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Head movement analysis during conversation: relations to verbal behavior and psychophysiological data

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Head movement behavior during conversation is recorded and analyzed by using a direct methodology that allows tracking of head positions over time with high accuracy [1]. This procedure results in a classification of head movement patterns according to their similarity with defined phenomenal criteria (e.g. head rotations to partner or head rising). As part of a nonverbal communication system head movements are usually embedded in a social context which influences their quantitative and qualitative features. Therefore, investigations concerning head movement behavior have to take into consideration various contextual variables. From a methodological viewpoint, a software package for recording, extracting, and analyzing head movement patterns should offer links to other sets of variables which are believed to yield important information for a functional interpretation of behavioral patterns.

For the realization of this claim, two types of integration of contextual variables into the data of head movement patterns are proposed: 1. The segmentation of verbal interaction (on the levels of speech acts, utterances, pauses between speech acts and utterances, etc.) is related to head movement behavior (and vice versa) (Module "VarRelative") and 2. localized head movement patterns are related to concomitant psychophysiological variables (and vice versa) (Module "HMP/VVC"). The basis of these connecting software modules is the time that is recorded for each variable (channel) as common reference. Thereupon, lists of time borders of relevant events are brought together and evaluated for the respective key variable. This means that head movement patterns are located e.g. in turns or pauses of verbal interaction (occurrence time and category of head movement pattern) or that concomitant physiological changes (e.g. vessel volume changes measured with photoelectric finger pulse volume; see [2]) are indicated during the appearance of classified head movement patterns.

For each module empirical examples are given to show the functional value of these linking procedures. For the connection between head movement patterns and the segmentation of verbal interaction, data are presented which show that the temporal occurrence of head movements differ in communicative situations of pauses depending on their pause categorization (i.e. with/without succeeding change of speaking turn). Concerning the inclusion of physiological variables, it could be shown that strong head rotations are correlated with physiological changes that are usually indicative either for stress or orienting responses. Stress responses are found in movement patterns which include only rotations away from the partner for more than 40 degrees, whereas orienting responses are found in all other head rotations of more than 40 degrees in both rotational directions (towards and away from the partner). During head rotations of more than 40 degrees towards the partners, there was no reaction in vessel volume changes.

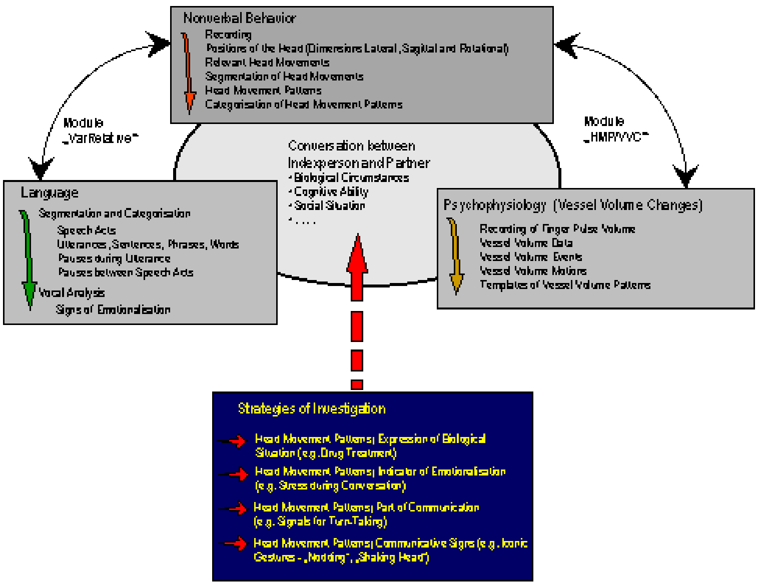

Figure 1. *Integration of software-modules "VarRelative" for the relation between verbal interaction and head movement patterns (HMP) and "HMP/VVC" for the relation between head movement patterns and vessel volume changes (VVC).*

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Measuring team situation awareness of reactor operators during normal operation in the research reactor at Risø: a technical pilot study

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A loss of sufficient Situation Awareness (SA) may lead to human errors, possibly resulting in accidents. SA is often conceptually described in terms of operators' correct *perception* and *understanding* of a situation. This conception of *individual* SA has been summarised by saying that an operator should be able to (1) recognise the relevant elements in a situation, (2) understand how these elements are interacting and, on the basis of this understanding, (3) predict the system status into the immediate future (Endsley, 1993). A high degree (1-3) of SA is usually related to good performance.

System information is often presented visually. Therefore it makes good sense to base the SA measure on operators' accessing of visually presented information (Hauland, 1996). Operators communicate through the process interface, i.e. they may infer what the other operator is aware of by watching key parameters in the process interface. Such Areas of Interest (AOI) may be substitutes for questions concerning each process parameter. It should be possible to define AOI's relevant to *team* SA and measure the line of gaze towards these AOIs by using eye movement tracking. Operators will also communicate verbally with each other. This communication may reveal how well the operators understand the developing situation. In studies conducted by Risø and the Danish Maritime Institute (Andersen *et al.*, 1996), a significant correlation was found between crews' communication related to future system states and performance in simulated (ship manoeuvring) tasks.

These initial ideas for a continuous measure of (team) SA were tried out in a small pilot study conducted in the reactor control room at Risø. The reactor control room is a real operative environment where the operators have to co-ordinate their tasks to achieve the desired level of safety and efficiency. The two main objectives of this technical pilot study was to (1) gain hands-on experience with the iView eye tracking system (SensoMotoric Instruments) and The Observer Video-Pro (Noldus Information Technology), as well as the specific set-up of this equipment in the field, and (2) to get insights related to the implementation of these suggested measures in analyses of team SA. In specific we looked at the feasibility of: Using head tracking in an operative environment, (accuracy/magnetic interference), defining *planes* and *objects* for automatic analyses of EMT and defining procedures for measuring team situation awareness.

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Locomotor behaviour in normal and monoarthritic rats assessed by a new computer-assisted method

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Aim of investigation

In order to model chronic pain states in humans, several models with long-lasting inflammatory or neurogenic pain in the rat have been developed. Injection of lambda-carrageenan into an ankle joint is commonly used as an inflammatory pain model of arthritis. It results in limping and a reluctance to place weight on the injected limb, which is usually measured by manual scoring of the guarding behaviour [2]. More objective ways of assessing this behaviour, i.e. by measuring the paw-elevation time on a rotating cylinder [6] or the weight-bearing of each hind limb [5] have been described. The aim of the present study was to investigate whether a new computer assisted method of analysing locomotor behaviour (named "CatWalk"), previously used to investigate neurological outcome after spinal cord injury, could provide more detailed quantitative information.

Material and methods

A saline solution of 300 μg lambda-carrageenan (Cg) was injected under anaesthesia into the left tibio-tarsal joint in male Wistar rats. Control animals were injected with saline. Cg produces a localised inflammation with peak guarding behaviour 4-6 hours after injection. Before and up to one week after injection of Cg, the rats were made to traverse a corridor over a sheet of glass in which light shone via one of the long edges. Light rays are completely reflected internally except when a paw is placed on the glass surface, resulting in a sharp image of areas of contact at a given moment [1]. We used an automated version [4] of the original method [3], and paw prints were videotaped from underneath for parameters related to paw usage to be analysed (Figure 1).

Results and conclusion

Rats injected with carrageenan spend significantly longer time to cross the corridor at peak effect, compared to control animals. They perform fewer steps by the injected paw, but compensate by increasing the number of steps and decreasing the stride length of the front paws. The foot print (both length and width) of the injected paw is significantly decreased, while the opposite is true for the contralateral hind paw. In addition, pressure exerted by the injected paw, measured as intensity of the paw image during walking, is lower than for the contralateral side, and also lower than hind paw pressure of control rats. In conclusion, this computer-assisted method of assessing inflammatory pain provides objective, detailed quantitative information on the changes in locomotor behaviour caused by the experimental arthritis.

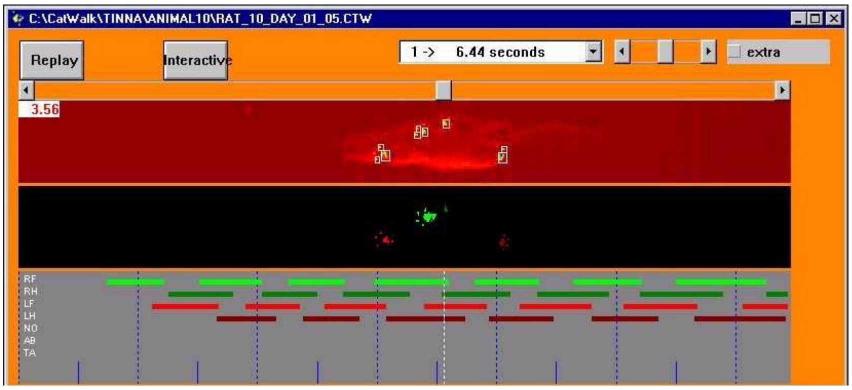

Figure 1. A rat walking, from right to left, through the CatWalk corridor. Top panel: Snapshot of the rat in the corridor where false colours represent the different intensities of the signal (red=low, blue=high). Middle panel: Track of footprints from one passage (right paws in green, left paws in red; front paws light, hind paws dark colour). Bottom panel: The time of floor-contact by the different paws. Blue dotted lines indicate seconds, and the white dotted line the snapshot in the top panel

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Characterization of early somatic and neurobehavioral development in two inbred mouse strains

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The present study investigated early somatic and neurobehavioral development in two inbred strains of mice: C57BL/6 and 129sv. Though these strains are most often used for behavioral studies in genetically modified mice and are known to differ in their behavior performance and learning in adulthood, much less is known about how these differences arise during development. In order to gain more insight into this question we used a battery of ontogenetic tests aimed to characterize maturation of behavior in these two inbred strains of mice. This battery covers development of a broad set of phenotypic traits from birth to weaning [1]. Application of this test battery to the analysis of comparative dynamics of behavioral development in the two strains demonstrated that C57BL/6 and 129sv mice are characterized by different speed of maturation of several important functional systems and learning abilities. Importantly, no general tendency can describe these differences since some of the functions mature earlier in C57BL/6 and some in 129sv mice. The results of factor analysis of the structure of behavior and application of classification methods to the behavioral phenotypes of both strains will be presented.

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Quantitative assessment of low back load exposure outside the laboratory

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In modern western society a high level of job specialization has brought about the still increasing socio-economical problem of work-related disorders, e.g. low back complaints. It has been reported in several studies that in a large number of cases of back complaints the causal mechanisms are directly related to forces occurring in the vertebral colon. This paper introduces an instrument for ambulatory monitoring of the moments and forces occurring in the low back in relation to internal and external conditions, called AMBER. The system monitors posture and movement of the trunk as well as surface EMG signals of some trunk muscles and uses this information to estimate spinal moments, allowing for future estimating of spinal forces. The method links all data to synchronized video images to assist interpretation and to allow for a link to work organization analysis. The spinal extension moment is estimated in two parts. The first part, representing the contribution of trunk and head is estimated using posture and movement of the trunk [1,2]. The second part, representing the contribution of arm movement and load handling, is estimated using the activation level of the erector truncii muscles, assessed with surface EMG, in combination with posture and movement of the trunk. For this a self-learning calibration procedure is developed relating the surface EMG signals to the moment contribution under different conditions of posture, movement and known external loads [3].

Figure 1 shows the physical set-up (a, b) and recording hardware (c). Trunk movement and orientation are estimated from the signals recorded from a 6-channel movement sensor. This sensor contains three mutually orthogonal mounted piezo-resistive accelerometers and three mutually orthogonal mounted solid state gyroscopes. The sensor module weighs a few grams and measures 5.5 by 3.5 by 3.5 cm. EMG is recorded from several muscles.

Figure 1. *Physical setup of an AMBER monitoring session. A. Inertial sensors are placed on the skin of the back above vertebras L3 and T10; surface EMG sensors are placed on the skin above the erector truncii at levels L3 and T10, 3 cm left and right of the middle axis. The data acquisition module is placed at the waist (right side). B. A railway employee with an AMBER system mounted performing his job unhindered. C. The AMBER recording hardware.*

For work place analysis the following information is generated by the AMBER method. First trajectories and descriptive statistics are generated for the trunk kinematics. These include absolute 3D trunk orientation, angular acceleration, angular velocity and linear acceleration. Also surface EMG trajectories and descriptive statistics are generated. Then trajectories and descriptives for the spinal extension moments around a rotation point thought in the intervertebral disk at spinal level L5/S1 are estimated. For situations of symmetrical loading the spinal compression force is also estimated following a single muscle equivalent model. For assisting valid interpretation synchronized video images are displayed with the various data representations (see Figure 2).

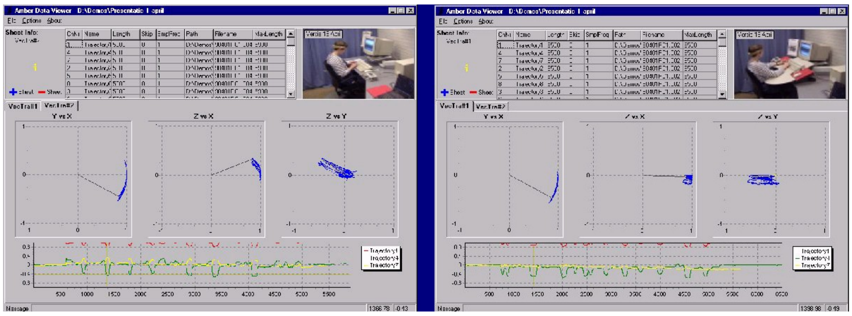

Figure 2*. Visualization of back load exposure data synchronized with video footage. Head movement relative to the trunk at standard computer work place (a) and an adapted computer work place for whiplash patients (b) are shown. In both cases the three upper graphs show the trajectories of 'point of the nose' in a top view, a side view and a frontal view. The lower graph shows the time course of three components of the 3D 'nose' vector in the trunk coordinate system*

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Robustness issues in automated statistical analysis of behavior

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It is common knowledge that experimental data are prone to have occasional gross errors. Such errors may have substantial effects on the result of the analysis. A large body of statistical literature exists on methods that are not only less sensitive to such errors, but which are also close to being optimal - resistant and robust methods. For example, instead of the non-robust mean, a trimmed mean or the biweight measure may be used; instead of the moving average, a robust LOWESS procedure may be used. Careful data analysis may allow researchers to identify the gross errors and thus take out much of their bite. This may partially explain why such methods have traditionally not been used in behavior analysis. The more recent ability to use automated data gathering systems, with very large data sets being automatically generated and summarized, inhibits the careful manual manipulation and inspection of the initial data, and increases the importance of the robust approaches.

In this talk I shall review the concepts of resistance and robustness, and give a few examples of simple robust statistics that are alternatives to the familiar summaries of center and spread. I shall demonstrate their importance on examples from rat and mouse exploratory behavior. I shall then present a robust smoothing procedure of the digitized path of a rat, and demonstrate the importance of using such robust procedures for that purpose.

Digital representation and experimental simulation of nonverbal behavior

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Nonverbal behavior research has significantly advanced methodological knowledge in the area of behavior registration and measurement during the last two decades. Based on standard video technology a series of high-resolution transcription procedures and coding strategies have been developed that provide detailed and accurate protocols for both body movement and facial behavior. Moreover, tools for automatic behavior registration have been introduced to the field recently, using sophisticated measurement devices such as data suits, infrared and ultrasonic sensors, and video based pattern recognition techniques for data acquisition. Automatic measurement devices provide fast access to high-resolution data, which can be easily re-transformed into moving objects by any standard 3D-animation tool. However, they mostly require the application of specific sensors or markers and thus may negatively influence the ecological validity of the observations made. Video-based coding procedures on the other hand are time consuming or lack the descriptive accuracy required for any computer animation. As most automatic motion capture devices share a common geometry with the professional 3D-animation tools, it may seem appropriate to refer to their generic 3D geometry when constructing a compatible transcription language for video based analysis. However, a closer examination revealed that describing an object’s spatial attributes in terms of translations and rotations along the axes of a three-dimensional coordinate system is very uncommon and hard to apprehend for the human observer. Thus it is not only difficult for the investigator to interpret motion capture data, it is also nearly impossible to edit such behavior records in order to experimentally control particular nonverbal patterns in effect studies. It became apparent that the implicit geometry of existing high resolution transcription systems – such as the Bernese System for Time Series Notation of Movement Behavior (BTSN; [2]) – could best be understood in terms of projection angles of an object's local axes rather then in terms of generic rotation angles. Based on this insight, algorithms could be formulated allowing for the translation of phenotypical projection codes (BTSN) into generic rotation angles that can be used as an input for professional 3D-animation platforms and vice versa. This conversion utility is at the core of a hardware and software platform, which we developed for the interactive coding, editing and experimental computer simulation of movement behavior [1]. A screenshot of the editing tool is shown in Figure 1. Basic features of the new methodology are described and implications for descriptive analysis and experimental computer simulation of nonverbal behavior are discussed.

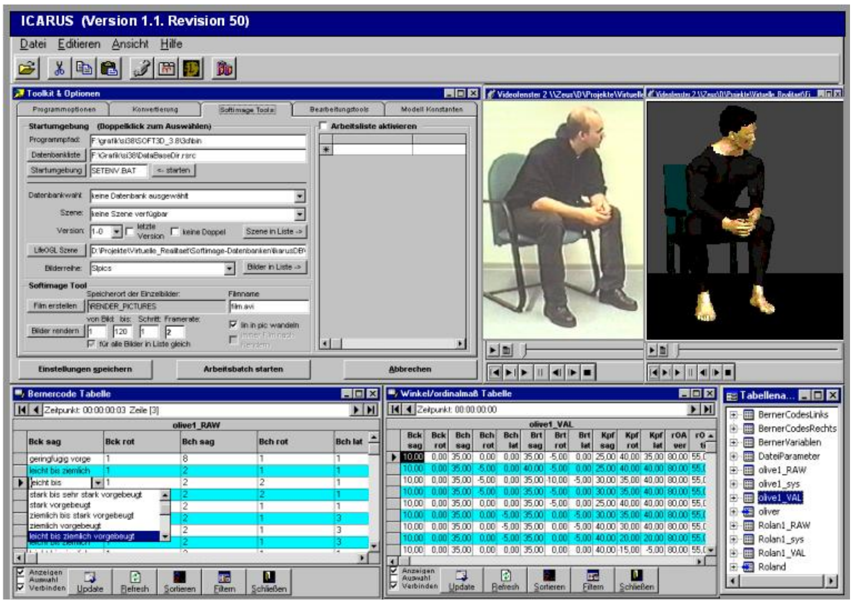

Figure 1. *Screen representation of the interactive coding and rendering software.*

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Using a classification of activity bouts to simplify observation in meat-type chickens

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Introduction

A detailed focal sampling study of general activity in chickens is helpful to establish the organisation of the different activities performed during the time the chickens spend awake. However, such a recording is very time consuming and difficult to practice in commercial conditions where chickens can not be followed with one's eyes for a long time. The aim of the study was to find out the way several behavioural patterns are organised and to elaborate a simplified method of observation.

Methods

Twenty five broiler chickens were videotaped and observed for one hour per day at 1, 2, 3 and 5 weeks of age using The Observer 3.0. All behaviour patterns expressed when birds were awake were recorded as "activity bouts" (i.e. from the moment a bird stood up until it remained idle for at least 30 s). The 708 activity bouts recorded were analysed by Principal Component Analysis followed by an automatic procedure of partitioning, defining several classes of bouts.

Results

1. Four different classes of activity bouts were obtained by the classification (Figure 1) and differed highly in the mean duration of the bout: SHORT (78 s), M-EATING (M = Medium, 252 s), M-DRINKING (134 s) and LONG (559 s) classes. The bouts of the 4 classes also differed in their occurrence (46%, 16%, 13% and 25% of the bouts, respectively) and in their level of activity (duration of walking per bout: 4 s, 15 s, 14 s, 66 s, respectively). The SHORT class contained short bouts with low activity and mobility, but many preening periods. The M-EATING and M-DRINKING classes contained bouts in which eating or drinking activities, respectively, contributed to the major part of the activity. The LONG class contained long-lasting bouts (almost 10

min), with high levels of activity, especially locomotion and exploration.
2. Age did not significantly affect the SHORT class. There was a large decrease in the occurrence and in the duration of the LONG class bouts throughout the life-span, whereas M-EATING and M-DRINKING classes bouts became more numerous as chicks grew up and represented the major part of the activity at the end of the growing period.
3. A simplified method using bout duration and the first 2 behavioural patterns occurring within the 3 first minutes allowed to predict the class into which each bout would fall with 76.8% accuracy.

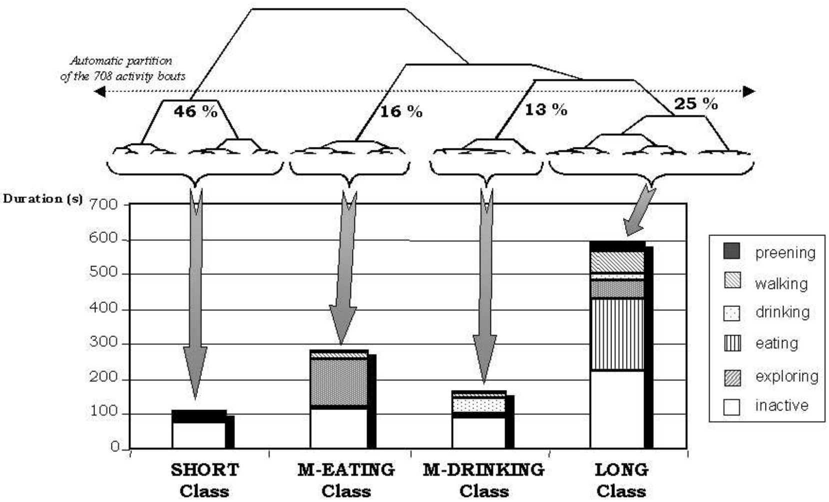

Figure 1. *Mean duration (s) of the behavioral patterns and total bout duration in each class.*

Conclusions

1. The activity bouts could be categorised into four classes, which differ highly in occurrence, duration and composition.
2. The LONG class contained bouts with high levels of locomotion and exploration. Their occurrence could be used as an indicator of general activity throughout the lifespan.

3. The relationship between the beginning of the activity bout and the entire activity suggests that the type of activity (composition and duration) performed by a chick is planned as soon as it stands up.
4. These results could be used in order to simplify the observation, and to decrease the time spent quantifying the behaviour of chickens.

Reaction time responding in rats

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The use of reaction time as a measure of information processing has a long-standing tradition in human experimental psychology. A great advantage of this parameter is that it directly reflects the assumed underlying psychological/ neuronal processes. Although the use of reaction time paradigms has been very powerful in studying human information processing, this parameter has not received much attention in animal research. It is assumed that valid reaction time paradigms in rodents can be valuable tools in studying the neurobiological mechanisms underlying elementary aspects of information processing.

Data will be presented in which the performance of rats is analyzed in a simple and choice reaction time task that was performed in an operant conditioning chamber. First, rats are pre-trained to push a hinged panel located in front of a food magazine to obtain a food reward. Then the rats first have to press the hinged panel and then a lever to obtain the reward. After acquiring this, the rats had to poke their nose for a variable period (i.e., hold duration) in the magazine and wait for a tone. The final stage of this task consisted of the following sequence. A trial was initiated by a rat by poking its nose into the food magazine. The rat had to hold it's nose in the magazine until a tone was switched on, which was presented after a variable hold duration (ranging from 0.5-1.5 s). If a rat withdrew its nose form the magazine before the tone was switched on, the trial was re-started and a premature response was scored. Responses after the tone were regarded as reaction responses to the stimulus, provided that the response was above 100 ms and faster than 1500 ms. Training in this task takes about 3-4 weeks. In the simple reaction time task only a high tone was presented and in the choice reaction time task either a high or a low tone was presented. If a low tone was presented the rat had to respond to the right lever and if a high tone was presented the rat had to respond to the other lever.

Based on mean reaction times and comparison between task conditions, it appeared that only the choice reaction time could validly be assessed in rats.

The validity of this reaction time paradigm was also demonstrated by other characteristics of the behavioral performance of animals in this task. Thus, the evaluation of the variation of reaction times of (individual) animals provides evidence that these correspond with observations in human studies. Further validation of this reaction time paradigm was obtained by pharmacological and electrophysiological studies.

It is concluded that reaction times can be assessed in a Skinner box in rats but that there are several constraints. Further, a detailed behavioral analysis is required to assure that the responses reflect true reaction times. Finally, it is claimed that this type of paradigm provides a new approach in studying neurobiological mechanisms underlying information processing in rodents.

Developing standardized behavioral tests for mice

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In many strains of genetically altered mice, the most salient changes are those in behavior. We have been developing test batteries for behavioral assays of these transgenic mice. This presentation reviews our test batteries for studying species-typical behavior, learning and memory and behavioral development in mice. Before such tests are conducted, however, background questions about the animals, confounding variables, and experimental design must be considered [1]. A test battery approach allows for the analysis of different types of learning and memory impairments and allows for the analysis of the effects of emotionality and other non-cognitive factors on learning and memory. Data will be presented on (1) the use of the Hebb-Williams maze to study learning and memory in mice and (2) on the analysis of the influence of anxiety and locomotion on object recognition memory, passive avoidance learning and spatial learning tasks. Developmental test batteries can be used for studying the effects of genetic modification on the age at which developmental milestones are reached and the effects of drugs on development. Examples will be given from our studies on the efects of ritalin on development in mice.

Research in this presentation was supported by NSERC of Canada.

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Procedural effects in measuring the expression of fear in rats of the Syracuse strains

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In 1899 Darwin pioneered the effort to describe some of the complex interactions between genetic, reflexive, physiological and experiential factors that control individual differences in emotions and their behavioral manifestations. In recent years some of these interactions have been clarified by means of selective breeding experiments with rats and mice, and, at the molecular level, by means of knockout and other physiological and genetic techniques. However, even with our most sophisticated genetic techniques, explication of the genetic and other factors that influence emotion depends on how we measure the expression of emotion in the behavior of our nonverbal animal models.

In this paper we present experiments, which use the open-field and conditioned-suppression (CER) paradigms, to study innate and conditioned fear, respectively. We compare the selectively bred Syracuse High- and Low-Avoidance (SHA/Bru and SLA/Bru) strains of rats, which differ genetically in their expression of fear and anxiety. The experiments demonstrate how our measurement techniques determine whether or not genetic differences are detected. Specifically, the traditional open-field procedure was used to establish the unlearned genetic difference in emotional defecation between animals of the SHA/Bru and SLA/Bru strains, without the artifact of differences in level of locomotor or other activity. However, the parameters of the CER paradigm determined whether or not those genetic differences are expressed in conditioned fear. We also show that differences in the morphology and physiology of the hypothalamic pituitary-adrenocortical (HPA) system are closely linked to the phenotypic difference in avoidance learning and the associated differences in innate and conditioned fear. These morphological and physiological differences may mediate those differences in the expression of fear. Corticotropic-releasing hormone (CRH) is known to activate the HPA axis and to have independent anxiogenic behavioral effects, e.g., enhancement of conditioned suppression. We also show that whether or not manipulation of CRH results in the predicted behavioral differences in emotional expression in the Syracuse animals is a function of the parameters of the CER procedure.

These experiments indicate that the genetic difference in expression of conditioned fear in response to exogenous CRH depends on the presence of behaviorally measurable conditioned fear, which, in turn, depends on the parameters of the conditioning paradigm.

The implications of these findings for further research on emotion are explored, and ways of improving the reliability, validity and sensitivity of some of the established techniques for measuring emotion are suggested.

Measuring animal temperament

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Many studies indicated that temperament and personality represent important categories of animal behavior. However, the description of animal individuality, encompassing broad and stable behavioral traits that generalize across time and situations, involves several difficulties. For example, there is often confusion between domain-specificity of behavior and generality and cross-situational consistency of individual differences. Adaptation dictates that behavior in general must be domain-specific, which would apparently make generalized individual differences impossible. However, applying concepts of behavioral consistency and generalizability from the human personality field can easily resolve this issue. "Consistency" is a correlational construct, meaning that the behavioral variable shows a high correlation over time or across situations even if its overall level changes. That is, an individual which is more fearful than others in one situation is likely to be so in another situation, even though the behavior overall differs in these situations.

When individuals, situations, response classes and times represent the basic conceptual units for the study of animal temperament, it becomes possible to define various kinds of behavioral consistency. For example, it can be possible to distinguish consistency of response profiles across situations (e.g. an individual may be high on fearfulness but low on dominance consistently in various situations) or consistency of time effects across situations (e.g. an individual may become more fearful with age consistently in various situations). A modular, hierarchical model of animal temperament, involving, at various levels, both broad and more situation-specific behavioral traits, is outlined.

Evidence will be presented that individual differences in many behavioral domains are consistent over time and across situations. They can be organized into a small number of dimensions, which represent a form of a hierarchical organization. These dimensions could be meaningfully interpreted in motivational, affective and cognitive terms, and are remarkably similar across species, both in the overt structure, function and underlying physiological mechanisms. Various approaches for measuring animal temperament will also be discussed, involving both objective ethological measurement, batteries of behavioral tests, as well as subjective rating assessment. The possibility that human observers may project the Big Five personality factors onto animal subjects will be also considered. Such possibility would in part explain why studies of animal personality based on observers' ratings usually reveal behavioral dimensions very similar to the Big Five personality factors found in humans.

Monitoring behavior of individuals in crowded scenes

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Much research in the area of automated monitoring is focused on tracking a small number of individuals, often in well-controlled environments. We present a method for tracking large numbers of objects simultaneously in open and crowded scenes over extended periods. Our application is monitoring the behavior of broiler chickens for assessing health and welfare. The application offers several challenges:

- Tracking a large number of objects simultaneously
- Poor discriminating boundaries between objects
- Poor contrast to an evolving background
- Variable short term behavior
- Open scenes that allow the number of objects to change continuously

In order solve these problems our approach employs methods for modeling both the shape and gray level variations of the objects in the scene combined in a hybrid Active Shape Model (ASM)/Condition Density Propagation (Condensation) framework [1,2].

Modeling the expected shape of individuals in an ASM, permits the identification of individuals in a crowd rather than only identifying groups. The Condensation framework provides a robust and efficient method of tracking the individuals over a cluttered and evolving background. This approach also overcomes the problem of the variable short term behavior of the birds, as it removes the need for a good *a priori* model of behavior required by a Kalman filter based solution. Other methods for identifying individuals such as that of Sergeant [4] do not attempt to model the shape or motion of the objects but solve a correspondence problem between frames. This becomes difficult to solve with the condition of an open scene, as the number of birds may not be consistent between frames.

The problems of poor contrast between the birds and the background and poor discriminating boundaries are resolved by using a measure of fuzz affinity [3] to test the homogeneity of regions in the image. The robustness of the tracker is further improved by modeling the gray level intensities of individuals in the scene, which is automatically updated to adapt to changes in lighting intensity.

The system has currently been evaluated over a 5-minute period during which 93 individuals entered the scene and up to 30 birds were required to be tracked simultaneously. Current results demonstrate over 90% of the birds can be tracked successfully over this period (Figure 1). The performance achieved is certainly high enough for analyzing the behavior of the birds and overcomes many of the problems associated with human observation over extended periods including intra- and inter-observer errors.

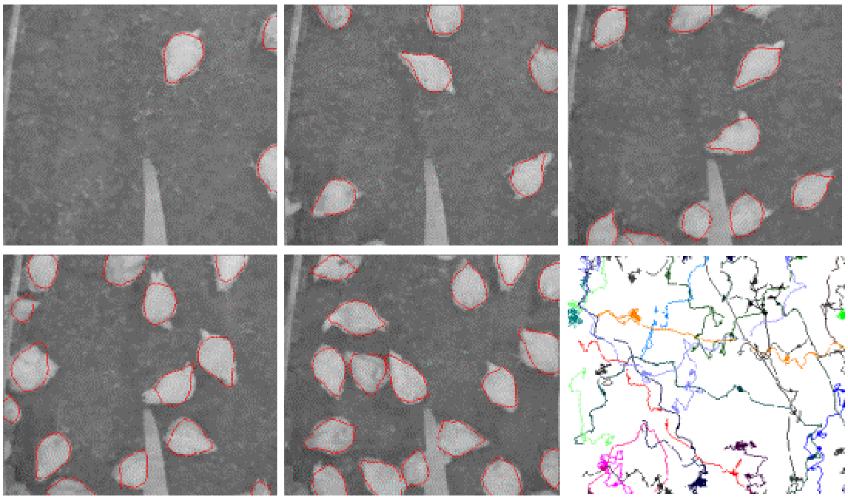

Figure 1. *Results for five video frames and trajectories produced.*

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Accelerometry-based activity monitoring: objective measurement of postures and motions

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In 1992 the research line 'Ambulatory monitoring of mobility-related activities' started at the department of Rehabilitation [6]. This research line is aimed at the development, validation and application of an 'Activity Monitor' (AM). The AM is a portable instrument, based on ambulatory accelerometry and aimed at long-term (several days) measurement of the quantity, quality and physical strain of postures and motions (e.g. standing, sitting, lying, walking, cycling etc.) during normal daily life. The AM consists of four body-mounted uni-axial piezo-resistive accelerometers, a portable data recorder and analysis software.

