducted to measure the host-searching behavior of *Cardiochiles nigriceps* (CN), a parasitoid of the tobacco budworm *Heliothis virescens* (HV), on tobacco and cotton. Behavioral studies with CN were conducted in the field with feral females, because laboratory-reared CN would not search for hosts in cages. Five potted plants of each species (tobacco and cotton) were placed in a 5 ha cotton field containing CN females; the pots were arranged in a random order in a row, 60 cm apart. Then, three HV early second instars were allowed to feed in the terminal of each potted plant for 2 h.

Before attempting to measure the host-searching behavior of CN females, their general behavior was observed and described. It included hovering, searching and oviposition. Once a foraging female located a host plant, she hovered around it, sometimes staying over a particular spot before moving on. When a female hovered near a host-damaged site on the plant, she landed on the plant and began searching for the host. Searching behavior involved antennating the plant until the female found the host. Antennation behavior can be described as "drumming" the antennae close to the plant. When a host was located, the CN female antennated the host, positioned herself over its body (away from the head, to avoid being bitten), inserted her ovipositor and deposited an egg in the host.

CN females sometimes used their ovipositors as a probe, to 'stab' a host down in the terminal or crevice of the plant, but often the host remained out of reach. Such unsuccessful searching was referred to as 'agony-search'. On other occasions, attempted oviposition was unsuccessful because the host dropped from the plant as a defensive response to an encounter with the parasitoid. Searching associated with a dropped host was referred to as 'drop-search'. At other times, some hosts whipped their heads back and forth and tried to bite the attacking CN female. The most common result of a successful head-whipping defense was that the female could not insert her ovipositor into the host. Searching associated with a host miss was termed 'miss-search'.

Nest, five methods were evaluated for measuring the host-searching behavior of CN females in the field. First, a stopwatch was used to try to time behaviors. This did not work well, since observation, timing and recording could not be done

simultaneously. Second, a tape recorder was used to try to keep a hands-free record of the times of behavioral events. However, it took too much time to transfer data from the recorded tape to the computer back in the lab. Third, a stationary video camera was used to try to record CN behavior. This did not work either, because when the CN female moved in and around the plant, she also moved out of sight. Fourth, we tried using a hand-held video camera. This did not work for several reasons, but mainly because it was difficult to keep the camera focused on a female hovering up and down and around a plant.

Finally, we tried using a Psion Organizer II Model LZ64 (Psion PLC, London, England) with The Observer software (Noldus Information Technology, Inc., Sterling, VA). This method worked very well. We could easily follow females wherever they went, and were still able to time each of the observed behaviors. The video camera would have been excellent for acquiring accurate data, but we were unable to obtain all of the necessary data with the camera. The data obtained with the Psion Organizer was accurate, user response time was quick and there was no significant difference in oviposition times obtained for CN females using a stopwatch versus the Psion Organizer.

Using the Psion Organizer, the searching behavior of CN females was observed and recorded for a total of 10 h. Analyses revealed that CN females spent more time searching in tobacco than in cotton. This supports an earlier finding that females preferred tobacco and expected an ovipositional reward in this crop.

Bootstrapping observational research techniques and technology into the undergraduate psychology curriculum

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While research methodology courses in the undergraduate psychology curriculum emphasize experimental design issues over observational techniques, technological advances now make it possible to better incorporate this aspect of the scientific method into our portrayal of the discipline. The advantages of exposing students to observational methods have long been recognized [1]. Among other things, students may gain an appreciation for: studying dynamic behavior; making reliable observations (and assessing that reliability); operationally defining and categorizing behavior; and performing simultaneous micro/macro level analyses. Because teaching observational research takes advantage of technological innovations for data recording (e.g. cameras), manipulation (e.g. recorders, editors, transcribers, titlers), analysis and presentation (e.g. software and hardware), students also benefit from exposure to important hands-on experiences with such technology.

A model for incorporating observational research methods into the psychology curriculum, and for overcoming possible technological hurdles, is presented. The special features of the course, *Seminar in Observational Research Methods*, are detailed and explained. These features include: (1) the potential to adapt the course to a variety of topical areas in psychology (e.g. comparative psychology, behavior analysis and the study of interpersonal communication); (2) the 'capstone' (i.e. upper-level, advanced, individualized) aspects of the course activities; and (3) the emphasis on real-world applications (participating in Institutional Review Board procedures, publicly disseminating research findings, etc.). Special emphasis is given to detailing the minimum technological requirements for meeting course goals. Cost-effective technology alternatives (e.g. adapting older analog equipment to digital formats) are also explored.