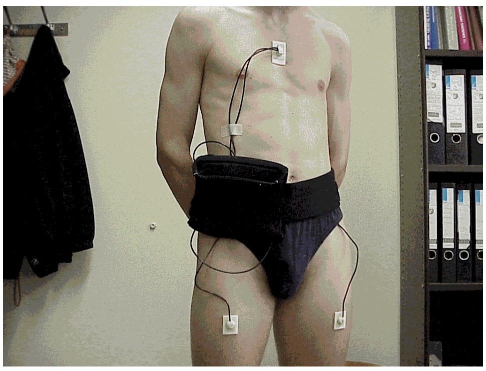

***Figure 1.** Activity Monitor configuration*

The first phase was especially aimed at the *quantity* aspect (i.e. posture/motion detection: which posture/motion is performed when, how often and for how long), and was characterised by initial development of activity detection (theoretical background [5], requirements to the instrument, technical issues [6]). Then a phase of validation started: the reliability/validity of the AM was examined in several populations (able-bodied persons, amputees, back pain patients, heart failure patients), using analysed videotape recordings as reference [1,2,3]. High agreement scores showed that the AM was a valid instrument to measure postures/motions. Recently, the possibilities of the AM were extended for research aimed at ambulatory measurement of arm-hand use. Other studies have shown that the AM is also sufficiently sensitive for measuring differences in daily functioning between groups (heart failure patients and patients with meningomyelocele versus healthy controls, and differences due to benzodiazepines [7]. Currently, the AM is used in three randomised clinical trials on treatment effects in heart failure, post-polio and migraine patients [8].

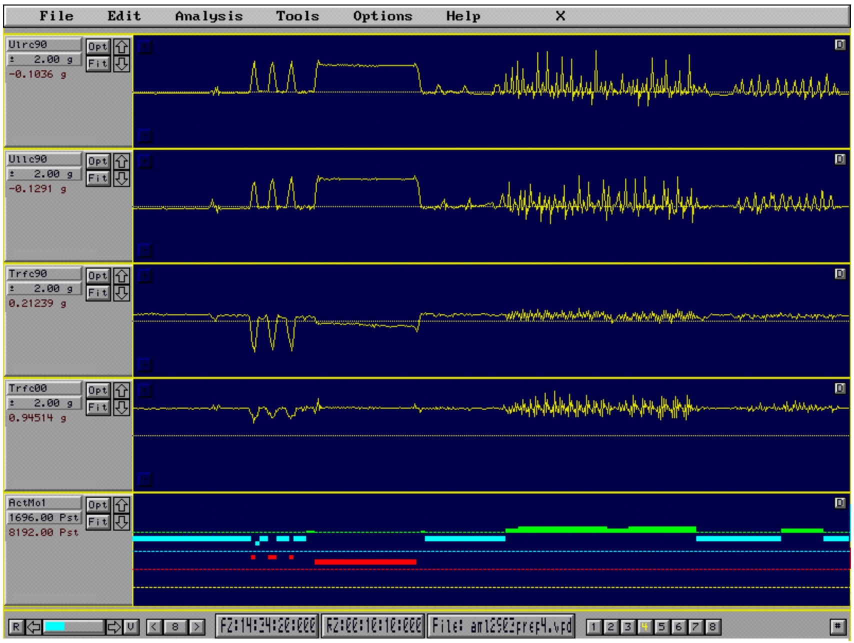

Figure 2. *Four measured acceleration signals and the automatic (1-second resolution) activity detection (red: sitting; blue: standing; green: walking).*

Quality of postures/motions is related to 'how activities are performed', movement pattern and movement co-ordination, especially in walking and the sit-to-stand transition. Gait quality in the elderly – using the acceleration signals of the AM as input – was studied, as well as walking of amputees. Currently a project is performed about the evaluative and prognostic value of ambulatory accelerometry during the sit-to-stand transition in stroke patients.

Physical strain during daily life is another concept to be measured with the AM. Physical strain can be determined by heart rate and motility, a derivative of the acceleration signals. Research performed so far was aimed at optimisation of the way of measurement of physical strain. Studies included the relationships between heart rate, motility and oxygen uptake in healthy subjects [4] and amputees during walking. Currently, measurements are performed to study these relationships during other activities than walking. Ambulatory monitoring of postures and motions appears to be a promising technique for prognosis and therapy evaluation. Not only for applied and clinical research in rehabilitation medicine and psychiatry, but also for other disciplines such as physiotherapy, behavioural sciences, psychophysiology and ergonomics.

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Model-based tracking of *C. elegans* for behavioural characterisation

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Caenorhabditis elegans (*C. elegans)* is a small (1.2 mm) soil-dwelling nematode worm that has been used extensively as a model organism. The anatomy and complete cell lineage has been well-characterised [1]. More recently the whole genome has been sequenced making *C. elegans* a versatile and tractable model for a number of biological systems. In particular it has been used to define genes involved in growth, development and ageing [2]. Mutations that affect these phenotypes are often associated with characteristic behavioural patterns that can be difficult to quantify. The development of software that can track and analyse motion efficiently would greatly improve phenotypic selection and help define as yet uncharacterised genes that have an impact on growth and behaviour.

Figure 1. *C. elegans in motion*

The worm is of a long thin semi-transparent appearance. It can adopt a wide variety of shapes and displays different types of motion for behaviours such as feeding and foraging. Figure 1 shows two worms in motion. To analyse the worms a deformable template model was used. Deformable models [3] describe a shape in terms of a mean and a set of modes of variation. These are calculated from a set of marked-up images of the object by the use of well-founded statistical techniques such as principal component analysis. Figure 2 shows a marked-up worm image. Deformable models have been widely applied by computer vision researchers for modelling a wide range of static objects [4]. They have also been used to provide quantifiable growth measurements for nematode worms [5].

Figure 2. *Boundary land-marked worm.*

Thirty worm images were selected from a four and a half-hour video sequence to form a training set. A deformable model of the worm was generated from the worm outlines in the training set images. The generated model was used to locate and track worms in 40 sequential non- training images. A 3D visualisation of a located worm can be seen in Figure 3.

***Figure 3**. 3D visualisation of located worm*

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Distance teaching of observational techniques of infant behavior

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This paper tries to verify the possibility of teaching observational techniques of behavior via the Internet. In the framework of the project “Funzione Gamma”, a CD-ROM was handed to 10 students of the Psychology Faculty of the University "La Sapienza" of Rome. It contained software for behavioral observation and two digital video files of five minutes each. The software was a specially adapted edition of The Observer (Noldus Information Technology), named “Student Edition for Funzione Gamma”. The two video files refer to a classroom situation. The students were able to communicate with experts in observational techniques via a Web site of the Psychology Faculty and ask them for advice about the working procedures of the software. The task given to the students was: make six observations in a fixed sequence and send, for each of them, the observational data (ODF file) to the Web site. Through the comparison of this coded data it was possible to measure inter-observer reliability. The comparison was made between the students’ observations and the experts’ observations.

From the first results we can see that the students keep getting better results in their observations as for the observers' matching (measured by Cohen's Kappa index). It follows that one can propose such a teaching method for distance learning of observational techniques.

Updates to the Graze program: movement analysis and compatibility with "The Observer"

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"Graze" is a program for analysing grazing behaviour data files collected by the "IGER Behaviour Recorder" [2]. The program (presented at *Measuring Behavior '98* [3]) has recently been improved to allow lying, standing and walking behaviour to be analysed. A tilt switch is attached to the animal's leg and this produces an active signal when the animal walks or lies down [1]. The Behaviour Recorder samples this digital signal at 20 Hz and stores the data in parallel with the jaw movement data on a compact flash memory card. The latest version of Graze determines the pattern of lying/standing bouts over the day and the occurrence of steps. Lying is recorded when at least 95% of the samples are active for at least 8 seconds. 3 parameters are used to define a step; minimum step length, noise tolerance and interval. An interval must occur between steps and noise tolerance is the maximum number of inactive samples that can occur during a step. The maximum length of a step is 8 seconds. Graze displays the raw digital samples from the movement sensor and then displays the results after the data have been analysed. Periods of lying are shown as a blue bar and steps are shown as red blocks, both are shown below the jaw signal interpretation. Graze stores the times of transitions between lying and standing and vice versa and it stores the start and end times of individual steps (the time at which a step 'event' occurs is taken as the start time of the step).

Graze has recently been improved to include the option to export the analysis results as an ODF file compatible with The Observer (Noldus Information Technology). Jaw movements, which consist of prehension bites, mastications and rumination chews, are classified as events, as are steps. The behaviours associated with the jaw movement analysis (eating, ruminating and idling) as well as body position (standing or lying) are classified as states.

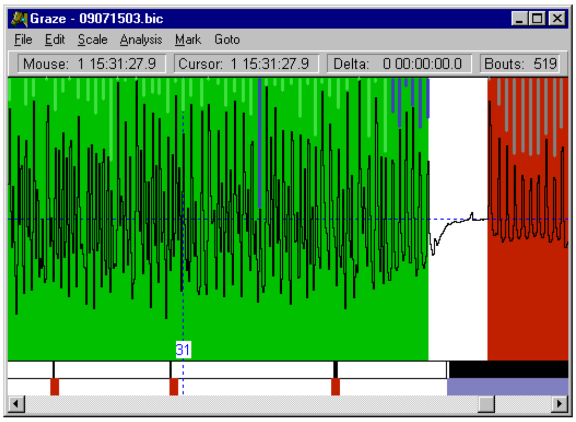

Figure 1. *A typical Graze screen showing eating (highlighted block on left), ruminating (highlighted block on right), walking steps (bottom left) and lying down (bottom right). Eating jaw movements are divided into prehension bites and mastications (highlighted by vertical lines).*

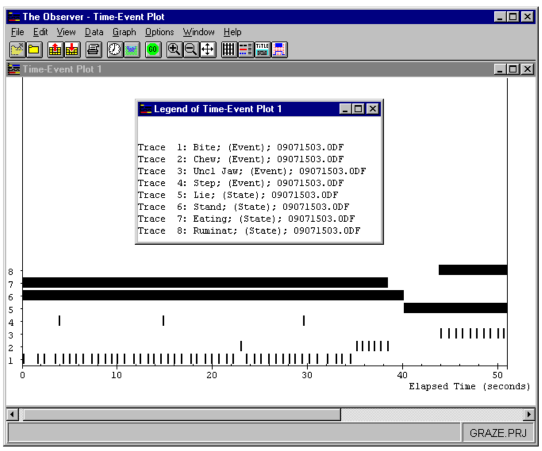

Figure 2. *A time-event plot produced by The Observer for the data shown in the Graze window above.*

Graze allows the user to define an extraction period from within the original recording period, for example a 24 h measurement period from a 25.5 h recording. Once the data have been imported into The Observer, the program can perform powerful behavioural analysis, such as summarising data over short intervals, determining distance moved per bite and testing the effect of external events and states.

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Image analysis to predict the moment of giving birth of pregnant ewes

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Due to the evolution of hardware and software, computers become more and more reliable, cheap and powerful. As a consequence digital image analysis techniques are used more and more integrated in bio-processes [2]. Such techniques are accurate, no contact has to be made and the continuous presence of man is not necessary. The objective of this research was to investigate if image analysis techniques can be used to quantify the behaviour of pregnant ewes in field conditions.

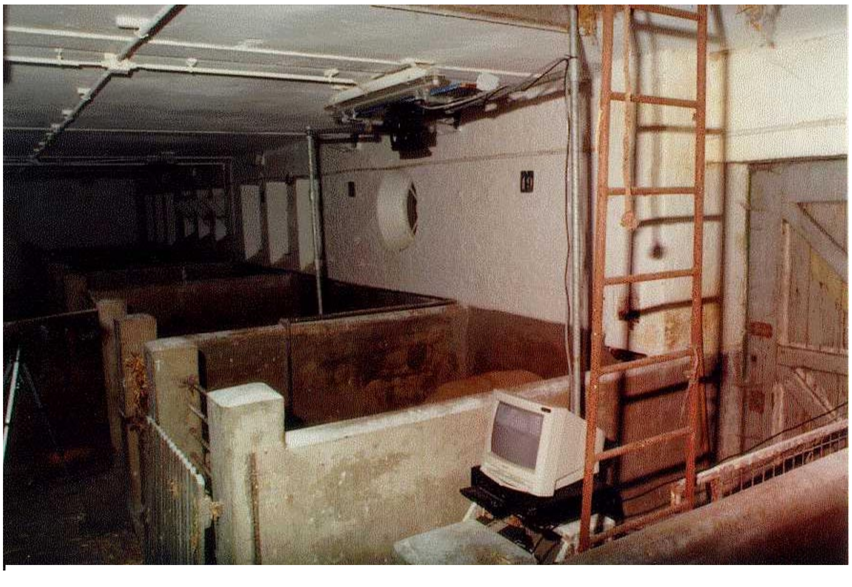

Figure 1. *Test installation*

An algorithm for image analysis was developed which allows making a distinction between lying and standing behaviour of ewes and this in situations of low contrast between animal and background. Using a monochrome CCD camera (speed of 25 images/second) and video recorder, the behaviour of four ewes (3 pregnant ewes and 1 non-pregnant ewe) was recorded starting 2 to 6 days before having a litter, depending on the ewe.

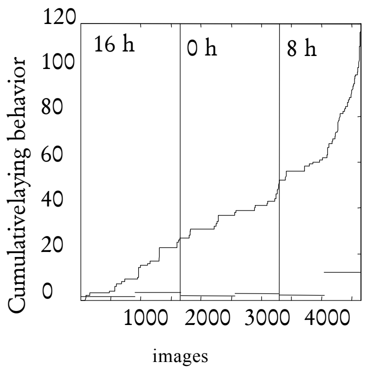

Figure 2. Cumulative traveled distance for ewe 2.

For a total of 34727 digitised images it was possible for 95 % of the images to make a correct distinction between lying and standing and this in lighting conditions of only 50 *lux*.

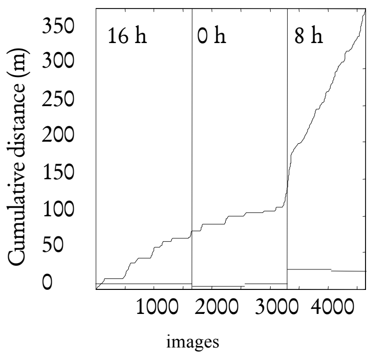

Figure 3. Cumulative lying behaviour for ewe 2.

The following variables could be quantified: travelled distance (m), lying time (seconds), standing time (seconds), activity (defined by [1]) and rotation index (number of rotations) of an animal. For 2 of the 3 pregnant ewes a change in behaviour could be quantified 6 to 7 hours before birth. In Figures 2 and 3 the traveled distance and the cumulative lying behaviour is shown for ewe 2.

Using such image analysis techniques it might be possible to monitor on-line the behaviour of pregnant animals in order to detect the beginning of birth.

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Computational patterning on locomotive behavior of the German cockroach in response to Ca^{2+} signal-inducing chemicals

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Ca^{2+} signal-inducing chemicals, thapsigargin and ionomycin, and a solvent, dimethyl sulfoxide (DMSO), were administered individually to males of the German cockroach (*Blatella germanica*) in topical application. Locomotive tracks were continuously observed through image processing in semi-natural conditions for 4-5 days. After the treatment of the chemicals including DMSO, long-range activity was decreased in scotophase while increased in photophase. Visiting frequencies were generally increased at the drinking place with the treatment of the signal inducing chemicals. Short-range activities at the other microhabitats and diurnal differences appeared in a diverse manner with different chemicals.

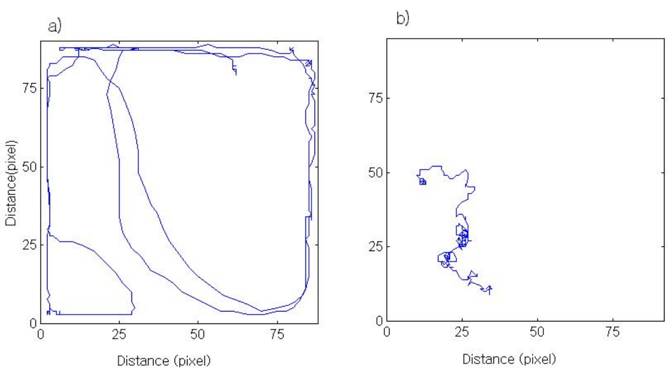

Figure 1. *Examples of locomotive tracks of the German cockroach, a) untreated, b) treated with ionomycin.*

When treated with ionomycin, the locomotive tracks appeared as twisted coils intermittently intervened with the numerous, irregular short-distance turnings resembling a “ball of entangled threads” (Figure 1). This was contrasted with the smooth, linear advancements observed in the untreated individuals. The locomotive tracks were also characterized by the repetition of circular movements for the treatment with thapsigargin, while the treatment with DMSO produced irregular short-distance turnings.

The data for the locomotive tracks were further analyzed by the two-dimensional Fast Fourier Transform (2-D FFT). 2D-FFT effectively brought out periodic data characterizing the patterns of different treatments such as twisted coiling and irregular short-distance turnings in the transformed map. This computational patterning on locomotive tracks could be an alternative to detect changes in response behavior of organisms exposed to various agents of stimuli.

Behavioural analysis of stereotypy in the laboratory mouse

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Many captive animals perform repetitive, relatively invariant and apparently functionless behaviours – commonly known as stereotypies (e.g. [1]). The underlying causes of this type of behaviour are unclear, but they may be indicative of poor welfare. Although much research has been carried out in this area, many unanswered questions remain. This study forms a preliminary investigation into the motivation behind behaviour that is without apparent function, using laboratory mice as a model species. A practical advantage of working with a species such as the mouse, with its relatively high developmental rate, is that the onset of stereotypy and its development could be monitored over a reasonably short time span. In addition, previous work has shown that laboratory mice will readily perform stereotypic behaviour (e.g. [2]). The aim of this initial investigation was to establish simple methodologies for sampling the behaviour of laboratory mice in order to objectively and efficiently quantify the incidence of stereotypies. The long-term aim was to use these sampling techniques to identify individual variation in stereotypy for use in developmental studies into the causes and effects of stereotypy as they relate to the welfare of captive animals.

General behaviour patterns were monitored in a population of 16 laboratory mice comprising both sexes and two outbred strains (CD-1 and NIH/S), covering their developmental period from weaning to maturity. These strains of mice are prevalent in experimental research, thus affording the study direct relevance to experimental animals. Observations were carried out over five months with video recordings at approximately monthly intervals. A combination of time lapse and real time footage was obtained, comprising in total, 70 hours of time lapse and 24 hours of real time footage per mouse. Of this, behavioural data were collected from 14 hours of time lapse video per mouse through scan sampling; and 12 hours of real time video per mouse through continuous sampling using The Observer 3.0 (Noldus Information Technology). Preliminary filming sessions monitored the animals' behaviour in standard laboratory conditions with sawdust bedding and ad libitum access to food and water. Having collected baseline data, the cages of half the subjects were modified through the addition of a nesting substrate in order to determine whether this environmental modification gave rise to changes in behaviour. Statistical analyses (using data generated by The Observer elementary statistics function) focused on the frequency and duration of behaviour directed towards the cage lid that may be regarded as stereotypic. Lid-directed behaviour comprised five mutually exclusive categories with quantifiable properties. Results obtained to date indicate that the frequency and total duration of observed cage lid-directed behaviour was significantly greater in the CD-1 strain at six and eleven weeks of age ($p < 0.05$). Environmental, gender and age comparisons, however, showed no significant differences in these measures, though individual differences in lid-directed behaviour was stable over time.

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The use of eye movement data in the analysis of neurobehavioral test performance

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In recent years, there has been increasing concern over the neurotoxic effects of workplace exposure to solvents and other noxious substances. Studies carried out within the field of neurobehavioral toxicology have shown that it is possible to measure decrements in cognitive performance in exposed workers using psychometric tests. However, positive results reported in these studies can be difficult to interpret. Many of the neuropsychological and neurobehavioral tests that have been employed require a variety of subskills, and decrements in overall test performance can reflect reduced capacity in any one or a subgroup of these. This causes particular problems for professionals making judgements about the health and safety consequences of these exposure-related decrements. This difficulty in interpretation is further compounded by the fact that observed effects are frequently at subclinical level. A better understanding of the underlying functionality of neurobehavioral tests, therefore, would be helpful in interpreting decrements reported in the numerous neurobehavioral studies carried out to date [2].

We describe an ongoing project that is investigating the potential of eye-movement methodology to provide information about the mental functions underlying neurobehavioral tests. Eye movements are thought to reflect ongoing cognitive processes and thus provide a “window” on the stages of information processing that underlie task performance. Tasks that involve processing and responding to an array of visual information are typically composed of a sequence of distinct subcomponents. Eye-movement analysis provides information about the time spent looking at particular items in a test, and the order in which they are fixated. This information can then be identified with previously identified subcomponents of the task, providing additional performance data.

Initial investigations have concentrated upon the digit-symbol substitution task; variants of this are found in several well-known test batteries. A group of healthy adult participants completed the task wearing a head mounted eyetracker (Applied Science Laboratories, Model 4000SU). Eye-gaze latencies associated with each specified subtask were used to derive three performance measures. Correlations were then carried out to determine the relative contributions of each subskill to the overall test score. Interestingly, work showed that motor response speed was not the most significant correlate of task performance. Instead, factors such as perceptual search speed and sustained attention made the most important contribution to the overall score [1].

The goal of current work is to establish the applicability of this methodology to other types of neurobehavioral tests. Further studies will seek to determine the specific effects of alcohol and demographic factors upon these measures. It is intended that this information can be applied retrospectively to appraise the nature of measured decrements in any previous study featuring the tests examined.

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Ground reaction force measurement in the mouse

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Measurement of the forces (P) acting on the ground at each limb placement during locomotion, has been shown to be a sensitive and non-invasive method for analysing the relative contribution of each limb to the breaking, support and propulsive phases of the gait cycle. Further, it allows subtle changes in movement associated with a variety of pathophysiological states to be assessed and the value of potential therapies quantified [1,3]. The smaller the animal, however, the more technically difficult the measurement becomes. The current emphasis on mouse models of human diseases has directed us more recently [2] to attempt to examine the reaction forces during locomotion of the mouse to give us a platform for future measurements in such models.

To this end each mouse (MF1 strain, mean weight 45 g) was placed in a perspex chamber 100 cm long x 4 cm wide x 6.5 cm high. Part of the chamber floor consisted of an array of glass plates forming the platforms of load cells to measure the vertical reaction force (P_z). The mouse was videoed from below to allow association of limb with force profile.

The peak P_z transmitted via right and left sides are symmetrical but those via forelimbs (FL) are about 5% greater than those via hindlimbs (HL) at 63.5 ± 0.6% and 58.5 ± 0.7% (mean ± SEM) of body weight respectively. The areas under the P_z curves for FL and HL, however, are not significantly different since the latter has a longer stance time (164 ± 6.1 ms and 190 ± 7.7 ms, respectively).

The P_z curves for FL and HL in mice travelling at or around average velocity each consists of 3 distinct phases, lasting from 12.4 to 27% of the total time. The major difference is that for FL two of the phases occur prior to the peak, while for HL two of the phases occur after the peak, reflecting presumed differential useage of FL and HL. We are currently identifying the paw contact features associated with these phases and examining P_z characteristics in abnormal mice.

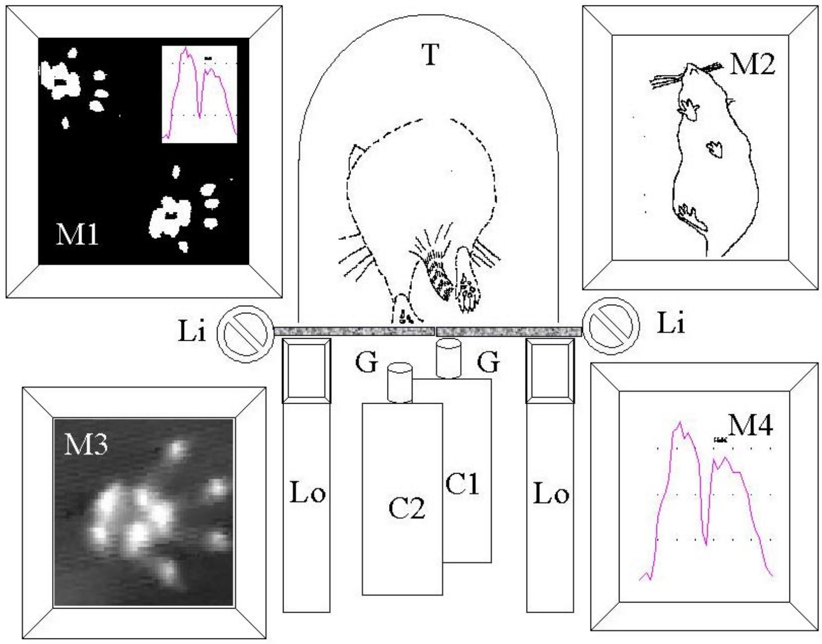

Figure 1. *Diagram of the apparatus used to collect spatiotemporal and vertical reaction force data. A plexiglass tunnel (T), over a glass walkway (G), internally illuminated by lights (Li) positioned along the edges, and under which are placed video cameras (C). For spatiotemporal data two cameras are used (C1 and C2) positioned to view short overlapping lengths of the chamber. Their output goes via a video splitter to monitor M1. Monitor M3 shows a detailed paw print of a passing image of a forepaw track through a frame grabber. For the purpose of vertical reaction force measurement, the glass walkway is divided into sections, each forming the platform of a load cell (Lo), with output to a data acquisition device . Image on monitor M4 is matched with load profiles of data acquisition monitor M2.*

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Examination of behavioral inhibition across contexts in rhesus monkeys

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Behavioral inhibition, a construct of temperament broadly defined in terms of response to novelty, has been measured across a wide variety of species by investigators in several fields. The various tests used to measure behavioral inhibition differ in the type of novel stimulus that is presented, the degree of fearful stimulus they include, and whether a fearful stimulus is social or nonsocial. Surprisingly, there has been little examination of the level of concordance among such tests. We compared behavior in response to four tests commonly used to measure behavioral inhibition in 44 young rhesus macaques living in large groups in outdoor enclosures.

The tests used were:

- a *freeplay test*, which assesses behavior in response to a novel environment (a novel room containing novel toys);
- a *remote-controlled car test*, which measures behavior in response to a sudden, nonsocial, potentially-threatening stimulus (a bright remote-controlled car driven towards the infant);
- a *human intruder test* [1], which measures response to a potentially threatening social stimulus (a human stranger making direct eye contact); and
- a *novel fruit test*, which measures response to novel food item.

The infant's mother was sedated and present during the freeplay and car tests to avoid the confound of separation anxiety. For each test, composite scores for behavioral inhibition and fearful/anxious behavior were calculated. Variables used to describe inhibited behavior include low exploration (freeplay, car, fruit tests), low toy play (freeplay test), and low time away from the mother (freeplay, car tests). Variables used to describe fearful/anxious behavior include high frequency of vocalizations (freeplay, car, intruder tests), fearful facial expressions (car, intruder tests), and physical withdrawal (car, intruder tests). These scores were scaled from 0-

100, such that the most inhibited or fearful/anxious behaviors were given a score of 0, and the least inhibited or fearful/anxious behaviors were given a score of 100.

We found that these composite scores did not correlate across tests (inhibited: $W=0.26$, $p>0.2$; fearful: $r_s=-0.17$, $p>0.2$). For example, monkeys that explored the novel room in the freeplay test did not show increased propensity to inspect the fruit in the novel fruit test ($r_s=-0.03$, $p>0.5$). And, monkeys that showed fear towards the car were not more likely to show fear during the human intruder test. In addition to these composite scores, we also compared individual variables across tests.

We conclude that context is very important in the measurement of behavioral inhibition. Moreover, choice of a test for behavioral inhibition should be based on the aspect of this measure that the investigator is interested in (low exploration, elevated anxiety or fear to a nonsocial stimulus, etc.). This principle will be particularly important when determining correlations between behavioral inhibition and specific physiological measures.

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Functional Near Infrared Spectroscopy: from a single-channel towards a multichannel approach

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Introduction

During the last six years, single and dual channel Near Infrared Spectroscopy (NIRS) has demonstrated that changes in brain activity can be assessed non-invasively. Similar to functional magnetic resonance imaging (fMRI), NIRS monitors changes in concentration of deoxyhemoglobin ([HHb]). However, NIRS is also capable to provide continuous and direct information on oxyhemoglobin ([O_2Hb]) and on total hemoglobin ([tHb]). Compared to fMRI, fNIRS has a faster sampling rate, is much less sensitive to movement artifacts, portable and relatively cheap. An inherent disadvantage of NIRS is the lower spatial resolution compared to fMRI. This can largely be overcome by using a multi-channel device that can image (part) the human brain. Our goal was to develop a highly portable and sensitive optical tomography device with fast sampling rate. Parallel to this process we developed software, using Matlab, to provide the user with the tools for direct and fast data analysis.

Materials and methods

The instrument consists of 4 light sources (laser diode) and 3 detectors (avalanche photodiode). The technology of the device is based on the continuous wave Oxymon® device, developed by the Physiology and Biomedical Enigineering Department of the UMC St. Radboud. Every light source has two wavelengths: 775 and 850 nm. Detectors and light sources are coupled to optical fibers. The fibers of 2 detectors are split, to obtain a total of 5 detectors. Detectors and light sources are placed alternately on square lattice points. The distance between the point is fixed at either 4.0 or 3.5 cm. Detectors are placed on the corners of the square and one in the middle of the square. The total imaging area is 8 by 8 or 7 by 7 cm. Currently two desktop PCs are used to run the instrument. Additionally to the hemoglobin signals, up to 16 anolog inputs can be stored simultaneously. The fastest sampling rate of the imager is 50 Hz. Using this high sampling rate the imager does not only measure changes in concentration of [HHb], [O_2Hb] and [tHb], but also measures cerebral arterial saturation.

Results

The functionality of the instrument was tested using a liquid phantom (20% milk in water) with a rotating rod of 1 cm in diameter and on the human brain during a finger-tapping task (20 s stimulus duration, tapping rate 2 Hz, right hand). A picture with time frames of [O_2Hb] and [HHb] during the finger-tapping task is shown in Figure 1.

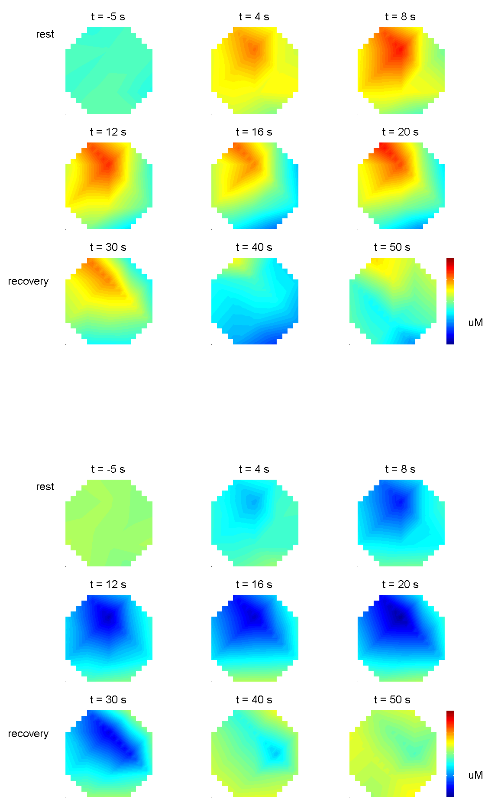

Figure 1. *Top: [O_2Hb]. Bottom: [HHb].*

Conclusion
The optical imager provides promising results for its application in human cortex mapping.

Acknowledgements
We would like to thank Prof. Ferrari and Dr. Quaresima for their stimulating discussions on optical topograghy and their help with the testing of the instrument.

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Measuring Behavior 2000: Overview of the conference

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It has become increasingly popular to study behavior with the help of video recordings, since only video recordings can show all aspects of the situation in which humans or animals interact with each other or with their environment. Using video creates many interesting methodological and technological problems that will be addressed during the conference. What kind of analog and digital recording techniques are applied to carry out these studies? How is the huge amount of video material maintained and archived? Recent technological developments make it possible to digitize and compress video information, i.e. to handle video information on computers and transfer it across computer networks. Digital technology offers completely new possibilities for the researcher, but creates also new types of problems. Which video encoding format should be used for archiving and for handling? How to handle the gigantic mass of information on servers and which media will offer efficient access in the future? Do we have to send media around such as CD and DVD or can we rely on access through the Internet? In the latter case one has to think about video streaming technologies, synchronization of various information streams and other aspects. New software packages support multimedia on computers and allow direct and efficient annotation. What kind of annotation schema will have to be used, how to store the annotations such that they can be exchanged with others, and how to find the material which you need for your scientific question at a certain moment? These and related problems will be addressed among others in the symposium on *Measurement Methodologies in Gesture and Sign Language*.