The first offering of this course at the College of Charleston in South Carolina is described. The topical focus of this class was interpersonal communication, and the primary course project involved the analysis of professors' gestures during class lectures. Available taxonomies of hand movements and gestures were adapted to this context by the students. Methodological issues of sampling, unitizing behavior, controlling observer bias and making ethical decisions about observing and recording public behavior were among those considered. The existing literature on the relationship between gestures and cognitive processes, as well as gestures and social processes, provided the basis for generating and testing several hypotheses regarding the functions of these pervasive non-verbal behaviors. Moreover, an analysis of verbal/vocal communicative channels was attempted by relating gestural behavior to certain types of speech disfluency. Students presented their findings in the public forum of a presentation to the college community. Available technology was employed to capture and represent the dynamic aspects of their data via digitized video clips. Finally, a formal evaluation of their efforts was undertaken by surveying the reactions of students and faculty audience members to the formal presentation. Suggestions for future offerings of this course are included.

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Measurement of active drag in swimming

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A considerable part of the energy expended in swimming is used to overcome drag [1]. Drag is therefore one of the factors that may limit swimming performance. Throughout the history of swimming research, attempts have been made to measure this resistance.

During swimming, it is obvious that the body changes form, since it needs to generate propulsion. It has been conjectured that the movements necessary to create propulsion could induce additional resistance. This so-called 'active drag' is difficult to determine directly, because the forces that act on the swimmer must be measured without disrupting the natural swimming movement. Unlike activities on land, propulsion is not generating by pushing off from a fixed point, but by giving an impulse to the water, which then gives way [2]. So, where should we attach the force transducer?

The MAD-system provides a solution to this problem by allowing the swimmer to push off from fixed pads with each stroke (Figure 1). These push-off pads are attached to a 22-m long rod. The distance between the push-off pads can be adjusted (it is normally 1.35 m). The rod is mounted \pm 0.8 m below the water surface and connected to a force transducer, enabling direct measurement of push-off forces for each stroke. Subjects use their arms only for propulsion; their legs are floated with a small buoy. If a constant swimming velocity is maintained, the mean propelling force equals the mean total drag force. Hence, swimming one length on this system yields one data point for the velocity-drag curve.

The force signal recorded between pushing off from the second pad and reaching the last (16th) pad is time-integrated, and yields the average force applied during a swim of $14 \ge 1.35 = 18.9$ m. The mean velocity is computed from the time taken to cover the distance between the second and last pads. Subjects swim ten lengths on the MAD-system, each at a different but constant velocity (range = 1-2 ms⁻¹). For each length, mean drag force and mean swimming velocity are measured. These ten sets of velocity/drag data are then least square fitted to the function:

 $Fd = A \bullet v^n$

Where Fd represents total active drag, v equals swimming velocity, and A and n

are parameters of the power function. Figure 2 gives an example of the drag dependent on speed for one subject, where drag was measured on three separate days. It shows the remarkable reliability of the drag measurements.

Among other things, this system can be used to estimate the magnitude of wave drag as a component of total drag (Figure 3).

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Figure 1. MAD-system mounted in 25-m pool.



Figure 2. Drag dependent on velocity.



Figure 3. Estimate of wave drag.

Drawing conclusions from user experience data: a multidimensional challenge

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The traditional purpose of observing interactive behavior in usability engineering practice and usability research is to make inferences about the way users struggle with interaction elements to reach their goals. Several sources of data can be collected (e.g. video capturing, user interface events, voice, time measurements, navigational paths, eye-tracking data), and these must be combined and interpreted in synergy to develop an interaction picture that serves the needs of the investigation. Beyond the need to identify user interaction problems, data interpretation should also lead to: prioritizing interaction problems (especially in industrial projects); identifying potential improvements to particular systems; using the data generated for advancing knowledge in specific fields; and improving innovation potential more generally.