Measuring behavior requires a clear answer to the problem of defining behavioral items and patterns. Therefore, it is necessary to identify the building blocks (units) of behavior. The classical approach implies partitioning behavior right from the start into simultaneously performed (synchronous) behavior patterns. In contrast to this approach, it is also possible to use controlled kinematic variables (also called collective variables, order parameters, key variables, relevant variables) which may or may not assemble into relatively fixed synchronous behavior patterns. It will be evident that each of these approaches has its own consequences for the development of systems that track, monitor, and measure movement and/or behavior. For that reason, particular attention will be given to the problem of the units of behavior in the symposium on *The Building Blocks of Behavior*.

Measuring behavior has become a central issue in behavior genetics. In fact, it is the "post genome" challenge to tie the outcome of the genetic mapping to behavior. The limitations and possibilities will be addressed in the symposium on *Behavioral Phenotyping of Rats and Mice*.

Measuring and monitoring body postures and physical activity is considered to be a promising approach for prognosis and therapy evaluation. Today, there are various techniques that allow reliable measurements of head positions, limb movements, body postures and/or whole body motions. Data acquisition systems are becoming available for recording, extracting and analyzing body movement patterns that can be linked to other sets of variables. In fact, each of these techniques has its own prospects and perspectives. For that reason, a special symposium is devoted to *Measuring Body Posture, Activity and Gait*.

Measuring behavior of individuals moving amidst other individuals requires sophisticated, non-invasive tracking techniques. Today, there are new developments in this field that will be discussed in the symposium on *Movement Tracking and Monitoring of Individuals and Groups*.

Operant methodology is considered to be an important tool for studies on cognitive functions in behavioral pharmacology, psychology and neuroscience. Experience is primarily limited to pigeons, rats and humans, although this approach has recently also been applied to mice. Today, there are several attempts to design operant techniques that allow analysis of identical cognitive functions both in humans and animals. The symposium on *Operant Conditioning Paradigms, Techniques and Tools* deals with these and related aspects of operant methodology.

Measuring behavior also confronts us with the question to what extent humans can exert control about the type of codes to be used to describe human or animal behavior. Should one use an exhaustive coding approach or start with what is needed at that moment? Does modern technology effectively support incremental coding? Techniques for creating behavioral coding schemes have been historically developed to use paper and pencil methods or audio and video recording methods. The advent of inexpensive, compact computing power opens the possibility of developing coding schemes that take advantage of real-time data expansion. Current computerized recording systems have automated collection of time-sequential data, but do little if any real-time processing of data during the collection phase. We have entered an era where coding schemes need to take advantage of significant advances in computing power. For example, with sufficient real-time computing it is possible to design coding schemes that are extremely brief and compact which are expanded in real-time during data capture by table lookup schemes. Such "data expansion" coding schemes could allow the capture of real-time data that could exceed what can be captured with audio recording and require little or no post-capture processing. Furthermore, new pattern detection algorithms allow us to discover behavioral patterns that would otherwise remain hidden in an "ocean of data". These and related problems will be addressed in the symposium on *Quantitative Analysis of Behavioral Observation Data*.

Another aspect that is inherent to the use of technology deals with the consequences and possibilities of human-system interaction. To what extent does the present-day technology of data collection influence the operator's perception and understanding of a situation or a group and, accordingly, his decisions? In case of failures such as aircraft accidents, it appears that the human factor has the largest influence on system performance. Are there indeed conditions during which digital support tools that automate various processes worsen the task performance? To what extent do subjective impressions play a role? Is it possible to evaluate objectively subjective impressions like time-varying quality of compressed video and speech material? Today, there are also developments showing that the human-system interaction creates fully new possibilities. For instance, it has become possible to use brain waves for controlling a computer system. These topics will be addressed in the symposium on *Human-System Interaction: Perception, Control and Situational Awareness*.

Combining different techniques for acquiring and recording side-by-side various biobehavioral variables provides a multimodal experimental approach that should belong to the standard equipment of the ideal laboratory for animal and human behavior. Given the importance of this multimodal approach in the near future, two distinct symposia are devoted to this topic. An illustrative example is the multimodal approach that is becoming the standard in cognitive neuroscience. The electromagnetic techniques (electro-encephalography: EEG; magneto-encephalography: MEG) provide high temporal resolution, but limited spatial resolution. In contrast, the hemodynamic methods (Positron Emission Tomography: PET; functional Magnetic Resonance Imaging: fMRI) provide relatively high spatial resolution, but limited temporal resolution. Ideally both types of measurement are combined within the same experiment. In the symposium on *Measuring the Brain in Action*, particular attention will be put on approaches that combine techniques with a high temporal resolution with techniques that have a high spatial resolution. Another typical example is the multimodal approach that is used to improve behavioral phenotyping by combining behavioral data with physiological parameters such as body temperature, heart rate, etc. The advantage of this approach will be addressed in the symposium on *Integrated Measurement of Behavior and Physiology*.

All these and related aspects are addressed at *Measuring Behavior 2000*. Currently new standards in the area of multimedia work are under discussion, new technologies are emerging, and new generations of software tools are being developed. We expect that the conference will help participants to understand the various approaches that are chosen in fundamental and applied sciences and will anticipate the technological and methodological trends.

Measuring behavioural priorities in captive animals

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Addressing the behavioural priorities of captive animals and the development of practical, objective measures of the value of environmental resources is a principal objective of animal welfare research. In theory, consumer demand approaches derived from human microeconomics should provide valid measures of the value of environmental [2]. Price elasticity (the perseverance of resource consumption in the face of rising cost) and income elasticity (the perseverance of resource consumption in the face of lower income) are most commonly suggested by ethologists. In practice, however, a number of empirical and theoretical problems render these measures difficult to interpret in studies with animals, particularly where a cost is imposed on access to the resource but time with the resource is used as a measure of consumption [3]. This may be a relatively straightforward protocol for recording resource use by automatic means, but a number of studies have found that animals can compensate for increased cost of access with longer visit length. Furthermore, direct observation of the test animals' behaviour have shown that resource interaction is more intense having overcome higher costs on access [1]. As a consequence measures based on time with the resource may underestimate resource consumption at higher access costs and demand curves derived from these measures may not be a true reflection of the value of different resources. An alternative approach to demand curves is "reservation price", which is the maximum price individual animals are prepared to pay to gain access to resources. This is not only a simple means of recording resource use, but maximum price paid is also analogous to measures used in human economics to investigate the value of providing additional resources on human welfare [4].

In studies using this approach, farmed mink (*Mustela vison*) paid higher prices in terms of pushing open weighted doors for access to food and for access to swimming water, than for access to resources such as tunnels, water bowls, pet-toys and empty compartments. These indicate that the mink placed a high value on food (as expected) and also on swimming water, and viewed these as more important than other resources. This was supported by the mink's response to denial of resources, as they showed an increase in urinary cortisol production and persevered with attempts to interact with resources when denied access to food and the swimming water, but not when denied access to other resources.

Figure 1. *Mink in water bath on experimental mink farm*

In conclusion, the maximum price paid to use a resource appears to be a valid means of assessing resource value, that is simpler to use and less prone to artefacts created by the animal's abilities to alter rates and bout lengths than measures based on elasticity, and whose findings are supported by independent measures of animal well-being.

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AWIN, an automatic weigh and identification nest-system to study petrels in Antarctica

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An automatic weigh and identification nest-system (AWIN) has been developed to study two closely related petrel species in Antarctica. It has been used for a study on the breeding and foraging ecology of the Antarctic petrel (*Thalassoica antarctica*) and the Southern fulmar (*Fulmarus glacialoides*) on Ardery Island, Antarctica (66S, 110E). In three consecutive seasons (1996-1999), 30 to 45 artificial nests (Figure 1) have been operational each year in two study colonies on the island. The nests in these colonies were connected with the datalogger-computer in the field camp with cables up to 800 m away.

***Figure 1.** Antarctic petrel on artificial nest.*

During the breeding seasons, about every 5 minutes data were collected from each nest on the identity and weight of the bird(s) present on the nest.

These data were immediately visible on the screen of the datalogger computer in the field camp. To identify individual birds a Passive Identification Tag (PIT) technique was used. Electronic tags, 'transponders', were moulded in a 19-mm glass tube (Figure 2) and had been implanted subcutaneously along the upper leg of the adult birds. Each transponder has a unique number, which is detected by an antenna inside the nest-unit. As transponders do not consist of a battery, they provide life-long identification of the bird.

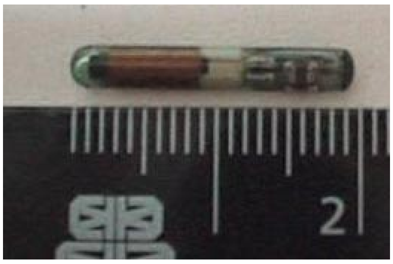

***Figure 2.** A 19-mm transponder.*

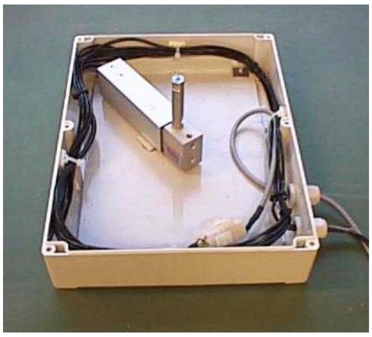

***Figure 3.** Antenna and load cell inside a nest unit.*

A high precision load cell was used to weigh the bird(s) on the nest (Figure 3). Weight measurements were accurate to 1 g. Each weigh session of a nest consisted of five repeated weighings in just a couple of seconds. The average of these five repeated measurements was used as the weight of the nest.

Thus, the reliability of each weight measurement was given as the calculated standard deviation of the five measurements.

AWIN has low power requirements and is powered by solar and wind energy, especially designed for remote areas (Figure 4). It continues collecting data in unfavorable weather conditions and at night. Birds easily adapted their new nests and no changes in breeding success have been recorded. The nest system enabled us to collect detailed information on attendance patterns, body weights, chick provision rates, chick meal sizes and chick growth, without the disturbance by regular manual weighing or by visual checking. In a case of an electronic failure, the disturbance is also minimised as the electronic control unit was situated in a box away from the nest unit where the birds were breeding. Also, when a power failure happened in a colony (e.g. at times when there was not enough sunshine to charge up the batteries), the artificial nests kept collecting data as each nest was supplied with a small emergency power source.

***Figure 4.** Field camp on Ardery Island.*

AWIN will be demonstrated in an experimental set-up during the conference.

The use of comparable neuropsychological tests in non-human primates and man

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This paper will consider the practical and theoretical issues involved in comparing cognitive function across species, in particular monkeys and man. Examples will be taken from studies investigating the precise nature of frontal dysfunction in the neurodegenerative disorders of Parkinson's disease, Huntington's diseases and fronto-temporal dementia and the neuropsychiatric disorder of Schizophrenia. Using standard clinical tests of frontal lobe function it has proven difficult to distinguish the impaired performance of patients suffering from these conditions from neurosurgical patients with localised excisions of the frontal lobes. In some cases the frontal type deficits observed in these neurodegenerative and neuropsychiatric conditions may be the result of a dysregulation in the neurochemical modulation of frontal lobe activity e.g. Parkinson's disease & Schizophrenia. Alternatively they may be due to a disruption of fronto-striatal circuitry, e.g. Parkinson's disease, Huntington's disease & Schizophrenia, or a disruption of fronto-temporal cicuitry, e.g. Schizophrenia & Fronto-temporal dementia. In order to characterize fully both the psychological and neural basis of these deficits in patients, it is necessary to perform selective neurochemical and neuroanatomical lesions in monkeys, in parallel with clinical studies. To this end, we have developed a computerised battery of tests presented on a touch-sensitive screen designed to enable not only the presentation of the same tests to both humans and monkeys, but also to allow a decomposition of the possible factors contributing to task performance. The psychological issues which are relevant to the design of such tests suitable for use in both humans and experimental lesioned primates will be discussed taking examples from studies using a computerised analogue of the Wisconsin card sorting test and a test of self-ordered sequencing.

Point-of-gaze, EEG and ECG measures of graphical/keyboard interfaces

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Eight experienced but not currently practising Air Traffic Controllers carried out simulation exercises using the TRACON II Autonomous Air Traffic Control (ATC) simulator at Eurocontrol Experimental Centre, (EEC), Bretigny, France. Each controller undertook four exercises, controlling 15 and 30 aircraft entering in 30 minutes, using graphic (trackball/pointer/windows) and coded keyboard input methods. The two lighter loaded exercises were carried out on one afternoon, following some preliminary training exercises, and the more heavily loaded exercises were carried out on the following afternoon, to minimise circadian rhythm problems.

A preliminary analysis was carried out using The Observer (Noldus Information Technology) on-line, to record major shifts of attention. Significant events during the exercise were noted and subsequently included in the record. The point of gaze was recorded using a SensoMotoric Instruments iView head-mounted eye-tracking device. Eye-movement analysis was confined to the busiest 20 minutes of each simulation. Initially, the location, duration and frequency of eye-movements were analysed on a minute-by-minute basis. The mean number of fixations per minute was approximately 15 per minute for the graphic mode, and 25 per minute for the keyboard mode. In keyboard mode, the controllers switched frequently between the keyboard, the active strip area and the radar. Controllers using the graphic interface spent about 57% of their time looking at the radar, 17% looking at the active strips and 17% looking at 'pop-ups'. Controllers using the keyboard interface spent about 47% of their time looking at the radar, 20% looking at active strips and 20% looking at the keyboard. Surprisingly, the traffic load made no significant differences in the duration or number of fixations, for either control mode. The controllers' left/right frontal electro-encephalogram (EEG) and electrocardiogram (ECG) were recorded using a Vitaport psychophysiological recorder. The estimated theta-rhythm power rose for higher traffic load in the keyboard mode, as might be expected. In the graphic mode, however, it fell. For both modes, the variability of heart rate (sinusarythmia) fell for higher task loads. There was a significant negative correlation between sinusarythmia and the number of fixations for radar, active strips, and keyboard and between sinusarythmia and the time spent looking at the radar.

There were significantly higher scores for the mental, physical and temporal demand and effort sub-scales of the NASA Task Load Index for heavier traffic load. The overall TRACON score was higher for higher traffic load, although the deliberate overloading of controllers in the high traffic load produced variable scores. Specific error frequencies showed a more complex pattern. There were more separation losses in the keyboard mode, suggesting less situational awareness. There were more handover errors in heavy task load conditions, suggesting that controllers may decide to 'shed' this task under time stress, and more missed approaches in the graphic control mode, which may be attributed to the lower precision of the graphic methods for height and speed allocation.

This was an initial feasibility study, which should be repeated with larger numbers of subjects. The observed results can only be regarded as tentative, but are indicative.

Comparison of two point-of-gaze measurement systems on a dynamic ATC simulation

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In a study reported in a companion paper, eight Air Traffic Controllers carried out simulation exercises using the TRACON II Autonomous Air Traffic Control (ATC) simulator at the Eurocontrol Experimental Centre (EEC), Bretigny, France, while wearing a SensoMotoric Instruments iView head-mounted eye-tracking device and electrophysiological recording equipment. Traffic density (high/low) and control mode (graphic/keyboard) were varied. An opportunity was found to employ an ASL Model 504 table mounted eye-tracking system in the same experimental context. Four suitable controllers carried out exercises using the graphical interface. Two controllers, who had participated in the previous study, carried out exercises using heavy traffic loading. The other two controllers carried out one light and one heavily loaded exercise using the graphical interface, matched to two controllers in the previous experiment. All other measures were taken as before. The Observer (Noldus Information Technology) was employed on-line to record significant events.

The iView system required the controller to wear a lightweight bicycle helmet, firmly but not painfully strapped to the head. EEG electrodes could be worn under the helmet. The ASL system used a remote, motorised camera surrounded by a ring of infrared emitters, and focussed on the controller's head. To assist in this process, a Polhemus head-position recorder was attached to the controller's head by a headband, and a signal transmitted to allow the camera to acquire the correct eye. No significant discomfort and no electrical interference were observed with either system.

The ASL system allowed the rectangular CRT display to be divided into specific zones, corresponding to the simulated strips, radar and communications zones. The system could identify fixations and record their position and duration. From these figures, it was possible to construct transition diagrams and frequency and duration charts of the controller's gaze. Selected periods of eye movement, such as those preceding an 'error' could be examined on command.

Similar data from the iView system could only be obtained by observation at reduced speed (20% of real time) and transcription using The Observer. (Previous studies suggested that manual analysis of similar recordings, without the aid of The Observer, had a speed of about 5% of real-time; see David, 1985) The iView system, however, can accommodate a far greater range of movement by the controller, who can stand up, turn round and carry out all reasonable movements.

Neither system was seriously affected by the wearing of spectacles by the controller. (No controllers wore contact lenses.) The iView system experienced some difficulties in calibration when the controller was looking downwards, and the ASL system appeared to have difficulty where the controller wore progressive lenses, although it coped correctly with bifocal lenses.

The detailed analyses made possible by the ASL system software suggest that the simple hypothesis (that ATC errors occurred because controllers did not see the developing problem) is unlikely to be true. At least three causes of error can be identified, which relate to the nature of the error.

This was an initial feasibility study, which should be repeated with larger numbers of subjects. The observed results can only be regarded as tentative, but are indicative.

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Measuring activity in the stabled horse

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Measurement of activity can provide useful information about the wellbeing of an animal under certain environmental conditions. Activity measurement in the stabled horse has been limited; the aim of the present study was to compare a variety of techniques (Infrared beams (IR), Passive Infrared (PIR), Accelerometer, Pressure mats and Pedometers) that were used to assess activity of the stabled horse. These techniques were validated against video observation of behaviour in three trials over a period of several weeks using The Observer 3.0 (Noldus Information Technology). Activity parameters recorded included walking, stepping, lift leg, stand, move head and flick tail.

Tabel 1.

Recording Technique	Number of Horses		
	Trial 1	Trial 2	Trial 3
Infrared Beams	12	6	6
Pressure Mats	12	-	-
Pedometers	12	6	6
Accelerometer	-	6	6
Passive Infrared	-	-	6
The Observer 3.0	12	6	6

Each horse was observed in the stable (top door shut) for 90 minutes; replicated once for trial 1 and twice for trials 2 and 3. A 12' x 12' stable was fitted with four IR mini-beams; pressure mats covered the floor and a PIR was suspended from the ceiling. Prior to each test, an accelerometer was fitted around the right fore metacarpus and 2 pedometers around the left fore and hind metacarpus. A final total was noted for each pedometer, counts were logged at intervals for all other equipment. Activity parameters were recorded from video in real time as states or frequencies using The Observer 3.0.

Correlation and multiple step-wise regression analyses were carried out to determine which of the techniques were best able to detect an individual or combination of activity parameters. The results show that IR is highly correlated ($R^2=75\%$, $p<0.001$) with walking, stepping, lift leg and flick tail combined. The pedometers were highly correlated ($R^2=81\%$, $p<0.001$) with walk duration and step. The PIR readily picks up head movement ($R^2=68\%$, $p<0.001$). The accelerometer, however, was sensitive to the intensity of limb placement ($R^2=54\%$, $p<0.001$). The pressure mats did not complete the trial due to damage.

This preliminary study suggests that the IR system in combination with the pedometers provide a useful measure when evaluating total activity of the stabled horse. And it gives an indication of how we could develop reliable methods for measuring ambulatory movement. However, although time consuming, observation in conjunction with programs such as The Observer 3.0 still provide the most accurate method for collecting information on specific activities.

Measuring behaviour: let the animals do all the work

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Science

The behavioural needs of farm animals may be quantified by demand functions generated by operant conditioning techniques. When using operant conditioning to quantify behavioural needs, the animals are required to perform an operant response (work) to get access to perform certain behaviours (reward). Typically, animals are required to press a lever for food rewards, but some operant responses may be more closely related to the reward than others. It has been suggested to use different responses for different rewards. In the set-up presented here the aim was to investigate the effect of response type on the demand for food in mink. The demand function is the change in the number of rewards as a function of work requirement. Chain pulling resulted in a demand function with a steeper slope than lever pressing ($p < 0.001$), the type of operant response influenced the demand function. This means that it is necessary to use the same type of response when comparing demand curves for different types of behaviours.

Figure 1. *Mink at work*

Technology
There is some "operant conditioning" equipment for studying the behaviour of rats on the market. However, we wanted to study farm animals full-time in their home environment. Designing the equipment for this required some lateral thinking. Take the feeder for example. As the feed had to be the standard "fish paste" feed, we used a caulking gun, eminently suitable for delivering pastes. For driving the feeder we used a windscreenwiper motor. The real problem was designing the levers and chains. How big, how long, what material, what force for pushing or pulling. Luckily technologists are allowed some anthropomorphism. Using this, we settled on a design that proved quite suitable, except for the choice of aluminium for the levers: mink love chewing them.

Figure 2. *Rear view of four chambers, showing the feeders.*

Controlling the equipment proved to be quite simple, using a PC equipped with a "Computer Boards PDISO8" I/O device (8 sensors to register actions, 8 switches to control). The basic principle for controlling the equipment and collecting the data was to do just that, controlling and collecting and no more. The PC showed only basic operation figures, number of presses, rewards, time since last press, and a monitor showing the reaction time of the PC (0.02 s, running 4 feeders).

As for data collection, all events were time stamped and recorded as plain text. Calculations, including reporting on the daily "work" of the mink, were carried out on a "real" PC using a standard data treatment package (SAS).

Conclusion

The method of controlling the equipment and collecting the data can be used for almost every kind of equipment and almost any kind of animal. The next part of the project will be to establish demand functions for different behavioural needs besides feeding, like the use of a nestbox, access to straw, etc.

Improvement and deficit in spatial learning of the eNOS-knockout mouse (eNOS-/-) dependent on motivational demands of the task: water maze versus radial maze

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As part of a project to behaviorally characterize the eNOS knockout (that is the endothelial nitric oxide synthase deficient mouse), we compared spatial learning using two paradigms with different reinforcement contingencies. These were the Morris type water maze, where escape from an aversive state provides a negative reinforcement, and the Olton type radial maze, where food acquisition provides positive reinforcement. Surprisingly, in the water maze the eNOS-/- mice demonstrated superior performance as compared to C57BL/6 and eNOS+/+ wild type littermates, whereas in the radial maze the eNOS-/- mice exhibited deficits in performance as compared to controls. The eNOS-/- mice also showed higher levels of anxiety as measured by the elevated plus maze and the open field test of anxiety. These results suggest that the motivational demands of the spatial learning tasks can determine whether a mutation will show an improvement or a deficit in performance. Although it is possible that other factors could account for these seemingly opposite results, it is likely that they are due to different reinforcement contingencies inherent in the tasks. For one, these results indicate that an assessment of spatial learning cannot rely on the employment of either the water maze or radial maze alone. An obvious conclusion is that at least both must be part of a strategy for the phenotyping of spatial learning in mutant mice.

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Operant conditioning using a human Skinner box

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One of the major research goals of our department is to investigate the elementary processes underlying learning and memory in animal and human subjects and to make between-species comparisons. A problem associated with these comparisons is to identify equivalent tasks. In many cases, human and animal tasks differ to such an extent that direct comparisons are severely invalidated. For example, operant conditioning tasks in rats are usually performed in Skinner boxes, whereas in human studies, seemingly comparable paradigms are presented using a computer or slide projector. Especially computerised tasks have become increasingly popular, despite the fact that this approach has widened the gap between animal and human conditioning paradigms, hindering extrapolation of outcomes.

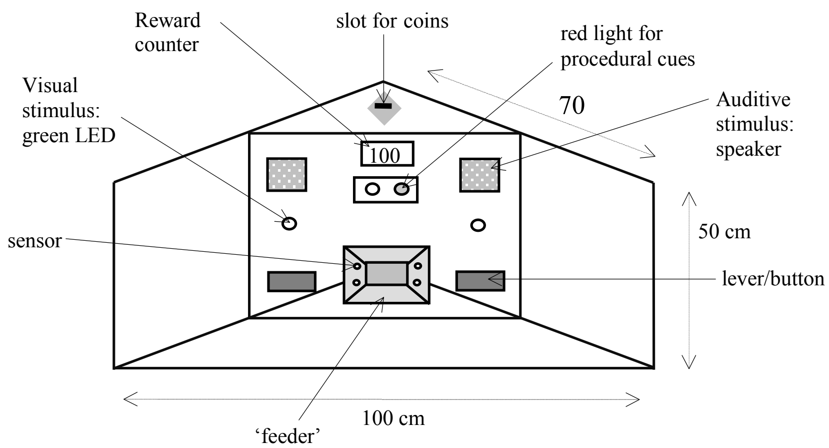

Figure 1. *Illustration of the human Skinner box.*

In order to enhance the comparability between animal and human operant conditioning tasks, a human analogue of the Skinner box was designed after an idea by Dr. W.H.I.M. Drinkenburg. As can be seen in Figure 1, this Skinner box shows a strong resemblance to the traditional animal Skinner box. The apparatus allows for the presentation of visual, auditive, and spatial stimuli as well as of reinforcements. The intelligence panel contains two speakers, one left and one right, while two green lights are placed below the speakers, and two 'levers' at the bottom of the panel. Between the two buttons a 'feeder' is placed containing two sensors on each side wall to detect a 'feeder visit'. The reinforcer, a coin, is delivered behind a magnetically regulated flap and can be obtained by pushing the flap backwards. The coins are maintained in a reservoir, which can be filled up through a slot. Two lights, a green and a red one, are placed above the 'feeder'. Additionally, the possibility to use a score counter instead of coins is enabled by a display at the top of the panel. A Macintosh computer with specially designed software runs the experiments. Lights and sounds can be used as conditioned stimuli, pressing one of the buttons or visiting the feeder as a response and receiving a point or coin can function as a reinforcer. It is possible to measure response latencies, response accuracy, and set performance criteria. All well-known experimental designs can be programmed and run. For instance, fixed- or variable ratio schedules, time interval tasks, conditional discriminations, occasion-setting paradigms, and countless other tasks and schedules. The most appealing feature of this human Skinner box panel, next to its physical resemblance, is the correspondence in task demands with the animal Skinner box. This gives the experimenter the opportunity to observe and compare learning and memory processes involved in operant conditioning in humans and animals. The apparatus has been used to study effects of aging on problem solving, while further studies are planned.

Sensory-motor control of free flight behavior in flies

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Whether circling garbage cans or cruising through alpine meadows, insects impress us with their agile aerial acrobatics. What external sensory cues and internal physiological processes govern when and where insects change direction? At the center of flight control behavior is a continuous feedback loop by which sensory information from several modalities modify motor patterns that in turn alter wing kinematics and the production of aerodynamic forces. We are currently attempting to dissect this control system in the fruit fly, *Drosophila melanogaster*, by using an automated free flight tracking arena. The stereo system of the arena operates in the infrared, so that the tracking procedure does not interfere with the visual system of the flies. By tracking the flies within a large arbitrarily-structured arena it is possible to reconstruct what a fly 'sees' as it moves through a structured visual landscape. We are using these data in an attempt to determine how optic flow influences saccade rate, path velocity, altitude, and other aspects of the free flight behavior. The flight paths of fruit flies consist of straight sequences interspersed with rapid saccadic turns, during which the animal changes its heading by approximately 90 degrees. While the temporal and spatial distribution of saccades may appear quite stochastic, after reconstructing the visual input it is possible to link nearly every saccade turn to a point when the rate of expansion within one visual field passed a critical threshold. After each saccade, flies attempt to stabilize sharp contrast edges resulting in the straight flight sequences. As they approach an object, however, the asymmetrically looming object elicits first a decrease in forward velocity and then a rapid collision-avoidance saccade. The net result is that animals fly slowly and saccade frequently within dense clusters of objects, whereas they fly rapidly and saccade less frequently within open landscapes (Figure 1). Attractive chemical odors appear to raise the threshold for collision avoidance responses and lower the threshold for landing responses. The influence of vision and odor combine to produce a quite robust and efficient search behavior.

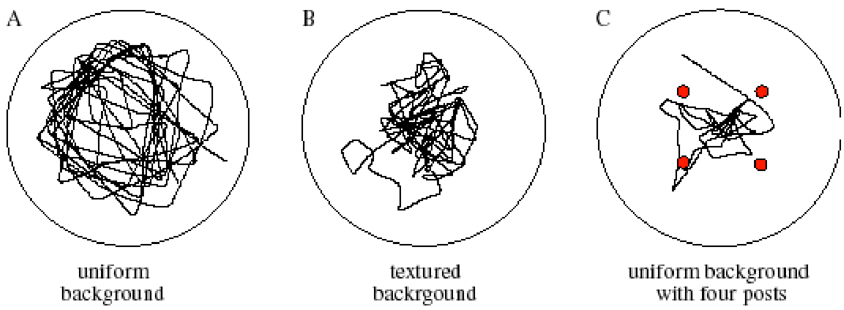

Figure 1. *Birds-eye-view of free flight trajectories of fruit flies in three different visual landscapes. The trajectories each show a single flight sequence from one individual fruit fly. (A) Flies saccade close to the wall when the cylindrical arena is uniformly white with a dark horizon. (B) Flies turn more frequently when the arena has a textured high contrast background. (C) In the presence of four vertical bars (red circles) flies restrict their flight to the center of the arena. The arena is 1 m in diameter and 0.5 m high.*

In conjunction with the free flight arena, we use a tethered flight simulator for measuring changes in wing stroke kinematics or flight forces while reconstructing or manipulating the sensory stimuli that the animals experience under free-flight conditions. The device consists of an electronic visual panorama that may be mounted within a rotational gimble and equipped with an odor-laden air stream. This apparatus is used to elucidate the interactions among the vision, olfaction, and gyroscopic (haltere) senses – three critical modalities in flight control. We are currently using data gathered from free flight and tethered flight to construct a comprehensive mathematical control model of the flight system. The goal is to develop a rigorous analytical framework with which we can test and modify increasingly complex models of flight control behavior.

Improving the homogeneity of the magnetic field in the magnetic search coil technique

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The magnetic search coil technique is the state of the art method for accurate measurements of eye movements. However, the data analysis relies on the assumption that the magnetic fields do not change during the measurement. This would only be the case if the magnetic field were ideally homogeneous or if the measured movements contained no translatory component. Especially when measuring eye movements with the head free, the translatory components are not negligible. Thus, any inhomogeneity in the magnetic field leads to measuring errors. Since the inhomogeneity of the magnetic field depends on the edge length of the field cube, the field cube should be as large as possible. The experimental setup, however, often imposes limitations on its size.

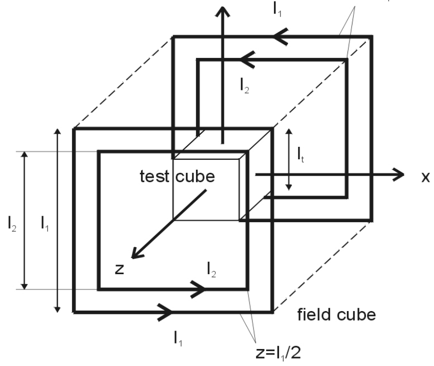

Figure 1. *Geometry of the configuration (l_1 = edge length of the field cube, l_2 = edge length of the supplementary field coils, l_t = edge length of the test cube, I_1 = current strength in the main field coils, I_2 = current strength in the supplementary field coils).*

The addition of a second pair of field coils arranged in the same planes as the main ones and centered around the same axis, but with shorter edges and reversed current direction can improve the homogeneity of the magnetic field. This reduces the field strength without changing the current strength in the main field coils. However, the procedure yields a homogeneity of the magnetic field comparable to that of a standard field cube with almost threefold edge length (obtained by optimizing the homogeneity in a test cube located at the center of the configuration which has a 0.2-fold edge length compared to the field cube). Figure 1 illustrates the geometry. In Figure 2 the inhomogeneity of the magnetic field strength in the standard configuration is compared to that after adding a supplementary pair of field coils.

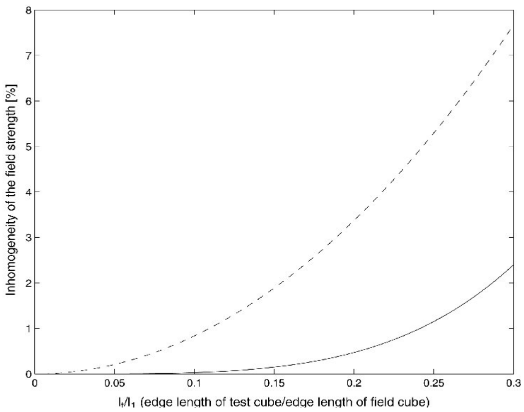

Figure 2. *The inhomogeneity of the magnetic field strength in the standard configuration (dashed line) is compared with that after adding a supplementary pair of field coils with l_2/l_1 (edge length ratio) = 0.75 and I_2/I_1 (current ratio) = -0.57 (solid line). The field strength at the center of the configuration is reduced by 49% compared to a standard configuration with identical current strength in the main field coils. The inhomogeneity of the field strength is defined as the maximum deviation of the field strength in a test cube (with given edge length l_t located at the center of the configuration) from the field strength at the center and given in %.*

Phenotyping of mouse exploratory behavior

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Behavior genetics relies critically on the comprehensiveness and accuracy of the measured phenotype in terms of its reliability and relevance. The need for such phenotyping has resulted in the design of batteries of behavioral and physiological tests. A central component listed in most test batteries is open field behavior (exploratory behavior, locomotor behavior in the open field). The variables recorded in this test typically include the cumulative distance covered by the mouse during a session, the ratio between staying in the periphery and center of the arena, activity decrement upon repeated exposures to spatial novelty, and the frequency of rearing, of sniffing, and of defecating. These measures are all cumulative and general, reflecting the common view that open-field behavior is largely stochastic in nature.