This leads to several goals and paths. In an ideal world, every interpretation of interactive behavior data within an engineering or research project should act like the piece of a puzzle to enhance our understanding of interactive behavior. This leads to interpretation challenges on several levels:

- Data context: most data are collected at a very detailed level (e.g. event logging, eye-tracking data) which does not efficiently support interpretation in terms of interaction elements and dynamics. For example, co-ordinating eye-tracking data with dynamic web content is expensive. Also, data collection support is typically based on higher level interaction characteristics (statics as well as dynamics).
- *Time:* sychronizing different interpretation sources is extremely timeconsuming and leads to problems in short-term (mainly industrial) user experience experiments, where interpretation and prioritisation is the primary input to ongoing projects. Furthermore, working with designers iteratively requires continous rather than discrete interpretation of user experience data. This leads to another level of interactive behavior understanding, in terms of ongoing design changes and their effects.
- Observation context: advanced environments, such as augmented reality or mobile interfaces, will require another level of improvements to be made; there is a growing number of co-operative and multi-channel systems to be studied.

- *Capturing:* capturing the interpretation in a form that can be used for different purposes is an ongoing problem that remains to be tackled; this is a prerequisite for comparing and consolidating interaction interpretations from different sources.
- *Data accuracy:* there are drawbacks regarding the precision of different data sources (e.g. eye-tracking data).
- *Dimensions of user experience:* many more observation dimensions must be taken into account to develop a more complete picture of interaction behavior; for example, aspects of trust, enjoyment or presence.
- *Knowledge context:* interpreting interaction data has much more value in the context of pre-existing interpretations.

These various challenges will be discussed in the context of experiences from a host of different projects.

Measuring upper extremity motions for modelling and diagnosis

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Movements of the human upper extremity are difficult to measure due to the specific structure of the limb, but they all involve a combination of movements of the humerus relative to a moveable base: the scapula. The scapula can translate and rotate relative to the thorax surface. Measuring such movements, however, are strongly hampered by the fact that the scapula moves underneath the skin. Consequently, the scapula cannot be followed in the traditional manner, i.e. by following the course of movements by placing markers on the skin. A second complicating factor is that a superficial proximal landmark on the humerus is difficult to define, which directly affects an accurate description of the movements of that segment.

To solve these problems, special measurement procedures have been developed involving general or individualized regression equations for determining scapulothoracic movements [1,2,3]. In addition, the proximal landmark for the humerus can be determined using either regression equations or screw-axes [4,5]. This procedure is now applied in several experiments, such as measuring the daily activities of patients with shoulder endoprostheses or wheelchair users. The method has proven successful and has been proposed by the International Shoulder Group as a standard procedure to the International Society of Biomechanics.

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The artificial vestibular system: design of a tri-axial inertial sensor system and its application in the study of human movement

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The human vestibular system senses linear and angular movements using inertial principles. It is an important sensory organ in human postural control. The availability of micro-mechanically produced inertial sensors, measuring acceleration and angular velocity, enables small tri-axial inertial sensor systems to provide movement information comparable to the human vestibular system. These sensors have high potential for application in human movement analysis.

The advantage of inertial sensing is that it enables movement to be assessed by taking measurements at a single point, without requiring a reference. The disadvantage is that several movement quantities are represented in one signal (e.g. inclination and acceleration), and these cannot generally be distinguished.

This paper reports progress in the development and application of movement sensors at the University of Twente and Roessingh Research and Development. A tri-axial accelerometer and tri-axial angular velocity sensor (i.e. a rate gyroscope) have been combined in a new inertial sensor, which measures forces acting on a single mass. Algorithms have been developed for optimal estimation of relevant movement quantities, on the basis of signals from a tri-axial inertial sensor. Applications for sensing ambulatory human movements using such sensors will be discussed.

Letting the cat out of the box: problems in the measurement and analysis of human conversational behavior

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A well known principle of Quantum Mechanics is that the act of observation may determine what you observe. Measuring human group behavior is not unlike determining the state of Schrödinger's Cat inside its box. Here, I will share my experiences in resolving the difficulties of observing cause-effect relationships in multi-modal human group communication. I will discuss how one can set up a complex, real-time measurement environment on five dollars a day, using equipment available at any music store; how one can precisely control the presentation of human conversational cues through the magic of computer mediation; and how co-variance analysis may help when everything else fails.

As an example, I will discuss our attempts to establish the function and effect of eye gaze behavior on human group conversation. In an early experiment, we found that turn-taking behavior is correlated with the amount of eye contact experienced. More recently, we evaluated whether this is because more eye gaze allowed subjects to better observe when they were being addressed. By collecting eye-tracking data during four-person conversations, we established that facegazing is indeed an excellent predictor of conversational attention.

To establish whether the communication of conversational attention is responsible for the effect of gaze on turn-taking, we performed an experiment to compare speaking behavior between two conditions: (1) in which subjects experienced gaze synchronized with conversational attention; and (2) in which subjects experienced random gaze. The amount of gaze was a covariate, but it did not vary beyond 12% between conditions. Subjects were 22% more likely to speak when gaze behavior was synchronized with conversational attention. However, covariance analysis showed that these results were due to differences in the amount of gaze perceived, rather than to gaze synchronization, with very high correlations (r = 0.62) between the amounts of gaze and subject speech.

These results imply that it is not the exact timing of eye gaze that conveys conversational attention. Instead, it seems that interlocutors sample their environment to see whether they are still receiving sufficient attention from others to estimate whether they should start or continue speaking. We believe that an energy conservation function associated with attention in human speech production and comprehension may be responsible for the above effects.

Do they know what we know? A comparative study of knowledge attribution in dogs and children

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Several attempts have been made to design non-verbal methods suitable for examining mental state attribution in children and/or animals. The non-human investigations, however, have focused mainly on primates, such that the capabilities of dogs have not yet been examined. It is hypothesized that the common evolutionary history of dogs and humans has resulted in parallel adaptation mechanisms, and that dogs may have been selected for highly developed social-cognitive abilities. Hence, we attempted to assess the understanding of both dogs and pre-verbal children regarding the connection between seeing and knowing, in the same non-verbal situation.

In the experimental trials we conducted, subjects could earn a reward via the assistance of a 'helper' person. The reward was hidden out of the subject's reach by a 'hider', who also hid a tool that was necessary for reaching the reward. The subjects witnessed these hiding events in all cases. There were four types of trials, with the 'helper' participating in the hiding of: (1) both the reward and the tool; (2) the reward only, (3) the tool only; or (4) neither of them.

Our results show that the behavior of both dogs and children was influenced by whether the 'helper' had participated in hiding the tool/reward or not. At the same time, the behavior of the dogs was found to be different from that of the human infants. Both mentalistic and non-mentalistic interpretations will be considered.

Communicative problems of orphaned children and tutors in situations of frustration

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The subjects in this study were two small groups of children: one containing 5 girls and 3 boys, and one containing 2 girls and 4 boys, all between 8-15 years old. These children, from two boarding schools for orphans in the Ukraine, were sent to the medical-sanitation Center of Tarara (Cuba) in 1999-2000. The aim of this research was to investigate how they helped each other adapt to life in a foreign country with an unfamiliar (tropical) climate where they did not understand the native language (Spanish). Only the children's tutors and one doctor could speak their native language (Ukrainian). I studied the specific characteristics of communication between the children and local inhabitants, medical personnel and interpreters. The prevailing environmental conditions created many problematical situations for the children, allowing detailed analyses of their interpretsonal transactions in various stressful situations.

Each study situation involved one child and one tutor. I observed the dialogue of the child: (a) with the tutor, and (b) with the other children. These observations allowed me to analyse the dialogue of 'atypical' children with other children. It was especially interesting to compare the construction of accusatory dialogue of orphaned children with those having parents. This was achieved by comparing the various reactions of orphaned children in problematical situations via transaction analysis (after Berne [1]). The methods of Rosenzwaige [2] were also applied, to analyse the subjects' reactions in situations of frustration or impediment (either spontaneously occurring or deliberately created).

My analyses focused on the three different types of solution reached in situations of impediment:

- the subject took personal reponsibility for resolving the situation
- the subject placed responsibility on the other person to resolve the situation
- the subject assessed the situation before deciding it had little significance and therefore did not require his/her participation, i.e. he/she avoided taking responsibility for resolving it

I applied this form of transaction analysis in combination with various other projection methods. For example, I used the modified projection method, which involved asking each subject to draw a non-existent animal. The children were then asked to describe their drawings and explain how their animal communicated with other animals. In stressful situations, the children subconsciously modelled their own method of communication: imperative, dictatorial, democratic, subordinating, etc.