In recent years, however, more detailed studies of rat exploratory behavior (ExB), done in our lab and by others, revealed that rat ExB consists of typical behavioral patterns with a distinct structure. Recently we have developed interactive software for analyzing this structure. This software is able to visualize and quantify the patterns of ExB, using as input the automatically digitized time-series of the animal's location. Preliminary results which will be presented in the conference will suggest that a considerable number of rat ExB patterns are also present in the mouse, and they have a significant potential as a phenotyping tool.

We will thus propose in our presentation to augment the commonly used measures of the open field test with a set of new, ethologically relevant parameters. These parameters are relatively independent of each other and reveal a natural structure that is relatively independent of the level of activity. They reflect processes involving motivation, navigation, spatial memory and learning. They can be measured automatically and efficiently, using setups and hardware that are already in use in many laboratories. In order to control the false discovery rate inherent in multiple testing procedures we rely on the FDR method developed by Benjamini and Hochberg. This study may promote a quantitative approach to the study of behavior patterns. It might also encourage interdisciplinary research between the fields of behavioral neurogenetics, ethology and cognitive psychology.

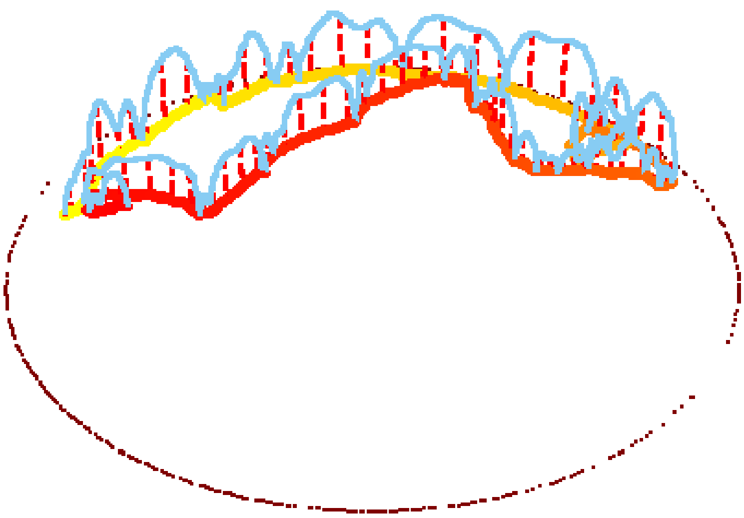

Figure 1. *A phase space representation of an excursion of a BALB/cJtau male from home base and back to it. The time course is coded by the color (yellow = start, red= end), and velocity is represented in azure in the third dimension. For ease of interpretation, the red dashed lines show the projection of some values of velocity on the plane of the path. The frequent short stops (velocity graph touching path on ground) characterize BALB/cJtau locomotor behavior.*

In a project now being carried out in our respective laboratories we plan to:

1. Isolate and quantify patterns that characterize mouse ExB.
2. Investigate which patterns have the highest potential as a phenotyping tool.
3. Develop standardized user-friendly software and a protocol for high-throughput analysis of mouse ExB.

4. Create a freely accessible web-based genetic repository of analyzed ExB along with the protocol and software.

This project is supported by NIH grant 1 R01 NS40234-01.

SEE: Software for the Exploration of Exploration

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The complexity of exploratory behavior creates a need for a visualization and analysis tool that will highlight regularities and facilitate the generation of new hypotheses and algorithms of quantification. SEE is a program developed by us for this aim. The raw data for SEE are a time series of the animal's coordinates in space, sampled at a rate that permits a meaningful computation of velocities (~10 Hz).

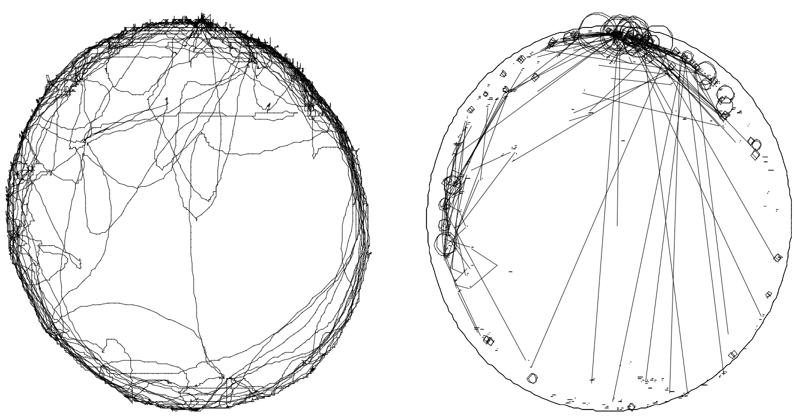

Figure 1. *A path plot created by a hooded rat in a 6.50 m diameter arena during a 20 min session (left) and an analysis of that path into segments (right). "Bubbles" represent stops, where the size of the bubble stands for stop duration. Movement segments are represented as straight lines that connect the start and end points of the segment, regardless of the actual path. The analysis on the right highlights home base location and the straight lines highlight the home base's high connectivity to most of the arena.*

SEE provides:
- Visualization of the path of the animal and a computation of the dynamics of activity (PathPlot, see Figure 1).

- Visualization of the decomposition of the path into several modes of motion (e.g. 1st gear, 2nd gear, 3rd gear; see [1]) and the computation of typical speed, spatial spread, and proportion of each of these gears.
- Visualization of the location of stopping episodes [3] together with a representation of the duration of each episode (TimePlot). This highlights the home base phenomenon [2] and permits a computation of the spatio-temporal diversity of stopping episodes [4].
- Decomposition of the animal's path into "excursions" and computation of the number of stops per excursion [3].
- Visualization of the phase space (path + velocity in the third dimension) of any segment or list of segments.
- Visualization of the way places in the animal's operational world (as highlighted by TimePlot) are connected one to the other, as well as any subset defined through computable properties (To[place], From[place], etc.).

We will demonstrate the properties of SEE on our computer demo both on our own and other laboratories' data, provided data files are sent to us for examination and preparation (smoothing and initial segmentation), and found appropriate, 6 weeks ahead of time. EthoVision track files are welcome, as well as any other format consisting of a time series of coordinates in a machine-readable form.

This project is supported by NIH grant 1 R01 NS40234-01.

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A novel automated apomorphine climbing test

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Apomorphine-induced climbing behaviour in mice is used by the pharmaceutical industry for selecting compounds, which interact *in vivo* with dopaminergic neurotransmission [1,4,5]. Classically, climbing is determined visually using various climbing scores: climbing/not-climbing [6], duration of climbing [1], or rank scales [2,4]. These methods require a well-trained observer, while observational bias may result in differences between two experimenters. An automated scoring system would minimise differences and improve reproducibility and efficiency. The validation of a novel, automated climbing system that detects the climbing activity of mice by means of electrical conductivity and infrared beam breaks is presented.

Figure 1. *The novel automated system as in use at Organon Newhouse, Scotland (built at ERG/MID departments, University of Nijmegen, The Netherlands)*

Test compound or vehicle is administered subcutaneously (SC) 30 minutes before apomorphine HCl (0.75 $mg.kg^{-1}$, SC). Mice are then placed individually in metal mesh cylinders (diameter 12 cm, height 14 cm, Figure 1) where they stay for 30 minutes during which climbing behaviour is monitored. The system samples continuously and outputs the data as either climbing scores or duration of climbing. The climbing scores and ED_{50} values for inhibiting apomorphine-induced climbing for five psychoactive compounds (Table 1) produced by the automated climbing system were compared to those obtained by visual rank scoring [4].

Average climbing scores per animal were determined by three methods:
1. The average of two visual scores taken at 10 and 20 minutes post apomorphine.
2. The average of the automatic scores in the 10-11 and 20-21 minute periods post apomorphine.
3. The average of the automatic scores in the 10-21 period post apomorphine.

A climbing score is determined by averaging the individual scores in each treatment group and each run. Fifteen climbing scores are thus determined per experiment.

Table 1. *ED_{50} values together with their 95% confidence limits for the inhibition of apomorphine-induced climbing by various psychoactive compounds.*

Compound	**Visual 10, 20**	**Automated 10, 20**	**Automated 10-21**
Clozapine	4.52 (3.19-6.40)	4.06 (2.57-6.42)	4.54 (2.87-7.19)
Diazepam	No Fit	No Fit	No Fit
Mirtazapine	15.5 (8.8-27.4)	15.4 (6.1-39.0)	16.0 (5.3-48.3)
Chlorpromazine	0.29 (0.19-0.45)	0.30 (0.18-0.49)	0.30 (0.19-0.47)
Haloperidol	0.023 (0.016-0.033)	0.017 (0.012-0.026)	0.018 (0.013-0.023)

For the compounds tested, 75 visual climbing scores were plotted against 75 automatic climbing scores, and a regression line was fitted. Results obtained showed a good correlation between visual and automated climbing scores (r=0.94, Figure 2) and calculated ED_{50}'s (Table 1).

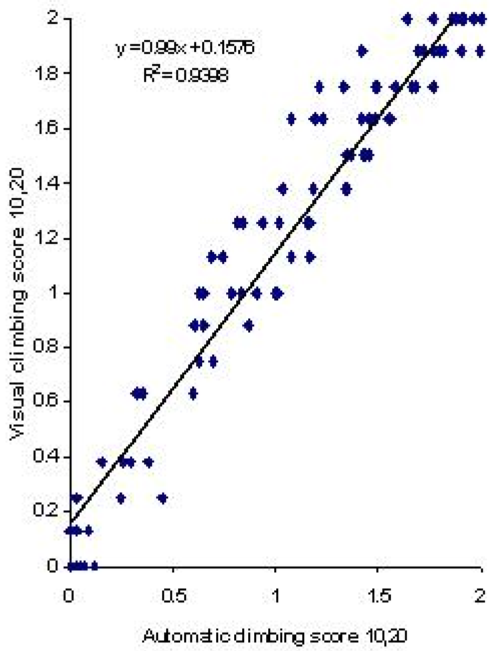

Figure 2. *Plot and the linear regression between the automatic scores and the visual scores.*

Automatically scoring climbing is not a new approach, a mechanical system using the force applied to a transducer by a mouse climbing a cage, was described as early as 1977 [3]. However, mechanical systems require calibration and are more prone to failure. Our automated climbing system not only correctly identified active test compounds, but also generated climbing scores and ED_{50} values similar to those obtained by visual scoring. This novel climbing system is an efficient and validated instrument for drug discovery and development.

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A proposed comparative study on fine hand posture to capture and quantify unimanual and bimanual dysfunctional behaviour in a virtual environment

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This paper proposes the need to scrutinize hand dysfunction, a subject that has a substantial body of knowledge. However, the departure lies in the inability to quantify or apply metrics to hand impairment. The paper proposes to apply virtual world technology in order to diagnose, quantify, enhance and revitalize hand usage that has otherwise been restricted or impaired with subsequent impact on life or later life. Hand dysfunction here covers: impaired function through disease rendering the hand physically abnormal relative to typical behaviour, the inability to construct precision patterns as a consequence of cognitive and/or motor brain dysfunction manifesting as tremor, spastic, Tourette's syndrome, or through bad health, aging, accidental mishap and birth defect. A highly specialized example of the functional use of precision patterns is in clinical-surgical medical practice or engaged in instrument making. The focus is on conduct and completeness of precision prehension patterns that are central to any intricate, delicate, dexterous and precise activity performed in daily life.

The proposed study suggests a departure from a passive un-inclusive instance to one where 3-dimensional quantitative measurement and monitoring occurs through applying virtual world technology (VWT). On a contempoaray basis, that comprises of a top-end workstation, with peripheral hardware, such as glove input device(s) (e.g. Cyberglove™) and a head-mounted device (HMD), that are used to interact/be immersed in a software- generated, 3-dimensional virtual environment (VE). It is the property of immersion and context of interaction that will register and define the type of hand dysfunction in a VE. The proposed first stage of testing lends itself to general 3-dimensional spatial-temporal quantitative measurement that observes a prescribed sequence of scenarios addressing both unimanual and bimanual behaviour. The study observes ethical practice in that the subject should not approach or register pain under the sequence of events. Subject(s) with hand dysfunction(s), that is unimanual or bimanual should at least be able to wear a standard glove-input device, with the proviso of not severe physical abnormality. The subject(s) proceed through routine manipulatory scenarios; dynamic and static, that is hand gesture and hand posture. The quality of the hand pattern is captured spatial-temporally in 3 dimensions. The second part of the test may act as a comparative template against the subject(s) database of behaviour with specialized hand function of a surgeon to normal cases. The essences of the study is to be able to quantify, introduce metrics and to define the disparities between a normal able hand, relative to specialized hand function of a variety of factors to hand dysfunction. The article places significance on the fingers (extensors) extremities tips, pads and sides, yet not with the inclusion of nails. The study appraises and captures hand capability and provides for a forum in recuperative or corrective strategies and behaviour of hand use.

The areas where the findings would have an influence is in rehabilitative physiotherapy (provides a new lease of manipulative activity to hand impaired subjects), dexterous robotic manipulators, clinical-surgical medical practice and telepresence in and out of a virtual environment. Another dimension addresses an aging population susceptible to diminished hand activity, as well as introducing a possible technique as a diagnostic tool to monitor onset of dysfunction. The ramifications of the work are widespread.

Gripping the tail of *taiep* rats a myelin mutant is an effective way to induce cataplexy episodes: an ontogenetic study

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The *taiep* rat is a neurological mutant with immobility episodes (IEs) which are elicited by gripping the animal's tail or body (thorax). During cataplexic attacks the cerebral cortex is desynchronized and theta rhythm appears in the hippocampus, suggesting a REM sleep state. In previous experiments we alternated gripping the animal's body (B) and tail (T) to induce immobility episodes. The present study tested which method T or B is better to induce IEs in male and female *taiep* rats from 5 to 12 months of age.

Figure 1. *Taiep rat during a cataplexic episode induced by gripping the animal's tail.*

Animals were maintained under standard laboratory conditions. All experiments were done at 8:00 A.M. when an acrophase of gripping-induced IEs arises. We tested the feasibility and dependency on the order of execution of gripping-induced immobility methods by performing the four possible combinations (TT, BB, BT, TB).

Gripping-induced IEs are more frequent after T than B. TT produced about 4.43 IEs out of 18 trials (24.6%), TB 3.67 (20.4%), and BT 4 IEs (22.2%), but BB only induced 1.38 IEs (7.7%). In the case of BT and TB 98% were induced by gripping the animal's tail. BB was statistically different from TT, BT and TB (ANOVA $p < 0.001$, followed by Dunnett $p < 0.05$). It was easier to induce IEs when the rats were between 7 and 8 months of age (ANOVA $p < 0.01$); after that the frequency of IEs decreased with age. At 7 and 8 months of age, the number of gripping-induced IEs is sexually dimorphic, being the males more responsive.

These results show that gripping the animal's tail rather than its body produces IEs. Seemingly, differences between methods to induce immobility episodes are frequent. For instance, narcolpetic Doberman-Pinscher shows food-elicited cataplexy more frequently than play-elicited cataplexy. *Taiep* rats also show more IEs at 7-8 months of age with a marked sexual dimorphism, an interesting phenomenon that is worth studying further. In human beings too the cataplexic episodes are dependent on the age of the patient and are produced by a strong emotion. These results support that *taiep* rats are a suitable model to study cataplexy.

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Simultaneous radiotelemetric monitoring of the effect of D_2-like dopamine receptor ligands on core temperature and home-cage activity in rats

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The D_2-like dopaminergic receptors play an important role in thermoregulation and motor behaviour. However, due to lack of selective ligands the functions of D_2 and D_3 receptors are still to be established. D_3 receptor preferring agonists such as 7-OH-DPAT or PD-128907 were found to cause hypothermia and hypoactivity in rodents. The preferential D_3 antagonist U-99194A induced increase in locomotor activity. It is assumed that these effects result from the action on postsynaptically localized D_3 receptors. However, changes in body temperature and in motor activity usally are measured in separate studies, often applying diverse doses of the agonist or antagonist compounds. Simultaneuos monitoring of the the two parameters by radiotelemetry, a technique obviating stressful interventions, could yield comparable and more reliable data while attempting to clarify the role of the dopamine receptor subtypes in these behaviours.

In our experiments we used a six-channel Mini-Mitter TR-3000 telemetry system and measured the body temperature and home cage activity of male Wistar rats weighing 200-220 g at the beginning of the experiment.

The D_3 antagonist U-99194A at a dose of 12 mg/kg sc. significantly increased the home cage activity of the animals without exerting any effect on body temparture. At doses of 0.1-0.3-0.5 mg/kg sc. (±)7-OH-DPAT elicited dose-dependent, significant hypothermia with maximal effect of -2 °C. The effect produced by the 0.5 mg/kg dose was not attenuated by 12 mg/kg sc. U-99194A. None of the tested doses of 7-OH-DPAT had any effect on spontaneous activity of the habituated rats; however, after concomittant adminstration with U-99194A a clear increase in home cage activity was registered. At 0.5 mg/kg sc. dose (±)PD-128907 induced 0.5 °C hypothermia. This mild, but significant hypothermia was partially inhibited by co-administration of U-99194A. Similarly to 7-OH-DPAT, PD-128907 did not alter the activity of the animals, but given together with U-99194A hyperactivity was observed.

Since U-99194A shows high selectivity to the D_3 subtype it seems reasonable to assume - in accordance with the literature - that the molecule exerted its observed activity via D_3 receptors. However, the two supposedly D_3 preferring agonist did not influence the activity of rats in the dose range in which they produced hypothermia. This lack of effect together with the fact that the antagonist was still able to induce hyperactivity in rats treated with the agonist molecules, suggests that D_3 receptors were unaffected by 7-OH-DPAT or PD-128907. The ineffectiveness of U-99194A against the hypothermia induced by 7-OH-DPAT also points out the absence of D_3 receptors in the action of the agonist compund. Contradictory to the above conclusion, the fact that U-99194A was able to inhibit the hypothermia elicited by PD-128907, a compound with higher D_3 selectivity than 7-OH-DPAT, suggest the involvement of D_3 receptors in the hypothermic action of PD-128907.

Intake behaviour of horses offered short chopped high temperature dried lucerne and short chopped lucerne silage

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The physiological process of particle breakdown commences with mastication during food intake. In ruminants intake behaviour has been measured extensively as an indicator for diet selection and apparent palatability of feedstuffs [1,4]. Short-term intake behaviour can also used as a long-term predictor of food intake and for its contribution to fragmentation of plant structures for nutrient release. Although equids cannot re-masticate feed and their digestive physiology predisposes particles to much less efficient breakdown [3], little research on ingestive behaviour and its effects has been done.

Nine horses, with no previous experience of lucerne products, were offered short chopped high temperature dried lucerne (DL; 0.87 DM) and short chopped lucerne silage (LS; 0.39 DM) in three phases using a latin square design (Phase 1: 400g DL, Phase 2: 400g LS; Phase 3: 400g DL and 400g LS). An ethogram was developed to record behaviour patterns for analysis of transition matrices and choice-selection behaviour. Three classifications of behaviour were identified: '*Olfactory/Sensory Response*': **sn**iffing, **ni**bbling, **no**dding, **bl**owing, '*Feeding*': **bi**tes, **ch**ewing **in** trough, **ch**ewing **out** of trough, **li**cking; and '*Rejection*': **m**oves **a**way (Figure 1). Intake behaviour was also measured by recording short-term intake rates (STIR; chews min^{-1}; chews $bite^{-1}$, chews kg^{-1} DM and intake min^{-1}).

A visual representation of intake behaviour, using timed sequential data of each behaviour pattern was produced with a specially constructed computer programme [2]. From this 'Olfactory/Sensory Response' increased significantly when LS was offered ($p<0.01$) and preference of ingestion to DL occurred ($p<0.01$; Figures 1a-c).

Stir data confirm this with a chewing rate of 30.57 (s.e. 4.69) and 54.04 (s.e. 2.14) chews/min for DL and LS respectively ($p<0.01$). Intake rate was significantly higher for DL (91.1 g DM/min, s.e. 5.38, LS: 37.29, s.e. 3.61; $p < 0.001$).

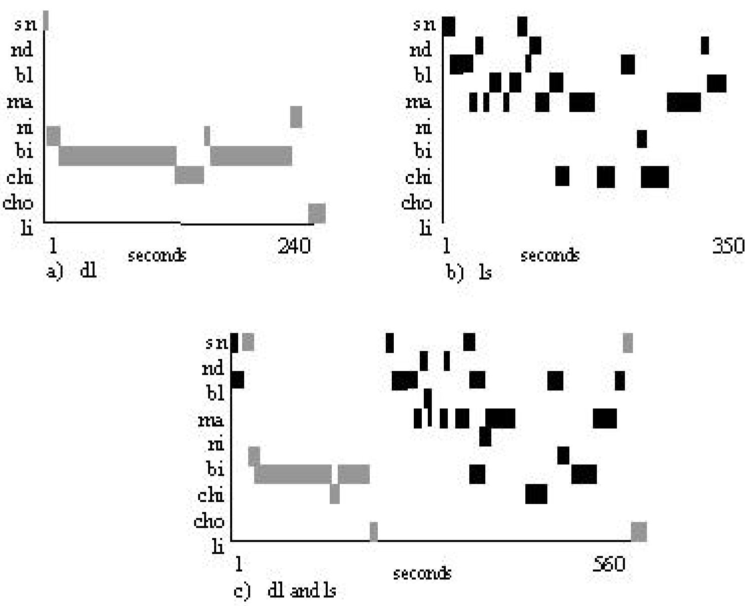

Figure 1. *Ethograms for one horse fed (a) dried lucerne, (b) lucerne silage, (c) choice of both.*

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Investigation of food retrieval behavior in rats

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A new model of studying of the food retrieval behavior (FRB) in normal rats and in rats with disturbed functions (e.g. olfaction and alimentary motivation) is suggested. Four small boxes like matchboxes (6 x 4 x 1 cm) are attached at the corners of the chamber (30 x 40 cm). A pellet is hidden randomly in one of these boxes. To be opened easily, all boxes are opened slightly (0.5 cm). The rats are food deprived for one day in their home cages before trials. The rat is placed into the chamber and is taken out after the finding of the food. Maximum time of staying in chamber is 10 min. For studying of FRB the following parameters are computed: 1) time of the food search till the moment of the taking out of the pellet; 2) the number of false attempts (when the rats open empty boxes); 3) unsuccessful searches (if the rats don't find the pellets in 10 min); 4) number of approaches to the boxes. The behavior of rats during search food period (grooming, rearing, freezing, etc.) can be investigated too.

In our experiments this model was used for studying FRB in rats with the lesioned amygdala and neurotransplantation (Ermakova *et al.*, 1984, 1989; Ermakova, 1987, 1999). In one of our researches FRB was investigated during the first 30-40 days (10 trials) following the electrolytical destruction of the basolateral part of amygdala and the transplantation of the embryonic tissue into the lesioned region (Ermakova *et al.*, 1989, 1990). A sampling experiment was carried out prior to the surgery. Only rats that found the food during 5 min were selected for experiments. Selected animals then were divided into groups, taking the time of food search in the sampling experiments into account.

The average amount of search time was 120-180 s. FRB of the operated rats was compared with the same of intact animals. The average value of the search food time in 10 experiments was significantly greater in the group with the lesioned amygdala (325 s) than in the group of transplanted rats (38 s) and in intact animals (40 s). This model has some modifications. For example using the model it is possible to study also cognitive functions (learning, memory, cognition, etc.) in rats, putting the pellet into the boxes in the special order, but not randomly.

Sleep-wake cyclicity in very low birthweight infants

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Introduction

State organization is an early indicator of the infant's orientation to the environment, self-regulatory capacities, and cognitive maturation. Premature infants typically exhibit difficulties in regulating sleep and wakefulness. In this study, sleep-wake cyclicity was compared in two groups of premature infants: infants born at very low birthweight (VLBW; 1000-1500 g, n=40) and infants born at extremely low birthweight (ELBW; <1000 g, n=30.).

Method

Trained coders observed the infant's states over four consecutive hours in 10-second frames and marked changes in infant state using a special computerized event-recording program. Observations were conducted for all infants at 37 weeks post-conception age. The following states were coded: quiet sleep, active sleep, transition, cry, unfocused wakefulness, and wakefulness. The relative frequency of each state was compared between the two groups. In addition, state cyclicity was measured using Fast Fourier Transformation (FFT) and the amplitude, number of cycles on the power spectra, and duration of each cycle were compared.

Results

Infants born at extremely low birthweight showed lower proportions of quiet sleep and wakefulness and higher proportion of active sleep. Results of the FFTs showed that the amplitude of sleep-wake cycles were lower in the ELBW, suggesting lower degree of state regulation. There was no indication of the Basic Rest Activity Cycle – a cycle of sleep and wakefulness lasting approximately 45 that is observed in healthy neonates – among the ELBW infants.

Conclusion

The results suggest that, compared to VLBW infants, infants born below 1000 g and before 30 weeks gestation may constitute a special risk group. This group may show more pronounced difficulties in state organization and proper regulation of sleep and wakefulness and these may be associated with specific forms of compromised development.

Fiat lux! Spotting a common experimental problem

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Type and intensity of illumination is a critical but often neglected factor for behavioral experiments in inbred and mutant mice. The lack of sensibility to this problem is partly due to technical problems. Even illumination of experimental arenas, for instance, is hardly achieved due to shadows caused by walls of the setup. Uneven illumination, however, might hamper behavioral analysis, if mice prefer darker zones. Importantly, such a preference might critically depend on strain and genotype, resulting in the risk of false positive or negative findings. To overcome these difficulties, we constructed a reliable light source that illuminates an experimental area (e.g. Open Field) evenly with a sharp edge at the border of light and dark and with a precisely controllable intensity between 0.1 and 1200 lux. Additionally, various filters can be used to restrict the light's wavelength or to project geometric figures onto the arena. In this way, a dark-light situation can be created, which, in contrast to common Dark-Light setups, allows observation of the animals in dark and bright zones without influence of thigmotaxis. By changing the position of the dark zone, the value of a possibly established home base can be quantified against the aversion of the brightly-lit compartment.

Our experiments performed with mice of various inbred strains (C57BL/6J, 129/OLA, DBA/2N) or mutant lines revealed considerable differences between strains and lines in influences of light-intensity on Open Field and Dark/Light behavior. Our findings stress the importance of characterizing a light-sensitivity profile for every strain/line. If light intensities will be individually assigned in follow-up learning tasks, strains could be compared for their cognitive functions at comparable emotional status. In addition, more sensitive experimental conditions would facilitate (or enable) the testing of anxiolytic or anxiogenic compounds.

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Multiunit recordings from the Higher Vocal Center (HVC) in freely moving songbirds using radiotelemetry

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Many brain functions that are involved in the control of behaviour are mainly studied in animals that do not behave because they are anesthetized or restrained. This is due to the lack of adequate recording techniques for the collection of electrophysiological data in freely behaving animals and the lack of powerful algorithms to analyze these data.

One of the important models in the study of the neural control and development of higher cognitive functions is the auditory/vocal system of songbirds. The song of male songbirds is a complex learned behavior that is controlled by a network of anatomically well-defined brain areas, the so-called vocal control network. The aim of the research is to relate neuronal events in the Higher Vocal Center (HVC, one of these brain areas) with overt behaviors of the freely behaving zebra finch (*Taeniopygia guttata*) under changing hormonal conditions.

In order to perform this analysis, we develop a miniaturized radiotelemetry system in combination with chronically implanted electrodes and backed-up by spike sorting software already available in our department. A first prototype of the miniature radio transmitter has already been developed (Figure 1). We show preliminary data collected with this system during singing in the vocal control nucleus HVC.

For the behavioural studies, animals are housed in male-male or male-female pairs in a small shielded enclosure (1x1x1 m). Their songs and body posture during singing are recorded on DAT recorders using acoustic switches. This allows detecting artifacts in the electrophysiological recordings. Further, with the videotapes we are able to analyze the circumstances of singing, e.g. in a sexual or aggressive context and to separate electrophysiological events related to auditory input to the vocal areas from activity related to vocal production. For the sound analysis we use commercially available software

(SIGNAL, Engineering Design, USA). The Observer Video-Pro (Noldus Information Technology) has been chosen as the tool for video analysis.

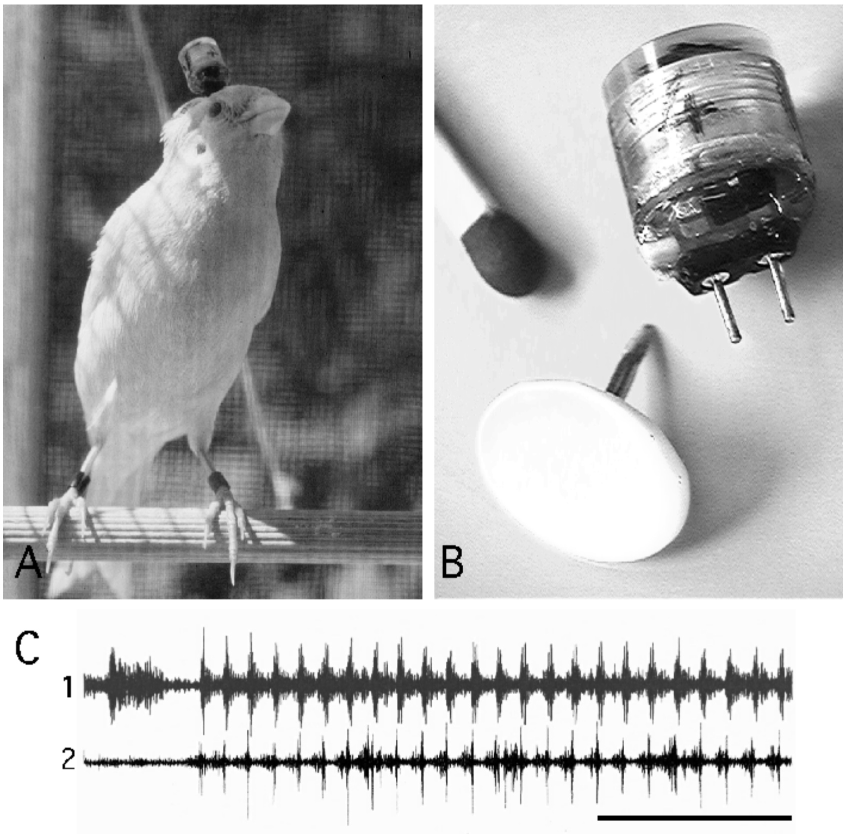

Figure 1*. Prototype of the miniaturized transmitter. A. Songbird with transmitter. B. The transmitter itself. C. Recording (2) of electrical activity during singing.*

The tail suspension test: a mouse model of stress reactivity and behavioral despair with genetic variability

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Introduction

The tail suspension test (TST) models "behavioral despair" and is a well-validated screening test for the behavioral effects of antidepressants in rodents. Remarkably, this paradigm detects the anti-immobility effects of a wide array of antidepressants, including tricyclic antidepressants (TCA), selective serotonin reuptake inhibitor (SSRI), monoamine oxidase inhibitor (MAOI), electro-convulsive shock (ECS), and even buproprion and atypical antidepressants.

Aims

This experiment was designed to test for genetic differences in "behavioral despair" and in imipramine responsivity among inbred mice strains. A second aim was to examine TST responses as a "stress reactivity" paradigm. We investigated the relationship between measures of immobility responses in the TST and the body temperature response following TST (a stress response).

Methods

Eleven inbred strains (129S6/SvEvTac, A/J, AKR/J, Balb/cJ, C3H/HeJ, C57BL/6J, DBA/2J, FVB/NJ, NMRI, SencarA/PtJ and SWR/J) were judiciously selected to represent the genetic diversity of inbred mouse populations. All mice underwent two trials of TST: (1) spontaneous, basal TST and (2) imipramine (30 mg/kg, i.p.) or saline TST. Duration of immobility was recorded during TST in 11 strains, and core temperature was measured in 4 strains (129S6, A/J, C57BL/6J and NMRI) following both basal and imipramine/saline TST.