I also drew diagrams representing the interations between the children and different people. In diagrams of the relations between the tutor and the children, vectors of 'crossed' transactions prevailed, e.g. "I am adult" - "I am child", "I am parent" - "I am child". Such crossed transactions represent classic transferral reactions, which create many problems for psychotherapists by interrupting the process of communication. In most cases, the tutor attempts to resolve the situation by taking the position "I am parent", because it is simpler and facilitates many automatic reactions in different educational situations (e.g. encouragement, punishment). It also saves time and energy, and removes the need to make non-trivial decisions in non-standard situations.

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Using video analysis to study the behavioral effects of butyl benzyl phthalate on threespine stickleback

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In a laboratory experiment, we investigated shoaling and bottom-dwelling behavior in the threespine stickleback, a teleost fish, after exposure to sublethal concentrations of the plasticizer, butyl benzyl phthalate (BBP), and compared our results with those from unexposed fish. The experimental fish were exposed to BBP for 26 consecutive days before experimentation began. Video recordings were used to measure their behavior. Two experiments were conducted, each consisting of 30 trials for controls and exposed fish. Each trial was videotaped for 10 min. In all trials, the fish were allowed to acclimatise before recording began.

1. Shoal choice. The test aquarium was divided into three compartments. In the two end compartments were placed one shoal of large fish and one shoal of small fish, respectively. The central compartment was defined as a neutral zone, where no choice was made. To start the experiment, one focal fish was placed in the central compartment and allowed to choose between the two shoals and the neutral zone. The amount of time it spent displaying interest in each zone was calculated from the videotape, along with the amount of time spent at the bottom of the tank. Neither exposed nor control fish preferred either of the shoals, but exposed fish spent less time in the neutral zone than in association with a shoal. Exposed fish also spent more time at the bottom compared to control fish.

2. Size-assortative shoaling, i.e. the segregation of a mixed-size shoal (containing small and large fish) into smaller groups. The test aquarium was divided into two compartments, separated by a removable partition. One shoal of mixed-size fish was placed in one compartment, after which the partition was removed and the fish could move freely. Using the videotapes, shoal composition was measured every minute for 10 min after the partition was removed. There was no difference in the ability of exposed and control fish to form size-assortative shoals. However, exposed fish tended to aggregate into fewer, larger shoals compared to control fish, which formed more, smaller shoals. The formation of smaller shoals by the control fish increased over time, but the exposed fish remained aggregated throughout.

These results may indicate that the exposed fish were more stressed than the control fish, since threespine stickleback under stress have previously been shown to aggregate more than unstressed fish. Bottom-dwelling behavior may also be a result of stress, as stressed fish tend to dive to the bottom to hide.

Impedance derived variables measured with the VU-AMS in a laboratory setting

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Although the VU-AMS has been developed for impedance recordings in everyday, real world situations, it may also be used in laboratory settings, as several studies have already shown. The present paper will discuss these studies, with a special focus on the results of a recent study in our own laboratory.

In this study, hemodynamic and autonomic responses were measured in 48 participants during an 8.5 minute memory search task, an 8.5 minute cold pressor task and three rest periods. The data collected were used to examine the relative contribution of parasympathetic and sympathetic influences to subjects with low and high cardiac output responses. Stroke volume and heart rate (derived from impedance cardiography) were used to index the cardiac output response. The pre-ejection period (PEP) was used as an indicator of beta-adrenergic sympathetic activation, and heart rate variability (HRV) as an index of vagal tone.

Based upon their cardiac response, participants were divided into high cardiac responders and low cardiac responders. Preliminary results showed no significant differences between high and low cardiac responders, though high cardiac responders tended to show stronger decreases in PEP and HRV than low cardiac responders.

In addition to the results of this study, the requirements for and limitations of the use of the VU-AMS in laboratory settings will be discussed.

EUDICO: a general tool set for annotating and exploiting multimedia signals

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At the MPI, a flexible tool set for annotating and exploiting multimedia signals containing different aspects of human or animal behavior is being developed. The nucleus is an Abstract Corpus Model (ACM), which can cope with many complex hierarchical annotation structures (including e.g. cross-references between annotations and dependencies between annotation tiers). An open XML-based interchange format has been defined to generate persistent output. The tool set covers an annotation tool that allows the user to specify an annotation structure, or select one from an existing tier set-up repository. To allow annotations in various languages, the EUDICO tool set fully supports UNICODE, and has input methods for writing systems such as Chinese, Arabic, Cyrillic, IPA and Hebrew. The annotation tool allows easy time alignment and is currently being extended to support the visualization of hierarchical encodings, such as interlinearized texts.