Results

For the 11 strains tested on TST, significant strain differences in immobility duration were found for both basal TST and imipramine response TST, with heritability estimates of 0.31 and 0.60 respectively. Immobility duration for the DBA/2J, FVB/NJ and NMRI strains were significantly reduced for the imipramine groups compared to their corresponding saline groups. Surprisingly, the reduction of immobility was independent of the basal immobility (r=-0.06). Using an imipramine responder (NMRI) and imipramine non-responder (129S6) on TST, blood and brain leves of imipramine did not significantly differ between strains. Significant strain differences were also found for basal TST-induced hyperthermia, with NMRI strain showing the highest (38.5 °C) and A/J the lowest (36.5 °C). Imipramine (30 mg/kg, i.p.) demonstrated significant pharmacological activity in reducing body temperature in the 129S6 and NMRI strains. Remarkably, imipramine (30 mg/kg, i.p.) differentially exhibited an anti-immobility effect on TST in only the NMRI strain, but not the 129S6 strain. Furthermore, in the 129S6 strain, the TST-induced hyperthermia was selectively blocked with propranolol (10 mg/kg, i.p.), while this agent had no effect on immobility.

Conclusions

1. Strain differences in the basal TST immobility demonstrate genetic variability and suggest that "behavioral despair" may be a "stress reactivity" trait.
2. Strain differences between imipramine responders (NMRI) and non-responders (129S6) represent pharmacodynamic differences and not pharmacokinetic differences.
3. The non-significant correlation between basal TST immobility and anti-immobility effect of imipramine in the TST indicates distinct genetic architecture for mediating these responses.
4. The differential imipramine responses in the 129S6 strain for the TST-induced hyperthermia and duration of immobility suggest that these phenomena are regulated by separate pathways.

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Cardiovascular measurements of small fish by radio-telemetry: a preliminary study

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For research in fish biology, basic information from individual intact stress-free fish about heart rate frequency, blood pressure, stroke volume and body temperature is essential. Radio-telemetry provides an alternative means of obtaining physiological measurements from awake and freely moving animals, without introducing stress artifacts [5].

In this poster we present for the first time the implantation technique of a telemetry transmitter implanted in the peritoneal cavity of a small fish (50-60 g) which enables us to monitor heart rate (HR), electrocardiogram (ECG) and body temperature in a freely moving fish. With this technique we hope in future to clarify the process of 'metabolic depression' [2,4]. This is a survival strategy commonly applied in animal kingdom in order to slow down the ATP-flux, save energy stores and diminish end-product accumulation (e.g. lactic acid). With direct calorimetry, measuring directly the heat production of cold-blooded fish during anoxia, a 'metabolic depression' was observed in goldfish, tilapia and eel. With a customized version of the EthoVision video analysis system (Noldus Information Technology) we demonstrated that the lowering of the metabolic rate was not caused by a reduction of external activity [3]. Based on these observations, we hypothesize that the cause of the process of 'metabolic depression' can be found at the cellular level. Fifteen years ago, Coulson [1] posed his 'blood-flow' theory, which states that the cellular metabolism is primarily regulated by the blood circulation and the factors it carries (substrates and oxygen). In addition, Guppy [4] posed the hypothesis that an organism under metabolic depression loses it characteristics of multi-cellularity and obtains the characteristics of a unicellular organism. Until now those two theories were neither rejected nor confirmed. Radio-telemetry of the cardiovascular system, in combination with direct calorimetry for measuring the metabolic rate, offers the opportunity to test the two theories of Coulson [1] and Guppy [4].

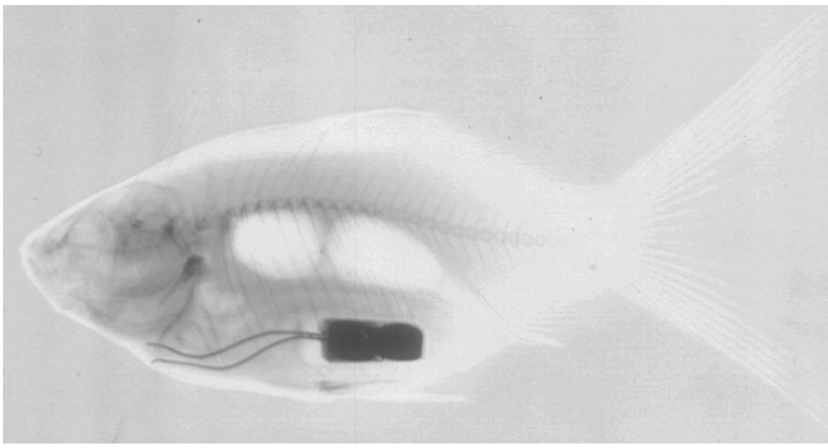

Figure 1. *Goldfish (Carassius auratus L.) of 50 gram with an implanted heart rate frequency transmitter (TA10ETA-F20-L20, Data Sciences International, St.Paul, MN, USA) to monitor heart rate (HR), electrocardiogram (ECG) and body temperature.*

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E-motion: digital image analysis of human body movements

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In the last twenty years of research we have tried to establish a behavioral repertoire of human communication on the bases of traditional coding with behavior categories. This research was basically unsuccessful, and we realized that:

- the meaning of signals seems to depend from too many variables,
- signals show high inter- and intraindividual variation,
- one signal can be substituted by another signal,
- signal combinations and combinations of combinations are possible,
- signals can be used independent from context,
- non-verbal behavior seems to be highly probabilistic,
- non-verbal behavior is norm-governed in different cultures, and
- the same category of behavior can be displayed qualitatively different.

These facts lead to an “atomizing effect” in behavior categories – for an exact description and a complete repertoire coverage the categories will become smaller and smaller eventually until every single performed behaviour has its own category [2]. In addition to these problems traditional coding has to apply information reduction in order to be feasible. Pattern recognition in behavior is only possible by adding a “world model” or “a priori” knowledge to the behavior. Thus, observing with defined behavior categories is already a data reduction, and it seems likely that the information put in the construction of a behavior definition is highly biased in favor of the research question.

In this talk I will introduce a method of behavior analysis which is independent from human categorical perception. The new method for the assessment of quantitative and qualitative description of non-verbal behavior does not use any assumptions on the structure and organization of behavior itself. The applied algorithm (motion energy detection) can analyze the number of movements, duration, size, speed, complexity and information content from videotaped episodes in body movements and voice on a real-time frame-to-frame basis. These parameters then can be translated in expressiveness and emphasis scores.

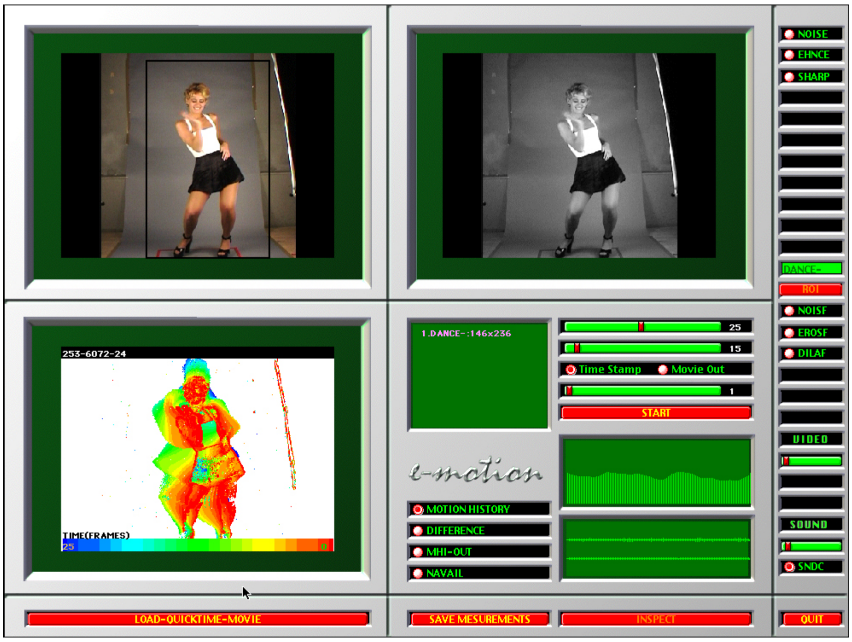

Figure 1. *Screenshot from E-motion 2.0 currently implemented on a Power Macintosh G3. The picture in the upper left is the original from a current study on the attractiveness of body rhythms, the frame shows the region of interest where motion energy detection takes place. The picture on the upper right is a result window for the first filtering steps (noise, sharpening). The picture in the lower left shows the results of motion-energy detection. Red color is the difference between the last picture and the current picture. Blue colors denote differences from now minus 25 frames (1 second). This type of information can be fed to neural networks for movement pattern recognition, or for calculating overall movement speed and acceleration.*

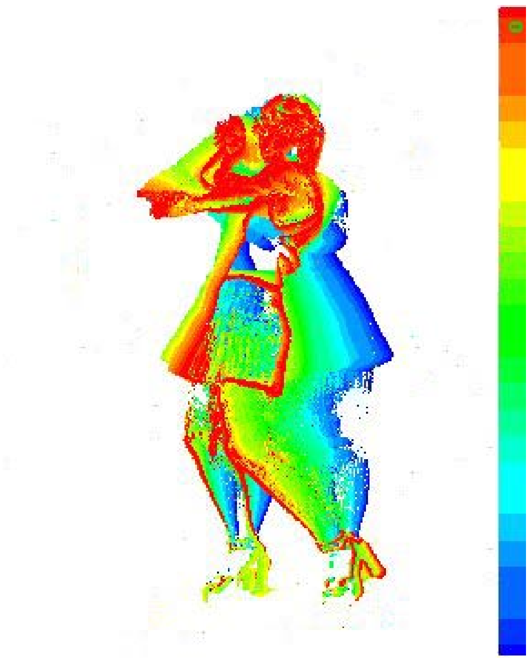

Figure 2. *This picture shows differences between single video frames from a movie of a dancing female. The red color is the difference between the current frame (t) and the frame before (t-1), blue is the difference between the two frames at t-25 and t-24. The colored areas show changes in the pictures - the size of the areas thus denotes the amount of motion. Motion energy is used in this study for detection of overall body rhythms and cyclic pattern stability.*

The areas of current applications are:

- detection of intentions and motivations in interactions among humans [3],
- detection of synchronisation and rapport in interactions, in combination with Theme, a pattern detection algorithm [4],
- classification of the "big five" personality traits and depression in structured interviews,

- gender recognition and classification of gender identification from gait patterns, and
- attractiveness of body movements during dancing (Figures 1, 2).

I will present examples and first results from these research areas and suggest extensions to current communication theories, where the syntactic elements are replaceable by qualitative changes of movements. These qualitative changes could determine the meaning of signals independent from its content. The mechanisms used for signal transmission are probably provided by "mirror neurons", which fire in the frontal lobe (rostral part of the inferior area 6) of the receiver with the same patterns the producer of the movements uses to generate the movements [1]. Thus the brain could be able to decode body movements automatically without adding additional categorical information. If this is the case, current communication theories are basically wrong or an insufficient framework for the explanation of human communication if they rely only on signals in their traditional definition.

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Strategies in birds: new methods to study reversal learning in pigeons

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Cognitive studies with human subjects reveal that performance differences under different conditions may emerge due to shifts in cognitive strategies and not due to neural processing limitations as such. We were interested to develop means for a detailed analysis of strategy shifts during serial reversal learning in pigeons. In this task, subjects first learn a simple color discrimination. After reaching criterion, they are required to repress responses to the rewarded stimulus and to respond to the previously unrewarded one. Upon reaching criterion again, contingencies are reversed once more, etc. Since the activation of NMDA-receptors within the prefrontal cortex are known to be relevant for reversal tasks, we were interested whether a local injection of AP5, a competitive NMDA-receptor antagonist, within the avian 'prefrontal cortex' results in reversal learning pertuberations.

Pigeons learned simultaneous color discrimination (red vs. green) with two pecking keys. They were reinforced with food; incorrect pecks resulted in 3-s time out. Acquisition was finished after reaching criterion (15 correct pecks in a row). In the next session, reinforcement values of the colors were switched. During such a reversal session pigeons first perseverated on the previously correct color. Thus, they were not reinforced at all. After about 40% of total trials needed, they switched from a color to a side perseveration strategy, i.e. they either preferred to peck on the right or the left key. Now the animals received reinforcement on about 50% of trials. Finally the animals learned to peck on the correct color and received food on 100% of trials.

Thus, pigeons followed two different strategies before reaching correct color-association. The relative amount of these three phases changed over serial reversals. While the first color perseveration phase was the longest in the first reversals, it was the shortest at later reversals. AP-5 animals showed a prolonged perseveration within each strategy without the general sequence of events being altered.

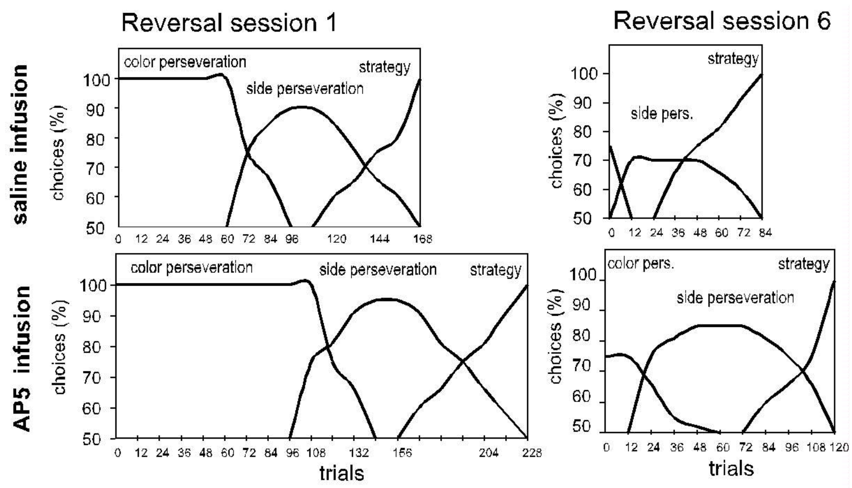

Figure 1.

These data show that a detailed analysis of single choices during serial reversal tasks reveals different behavioral strategies of the animals that resemble 'hypotheses testing' plans in humans.

During the presentation, focus will be placed on methodological and technical aspects of these operant conditioning experiments.

Measuring gripforce on the computer mouse

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During the performance of more demanding writing and pointing tasks, subjects exert more pen pressure towards the working [1]. This is a natural stiffness response to the noisier neuromotor signal in stressful conditions. Both physical and mental stress lead to such adaptive stiffness [3]. Higher stiffness, once the movement is initiated, can be achieved by speeding up the movement or by regulating the level of co-contraction of agonist and antagonist muscles. Acceleration is rather harmless and will only decrease the accuracy. Co-contraction can however be thought of as driving a car while applying the breaks. There is no return of the investment. Co-contraction also diminishes blood flow and thus the supply of nutrients and removal of carbon dioxide in the tissue. It could therefore lead to the beginning of RSI [2]. Being the most widely used input device for computers we designed a squeeze-mouse, sensitive to pressure applied to its sides to test the motor noise theory (NICI technical report 99-05) in the area of human-computer interaction. To measure grip forces, a steel construction, force receptors and an A/D measurement device were placed inside the mouse (Figure 1).

Calibration of the first prototype showed that no conversion of A/D-values to absolute force values could reliably be obtained. Within an experiment the baseline remained constant but was variable on longer time scales. Thus only within-experiment estimates could be obtained. In collaboration with the Hogeschool Enschede two main squeeze-mouse problems were identified. First, the characteristics of the mouse-material influence the measurements. Secondly, there is some type of noise in the signal that is hard to relate to any specific cause. Notwithstanding these problems the results of a first experiment with the mouse confirm the predictions made in the neuromotor noise theory [4].

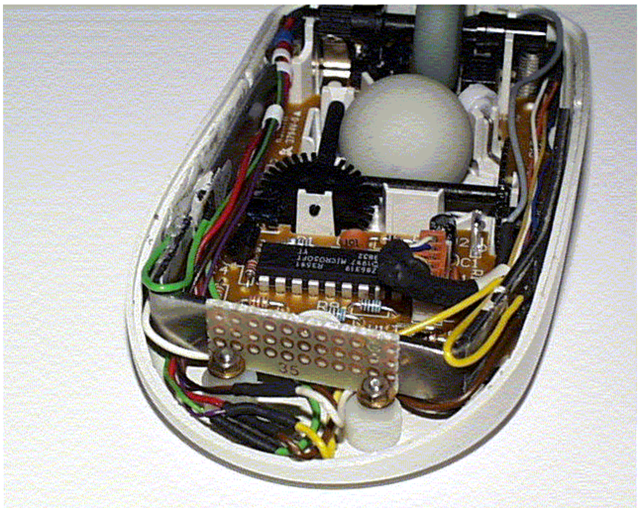

Figure 1. *Interior of the sqeeze-mouse.*

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Measuring what makes behavior possible

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"It is inaccurate – worse, it is misleading – to call psychology the study of behavior. It is the study of the underlying processes, just as chemistry is the study of the atom rather than pH values, spectroscopes, and test tubes." (D.O. Hebb, 1980)

The purpose of measuring behavior in psychology is to make inferences about the cognitive architectures of complex human skills such as perception, memory, language, action, etc. However, the recent decade has seen an enormous development in possibilities to measure and visualize the brain activity that underlies behavior. In this way the neural architectures underlying cognitive skills can be investigated more directly than ever before. This provides an alternative route to making inferences about cognitive architectures. Therefore, next to measuring behavior, measuring the brain has become an important research tool in psychology and cognitive neuroscience. In my lecture I will give an overview about the major brain imaging methods (EEG, MEG, PET, fMRI), their strengths and weaknesses. I will show what they reveal about complex cognitive skills. I will also discuss the advantages of measuring brain activity in the absence of concomitant measurements of behavior, especially in patients with brain damage. This presentation is an introduction to the more in-depth presentations of the other speakers in the symposium "Measuring the brain in action".

Investigation of a new method for physiological and behavioral monitoring of laboratory animals by telemetry

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Measurements of body temperature, heart rate and activity by radiotelemetry have been previously described for laboratory animals as an efficient, reliable, less labor-intensive and more cost-effective means of acquiring data than other measurement techniques which involve animal restraint. One limiting feature however of many telemetric systems is the necessity for battery powered telemetric implants limiting the length of a given study to the life of the implanted battery. We describe the use of a commercially available telemetry and data acquisition system to record heart rate, body temperature and activity of freely moving rats with transmitters that operate without batteries. The system uses PDT-4000HR E-mitters (Mini Mitter Co., USA) to acquire animal temperature, heart rate and activity data. E-mitters obtain power from a radiofrequency field produced by an ER-4000 energizer/receiver so that implanted transponders can collect data on temperature, heart rate and gross motor activity for the lifetime of the animal. ER-4000 energizers/receivers are designed to be placed below the implanted animal's cage. Data output from receivers is managed by an integrated Windows PC based data acquisition system, Vital View, which is capable of monitoring 32 individually housed subjects implanted with E-mitters. Open field behavior is measured with an automatic video tracking system (EthoVision, Noldus Information Technology).

Adult male Sprague Dawley rats (230-250 g) were used as experimental subjects. Weight gain, food intake and home cage activity showed a progressive recovery following intraperitoneal E-mitter implantation surgery with subcutaneous biopotential lead placement, returning to pre-surgery levels 5-7 days following the procedure. Animals with implanted E-mitters performed similarly to un-operated controls in an open field test including the distance moved, mean velocity, rearing and grooming (frequency and duration). Two weeks following surgery daily telemetric recording was started. Diurnal rhythms for all parameters (low during light period 08:00-20:00 h) and high during the dark period 20:00-08:00 h) were established in rats with E-mitters implanted. Pharmacological validation of this system using apomorphine, a non-selective dopamine agonist that has well-documented effects on locomotor activity, core body temperature and heart rate upon acute administration will also be described. We have recently documented the effects of apomorphine using non-telemetric methods [1] so that comparisons can be made between assessment of the response to apomorphine using both telemetric and non-telemetric methods. In conclusion, PDT-4000HR E-mitters with VitalView data acquisition offer a battery-free, valid and reliable means to monitor body temperature, activity and heart rate in freely behaving unrestrained laboratory rats.

Supported by the Higher Education Authority of Ireland.

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The 'Five Freedoms' and laboratory animals

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The concept of 'Five Freedoms' – freedom from hunger and thirst; freedom from discomfort; freedom from pain, injury or disease; freedom from fear and distress; and freedom to express most 'normal' behaviours – was initially used to develop and promote improved husbandry systems for farm animals [2]. This ideal has subsequently been applied to animals kept by humans in a broader range of contexts including zoo, circus and companion animals. Its application to laboratory animals can be particularly challenging, however, as scientific procedures also necessitate compromising one or more of the 'Freedoms', sometimes to a substantial degree. This compromise can often be partly redressed by focussing on the fifth Freedom and trying to encourage 'normal' (but not necessarily entirely 'natural') behaviour. Definitions of 'normal' (or desirable) behaviour often vary, however, and may be based on ethograms, motivational tests or comparisons with feral animals or ancestral species. In practice, dividing housing into separate areas for different activities and providing items for environmental stimulation makes space more complex and interesting, encouraging animals to use all three dimensions of their pens or cages [1]. This is especially important as many experimental animals spend the majority of their time in their holding pens or cages, not undergoing procedures, so they need to have a good quantity *and quality* of space.

The BVAAWF[1], FRAME[2], RSPCA[3] and UFAW[4] Joint Working Group on Refinement is producing a series of publications that explore the potential for applying all of the Five Freedoms to research animals. The reports produced to date are:

- Rabbit husbandry [4]
- Mouse husbandry [3]
- Removal of blood from laboratory mammals and birds [5]

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[1] British Veterinary Association Animal Welfare Foundation
[2] Fund for the Replacement of Animals in Medical Experiments
[3] Royal Society for the Prevention of Cruelty to Animals
[4] Universities Federation for Animal Welfare

- Administration of substances [in press]
- Bird husbandry and use [submitted]
- Transgenic mouse husbandry, care and use [in production]

The RSPCA and UFAW also hold joint annual meetings on rodent and rabbit welfare which focus on refinements in husbandry and procedures. All of these initiatives enable those involved in laboratory animal care and use to improve welfare and reduce suffering with the added benefit of improving experimental results.

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Classifying behavior of freely moving rodents with the help of fuzzy logic

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A variety of computerized systems, such as tracking systems producing X,Y coordinates to classify behavior (e.g. EthoVision [1]) and coding systems using operationally defined behavioral items (e.g. The Observer [3]), has been developed for the analysis of behavior of animals and man.

One has attempted to improve the quality of tracking systems by enhancing the spatial resolution and the sampling rate. However, these improvements do not solve the problem of "splitting" behavioral items, a traditional issue in ethology. For instance, it remains a matter of definition to describe "walking" and "non-walking" as "moving over a minimum distance of 10 cm/s" and "moving less than 10 cm/s", respectively. This problem is the consequence of assessing classic logic in which crisp sets such as the above-mentioned Yes/No splitting are used.

The mentioned problem can be solved by assessing fuzzy logic, a multivalued logic, that allows the merging of data collected with tracking systems and data collected with coding systems. As a result, an infinitive number of alternatives between *Yes* and *No* notations can be mathematically formulated and processed by computers. In this way it becomes possible to differentiate behavioral items such as *walking at normal speed* and *walking just slower than normal* on the basis of the calculated confidence factors.

We will present a method in which fuzzy logic is used to classify behavior of freely moving rats that has been recorded on videotape. The first step of this method implies the classification of postures of rats with the help of Fourier descriptors and a neural network. This results in a coding system in which four-digit codes are used to label postures [2]. The second step of this method implies the calculation of the position (X,Y) and the orientation of the rat in the open field with the help of a tracking system. Finally, fuzzy logic is used to merge both sets of data in order to classify behavior.

We will illustrate that this approach helps to solve the problem of the subjective attribution of labels to behavioral elements as it is normally done in coding systems using operationally defined behavioral items. Apart from this, we will illustrate that this approach can also be used for attributing a mathematically calculated confidence factor to each classified behavioral item.

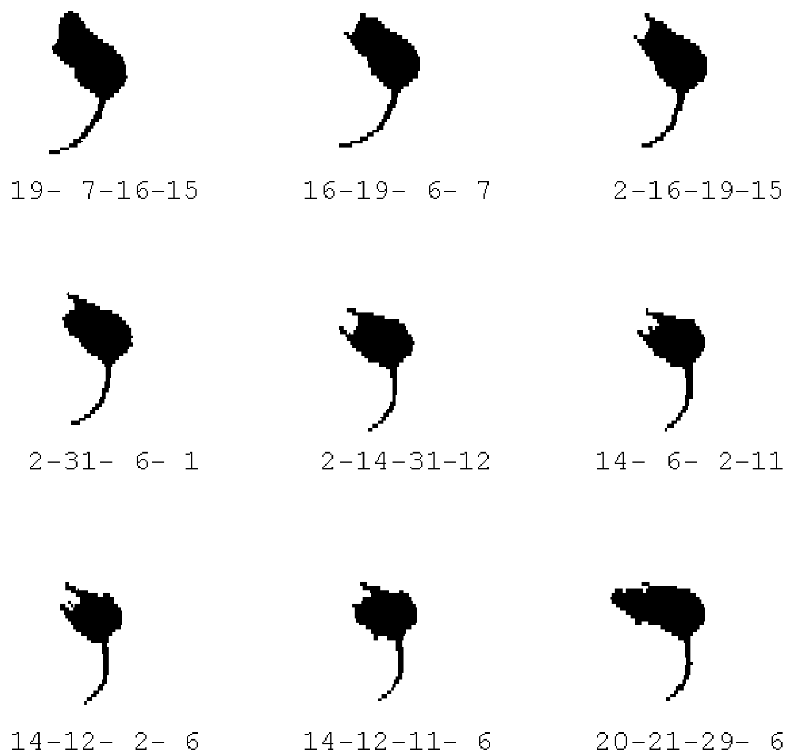

Figure 1. *An example of a coding system, in which a four-digit code has been assessed to assign distinct postures.*

The method including the software program has originally been developed for the analysis of behavior. However, it is generally applicable in a great variety of research areas.

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A model-based study of left-hand fingering on the classical guitar

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A piece of music can be played in many ways on a guitar: almost every note can be stopped in several locations on the guitar neck, and four fingers of the left hand can be used. The result of deciding on a location and a finger for each note is called a left-hand fingering. Even for three notes in a row, there are thousands of possible left-hand fingerings, but when preparing a piece of music for performance, a guitarist considers only a small subset of these fingerings.

In this study, we investigate the influence of the distance the hand has to travel, the initial shoulder angle, and the finger spread on the biomechanical complexity of the fingering. We have designed a model that predicts a ranking of fingerings according to cost functions based on these biomechanical complexity factors. To gain support for this model, an experiment was designed, in which professional guitarists play short musical sequences. The distance the hand has to travel, the initial shoulder angle, and the finger spread are manipulated by prescribing different fingerings. While the guitarist is playing these scale patterns, the three-dimensional movement of the fingers of the left hand is monitored using the OptoTrak system. The sound of the guitar is recorded simultaneously. The design, as well as some preliminary results will be presented.

The automated hole-board COGITAT detects long-term effects after cerebral oligaemia and intracerebral iron

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In order to follow the development of event-related deficiencies, whose appearance may be delayed or may be progressive, and in order to gain an accurate impression of the time course of such abnormal behaviour patterns as may arise, it is necessary, at various times to follow many different behavioural parameters *simultaneously* under comparable conditions.

Features thought to be associated with neurodegenerative diseases include oligaemic episodes and increased iron concentrations in discrete brain regions. Therefore, male Wistar rats which had a 60 min oligaemic episode (bilateral clamping of carotid arteries: BCCA) or sham-operation were injected one week later with $FeCl_3$ either intranigrally (35ng/0.25μl, bilaterally) or intrastriatally (1.5μg/2μl, unilaterally), or the same volume of buffer.

The mechanical opto-electronic system COGITAT (Cognitron GmbH, Göttingen, Germany) was developed for the *simultaneous* measurement of spatial learning, working and reference memory, overall exploratory activity, visits deep in the holes of a hole-board as well as perfunctory inspections of the holes, and the sequential collection of hidden food pellets, as well as re-learning after different time intervals, and the shifting capability, *together with their statistical and graphic presentation*. The board, with 25 deep holes, is framed by transparent walls and has a special entrance with a starting box where the rats adapt for 10 s before entering the board. Eight of the holes are serially baited with small (40 mg) food pellets distributed in a distinct pattern not visible to the animals while walking. The animals are tested in a random manner, and learn the pattern during exploration, using their individual strategies. A trial on the board ends as soon as the animal has found and eaten all of the 8 pellets or after a predetermined time, whichever is sooner. Care has to be taken that subsequently the animals are always handled by the same experimenter, and experience the identical environment including identical intra-maze and external cues, and that they are tested at the same time of day, taking the yearly summer and winter clock changes into consideration. Starting one week prior to the test period, and throughout the entire experimental session, the animals have to be put on starvation rations (12-15 g of laboratory chow), so their weight falls to only ~90% of normal [1]. On experimental days, animals have to be adapted to the experimental room for 1 h before the start of the experiment, remaining in their home cages, and during this time receiving their whole daily food ration *before* the experiment begins. After having learnt to find all the hidden pellets distributed in a pattern "A" mainly in the centre of the board over 10 3-min sessions (1/day), over 8 1-min sessions, and finally 13 30-s sessions three months after surgery, the animals were then immediately confronted with pellets hidden in a new pattern "B", adjacent to the board enclosure [1]. After 6, 9, 12 and 15 months after surgery (for striatally injected rats), or 7, 12, 15, and 18 months (for nigrally injected rats), the patterns were offered to each animal in an alternating sequence: pattern A on five successive days, followed the next week by pattern B on five successive days, followed by pattern A again the next week, and vice versa, i.e. after a break of about three months starting with that pattern that had not been presented at the last experimental session previously.

Intracebrally increased iron, alone or after BCCA, leads to alterations in the hole-board performance. This however depends on which side the iron was injected. While the effects of unilateral striatal iron amounts seem to be made worse by an oligaemic episode, one week beforehand, a previous BCCA episode appears to ameliorate the adverse effects of the bilateral administration of minuscule intranigral iron deposits. Remnant subtle deficits seem to get corrected through an altered learning strategy. The COGITAT system provides data that enable one to recognise specific deficiencies in different pathological situations by analysing the complete range of at least 25 different behavioural parameters and can thus provide an objective characterisation of any system being analysed.

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Signals behind motoric expressions: I. Recognition and spatial preference in juvenile birds

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Juvenile learning in the avian model involves at least two components of mutually contrasted motoric expressions: one set involves distinct calling patterns such as isolation-induced despair vocalizations (DV; [2]) and has been found to be a reliable measure signaling emotional and hormonal status [1]. The other set is provided by progressive movement and has been taken as an indication for early exposure learning in a long series of experiments. Here we combine both groups of signals and study their inter-relation under semi-natural conditions. DV calling patterns are recorded simultaneously together with spatial location preference within cue-polarized fields. Visual cues are provided by specific spatial arrangments of mirrors. It is shown how place responses can become dissociated by measures of emotional expressions and postnatal experience (isolation, social groups with conspecifics, grouping with undisposed visual signals).

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CAPTIV: software for the analysis and prevention of vehicle accidents

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The aim of the present study was to provide practical assistance to HGV drivers when reversing into a freight-handling bay. Too many serious and even fatal accidents occur during this maneuver and driving instructors themselves have no effective tool for assessing its performance.

Prior in-depth knowledge of driver-implemented maneuvering procedures is required to design an efficient form of assistance. Visual requirements form one of the most important factors for the work especially in relation to vehicle driving. Performance of this analysis has been possible through the use of an advanced data acquisition unit, CAPTIV, which allows the recorded image of the situation to be registered, analyzed and synchronized with each type of event reported through sensors or a visual behavior data entry keyboard.

Using a data entry keyboard, an experimenter sitting in the driving station passenger seat records the localization of the driver's look at four different zones of the visual field (at the same time, the driver is filmed by a dashboard-mounted mini video camera). However, for its interpretation, this parameter has to be related to other indicators connected with the situation under study. The angle of break between trailer and tractor unit was measured indirectly by a potentiometric sensor positioned as close as possible to the fifth wheel (part located between the trailer and the tractor unit, which ensures articulation of the vehicular combination).

The lorry trajectory is also identified by means of a mini video camera positioned at the rear top center of the semi-trailer, which records a rearward view from the semi-trailer and enables it to be localized with respect to marks on the ground.

The maneuver is considered to have started when the driver engages reverse gear and to have ended when the lorry comes to a halt. An attempt is counted when the lorry re-passes the parking line in forward after entering the parking line in reverse. Final position accuracy is evaluated by measuring the distances in centimeters between the obstacle(s) and the semi-trailer when the lorry has completed its "handling bay entry" maneuver.

Simply describing the procedures adopted by drivers has allowed identification of a number of the factors, which make the maneuver difficult. It has been possible to break the maneuver down into several stages which, when compared with HGV driving instruction strategies, will enable development of a maneuver teaching procedure and design of a reversing assistance system based on ultrasonic detection of obstacles with in-cab audio feedback.

The planned ensuing study will focus on analyzing changes in driver activity after introducing this reversing assistance system in the cab. The study will enable the approach aimed at understanding the perceptive and operating difficulties associated with the task to be supplemented to remedy these difficulties.

Fuzzy-neural approach for improved classification of pig-cough frequency features

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The ability to adapt information of acoustic bio-responses from pigs in animal houses will mainly depend on an accurate automatic recognition of the sound of interest. A natural acoustic indicator of animal welfare is the appearance (or absence) of coughing in the animal habitat. In previous research a simple on-line recognition technique for pig coughing has been presented. This resulted in positive cough recognition of 92% of the sound database consisting of 5319 individual sounds among which 2034 coughing. Sounds were collected on 6 healthy animals and contained both animal vocalisations and background noises. Each of the test animals was repeatedly placed in a laboratory installation in which coughing was induced by evaporation of citric acid. A 2-class classification into 'cough' or 'other' was done by application of a distance function to a spectral sound analysis. However, for the whole sound database there was a misclassification of 21%. As spectral information up to 10000 Hz is available in this paper an improved overall classification on the same database is presented by applying the distance function to several frequency ranges in combination with a neural network approach.

Telemetric measurement of heartbeat sound during behavioural testing in laying hens

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As part of a study on feather pecking behaviour in laying hens we wanted to evaluate the effects of genetic selection for high and low levels of feather pecking by (1) a characterisation at the behavioural level and (2) a relationship with a relevant physiological variable. Therefore, we developed a simple non-invasive telemetric method to monitor the heartbeat with a microphone of freely moving hens.

Birds originated from two batches of the S3 generation of lines selected for high (HL, n=24) or low (LL, n=24) levels of feather pecking [1]. Behavioural testing included Tonic Immobility (quantified by number of inductions and duration) and Open Field responses (recorded on videotape and concurrently coded for latency scores and locomotor activity during 10 minutes observation periods). The heart rate recording equipment consisted of a microphone, a custom-built amplifier, an UHF FM radio-transmitter with short antenna, and a battery package all mounted in a nylon harness fitting the thorax of the bird. At a distance of 3-10 m from the experimental bird signals were received on a radio-receiver coupled to a filter, an oscilloscope, and a DAT recorder. The microphone (Knowles 2833) was fitted with a conical metal collar and coupled to the skin above the left m. pectoralis by harness pressure. Signals were high-pass filtered (25 Hz), amplified by a factor 100, and transmitted at 418 MHz (Radiometrix TXM-418-A) to the receiver (Radiometrix SILRX-418-A). Here signals were band-pass filtered (100-150 Hz) by custom-built four-poled active filters and monitored on a Philips digital oscilloscope, while being recorded on DAT (Sony TCD-D10 PRO). The processing of heartbeat recordings was performed off-line with sound analysis software (BatSound Pro 3.0, Pettersson Elektronik AB) after digitising (Soundblaster) the DAT recordings. The heartbeat rate was quantified by manually adjusting measuring cursors and using the pulse interval analysis feature to calculate an average value of heartbeat rate every 5 seconds throughout the test periods.

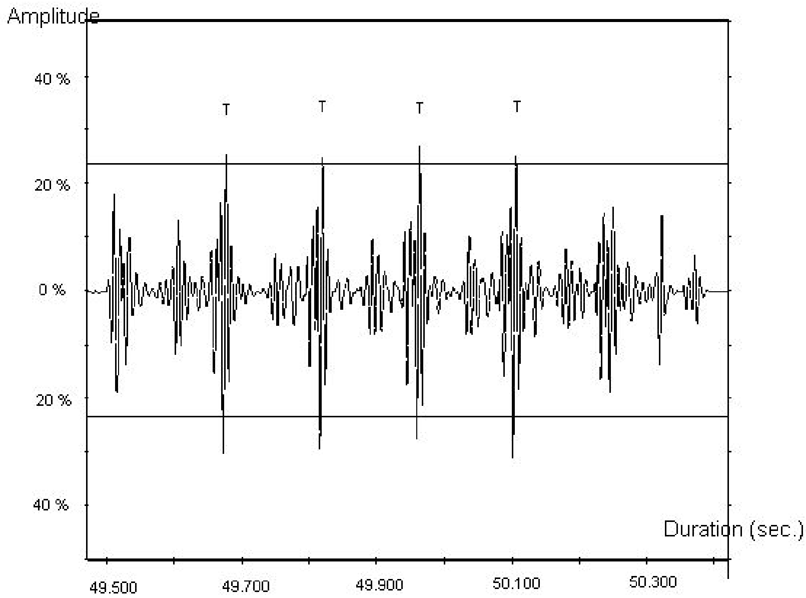

Figure 1. *Heart beat signals with measurements identified. Heart rates were calculated in beats per min based on the duration recorded from the peak of one T wave to the peak of the next T wave.*

Heartbeats were easily distinguishable from infrequently occurring movement artefacts and easily quantifiable. We only quantified heart rate but the clear-cut heartbeat sounds (Figure 1) have great potential for further analysis. The two lines of hens differed significantly in heartbeat rate during both types of behavioural tests, although there were no significant differences between lines at the behavioural level in terms of duration of Tonic Immobility and general Open Field activity scores. This simple method has great potential for providing a physiological correlate in future behavioural studies of feather pecking in laying hens.

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Coding behaviour of human and computer in terms of intentions

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Behavioural mismatches in human-computer interaction can be traced back to mismatches between the user's intention to do a dialogue step and the designer's intention to make a dialogue step executable. Mismatches are indicated by user complaints when selecting an inappropriate menu option, or being puzzled by a system's reaction, or unsuccessfully searching for an expected menu option. Mismatches, often referred to as user errors, indicate that something is wrong with the usability of the system. For measuring the usability of software products or improving a prototype, appropriate criteria are needed that allow a valid assessment.

Human-computer interaction is a behaviour sequence that can be described in terms of user actions and system reactions. A number of models and languages have been developed to provide for a complete description of interaction. Commonly known models allow empirical measurements in terms of user performance time, number of elementary user actions, number of keystrokes. Examples are GOMS [1], CLG [5] and TAG [6]. With the aid of such measurable entities one is able to compare software products regarding the key criterion of usability which is user efficiency. But there are some disadvantages. First, we get only relational quality assessments, that is, we can only say a system is better than an other one regarding the time it takes an expert to accomplish a certain task without errors. Second, the concept of usability as defined in ISO 9241-11 (1998) implies that the main indicator indicator of user efficiency is that the user is able to reach an intended goal. The absolute quality of a software product then depends on the extent to which the system's behaviour matches with the intentions of the user. In order to measure intentions, we can also interpret the system's behaviour as intentional if we take into account the designer's intention in deciding for a specific system feature of behaviour. If there is a gap or mismatch between the user's intention and the system's intention, the software reveals a usability defect.

The background of an intention-based coding of interactive behaviour is the theory of human action regulation [3]. A basic concept of this theory is the notion of "complete task", elements of which are preparatory action, exploratory action, conduct of intermediary steps, error management, assessment of intermediary or final results, etc. Starting from these rather abstract elements of a task structure one can develop a refined intention-based coding scheme for analyzing the interaction.

We are especially interested in the "critical incidents" of interaction, that is, a situation in the flow of dialogue steps, which (possibly) leads to problems regarding the user's task performance. In a field setting we want to record the user's dialogue with the system by means of an established analysis scheme, called use scenario, in order to define the appropriate test criteria [2]. In practice, we do not need to code the entire sequence of dialogue steps when using, for instance, an observational laboratory, since the focus of investigation is on critical incidents. If such an incident is indicated, an intention-based coding scheme of interactive behaviour is expected to help measure intentional mismatches. The coding scheme needs to be refined to an extent that enables valid measurements. Examples for a refined scheme of user behaviour are opportunistic performance, searching for information, carrying out procedures, etc. [7]. The designer's intentions can be inferred from the rationale of design decisions.

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Multitiered strategy for behavioral phenotyping of transgenic and knockout mice

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The emergence of techniques that permit the manipulation of the brain at the genetic level has provided neuroscience with a valuable research tool. Studying the behavioral phenotypes of transgenic mice (which have additional gene products) and gene knockout mice (in which a gene is inactivated) can be a powerful means to understand the neural basis of behavior and the pathophysiology of neurological and neuropsychiatric disorders. There are also important caveats and limitations to the gene mutation approach to studying behavior. One central concern is the potential for general deficits in health and neurological function, or impaired sensory and motor abilities, to impact performance in behavioral tests.

In our laboratory we have employed a multitiered strategy for behavioral phenotyping of transgenic and knockout mice to explain any specific behavioral phenotype in the broader context of sensory, motor and neurological function, and thus reduce the potential for false positive/negative interpretations of mutant phenotypes. Preliminary observations begin with direct monitoring of home cage behavior for any abnormal hyperactivity, aggressive behavior, sleeping and nesting patterns, or poor feeding. Next mice undergo a comparison with wild-type littermates on indices of general health, such as the condition of the fur, skin and whiskers, limb tone, body weight, and core body temperature. Sensory and neurological functions are measured using a battery of simple tests for basic eye, ear, and whisker reflexes, acoustic startle responses, nociceptive responses, and visual perception. Lastly, muscular strength and motor abilities are tested by use of the wire hang test, accelerating rotarod, ring test for catalepsy, and locomotor activity in a novel open field. A mutant mouse that appears to be in good health and which has grossly intact neurological function is a suitable subject for more sophisticated tests which focus on a particular behavioral domain. For example, to test for a learning and memory phenotype, the Morris water maze, T-maze, Barnes maze and social transmission of food preferences are examples of hippocampally-mediated tests. As an important complement to these spatial memory tasks, the cued and contextual fear conditioning paradigm is a popular means to test for amygdala-dependent memory function in mutant mice.

Using the multitiered strategy, we have recently examined the behavioral phenotype of transgenic mice overexpressing galanin, a neuropeptide that has been linked with Alzheimer's disease pathology and cognitive deficits. GAL-tg mice were found to be healthy and normal across the range of neurological, sensory and motor tests described. Against this background, testing for learning and memory in the Morris water maze revealed a highly specific deficit in spatial memory in adult and aged GAL-tg mice.

Data synchronisation through post-processing

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One of the almost sacred paradigms in experimental research is the recording of all data on one single recorder. Sometimes several tricks have to be used to accomplish this feat. The advent of modern computers has led to the possibility to store all data in separate data files, whilst still using a common clock. This allows more efficient data storage whilst maintaining the required time lock. For ambulatory experiments, as performed at the National Aerospace Laboratory NLR, it is sometimes necessary to record data at separate places without the use of elaborate and overlapping clock information. However, at the same time, it is often possible to record a simple signal at all recording places. This is true even if the raw signal information is not maintained. For example, when recording video and performance data, it is normally possible to use a flashing (infrared) Light Emitting Diode (LED). The flashing sequence can be measured electronically with the performance data, whilst the (ambulant) light changes can be recovered from the video information.

This presentation deals with the problem of how to correct the time differences using the overlapping information in the separate recordings. Two main problems need to be corrected. The first and most obvious one is the start time. In practice it is almost impossible to start all recordings at exactly the same time, therefore some time-offset has to be applied to one (or multiple) of the recordings. The second problem deals with differences in recording speed. As much to our surprise, we have encountered differences in clock-speeds of up to 5%. Several causes can be mentioned for those differences. The simplest one is a difference in recorder clock speed, which can be overcome by using appropriate devices. The way the recording has been integrated into, for example, the simulation software also presents surprises. Problems in this respect were encountered using simulation devices from several European organisations, so the problem seems universal in the way that small mistakes or inappropriate assumptions are made over and over again.

If all separate recordings are not too diverse in their time-channel information (e.g. do not contain hidden jumps in the recording times), the separate data files can be linked together using the information correlation in overlapping channels. In this respect a single recording is assumed to contain multiple parameters, linked together through some internal clock. The separate parameters may be sampled at different rates or may even be different modalities (for example equidistant analogue sampled versus discrete event based data).

To enhance the resolution of the correlation function, a special digital code can be used. The code requirements can be summarised as having a high correlation for signals without time offsets and a low correlation for signals with some time difference. Also the 'code-repetition distance' should be sufficient to avoid inappropriate locks. A large amount of research has already been performed in this area of Pseudo Random Noise (PRN) codes, the earliest references dating back to 1965 [1,2,3,6]. Some navigation systems like the Global Positioning System (GPS) even rely solely on similar types of codes. Also similar techniques are widely used in cellular phone systems like GSM. An example of a PRN code is given in Figure 1.

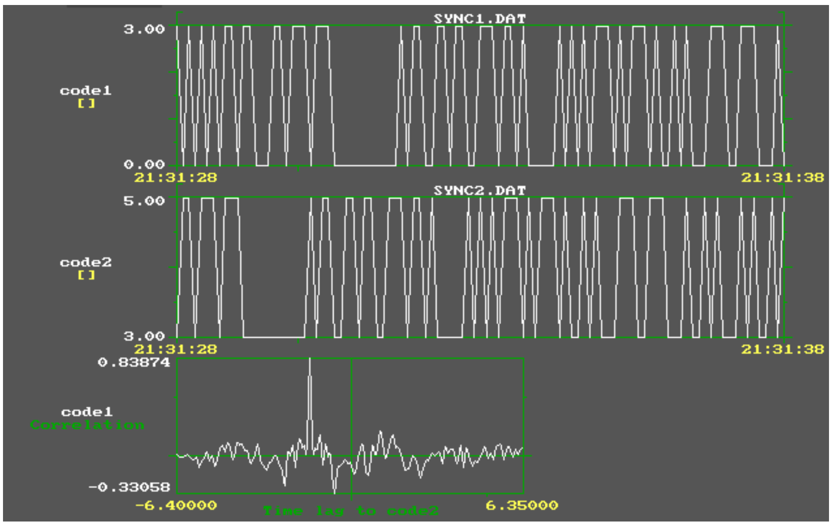

Figure 1. *Time histories of code signals, taken from two separate measurements.*

The picture shows two different measurements containing overlapping information 'code1' and 'code2'. The chip-rate for both codes is 10 Hz (meaning a maximum of 10 signal changes per second). The correlation between the two signals is indicated in the lower display. Clearly can be seen that the peak of the correlation is about 1.5 s before the 'no offset' location (green vertical line). The same conclusion can be derived from the two time-histories, from which it is easy to see that the code2 signal is earlier than the code1 signal.

Another conclusion from the example is that the peak in the correlation function is still relatively high when considering the time-difference of 1.5 s combined with a data window length of only 10 s. Increasing the data window length can easily enlarge the peak at the cost of increased computation times.

The example shows the suitability of using the PRN for detecting differences in recording times. However some questions on its use remain. Within the context of the HEART [4] and Visual Lab [5] projects, some simple experiments have been performed to analyse the suitability of the application of the 'pseudo-random bit'-code for the purpose of synchronising the data files through post-processing. The experiments focussed on the performance of different kinds of 'synchronisation function' implementations (like automated determination of time offset, time gain and time jumps). It was found that the correlation technique is highly suited to detect time differences between the different measurements. Major deformations in the signal representation are allowed. By using a 'sliding window technique' the occurrence of time jumps (including its magnitude) between measurements can be detected. However the main problem found is that the robustness for differences in recording speed (time gain) is lacking. Therefore, other information, like the estimated frequency of code changes, has to be used to make the whole synchronisation technique reliable and suitable for automation.

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Non-invasive temperature tracking with automated infrared thermography: measuring inside out

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Fluctuations in body temperature are frequently used as indicators of an animal's responsiveness to stressors. A well-known short-term response is an immediate increase in core body temperature. On the long term, stressors may affect the amplitude of the circadian temperature rhythm. The two main methods for measuring body temperature are by rectal probes and by telemetry devices. Drawbacks of both methods are (1) that the animal has to be disturbed for the insertion or implantation of the measuring devices, and (2) that the distance between the animal and the receiving apparatus usually limits the study area. Furthermore, changes in body temperature need to be corrected for changes in activity of the animal.

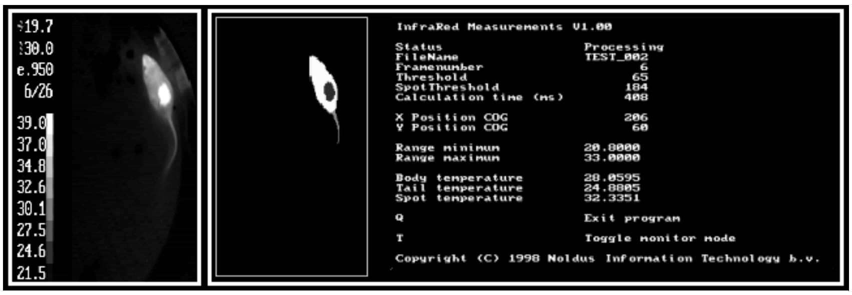

Figure 1. *Left: sample of a thermographic recording of a rat. Grey values correspond to temperatures (see index bar on the left). Note the shaven spot (light) on the rat's back. Right: Image after analysis: computer discriminates tail (24.00 °C) and shaven spot (32.34 °C) from the rest of the body (20.06 °C).*

We developed a new, non-invasive method for recording body temperature. It combines an infrared thermographic camera with an enhanced version of the automated behavior recording software EthoVision (Noldus Information Technology). The camera outputs a PAL video signal that can be processed by digital imaging software. With this method it is possible to track changes in both behavior and surface temperature continuously (Figure 1). The advantage is that animals can be tracked without disturbing them, in various environments, even in darkness. A new feature is the possibility to measure temperature at different parts of the body (e.g. head and tail) simultaneously (Figure 1, right panel).

The surface temperature measured by our method reflects to a large extent vasoconstriction and -dilation, involved in regulating core temperature. We compared the relationship between both temperatures in rats. On long term (days), skin and telemetrically measured core temperature patterns show a close relationship. On short term (minutes) however, both temperature measures are often at variance. One explanation is that small, autonomously mediated responses to stressors affect skin temperature more directly than core temperature, which may be buffered by other processes. We tested the responsiveness of skin temperature to various stressors in enriched and standard housed rats. Especially the tail temperature response (Figure 2) differed between groups and between stressors of different intensity.

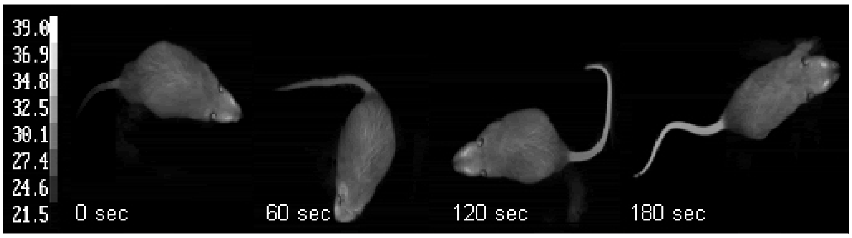

Figure 2. *Four samples of a thermographic recording of one rat. Time interval between first and last sample is 180 s. Note the rapid increase of the tail temperature from slightly more than ambient temperature (22 °C) to over 30 °C.*

The results indicate that our automated thermographic method may serve as a non-invasive, longitudinal alternative to other methods of temperature measurements. It also provides additional information by detecting small and acute skin (tail) temperature responses to stressors of different severity. We discuss the implications of present method for biophysiological research, its specific limitations and possibilities. We conclude that the method is a useful, additional tool in behavioral, health and welfare research.

Behavioral analysis of transgenic mice carrying multiple copies of tryptophan hydroxylase gene

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We have produced lines of transgenic mice carrying multiple copies of the tryptophan hydroxylase (TPH) gene by pronuclear injection of TPH gene. TPH is the initial and rate-limiting enzyme in the biosynthesis of the neurotransmitter serotonin (5-HT). The synthesis of 5-HT can proceed only through this enzyme-catalyzed step. Serotonin is one of the known monoamine neurotransmitters, mitogens and hormones that mediate a wide variety of behavioral and physiological processes in the mammalian central nervous system. As an important neurotransmitter, 5-HT mediates pain, sleep, thermoregulation, food in-take, locomotion, and learning. From a clinical aspect, altered 5-HT function has been implicated in depression, obsessive-compulsive disorder, autism, and impulsive self-destructive behaviors such as aggression, suicide, schizophrenia, anxiety, insomnia, and drug abuse. In order to understand molecular mechanisms underlying the regulation of TPH gene expression, transgenic animals were produced by pronucleus injection of TPH cDNA under the transcriptional control of TPH 5'-upstream flanking genomic DNA fragment, so that in these transgenic mice, the TPH gene could be overexpressed in serotonergic cell types. Out of the microinjected 5,714 embryos transferred into the female oviduct, 110 offsprings were produced. Five transgenic founder lines were established as permanent lines. From cellular phenotypic characterization using 5-HT immunohisto-chemistry, the transgenic lines were confirmed to produce increased immunoreactivity compared to their non-transgenic littermates. To measure behavioral characteristics of transgenic lines harboring more than sixty copies of the TPH gene, the folowing tests were performed: motility test, elevated plus maze test, Y-maze test, passive avoidance, and climbing behavior test. Among the behavioral tests, the transgenic animals exhibited significantly more locomotive activity than the control littermate siblings. Details of the behavioral profiles obtained by measuring behaviors of these transgenic mice will be presented.

Postural responses to real-world moving video: an objective measure of *presence*?

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Technological development in networks, computing power and displays, as well as improvements in human-system interfaces, enable the creation of services that are able to elicit a subjective sensation of 'being there' in the mediated environment. This sensation, known as *presence*, has been studied in relation to various media, most notably virtual environments, since the early 1990's. Two general approaches have been taken to measuring presence: subjective and objective [4]. The majority of presence studies to date have used subjective measures such as questionnaires and rating scales to assess the presence experience. These methods have the advantage that they do not disrupt the media experience, are easy to administer, and have face validity. However, subjective measures are known to be potentially unstable, with inconsistencies across different raters and rating situations [2]. In addition, subjects may be responding to the demand characteristics of the experiment, rather than reporting on their actual psychological state. An alternative approach is to measure user responses that are produced automatically and without conscious deliberation, but are still sensibly correlated with measurable properties of the medium and/or the content. Such user responses are related to presence through the premise that when observers experience a mediated environment that makes them feel present, they will respond to stimuli within the environment as they would to similar stimuli in the real world [3]. Following this principle, termed *behavioural realism*, we report an experiment in which we measured postural responses to real-world moving video.

Twenty-four observers (13 female, age range 18-30, all with normal vision and good stereo-acuity) were shown a video sequence shot by stereoscopic cameras positioned on the bonnet of a rally car travelling at speed around an off-road rally track, using stereoscopic and monoscopic presentation.

Observers viewed the stimulus film on a large curved stereoscopic projection display with an image size of 50 degrees visual angle horizontally. A Flock of Birds® magnetic position tracker was used to measure observers' x, y, z positions (Figure 1). Results demonstrated a significant effect of motion on the magnitude of the lateral postural movements for the stereoscopic viewing condition. A significant effect of both stereoscopic presentation and image motion on post-test subjective ratings of presence was found, consistent with results from earlier experiments [1,3]. This provides weak support for the use of postural responses as an objective corroborative measure of presence, in particular for evaluating displays intended to provide a sense of movement.

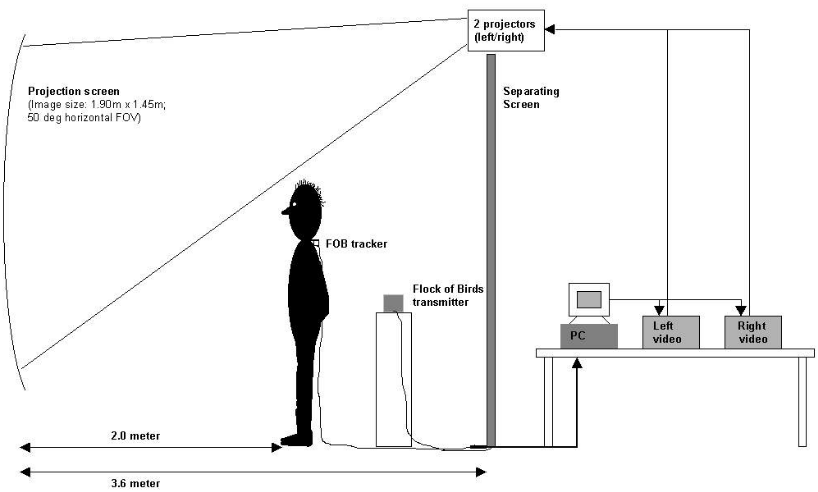

Figure 1. *Schematic diagram of the laboratory set-up illustrating the observer's position in relation to the display.*

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Genesis of learning: the behavioral effects of a single reinforcement

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The general principles of reinforcement are well understood. However, the underlying behavioral mechanisms that make reinforcement principles work are not well researched. Research has shown that the microstructure of behavior during transition periods can in fact be quite systematic and understandable when behavior is analyzed conditional upon the environmental events that guide the transition [1].

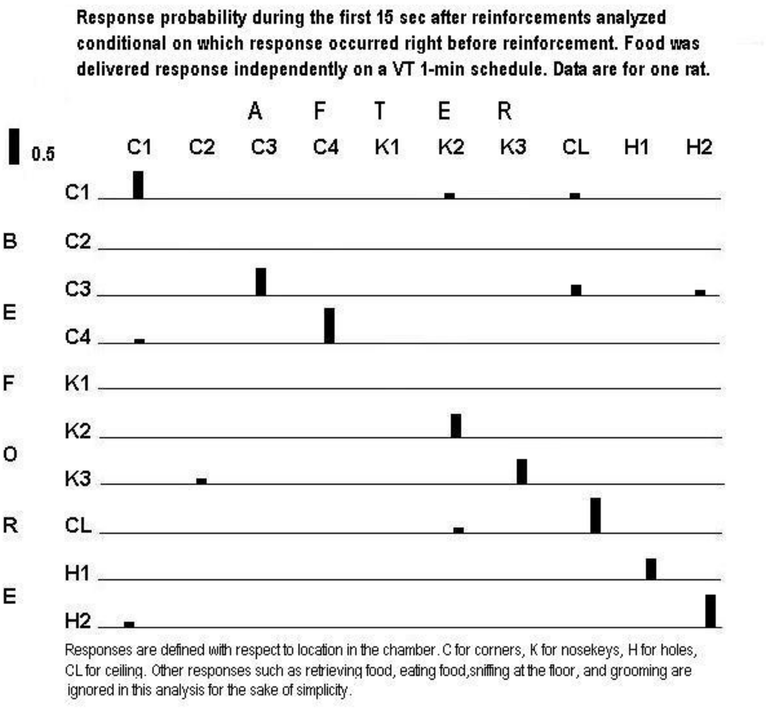

Figure 1.

The research reported here builds upon this earlier work and takes a fresh look at the changes that take place when one zooms in on the microstructure of behavior during the very first moments of learning. Because reinforcement is critical for learning, the research begins by looking at what happens to behavior when reinforcement is presented. Several experiments examined how a *single* reinforcement influences the ongoing stream of behavior. In one set of experiments, food-deprived rats are presented with food pellets delivered unpredictably and response-independently.

Figure 1 illustrates data for one rat from a single 30-min session with response-independent reinforcement delivered on a variable-time 1-min schedule; several rats were used. Bars show the probability of a given response during a 15-s period after reinforcement *conditional upon* which response happened to occur right before that reinforcement. The data indicate that the response that is most likely to occur after a given reinforcer is the same response that occurred right before that particular reinforcer. Hence, a single reinforcement can momentarily strengthen the response that happens to precede it even when the response does not produce the reinforcer. Control conditions show that this effect is not simply due to a more general mechanism of one response being most likely to follow itself. Additional research has also identified a momentary induction effect of reinforcement in experiments that present only a single reinforcement to each rat in one 10-min session. A box with a vertical holeboard records visits to each hole [2]. After a short period of habituation, a single food pellet is presented in one of the holes.

Figure 2 shows data before and after pellet retrieval for one rat (left) and accumulated data for 8 rats (right). The pellet was presented in the darkened target hole. The height of each bar shows the duration of visiting the corresponding hole. Results showed an increased frequency of visits to the target hole and an increased visit frequency to neighboring holes after pellet retrieval. The experiments illustrate the basic mechanisms of response strengthening and induction that take place at the moment learning begins.

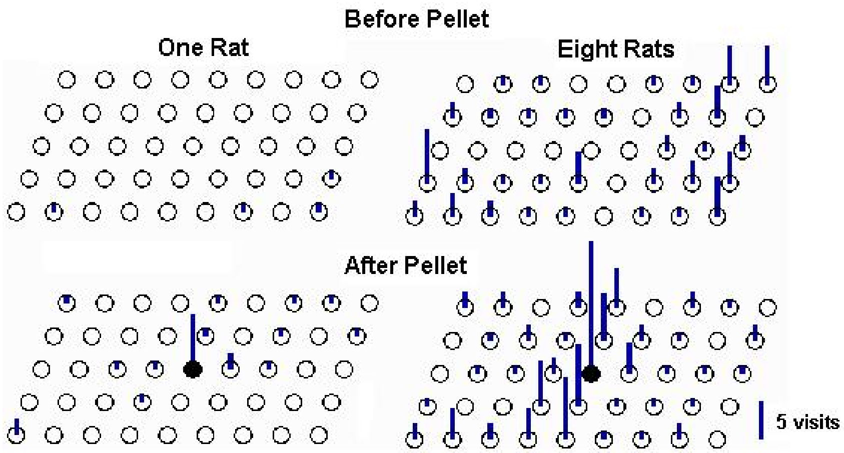

Figure 2. *Vertical holeboard with 45 holes. Visits recorded with photocells. Data show visits for 5 min. before a single pellet is placed in the darkebed hole and data for 5 min. after the pellet is retrieved. Rats have a single session only. Bar height shows visits to a hole.*

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Making totally paralyzed patients "move" by translating their brainwaves into cursor action on a monitor

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The purpose of the research is to enable totally paralyzed patients to communicate by means other than muscular activity. We used a computerized on-line task that translates signals from the encephalogram (EEG) into visual feedback [1,2]. Specifically, we use slow cortical potentials (SCP) from the EEG of patients with amyotrophic lateral sclerosis (ALS). The task is divided into individual 6-s trials. The first 2 s serve as a baseline period; during the next 4-s response period, the patient can make a response by changing the SCP compared to the baseline period. The patient faces a monitor that shows a ball-shaped cursor and a target. The vertical ball movement is determined by the EEG signal and gives visual feedback. SCP negativity (relative to baseline) moves the ball upwards and positivity moves it downwards. Thus, the patient has to self-regulate the polarity of the SCP to make the ball hit the target. We used operant conditioning methods to train the patients to control their EEG. Training progressed from moving the ball to a target to spelling of words. In spelling, the characters to select from are split into two letter banks, which are presented successively at the bottom of the monitor as the target. When a target is hit, it splits the presented characters into two halves, etc. Eventually the patient can choose between two characters. Training of spelling progressed from a reduced alphabet and predefined target words (copy spelling) to larger alphabet sets and free choice of what to write. With the full alphabet, the average number of trials to select a single character is 7. Thus, spelling is slow, usually two characters per minute. Two patients have learned to write using this method, and both currently write letters to friends and family. The same basic task has also been used for assessment of cognitive skills. The monitor presents two choices, and the patient is instructed to move the ball to one of the choices; for example, the screen presents an X and a Y with the instruction to move the cursor to the X (see Figure 1). The presentation will illustrate how brainwaves are translated into cursor movement, how the patients are trained, and presents results from the cognitive assessment trials.

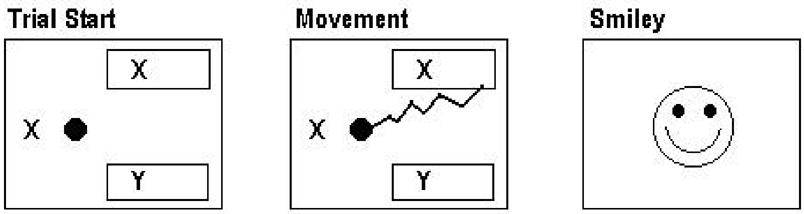

Figure 1. *Example of one trial from a matching-to-sample task. The object (ball) has to be moved by the EEG to the correct target (X). If correctly done, a smiley appears on the screen. The trial lasts 6 s.*

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Conduct problems in children: translation and adaptation of family and peer process code

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It has been hard to prove consistent positive treatment effects for conduct problems in children, especially among older ones. This may partly be due to difficulties in finding appropriate intervention programs for this group, and partly to methodological problems in measuring behavioural changes.

In Norway the government has implemented a large-scale program in order to develop various interventions programs for children with conduct disorder and antisocial behaviour. Among others, a collaboration has been established with the Oregon Social Learning Centre (OSLC) in Eugene (Oregon, USA), in order to train Norwegian therapists in the method of Parent Management Training (PMT). Reviewers of the literature have unanimously concluded that PMT produces the most consistent positive treatment effects for antisocial children.