Various views of the data are supported, covering different types and numbers of media streams, such as video and audio channels, and an unlimited number of textual tracks. It is intended to extend this to time series data, such as those from eye-tracking and gesture-recording equipment. A flexible search tool allows the user to specify various combinations of patterns and distances between such patterns. The generated 'hit list' can then be used to return immediately to the fragments in the corpus. Combined with the browsable corpus tools, one can extend the search to whole corpora or corpus parts. In summary, we can say that the current version of EUDICO offers a number of new features, such as:

- a fully functional and flexible annotation component
- definition of a general XML-based exchange format
- several different input methods and writing systems
- mixing of input methods
- full UNICODE support
- symmetric functioning for audio and video recordings
- a search function operating on the corpus, fully supporting UNICODE

Thus, the EUDICO tool set supports a distributed corpus scenario (i.e. media and textual data can reside on different hosts in the web). It also supports working via the internet, through which only the relevant media fragments are distributed. EUDICO is written in Java, and is already being used in international projects. Easy download and launch is possible via the webstart mechanism from SUN, and a central, web-accessible bug report database should help with user interaction.

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Exploiting video-tracking data to dissect water maze learning and strategy choice in mutant mice

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Place navigation in the water maze is a popular procedure used to investigate spatial learning and cognitive abilities in rodents, including genetically modified mice. Using extra-maze cues, subjects must learn to find an escape platform that is hidden at a constant position in cloudy water. A probe trial, without the platform present, serves to verify the spatial preference learned. Hippocampal lesions and manipulations of NMDA receptor-dependent synaptic plasticity disrupt learning of this task, both in rats and in mice.

Learning this place navigation task is a multi-stage process that requires complex adaptive responses and involves multiple memory systems. Mice explore many different strategies as they gradually learn to master the task (Figure 1). Initially, they swim along the wall (thigmotaxis) and try to escape there. This is followed by random exploration of the pool surface, which allows them to hit the platform for the first time by chance. By scanning the interior of the pool more systematically, mice then rapidly increase their chance of hitting the platform. After a while, they realize that the platform is placed at a constant distance from the wall and adopt a circular swimming pattern (chaining), which dramatically shortens escape latencies. Eventually, the animals realize that the goal has a fixed position in space. Using the extra-maze cues, they begin to focus their search on successively smaller areas of the pool, until precise navigation leads them directly to the platform from any release point. Experimental manipulations can interfere with any of theses learning stages, but do not necessarily disrupt spatial navigation per se. Before drawing conclusions about spatial memory if an animal fails to reach the final stage, it is necessary to verify that learning progressed normally up to the stage where the processing of spatial information becomes limiting.

Video-tracking systems sample swim paths at a high frequency and spatial resolution. Specialized software calculates a multitude of variables that can be used to describe the animal's behavior. Given this computing power, one would expect to be able to quantify each learning stage by its own set of specific variables. However, when we ran principal component analysis (PCA) on more than 120,000 individual water maze tracks collected during the past fifteen years, we found that many of the variables designed to describe different aspects of spatial navigation were highly redundant, being correlated with very early (rather than advanced) learning stages.

This prompted us to implement an automatic software algorithm, combining newly designed and previously published variables with empirically determined thresholds, to classify swim tracks according to the predominant strategy. When applied to our database of water maze experiments, the algorithm revealed characteristic differences in strategy choice between commonly used mouse strains. Furthermore, it showed that many targeted mutations interfere with very early stages of water maze learning, which are largely independent of the processing of spatial information. In some models, by contrast, the algorithm allowed us to show that the mutation specifically affects spatial navigation during advanced learning stages.



Figure 1. Representative tracks of swim strategies.

Housing matters: implications of developmental plasticity for behavioral phenotyping

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Developmental plasticity is the extent to which organisms can differ in morphology, physiology and behavior as a result of environmental variability during development. In rodents, it is well known that maternal and other environmental influences during early ontogeny can fundamentally change brain development, and thus the physiological and behavioral responses exhibited by adults. Therefore, the behavioral response of an animal in a particular test situation depends critically on the environmental background of that animal. Because environmental conditions during ontogeny can interact with the genotype of the animal in specific ways, behavioral phenotypes may be idiosyncratic to particular genotype x environment interactions. Moreover, inappropriate sensory inputs during ontogeny can disrupt the normal functioning of the brain. Thus, environmental conditions that overtax the animals' capacity to adapt may result in behavioral profiles representing pathological artefacts.