In order to examine to what extent PMT may produce the same positive treatment effects in Norway, and to compare our results with those of OSLC, we have applied some of the key measures from various OSLC studies. Thus, the first aim of this study is to translate and accommodate the Family and Peer Process Code (FPPC) to Norwegian. FPPC is OSLC's latest strategy for capturing behaviours of interest in family interactions. FPPC is an amalgamation of three closely related behaviour codes developed over the years by OSLC. FPPC consists of four dimensions, three of which are simultaneously receded at all time: Activity or Withdrawal Qualifier, Content and Affect. Activity refers to the general setting in witch the subject is being observed and consists of six categories. The Withdrawal Qualifier records the absence or presence of the collection of behaviours called withdrawal. The content code describes an individual's behaviour as it changes through time. There are 24 content codes, which are further divided into verbal, nonverbal, etc. Affect, or valence, is receded with every content and has six ratings. FPPC can be used to code both live observations as well as watching videotapes. In this study we will videotape families in sessions where they perform a series of time-limited tasks.

The FPPC is a rather complex coding system. This does not only increase the expenses for training coders, but may also reduce the he inter-rater reliability. Therefore, the second aim of this study is to try to take advantage of the power and flexibility of The Observer Video-Pro (Noldus Information Technology).

If we succeed in adapting the FPPC to The Observer, the third aim will be to collect and analyse the interactions between parents and their child in standardised settings, before, during and after treatment with PMT. A final aim of the study will be to compare the observational data with various standardised test children, as for example the Child Behaviour Cheek List (self, parent and teacher).

Optical imaging of human brain function: application of near-infrared spectroscopy in a language study

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Introduction

In the past decade, Near Infrared Spectroscopy (NIRS), a non-invasive optical technique, has proven itself useful for investigating oxygenation changes in the human brain. It has already been successfully applied in cognitive, visual, auditory, and motor studies. In this study, we applied functional NIRS to assess the human language area. We used a picture naming protocol to investigate the area for phonological encoding (Broca's area) in the left inferior frontal gyrus.

Methods and materials

Eight right-handed healthy volunteers participated in the study. The optodes of a NIRS instrument (Oxymon® [1]) were placed over the posterior part of the left inferior frontal gyrus. The language task consisted of the aloud naming of 12 different pictures that were presented on a computer screen (1 per 2 seconds), followed by a rest period of 34-46 s. Twenty cycles of picture naming were performed by each volunteer. A series of 12 pictures represented either high frequency (HF) words or low frequency (LF) words. Optodes of a second NIRS device were fixed over the right parietal region of the head. Data obtained here were used as a control. Data were averaged over 20 cycles. The stimulus period was compared to baseline values 10 s before the start of the stimulus, and to the rest period afterwards.

Results

A significant increase in [O_2Hb] and decrease in [HHb] compared to baseline values was found during the picture-naming task ($p < 0.01$). No significant differences were found between cycles of naming pictures with HF words and those with LF words. In the control area, no change in oxygenation corresponding to the stimulus was found.

Conclusion

This study shows that it is possible to monitor oxygenation changes in Broca's area in response to a picture-naming task. The results furthermore suggest the utility of NIRS to study speech production and recognition.

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Relation between self-esteem, personality dimensions of extraversion and emotionality and real-time patterning of social interaction

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A pilot study is presented where the real-time structure and synchronization of verbal and non-verbal behavior is analyzed and related to self-esteem and personality dimensions of extraversion and emotionality. Twenty-four dyadic interactions between male students were analyzed. The software package Theme was used to detect real-time patterns in real-time behavior records [3,4,5].

Research has shown a strong relationship between verbal and non-verbal communication and cognition and social adaptation [1]. An earlier study suggests a strong relationship between the level of a subject's self-esteem and the number of behavioral patterns produced in dyadic interaction situtations [2]. No research exists on the relation between real-time behavior organization and personality. It is unknown whether such behavior analysis would reveal a difference in real-time patterns produced by persons with different scores on Eysenck Personality Questionnaire.

Initial results indicate that these interactions are highly synchronized and structured. A strong correlation was found between a subject's self-esteem and complexity and frequency of behavioral patterns detected. A high correlation was also found between a subject's personality and complexity and frequency of patterns.

Certain pattern types were found exclusively to be produced by extroverts and other by introverts. High and low self-esteem subjects were also found to produce different types of behavioral patterns. The type and amount of behavior emitted by extroverts and subjects with high self-esteem also differed from behavior emitted by introverts and subjects with a low self-esteem.

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Detection of real-time interaction patterns in football

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The objective of the research presented in this paper was to search for particular types of repeated behavior patterns in football matches and to relate those patterns to elementary statistics and analysis. The pattern search was based on a method especially developed to detect such real-time behavior patterns using the computer software Theme [2,3]. Conventional football analysis has focused mostly on elementary statistics and field plots. Analysis of this type can provide information about the frequency of a team's and player's passes, the tendency of a player to take shots from one side rather than another and so on (see Figure 1).

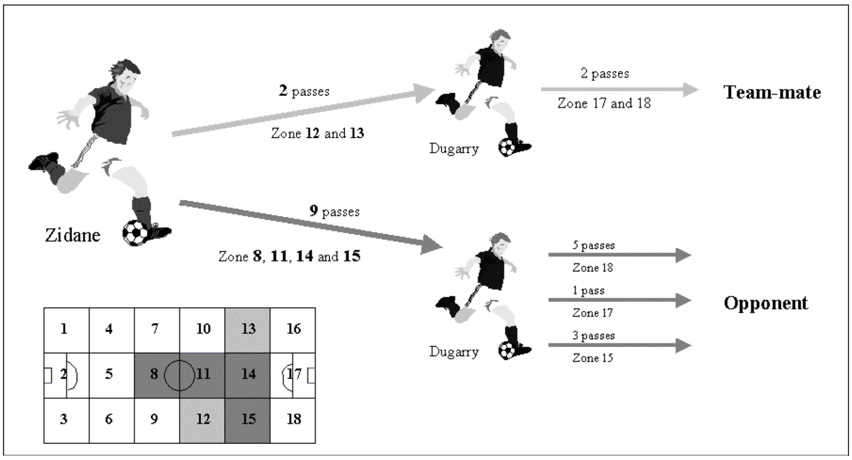

Figure 1. *Results of passes from Zidane to Dugarry (Iceland vs. France, September 1998). The figure shows from which zones Zidane made his passes to Dugarry and what happened to the ball after Dugarry received it. Passes from zones 12 and 13 to zones 17 and 18 were passed on to a teammate. Passes made from zones 8, 11, 14 and 15 to zones 15, 17 and 18 were lost to the opponent.*

This type of analysis, useful as it may be, does only to a very limited extent make it possible to study the relationship between the events described. This limitation is severe as a football match is not only a series of events but also highly structured. The fundamental elements of the game, the cooperation of (and competition between) a fixed number of actors in pursuit of a clearly defined objective, and the limits set on behavior, i.e. the usage of a clear set of rules and the well defined time and space frame, indicate the possibility of finding a causal relationship between events.

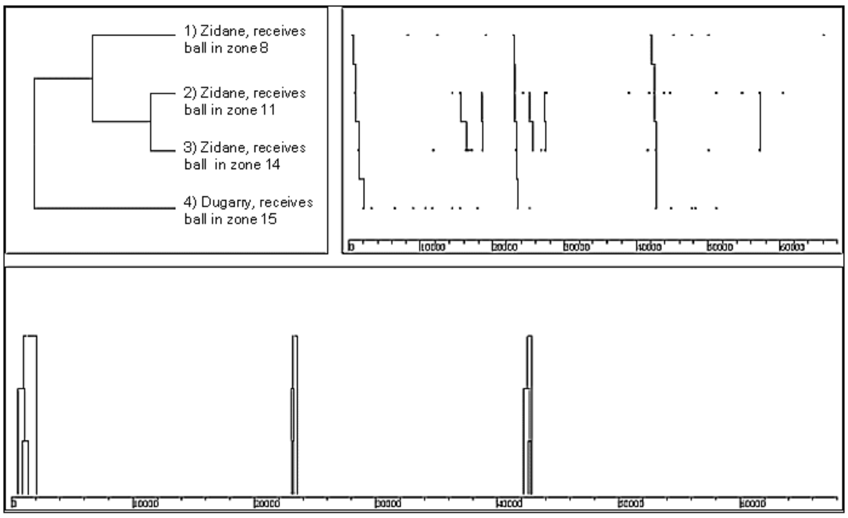

Figure 2*. This pattern occurred three times during the first half of a match between Iceland and France, September 1998. The pattern displays how Zidane, cooperating with his teammates, (1) receives the ball in zone 8 (plays the ball towards the Icelandic goal), (2) receives the ball again in zone 11 (passes the ball forward), (3) receives it again in zone 14, (4) and finally he passes it on to Dugarry in zone 15.*

Furthermore, teams as well as individual players have strategies that result in repeated patterns of behavior (see Figure 2) [1]. Some of these patterns can be observed whereas others require a sophisticated structural analysis to be detected. The current study focuses on the detection and analysis of complex intra- and inter-individual patterns. The Theme software detects such patterns by performing structural analysis of real-time behavior records that takes simultaneously into account information about both the order and the relative timing of behavioral events. Data from several World Cup and European club and national team games were collected using the Theme coding module, The Observer (Noldus Information Technology) and a match analysis system developed at the Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, UK. The patterns detected were then related to elementary statistics, field plots and performance assessment.

The number, frequency and complexity of patterns detected in this pilot study indicates that the behavior of football players is more structured than the human eye can detect. This patterning was found to exist on different levels, with highly complex time structures that extended over considerable time spans, often in a cyclical fashion, as well as less complex patterns with a shorter time span. Winning teams were found to be more structured than loosing ones. Patterning of this kind was found to correlate highly with standard statistical assessment of individual performance and, notably, a higher correlation was found with performance assessment by professional coaches than by amateurs (see Figure 3).

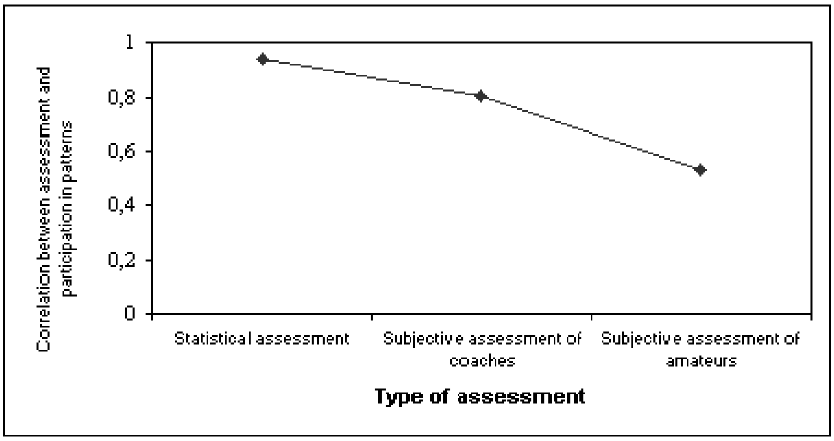

Figure 3*. Strong correlation was found between players' participation in patterns and standard statistical assessment of individual performance and a higher correlation was detected with performance assessment by professional coaches than by amateurs.*

The results indicate that such pattern analysis can be used to study the structure of interaction in football and even to discover strategies and team structure.

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Factors influencing vessel volume changes: their integration into software for peripheral blood flow analysis

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There is consensus that psychophysiological variables such as vessel volume changes are apt indicators of emotionalization. The relevant theoretical background and some basic methods of analysis (VASC Analyser software) were already presented at the *Measuring Behavior '98* conference in Groningen [1,2].

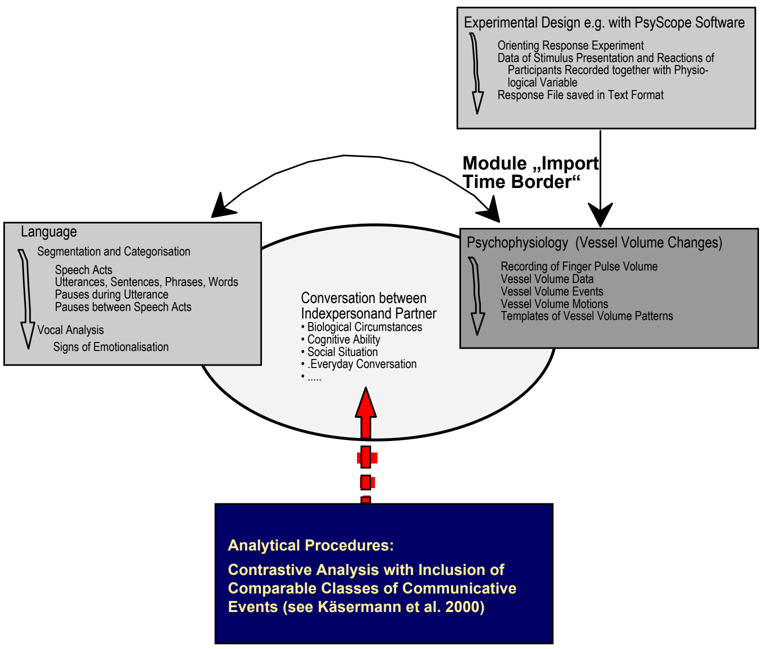

Figure 1. *Integration of the software module "Import Time-Border" into VASC Analyser.*

Several factors are known to influence vessel volume changes, e.g. listening to stressful partners' speech may have an arousing effect whereas speaking about anxiety-evoking events may calm down a high arousal level. The time-exact coordination between measures of such contextual and physiological events is by no means a trivial problem. Often it is still solved with marks applied manually on data records. In contrast, the module "Import Time Border" (Figure 1) enables the researcher to project the time border of relevant events (e.g. the beginning and the end of stressful partner utterances) onto the physiological record. This allows for selecting concomitant physiological data for further analysis. While this procedure was developed for dealing with events occurring during natural situations (especially conversations), it is also applicable to data gathered within an experimental setting, e.g. for an investigation of orienting and defense reactions. Both types of coordination of situational factors with psychophysiological functioning are demonstrated.

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SEE analysis of photo-beam raw data

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SEE ("Software for the Exploration of Exploration") is an advanced program for the visualization and analysis of rodent spatial behavior in the open field [1]. Rather than employing arbitrary, ad-hoc parameters introduced by the investigator or the automated measurement system (e.g. "activity"), SEE displays and quantifies the intrinsic patterns or "units" of which spatial exploratory behavior consists. The first and necessary stage of SEE analysis is the segmentation of the animal's path into the most basic of these intrinsic units: stops (within place behavior) and movement segments (going between places). This segmentation is based on the empirical distribution of movement speeds, in which more than one component can typically be shown to exist [2]. It was essential therefore to determine how general these components are, and how independent they are of arena size, experiment treatment and tracking system properties.

SEE was developed and demonstrated with data of the normal behavior of rats and mice, measured by a video tracking system in large (3 m to 6.5 m) circular arenas. Here we report its application to data from drug-injected rats, measured by a standard photo-beam chamber 43 cm wide at a much lower rate. Subjects were Sprague-Dawley rats, injected with phencyclidine (five doses including saline) or d-amphetamine (four doses including saline). The raw data of the animal's coordinates were fed to the same SEE segmentation algorithm used with the video tracking data. Results show that, with both drugs and with all doses, components of stops and movement segments are statistically significant in the distribution of speeds. Typical values of the high-speed component were, as expected, lower relative to those found in large arenas. As in the large arena, however, there was a significant difference between the spatial spread of the components, typically 5-10 cm for the low-speed component and 20-30 cm for the high-speed component, indicating that they indeed represent different behavioral categories of moving within a place versus going between places. There was no need for any substantial altering of the algorithm in order to accommodate for the very different experimental conditions.

These results support the generality of the intrinsic categorization of rodent's spatial behavior into stops and movement segments. They also suggest that the full power of SEE analysis can be applied to photo-beam measurement of drug-induced locomotor behavior. Several possibilities for sophisticated querying, visualization and quantification of such behavior will be demonstrated.

Researchers interested in using SEE are encouraged to contact Ilan Golani (ilan99@post.tau.ac.il).

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Relative phase and traveling waves as building blocks of coordination patterns in free locomotor behavior

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Coordination patterns of oscillatory movements, such as in various forms of locomotion and various gaits, are currently well understood as arising from a constant relative phase. For example, the relative phase between movements of the hindlegs in a quadruped mammal, is half a cycle during walking and running, and slightly more than zero cycles during gallop. In the field of Coordination Dynamics, such patterns can be modeled by systems of coupled oscillators. During free (spontaneous) behavior, however, most movements are not strictly oscillatory, but rather quasi-periodic or discrete. Generalization of the relative phase for understanding coordination patterns of free movement is thus not straightforward.

In order to investigate this problem we analyzed free locomotor ("open field") behavior of ferrets, measured by video tracking 10 points of the body axis and feet at a rate of 25 Hz [1]. We suggest a framework in which the basic building block is oscillatory movement. Any other movement, such as a discrete movement, can be regarded as part of an oscillatory movement, and its phase can thus be measured. We introduce a numeric algorithm for the measurement of phase in such movements. Coordination patterns between concurrent movements of several body segments can thus be captured by their relative phase, even when they are not oscillatory. For example, a slight phase delay in the movement of each successive segment will result in a traveling wave pattern, such as the traveling wave that was extensively studied in the undulation swimming of the lamprey. We used this framework to show that in the free locomotion of ferrets, lateral movements of the body axis during both forward locomotion and turning can be regarded as a traveling wave [1]. Turning is considered as an asymmetric wave in which the movement of each segment is part of an "off center" oscillatory movement. Reinterpretation of data from the literature indicates that turning in the lamprey also consists of the same asymmetric wave.

Modeling and recognition of the building blocks of spontaneous behavior is a difficult problem because such building blocks are in fact complex coordination patterns between many degrees of freedom. The application of relative phase and traveling waves may promote our understanding of this problem, and integrate diverse disciplines such as Coordination Dynamics, neural mechanisms of locomotion and open field measurement of spontaneous and drug-induced behavior.

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Measuring grooming in stress and comfort

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Changes in grooming (G) are not only often seen in behavioral experiments but in some cases are the only parameters that change significantly. Considering that in rodents and some other animals G is activated both is stress and comfort, we have designed an algorithm to distinguish between the effects on G produced by such opposite factors. The first stage of our G-analysis algorithm (GAA) deals with identification and separate registration of certain patterns of a grooming ritual, namely: paw licking (1), nose wash (2), face wash (3), head wash (4), body wash and fur licking (5), leg licking (6), tail and genitals licking and wash (7).

Comfort G is characterized by a quiet progressive transition from one stage to another, which starts from stage 1 and ends up at stage 7. The more stress the more animals demonstrate incomplete (abortive) G acts which do not reach stages 5-7. Time spent at G is also a useful index: the ratio incomplete/completed G (or time spent incomplete G/total time spent at G) would be higher in stressed animals (index [1a,b]).

Further step in G analysis is studying transitions between its stages. In comfort the transition patterns in G are progressive (1-2, 2-3, 3-4, etc.) while hyperactivated stress-related G' stages are rather chaotic and often seen as invalid, i.e. omitted or reversed (3-2, 1-4, 3-1, etc.). The number (%) of "invalid" transitions per total transitions between G stages registered can serve as an additional index [2] of stress or comfort (it is higher in stress).

Stopping of G (interruptions) is also an interesting parameter. Animals in comfort would interrupt their G less frequently and duration of the interruptions will be shorter. Higher interruption rate will indicate anxious arousal state of the animals (but only for short interruptions up to 10 s, as longer interruptions from 15 s can represent freezing, a fearful stress-related nonspecific behavior). Thus, interruptions of G shall be registered separately depending on its duration. The percentage of *extra-short* and *extra-long* G interruptions per total interruptions (index [3] and [4]) can reflect both stressful states but present its different aspects (i.e. anxiety/panic- and fear-related compounds, correspondingly).

A synthesis of the latter ideas will be in analysis of G transition interruptions. "Quiet" animals in comfort would more likely interrupt G *within* the same stage (e.g. 2-INT-2, 3-INT-3) while in stress they would more often interrupt *between* the stages (e.g. 3-INT-4). The rate *"between"/"within"* or *"between"/* total transition interruptions (index [5a,b]) will be an indicator of stressful/comfort G.

If past-interruption G stage is reversed (i.e. G continued from stage previous to the one it has started at), the stress state is more likely to consider. The number of reversals after interruptions per total number of interruptions might be a sensitive index [6] for a proper G analysis (it is high for stressed and low for comfort animals).

Finally, in accord to Lorentz's motivational analysis, one might wish to consider non-grooming behaviors (NG) that follow G. They can be split in two groops. If it is freezing, aggression or self-aggression, risk assessment or flight, the stress is likely. For other post-G patterns (exploration, appetitive behaviors, etc) the comfort state is playing a role. Ratio [stress-/comfort-related] post-G NG or total number of stress-related post-G NG per total post-G [G + NG] patterns are additional indicators [7a,b] for interpreting changes of G seen in experiments.

The GAA outcome, spider diagrams with the 7 above indices at 7 different axes, will give a picture of the real nature behind changes in G seen in experimental animals vs. controls. Briefly, the more stress, the bigger square will be at the diagram.

We believe that such an approach will assist in correct interpretation of animal G behavior both in stress and comfort. Moreover, with certain adaptations, it might be used to distinguish between normal, anxiety- and depression-related G in rodents.

Role of eccentricity and size in perception of whole and parts

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The perception of whole and parts was investigated in human subjects. Using computer generated visual stimuli, the roles of eccentricity and size and their possible interaction on the speed of processing of global and local levels was examined. It was argued that the measurement of the speed of processing of wholes and parts would not be accurate if the variable of eccentricity was not controlled. In this study, the variable of eccentricity was controlled using electrodes attached around the eyes. The results showed that if the confound of eccentricity was controlled, wholistic properties of a visual stimulus would process faster than local properties. Somewhat surprisingly, the pattern of response times as a function of eccentricity was quadratic. Subsequent experiments indicated that the quadratic functions obtained resulted from the summed individual effects of size and eccentricity. The results indicate that size and eccentricity are the main determinants in order and speed of processing of wholes and parts, and many previous findings (e.g. [1,2]) may be explained in terms of these effects.

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Use of principal component analysis and discriminant analysis to simplify the assessment of pain

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The routine castration and tail docking of lambs with rubber rings has been shown, using behavioural and physiological methods, to be painful. To improve the welfare of lambs during such routine procedures it is important to validate the methods for assessment of pain. This was considered ethically acceptable, as groups of lambs would be subjected to decreasingly severe castration and tail docking treatments.

Forty-two lambs, 5-6 days of age, were subjected to rubber ring castration and tail docking of different severities. Six treatments were ranked, before the experiment, in descending order of severity according to the amount and sensitivity of the tissues involved and the established effectiveness of local anaesthetic. Treatments were as follows: (1) bilateral castration and tail docking, (2) bilateral castration, (3) unilateral castration, (4) short scrotum castration, (5) short scrotum castration with local anaesthetic (LA), (6) handled untreated control lambs (H). A seventh group (n=7) of lambs were tail docked. Because this treatment did not involve visceral tissue, it was not ranked prior to treatment, although previous experience suggested that this procedure was less painful than bilateral castration. Nine active behaviours (getting up and down, rolling and jumping, foot stamping and kicking, easing quarters, tail wagging, head turning and vocalisation), thirteen lying and standing postures, and changes in plasma cortisol were monitored for 180 min after treatment. Eleven 2-ml blood samples (using Sarstedt Monovets and 20g x 1" needles) were collected by jugular venipuncture. Two pre-treatment samples were taken and at 12, 24, 36, 48, 60, 72, 96, 132 and 180 min after treatment. Behaviour data was collected live on to paper using one observer and one writer for the first 60 min and one observer/ writer thereafter. Active behaviours were recorded continuously. Postures were recorded every 2 min for 96 min and then every 6 min upto 180 min after treatment. Principal component analysis (PCA) and discriminant analysis (Minitab v12) were used to help determine the best single or combination of behavioural and physiological indices for allocating lambs to their correct treatment group.

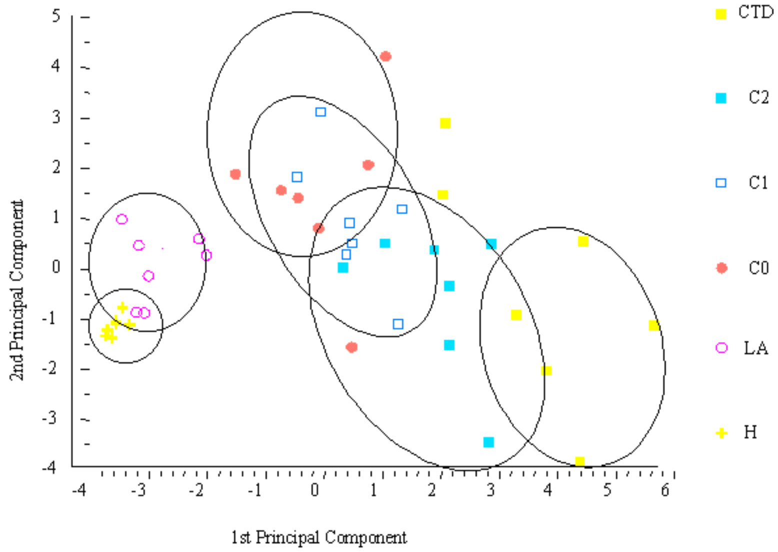

Figure 1*. PCA showing the relationship between lamb behaviour (60 min data) and the pain resulting from rubber ring castration and tail docking treatments of decreasing severity. Treatments: CTD bilateral castration and tail docking; C2 bilateral castration; C1 unilateral castration; C0 short scrotum castration; LA short scrotum castration with local anaesthetic; H handled control lambs.*

The PCA showed that four postures involving lying with full extension of the hind limbs were associated with the most severe treatments, as were most of the active behaviours. Abnormal motion, standing still and lying with only partial extension of the hind legs were postures associated with treatments of intermediate severity. Vocalisation and trembling were also associated with these treatments. Lying on the sternum with all legs tucked in and standing with no abnormalities were postures associated with the LA and H lambs. Most lambs could be correctly allocated to their treatment groups when data collected for the first 60 min after treatment was analysed. Discriminant analysis showed that combining normal lying and standing postures allocated 62% of lambs to their correct treatment group, as did taking the sum of the active behaviours involving limb movements e.g. rolling, foot stamping, easing quarters (62%). A particular combination of postures and activities successfully allocated 78.6% of lambs to their correct treatment group. The inclusion of peak plasma cortisol values did not improve the allocation. The postures or activities were combined according to their close association within the PCA of the individual behaviours (Figures 1, 2).

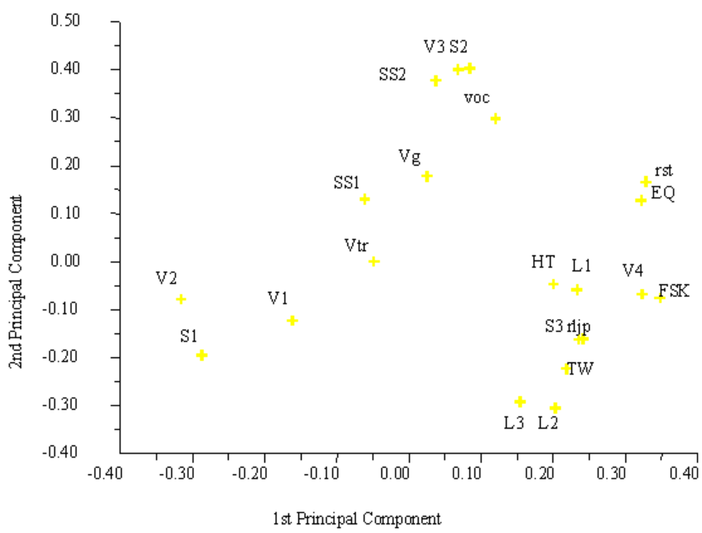

***Figure 2**. PCA showing the relationship between lamb behaviour (60 min data) and the pain resulting from rubber ring castration and tail docking treatments of decreasing severity. Behaviours: V1 (head down) and V2 (head up) ventral lying with legs tucked in; Vtr V2 with trembling; Vg dog sitting; V3 ventral lying with partial extension of the hind leg; V4 as V3 with full extension of the hind leg. L1 (head up); L2 (head down); L3 (with rolling) lateral lying. S1 standing with no obvious abnormality; S2 standing with unsteadiness of gait; S3 standing with obvious abnormality including falling, walking on knees, stretching; SS1 standing still without eating or other obvious normal activity; SS2 standing still with obvious abnormalities e.g. trembling, hunched back, tail tucked between legs. EQ easing quarters; FSK foot stamping and kicking; HT head turning; Rljp rolling and jumping; Rst restlessness (getting up and down); TW tail wagging; Voc vocalisation.*

It is concluded that an index of behaviours can permit the severity of acute pain from castration and tail docking with rubber rings to be assessed with greater than 70% accuracy. A similar index could be used in clinical conditions for recognising and assessing, with greater accuracy, unacceptable levels of pain of this type in lambs.

Possibilities of code-embedded observation in WWW-based educational software development

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This paper describes a project, which goal is to develop a powerful, but easy to use, data recording system for the development of teaching materials. The paper focuses on data collection algorithms and problems of measurement handled trough research questions about specific experiment.

Introduction

The World Wide Web (WWW) offers a good opportunity to produce and deliver learning materials. The WWW platform makes possible to support different constructive learning theories by many kinds of interactions, which can be used in quite free and dynamic environments. The WWW also promises to be very a rich environment for educational research, as many powerful data collection algorithms can easily be added to WWW-based learning materials. With these algorithms researchers can record every mouse or keyboard input with an observation system that is invisible for the user of learning materials.

According to Loomis *et al.* (1999) the traditional relationship between experimental control and ecological validity of research is negative: when the experimental control of research is high then the ecological validity is low, and when ecological validity of research is high, then experimental control is low. By using a virtual environment as a research and observation environment, the ecological validity and experimental control of research can both be quite high (Loomis & Blascovich, 1999). Although the WWW is not a virtual environment in the full meaning of that word, we can assume that hidden observation in WWW-based learning materials can give more ecologically valid data from using the material than some traditional observation. Naturally, we can only have information about the learning materials' use. When comparing this kind of code-embedded observation and traditional observation in quantitative research, we cannot find any major differences in quality of data. The implementation of a test is not important, most important and meaningful is that we know what kind of information we want to have with the test (Buchanan & Smith, 1999). In quantitative research, we can even have a good benefit from code-embedded observation when code is written so that data is written direct to a raw matrix.

Research questions and method

Our research contains two groups of 6-year old children: experiment group (n=30) and control group (n=30). Both groups were pre- and post-tested considering their geometric skills. Only the experimental group uses the learning materials about geometry (45 min); the control group did not get any educational effect. Measures of the study are scheduled for completion in April 2000. The research questions of the study are summarized as follows:

- What kind of general differences in use of material can be found?
- Is there any connection between use of materials and learning results?

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Sequential analysis and attention

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The main peculiarity and privilege of animal model is the visibility of attention as a behavioral motivational reaction: approaching and searching a subject during spatial learning. Sequential change of the target's attention may be determined as a basic cognitive element, characterizing spatial learning in both individual typical normal variants and in psychopathological state models. Using a surplus number of sense elements - rewarded (F1-F2) feeders together with un-rewarded, or false ones (F3-F4) in the complicated T-maze (OTO-like form, with two going out in symmetrical ring alleys) we analyzed the probability of the sequence from both rewarded elements F1-F2 in rats. The interrupted registration of all reaction was done by a hand computer method during every 13-minute session (3 weeks duration), followed by analysis with a statistical program. Normal and limbic brain damage (amygdalectomised) groups of animals were compared.

Only about 10% of the rats showed a fast increase of the probability from day-session to session during the first 3-5 experiments. The general attention to both these elements correlated with earliest arising of whole optimal 4-elements sequence of learned cyclic habit (going out from the maze after food taking from both F1-F2 and re-entering). However, early arising didn't combine with stable reproduction of the whole optimal cycle , which varied from trial to trial (deficit of working memory?). The alternative variant (20%) showed latest arising of the sequence F1-F2- stable reproduction.

The crucial difference of limbic brain damage animal was revealed as arising of some abnormal sequences (like F1-F3), including non-essential elements – false feeders, which were "cut" in the norm during first trials. Thus original aberration of attention, induced by an "inhibition mechanism of motivational estimation" disorder, may be cue one for some mental diseases (schizophrenia).

A new approach to studying individual peculiarities of learning and memory in animals

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Nowadays, a paradoxical situation has formed in neurobiology: the more complicated and expensive molecular-genetic methods are used to study mechanisms of brain functioning in animal learning, the more primitive behavioral tests are applied as the screening method. In our opinion, this is a serious shortcoming as a battery of simple tests excludes an opportunity to carry out a complex estimation of various aspects of animal cognition, learning and memory within one experiment. The aim was to demonstrate the advantages of system approach in studying individual peculiarities of learning in Wistar rats.

Method

Animals (n=60) had to form a cyclic 4-link habit in a multiple-alternative maze by themselves. The task semantics was modeled as human-like intellectual activity and consisted of 4 logic elements: *if, after getting a portion of food in one or two feeders located in the maze (1, 2), the animal leaves the maze (3) and enters it again (4), there will be a new portion of food available in the feeders*. The peculiarities of the model are the following: 1) the problem task offered to the animal cannot be solved at once because the input information capacity (route diversity - 18^{12} , semantic diversity - 7^4) exceeds the brain capacity (7 ± 2 units of information); 2) the multi-alternative structure of the maze allows a number of equivalent locomotor realizations of formed plan of behavior; 3) the task is presented to an animal in implicit form and generation of several working hypotheses is required in order to find out the rule of behavior. Main ideas of the information theory, semiotics and psycholinguistics were involved in the analysis of behavior.