Despite our knowledge of these relationships, environmental background is largely ignored in the behavioral phenotyping of mutant mice and, in fact, in much animal experimentation in biomedical research. As a result, current approaches to the behavioral phenotyping of mutant mice are seriously flawed in two main ways. First, without systematic variation, standardization of the environmental background of the animals involves the risk of obtaining artefacts that are idiosyncratic to the particular study [1,2]. For example, some studies report behavioral effects of gene knockouts in mice that have been reared under standard housing conditions, but not in mice exposed to a more enriched environment, or in animals handled postnatally. Thus, external validity of behavioral phenotypes might often be limited to a specific husbandry protocol, which makes it difficult to justify both the resources (money, manpower) and animals used for the research.

Second, increasing evidence indicates that current standard housing conditions for rodents impose serious constraints on the behavior and brain development of these animals, resulting in aberrant or maladaptive brain functions [3]. For example, when mice are reared in barren standard cages, they develop persistent stereotypic behaviors. Contrary to the commonly held belief that such stereotypies represent normal behavioral habits in a non-stimulating environment, recent evidence indicates that they are a symptom of cage-induced basal ganglia dysfunction. Again, this has serious implications for both the validity of the research and the wellbeing of the animals.

Providing animals with environmental conditions that meet their species-specific behavioral needs, and systematic variation of these conditions, therefore appears to be crucial for generating data that fulfil the requirements of good laboratory practice, in terms of both scientific validity and animal welfare.

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Studying collaborative navigation in a Collaborative Virtual Environment (CVE)

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A spatial 3-D collaborative virtual environment (CVE) allows multiple users distributed across a computer network to enter a shared space constructed from 3-D computer graphics [1]. Many tasks in these systems have an element of collaborative navigation, in which several users explore the virtual environment and then try to navigate to a common location to work together. One of the largest problems in this type of task is how to establish a mutual understanding of viewpoints among CVE participants [2]. To facilitate this type of work, we need to study people's behavior when they navigate collaboratively in a CVE.

In our ongoing investigation of the effects of different perspective displays on collaborative navigation [3], we utilize a variety of means to collect data. Our test paradigm involves a collaborative search and probe task, and a custom built CVE system has been developed for this task. A pair of subjects, one called a 'guider' and the other a 'driver', take part in each experimental session. The driver controls a virtual submarine within a virtual water tank and searches for a target, but without knowing which object is the target. On another computer in a different room, the guider is able to identify the target as it flashes once on the screen. The guider and the driver can communicate over an audio link.

To measure the performance of their collaborative search, a Target-Found-Time is recorded. To measure the time for the guider to guide the driver to the target, a Travel-Time is calculated. All of the reaction time data, as well as the view trajectory data, are sent in real time to a monitoring computer and logged. Here, the experimenter can see what both subjects see by switching between their views during each experimental session. The time-stamped view trajectory data are used to reconstruct subjects' actions for replay and analysis. Each experimental session is also captured on video and digitized for synchronized replay with the 3-D view transition. This facilitates the coding of communication patterns and is also helpful in identifying subjects' search strategies, along with specific problems of a particular perspective display.

To measure the subjects' geometric understanding of the virtual environment, the software periodically clears the screen and asks the subject multiple-choice questions, such as "what is your current position and orientation?". These questions are generated in real time and are graded automatically by the software.

Similarly, at the end of a session, questions about the global distribution of targets are asked and graded by the software.

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Quantifying locomotion and paw slips in a grid-actometer/ataxia-meter chamber

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A new apparatus for measuring motor performance has been developed using force transducer technology. This grid-actometer measures locomotor activity (distance travelled) and motor performance (slips from a grid) as a mouse travels around a 28 x 28 cm arena. The bottom of this arena comprises aluminium bars spaced 1 cm apart, forming a grid, with one force transducer positioned at each corner. A second surface beneath the floor, made of a honeycomb platform covered by a sheet of aluminium, is positioned 1 cm below the grid and parallel to it. Whenever a mouse slips from the grid, its paw lands on the lower floor and is detected by four more transducers, positioned at the corners of the lower floor.

All eight force sensors are serviced by a computerized data collection system, allowing on-line, real-time measurement of the forces applied at 50 Hz. In-house software permits the force data to be visualized in real-time. Data can be reviewed in their original integer form, or transformed to text for importation and processing by third party graphical or statistical programs. Initial recordings with C57BL/6 mice show that these animals slip from the grid an average of 1.6 times per metre travelled, strike the under floor with an average peak force of 13 g, and slip for an average duration of 0.25 s. Compared to an actometer comprising only the lower floor, the new grid produces changes in walking gait and significantly more excursions to the centre of the arena, thanks to a central support bar across the grid floor (Figure 1).

This measurement system may allow observations of differences between mouse strains, as well as the effects of genetic and pharmacological manipulations on locomotor activity and motor performance, with minimal experimenter handling and no explicit mouse training required. The apparatus should be useful in research areas where recovery from ataxia is used as an indication of repair to spinal damage, in studies of recovery from peripheral neuropathy, and as a general tool for phenotyping transgenic mice. Initial trials of this measurement system will be used to gather data on ethanol-treated mice.

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Figure 1. Data are shown for one C57BL/6 mouse during the 2nd and 3rd minutes of exposure to the grid-actometer chamber. Panels on the left show total (z) force against time, and panels on the right show spatial plots. Upper panels are from the grid. Lower panels are from the lower floor. The lines in the left panels show the average z force for each sample, and represent the body weight. The straight line in the top right panel represent the location of the grid support bar. The straight line in the left bottom panel at 3 g indicates the force threshold for scoring paw slips.

A cost-effective system for measuring motion activity based on video image analysis

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Measuring motion activity is the objective of many behavioral or physiological studies. To date, several systems have been devised for automating motion detection. They are based on mechanical or electronic sensors, or infrared diodes. Applications of such systems are usually restricted by the size of the objects studied, and by inflexibility: once each system has been constructed, it is difficult to adapt it for different arenas and/or organisms. Moreover, the precision of motion detection by sensor-based systems depends on the number and sensitivity of sensors, which might not be sufficient for particular types of research.

In recent years, the rapid development of computer technologies has produced relatively cheap frame grabbers, which can be used for real-time image analyses of video signals. We describe a simple activity monitoring system consisting of a CCD video camera, an Intel 486 computer, a black and white high speed frame grabber board FG 201 and customized software. Object motion is detected by comparing two subsequent video images. When the difference between images is greater than a specific noise threshold, the sample is scored as 'one' (activity); otherwise, it is scored as 'zero' (no activity).

The software allows separate analyses of four rectangular image regions and permits integration of activity over defined summation intervals. The system is highly versatile and, with suitable optics, can be used in the study of objects ranging from microorganisms to vertebrates. We have successfully applied the system to measuring locomotor activity in insects. Some results will be presented as an example of data output, and comparisons with video-tracking systems like EthoVision will be discussed.

Detecting interaction patterns in task-oriented small groups: video analysis in social sciences research

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The aim of our research is to search for communicative patterns in task-oriented small groups from videotaped interaction sequences, using the software Theme [2]. This software has been developed to detect and analyze particular types of repeated syntactical real-time patterns based on probability theory, regardless of the type of behavioral unit or time scale used.

In Study One, an instructional psychology project with a cognitive science background, we analyzed collaborative knowledge construction processes within a Problem-Based Learning (PBL) session [3,4]. In this study, we found that interaction patterns in a learning group would change in quality and quantity, both before and after a training phase. For example, participants displayed more complex interaction patterns in the final discussion, after an individual learning phase, than at the beginning. This change of pattern was comprehensively visualized by the Theme output graphics (Figure 1).

In Study Two, an interdisciplinary project involving psychologists and linguists, we analyzed observed gender interaction and gender construction processes at the workplace in same-sex and mixed-sex team conversation [1]. The focus was on power-related and support-related behavior, as well as on behavioral quality and verbal/non-verbal patterns. A turn- and sequence-based coding scheme was developed to analyze data from 20 teams, which were audio-visually taped during two or three of their routine team meetings. Using Theme, we were able to find specific interaction patterns that would not otherwise have been easy to detect.

The use of Theme in these two different contexts, and its potential for wider research within the social sciences, will be discussed.

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Figure 1. Example of an analysis of visual dominance behavior and other non-verbal dominance cues in the context of a training team meeting. Left: THEME graphics output of a t-pattern. Right: Multimedia behavior coder and categories.