Results

Three behavioral phenotypes were observed in each group of ten Wistar rats. 60% of rats failed problem task solving. 40% of rats, “excitatory” (10%, type I) and “inhibitory” (30%, type II), were able to form a food operant behavior during 9-13 sessions. Type I having an exponential learning curve was characterized by: high locomotor activity, low level of fear, the highest associative abilities in the group (first correct solution appeared in the 2nd session). Unlike type I, type II had an “insight-like" learning curve and was characterized by: a higher level of fear in unknown situations, lower speed of learning and fast extinction of mistakes. Working memory in the habit realization played a leading role in type I as an integral solution was operatively reconstructed during a session, while long-term memory played a leading role in type II as an integral solution was extracted in the first trial of a session.

Conclusion

This behavioral model was successfully used for studying the influence of pharmacological (opioids, ethanol, heparin) and physical (magnetic field) factors on animal cognition in rats and mice. The data shown testify that a complex screening behavioral model allows obtaining data on individual cognitive abilities, principals of behavioral autoshaping, learning strategies, and differences in memory functioning during comparatively short-time experiments (10-15 sessions).

Does conditioning influence the increase of heart rate and body temperature as provoked by handling in the mouse?

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Animals subjected to various laboratory procedures and environmental changes will react to new situations with changes in their physiological responses. Handling of mice or offering them a new environment such as a new cage with clean bedding results in an acute increase in heart rate (HR) [2,3] and body temperature (BT) [1]. Radio-telemetry with an implantable transmitter provides an accurate and reliable way for obtaining these physiological measurements from awake and freely moving animals in their own environment. Previously we found that the HR of freely moving mice, implanted with an electrocardiogram (ECG) transmitter, increased from 400-450 beats per minute (bpm), measured in their home cages at rest, to 750-800 bpm measured after handling and/or placing the animals in a new cage [2]. BT, also measured with the radio-telemetry technique, increased with 1.5 °C after handling [1]. HR has been reported as an indicator for animal welfare and stress and has been used as a physiological parameter in testing the conditioned response in rats.

Handling of rats and mice is a common procedure in the laboratory animal house. The purpose of the present study was to investigate whether conditioning of the mouse with an acoustic stimulus (10 kHz, 60 dB), will reduce the effect of handling on HR and BT. Preliminary results seem to indicate that there is no adaptation of the animal to repeated handling, as would be reflected by a decrease of the response of HR and/or BT. Also no evident conditioning effect of the acoustic stimulus could be shown.

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EEG and radiothermomapping in healthy persons and Chernobyl patients during mental activity

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The present study was performed in 20 healthy persons and 36 patients, who took part in cleaning up of the Chernobyl accident's consequence, in 14 years after irradiation by low doses. EEGs and radiothermomappings were performed in awake patients during mental arithmetic and after it. EEGs were recorded from 16 electrodes and coherence coefficients were computed for 6 spectral bands for 26 intrahemispheric and 8 interhemispheric pairs. The new noninvasive method of radiothermomapping was used. 12 antennas (scheme 10x20 for EEG investigation) were placed over the head of investigated person.

In healthy persons the maximal increase of EEG coherence during calculation was observed in the frontal-temporal areas of the left hemisphere, and in the parietal areas of the right hemisphere. After mental activity coherence values had tendency to basement levels. In Chernobyl patients EEG coherence changes during mental activity were more expressed, in comparison to healthy persons, and had different dynamics. General increase of EEG coherence was observed in all brain areas in 50% of patients. An increase of EEG coherence in one hemisphere, accompanied by some diminish of EEG coherence in the other hemisphere, was obtained in 40% of patients. In 10% of persons the global lowering of EEG coherence was noticed. After mental activity, as a rule, the inversion of EEG coherence dynamics was observed: the global increase was changed by the global decrease and vice versa.

Temperature dynamics was recorded during the mental arithmetic performing (10-15 min) and after it (5 min). In healthy persons during calculation, the temperature increase was obtained in the right fronto-temporal and parietal, and left frontal and fronto-temporal cortical fields (for 30%-40% of measurements, in other cases the temperature did not change). In other brain fields, positive as well as negative temperature changes could be noticed. Temperature changes in Chernobyl patients, during and after calculation, were reliably more significant than in healthy volunteers. After calculation, healthy persons had the tendency to increase the average temperature of the brain surface, and localization of fields with increased and decreased temperature was individual. The Chernobyl patients had the tendency of the mean brain surface temperature lowering

The investigation showed the similarity of dynamics and localization for EEG and radiothermomapping characteristics, which reflects a possible correlation between electrogenesis and local circulation of (metabolic) human brain processes. Such an approach displayed marked breach EEG and thermodynamics cognitive activity in Chernobyl patients, which could witness some remote pathological process in brain.

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Refinements in acute models for the study of pain: outcome of a LASA workshop held on 28 October 1999

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Models for the investigation of pain attract considerable scrutiny since there is an unavoidable tension with legislation which demands that pain, suffering, distress or harm are limited as far as possible [1]. A workshop sponsored by LASA (Laboratory Animal Science Association), working closely with the UK Home Office, looked at acute models for the study of pain, with emphasis on the refinement of these models. The workshop considered acute models only, including:

- Intraplantar formalin
- Application of pressure (paw withdrawal threshold)
- Application of heat or cold
- Inflammatory models
- Surgical models

These models, used in combination, are regarded as highly predictive of analgesic effects in man. Many refinements relate to controlling the experiment to improve data and reduce the number of animals required. Species and strain choice is important, e.g. inbred strains of rat appear to be more sensitive for many measurements but may be more difficult to work with. Husbandry also should be tightly controlled; e.g. pinworm infection can double the paw withdrawal threshold. Similarly, operator variability for paw pressure methods is apparent since there is a subjective element to the measurement.

Other refinements relate to animal welfare. These involve reducing the impact of measurements by limiting the severity and duration of stimuli where possible. Heat application protocols should not lead to tissue damage (e.g. 55 °C for a maximum of 30 seconds may be sufficient). Similarly, by using early markers of pain the pressure in paw withdrawal studies can be limited to 100 g (250 g or more is commonly used). A quiet, controlled laboratory environment and the provision of environmental enrichment [see 2] before a study commences are also useful in calming animals.

Details of possible refinements in design and stimuli will appear in a report of the workshop to be published by LASA.

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The breathing pattern shows 'freezing'

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The special type of external breathing in rats is developed spontaneously or induced by an external factor. The figure shows different breathing patterns of rats: a - the special pattern, b and c - usual patterns. The special type of breathing is accompanied by 'freezing'. The state of 'freezing' is produced by a light pressure on the neck. Freezing is not a passive type of behaviour. This is a way to escape danger.

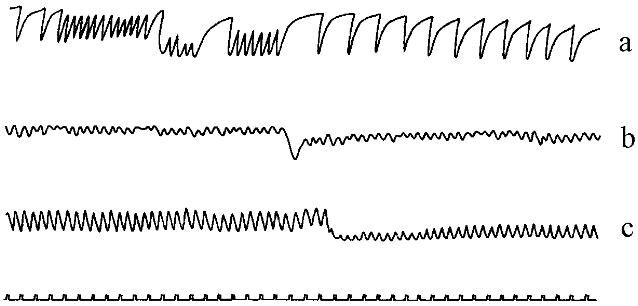

Figure 1. *Different types of breathing in rats: a. the special pattern of breathing; b, c. usual patterns. The downward deflection of the line corresponds to breathing in. The time scale is graduated in 1 s.*

Rats with the propensity to freezing demonstrated higher levels of exploratory and locomotor activities in the Porsolt test and a better avoidance learning in the shuttle-box, than rats without propensity to freezing. Rats with the special type of external breathing differ significantly from those in normal state in lower open-field activity. Rats with different propensity to freezing have different behavioural strategies. The special type of external breathing represents a reliable marker of the state in rats.

Mice at work: rating of housing conditions by means of an operant task

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Male mice (*Mus musculus*) were given the choice between two housing conditions. The apparatus comprised two standard cages (Makrolon type III, 37x21x15 cm) connected by a tunnel. One cage was left unstructured. The other cage was environmentally enriched with a wooden scaffolding and a plastic box with several openings. The tunnel incorporated a lever and two "one-way-streets" with two doors each. The mice could push the doors open and pass through in one direction only. The door that led to the enriched cage was locked by an electromagnet that was de-energized when the lever was pressed a number of times according to a fixed-ratio (FR) schedule. The way back to the standard cage was left unlocked. The mice had to work on the lever up to 16 times for one single entry to the enriched cage. During a period of 24 h, observations were conducted with digital imaging techniques at five different fixed ratios (FR1, FR2, FR4, FR8 and FR16). Preference was measured by the total time spent within the cage and the number of entries to the enriched cage. All mice preferred the enriched cage even if they had to work for it, although the number of entries to the enriched cage decreased at higher fixed ratios.

Human economics theory predicts that consumers with fixed incomes purchase less of a commodity as the price increases. A demand function can be calculated by relating the quantity of the commodity gained, Y, to the effort required to gain the commodity, X. The rate of decrease of the demand function is related to the perceived importance of the item: for luxury items such as champagne, the quantity purchased decreases at a rapid rate. For more essential items such as bread, the rate of decrease is relatively small. In analogy to human economics theory, the perceived importance of commodities concerning animal welfare (e.g. environmental enrichment) can be rated by means of operant conditioning techniques when an increase of price is simulated by an increase of the required fixed ratio.

The demand curve for access to the enriched cage was calculated by relating the number of entries per 24 h to five different FRs. As a control, a second demand curve was calculated from data derived from the same choice apparatus comprising two unstructured cages. Thus, the perceived importance of an environmentally enriched cage could be compared to the perceived importance of another standard cage.

The slopes of both demand curves were relatively small, a fact that indicates a high demand for both a second standard cage and an environmentally enriched cage. Whereas the slope of the demand curve for the enriched cage was significantly smaller, indicating a greater demand. This leads to the conclusion that (1) mice are clearly motivated to explore any given amount of additional space and (2) the access to environmental enrichment is perceived as even more important.

Assessing behavior, memory and learning of genetically modified mice by factor analysis based on track analysis using EthoVision and WinTrack

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Video tracking and computer-assisted analysis of locomotor paths is a powerful tool in the growing field of phenotypic analysis of genetically modified mice. The technique lends itself to tests requiring large arenas such as the Morris water maze and open field analysis, but is also applicable to other tests based. We have tested water maze learning of 3500 mice from many strains and genetically modified lines, using two standardized procedures. Likewise, nearly 2000 mice have been tested in an open field set-up. Most data have been recorded by using a Noldus EthoVision system. Because of the constantly ongoing refinement of data analysis, we use an off-line analysis program (WinTrack by D.P. Wolfer). By means of a macro language, the stored path data in form of XY-coordinates from every trial are first cleaned from recording artifacts. Behavioral variables are then extracted and tabulated in ASCII code as specified by the experimenter. The tables can be imported into any statistical program. WinTrack also imports track data from other systems. This approach enables us to conduct meta-analyses on large data sets, primarily by ANOVA and factor analysis, which reduces the large number of variables to a smaller set of factors thought to reflect processes underlying activity, learning and memory.

For the *Morris maze* (Figure 1), factor analysis revealed the following:

- The range of behavioral variation across "normal" mouse strains is as large as the variation found across genetically modified mice. This means that environmental variables and genetic background must be controlled carefully. For genetically modified mice, we recommend to test littermates from crosses involving two inbred strains.
- 3-4 independent factors account for most of the behavioral variation. The predominant factor is wall hugging ("thigmotaxis") which co-varies with many measures of acquisition such as path length, time in target quadrant, swim path length and special indices such as the Gallagher index. A second factor is differential swimming speed, while a third

independent factor is linked to differences in probe trial scores, that is, a trial in which the animals are searching around the position of a removed target platform. Despite of its frequent citation as a spatial memory index in the literature, it is rarely influenced specifically by targeted mutations. Rather, our data imply that most genetically engineered mutations with behavioral phenotypes in the water maze increase thigmotaxis, probably by reducing behavioral flexibility.

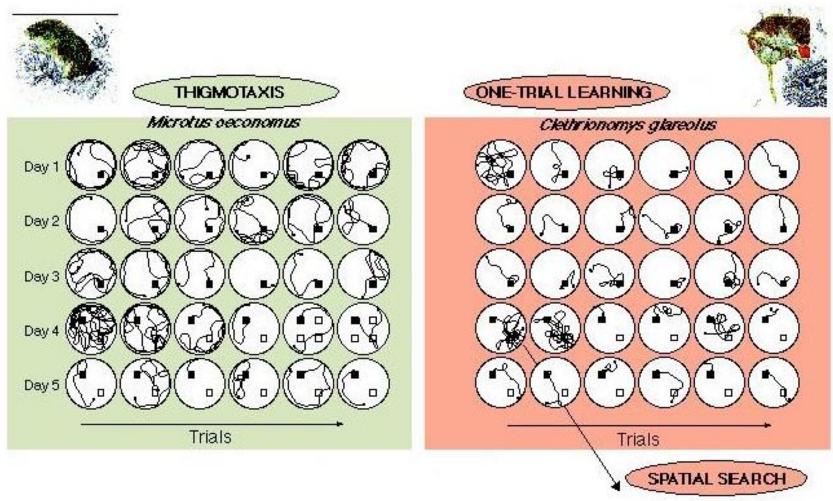

Figure 1. *Representative swimming tracks of two species of mice in the Morris maze.*

For the *open field*, are data are more congruent with the rat literature in revealing 3-4 factors:

- a factor reflecting basic activity/passivity including locomotor speed (changed most frequently by targeted mutations),
- a factor reflecting wall hugging (here interpreted as “agoraphobia”),
- a factor reflecting habituation, and
- a factor reflecting patterning of locomotor activity.

In conclusion, the analysis of paths provides remarkable insight into the genetic and functional architecture of memory and learning.

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A miniaturized GPS system and WinTrack software for analysis of homing paths in pigeons

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How pigeons find their way back home is still enigmatic, although partial mechanisms have been identified. The importance and interaction of putative mechanisms such as perception of magnetic fields and olfactory processes remains a matter of debate, however. The experimental analysis has been impeded by the crude behavioral techniques to analyze the orientation of the birds, namely vanishing bearings at the release site and recording of homing times. Hence, future analysis requires routine recording of the homing path.

Several path recording methods have been tried: tracking by airplanes and helicopters (costly and difficult), triangulation of pigeons carrying radio emitters (tedious and limited), tracking pigeons carrying radio emitters by the ARGOS satellite system (localization error up to 3 km), and compass-based route recorders [1] which have been successfully employed for more than 10 years, with one important limitation: calculation of flight paths from angular changes during flight requires the assumption of constant flight speed. This restriction, however, is not present in data loggers using global satellite positioning (GPS) as they record both true geographic location and flight speed.

Here we present a miniaturized GPS tracking system with an overall weight of 33 g (including casing and battery), carried on the pigeon's back. It is based on the GPS chip of the company μ-blox. The chip is controlled by a microprocessor permitting data logging for three hours in continuous mode, and up to 8 hours in energy-saving mode. After return of the pigeon, data are downloaded and analyzed using the homing pigeon module of WinTrack (D.P. Wolfer). This program eliminates recording artifacts, reconstructs missing data points, calculates common variables such as path length, speed, average distance to target, but also more complex measures such as directionality of circling at the start, path tortuosity and quantitatve similarities between different flight paths. A macro language permits to define and extract new variables from the stored data if necessary. In collaboration with the GFT Gesellschaft für Telemetrie-Systeme mbH (R. Laschefski-Sievers, Horts, Germany), the system is being expanded to communicate with the ARGOS satellite system.

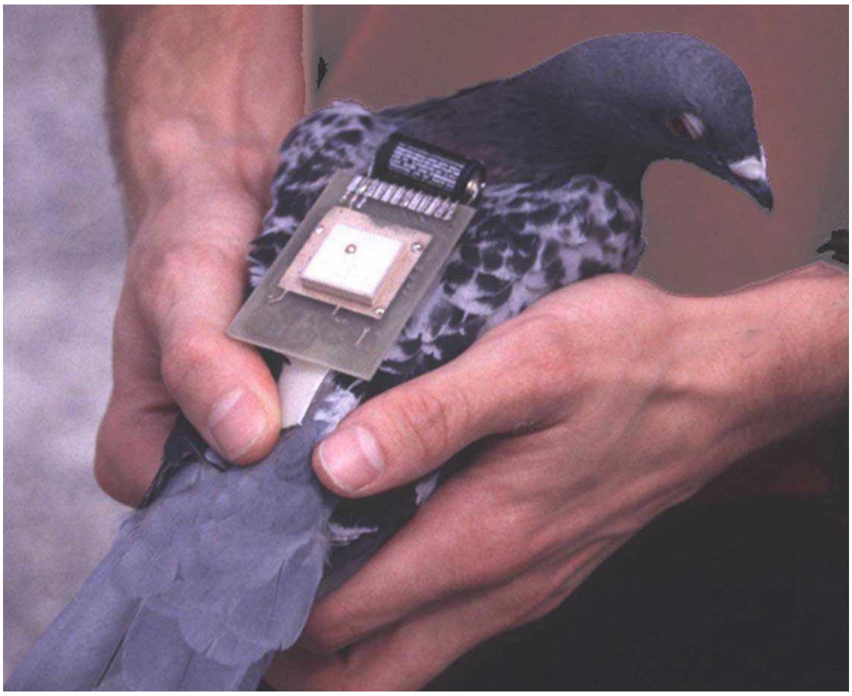

Figure 1. *GPS route recorder on the back of a homing pigeon. Casing has been removed for better view.*

At present, we are testing a set of prototypes and expect that this GPS system will permit to re-analyze a number of classical problems in homing pigeon research. In addition, we expect that these route recorders will permit studies that require constant path tracking, such as the problem whether pigeons read continuously geomagnetic or other cues during homing, or whether they rely on a navigational strategy known as dead reckoning.

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Dynamic correlates of searching behaviour of mice in different spatial experimental tasks

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The dynamics of spatial and motor related characteristics of searching behaviour of C57Bl/6 mice were analyzed and compared during operant learning, open field and elevated plus-maze tasks. Different movement and location measures of behaviour were processed during the tasks performing in order to reveal correlates between both individual strategies and dynamic parameters of activity in these three tests. Factor analysis of time-dependent modifications in behaviour was used as well as spatial movement time series analysis of dynamic complexity of step-by-step environmental searching, including evaluation of behaviour attractor dimensions. Heterogeneity of mice populations was found correlated with different searching strategies and complexity of behaviour.

Modeling complex real-time behavioral streams as optimized sub-sets of mutually exclusive and nested T-patterns

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The modeling of a behavioral stream here begins with the set of all T-patterns detected in a real-time behavior record coded in terms of the real-time occurrences of many different types of behavioral events. The T-pattern type and an algorithm (in the Theme software) for its detection have been described elsewhere [1,2,3,4]. T-patterns, which are recursively defined (as patterns of patterns), are essentially repeated chains of events characterized by fixed event order *and* significantly similar time distances between the consecutive parts of the chain over its repeated occurrences. While each detected T-pattern may capture structural aspects of particular temporal segments of the behavioral stream, the kind of model described in this paper combines the information contained in different patterns to describe the whole stream as alternating and/or temporally *nested* performances of sub-sets of the detected T-patterns.

A special algorithm first considers mutually exclusive patterns. It establishes all possible sub-sets of detected patterns where none of their respective occurrences overlap in time and selects the set (A), which has the maximum combined duration of its patterns, i.e., covers the largest proportion of the observation period (typically at least tens or hundreds of millions of sets need to be considered); see Figure 1. Nested patterns are considered next. Per definition, a T-pattern X is nested in T-pattern Y, if X is *not* a sub-pattern of Y but occurrences of X only take place during occurrences of Y (partially nested if at least one occurrence of X does). Patterns that are nested in any one of the patterns in A are then identified and added to the model, which thus gives a more complete description of the whole behavioral stream. Models of this kind are presented describing different types of human interaction such as children's collaborative problem solving and discussions between adults.

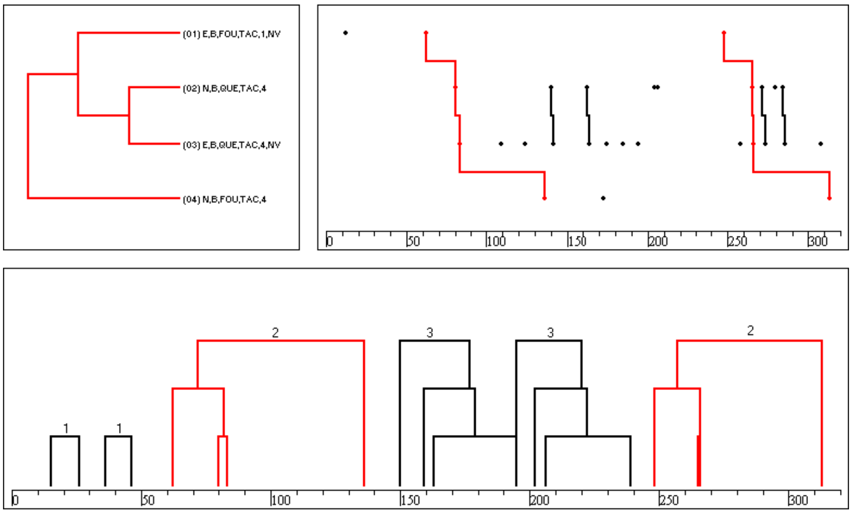

Figure 1. *The lower part of this figure illustrates how a behavioral stream (here 320 s of children's dyadic object play) can be described in terms of alternating occurrences of (here three, marked 1, 2 and 3) different non-overlapping T-patterns. Considering all possible combinations of the T-patterns that the Theme program detected within this behavioral stream, it automatically identified this particular sub-set as the one covering the greatest percentage of the observation time (total duration optimization). The upper part of this figure shows in more detail only one of the three patterns; marked 2. For an explanation of how to read this kind of pattern diagrams see Magnusson (1996a, 1998, 2000). It turns out that still other independent patterns may be nested within (i.e. occur completely within) the patterns of such optimized pattern sets.*

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Diagnostic possibilities of behavioral time structure analysis: discovering group differences through statistical analysis of detected T-patterns

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This kind of analysis begins with the detection of T-patterns in a number of real-time behavior records describing human interactions in terms of the real-time occurrences of various types of behavioral events. The T-pattern type and an algorithm (the Theme software) for its detection have been described elsewhere [2,3,4,5]. T-patterns, which are recursively defined (as patterns of patterns), are essentially repeated chains of events characterized by fixed event order *and* significantly similar time distances between the consecutive parts of the chain over its repeated occurrences.

In human interactions the observable behavior may vary as a function of the subjects (individuals) involved. Interactions involving particular types of individuals may thus involve different kinds of and/or varying amounts of directly coded behaviors and these differences may be strong enough to allow their classification or clustering into previously known or unknown classes of diagnostic interest.

But varying kinds and quantities of directly coded behaviors may not be a sufficient basis for such distinctions (classification/clustering). In such cases particular temporal relations between the observed behaviors may provide the necessary added information. This paper thus presents examples from studies of both normal and handicapped children where statistical analysis of detected T-patterns has allowed classification while similar statistical analysis of the initial behaviors, irrespective of temporal patterning, did not [1,6,7,8]. The examples presented concern interactions between different kinds of normal and handicapped (deaf-dumb, mentally retarded or autistic) children.

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Measurement of cooperation between pointing gestures and constrained speech during human-computer interaction

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This presentation will deal with the measurement of the cooperation between gesture and speech.

First, we will explain TYCOON, a framework that has been proposed for the analysis of multimodal behavior [5]. This framework is based on a typology made of six primitive types of cooperation: equivalence, specialization, transfer, redundancy, complementarity and concurrency. We have already applied this framework to the analysis of the multimodal behavior of subjects in a Wizard of Oz experiment at the Stanford Research Institute [2].

Secondly, we will describe a video corpus developed within the European project “Chameleon” [4]. In this corpus, twelve subjects have been recorded while making pointing gestures on a map and speaking constrained commands (i.e. “who is in this office?”). The aim of this corpus was to identify the features (hand shape, dynamics, etc.) of pointing gestures in a multimodal context in order to design a gesture recognition [1,3].

Finally, we will discuss how the TYCOON framework could be used for the analysis of the cooperations between pointing gestures and constrained speech in such a corpus. Referenceable objects of the map will be identified (i.e. rooms, walls, etc.). Rules will be proposed for computing the salience of this objects in gestural or spoken references (i.e. repeating pointing gestures could be considered as a way to increase the salience of the pointed object in the reference). Then, the rate at which the subject’s behavior is either redundant or complementary could be computed with the following formula: a global salience value has to be computed over all referents *rk* of all the commands *Cj* expressed by the subject; then this number is divided by the number of referents expressed by the subject as observed in the corpus.

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Time-resolved laser spectroscopy of brain tissue in freely moving rodents: an opportunity to assess energy metabolism during behavioural activity

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We present a method allowing potential identification and following of any fluorescent compound in all brain tissue (cortex or deep nuclei) of unanaesthetized freely moving animals, with a good spatial resolution. By time-resolved spectroscopy and a UV-visible kHz femtosecond laser, and using optical properties of NADH and oxidised flavins, we are able to perform rapid assessment of the metabolic changes occurring within defined brain regions. The temporal resolution is 10 seconds. The measures can potentially be performed for several hours to weeks within a single individual.

We analyse spectrotemporal parameters of autofluorescence at different excitation wavelengths. This allows measurements of metabolic activity by means of intramitochondrial NADH (excitation wavelengths: 337 and 355 nm) and flavins (excitation wavelength: 415 nm). Moreover, using the 480 nm excitation wavelength, we investigate autofluorescence in the range of Green Fluorescent Protein (E-GFP) absorption. Our method may then allow the following of a reporter gene activity.

Allowing to work with freely moving animals and providing real time measures, this method leads the way for real-time recordings of brain metabolism variations and genic activity concomitantly with the assessment of other physiological parameters (EEG, EMG, etc.) and behavior.

Signals behind motoric expressions: II. Body posture and social proximity in adult birds

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Body posture and social proximity in many avian species are well-established measures of emotionally guided behaviour. Here we show how both measures combine in a contextural way depending on previous experience, hormonal status and stimulus situation (Figure 1). In particular, we discuss the sensitivity of both variables to photoperiod dependent gonadal changes in male birds. Further, computer-based feature extraction is used to distinguish the critical features behind body posture within the context of visual stimulation. It is shown how very simple measures of body posture, such as center of gravitiy points for binary masks, can be used for an efficient and sensitive description of emotional responses to conspecifics within one-dimensionally restrained observation designs. Such measures may be extremely useful for standardization, a prerequisite for the development of comparable test paradigms in behavioural research.

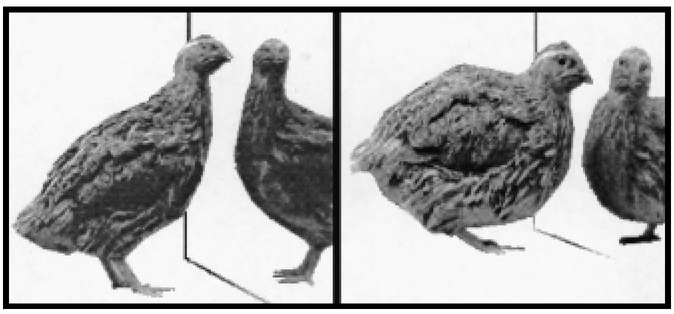

Figure 1. *Visual access to mirror images causes a spontaneous change in body posture in male quail. This response is not observable in females or gonadally regressed male birds.*

Y-maze odor discrimination in Tg_{2576} APP-overexpressing transgenic mice

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Transgenic mice (Tg_{2576}) overexpress amyloid precursor protein (APP) and develop plaques; hallmarks of Alzheimer's Disease (AD). Consequently, this mouse is considered a model of AD as deficits in Morris water maze learning are claimed to correlate with amyloid burden (Hsiao, 1996). However, we are unable to demonstrate any cognitive changes in these mice that relate to increased amyloid deposition. Amyloid deposits in these mice are observed by 10 months of age in several brain regions including olfactory bulbs. Presumed neurotoxic effects of amyloid could therefore interfere with the ability to discriminate odors. We exposed Tg_{2576} mice to an Y-maze odor discrimination task, presumably allowing us to describe a functional relevance of amyloid deposition in these mice. Three strains of mice, BL6/SJL, Tg+, and Tg-, and three age groups within the strains, young (9 mo), middle (11-12 mo) and aged (14-15 mo) were used. The animals were food-deprived such that 80% of initial body weight was maintained. Each animal was assigned a positive reinforcement (S+) odor (almond, lemon, peppermint) which when discriminated would result in a food reward. Animals were introduced into the Y-maze 6x for scent training prior to the discrimination session. Valence numbers were assigned to order of Y-maze arm entry for data analysis. There were no statistically significant main effects or interactive effects of strain and age suggesting these mice are not cognitively impaired.

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Gesture and speech multimodal conversational interaction in monocular video

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We present our work on the determination of cues for discourse segmentation in free-form gesticulation accompanying speech in natural conversation. The basis for this integration is the psycholinguistic concept of the co-equal generation of gesture and speech from the same semantic intent. We use the psycholinguistic device known as the 'catchment' as the locus around which this integration proceeds. We present a detailed case study of a gesture and speech elicitation experiment in which a subject describes her living space to an interlocutor. We perform two independent sets of analyses on the video and audio data:

1. We process the video data to obtain the motion traces of both of the subject's hands using the *Vector Coherence Mapping* algorithm that combines spatial, momentum and skin color constraints in parallel using a fuzzy image processing approach. We extract the voiced units from the audio signal as F_0 signal groups.
2. We perform expert transcription of the speech and gesture data by micro-analyzing the video tape using a frame-accurate video player to correlate the speech with the gestural entities. We also perform a higher level analysis using the transcribed text alone. The results of the psycholinguistic analyses are compared against the computed features to identify the cues accessible in the gestural and audio data that correlate well with the expert psycholinguistic analysis. The results of our analysis show that the feature of 'handedness' and the kind of symmetry in two-handed gestures provide effective cues for discourse segmentation.

We also present observations on how the gesture traces provide cues to segment the gesture stream, indicate high level discourse repair, and serve as super-segmental cues for discourse grouping.

Measuring behaviour of transgenic mice by using the LABORAS system

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This study evaluates the effects of biotechnological procedures involved in the process of microinjection-induced transgenesis in the mouse. We have compared four groups of C57BL/6 mice which differ in their transgenic history (transgenics after integration of a functional corticotrophin-releasing factor (CRF) gene construct, transgenics after integration of a non-functional CRF gene construct, non-transgenics after transgenic procedures, controls). These four groups have been tested in a 10 min light-dark test and a 24 h behavioural observation test, both using the automated behaviour registration system LABORAS™ (Laboratory Animal Behaviour Observation, Registration and Analysis System; Metris b.v., Hoofddorp, The Netherlands) presented previously at this conference [1]. With this system, the position and the six behavioural categories immobility, locomotion, grooming, climbing, eating and drinking can be deduced from the vibration patterns evoked by the individual mice. The system was recently adapted to accommodate a light-dark test cage and to analyse the data accordingly.

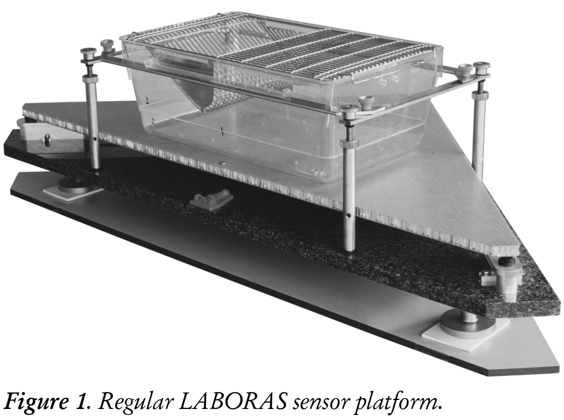

Figure 1*. Regular LABORAS sensor platform.*

The tests revealed differences in behaviour between the transgenic CRF animals and the controls; transgenic CRF animals showed more anxiety in the light-dark test and less locomotion, more immobility and less climbing behaviour during the 24 h individual observation test than the controls. For the other two groups no significant differences from control animals were found. Neither the integration of a DNA construct into the genome (without gene expression) nor the biotechnological procedures of microinjection seem to have a major effect on the behaviour of the mice. Previous results, obtained by screening the animals in the pre-weaning period substantiate these observations. The behavioural tests used in this study seem to be sufficiently discriminative to differentiate between the treatment groups and the controls. Thus, it is concluded that LABORAS can be used for behavioural phenotyping of newly produced transgenic lines.

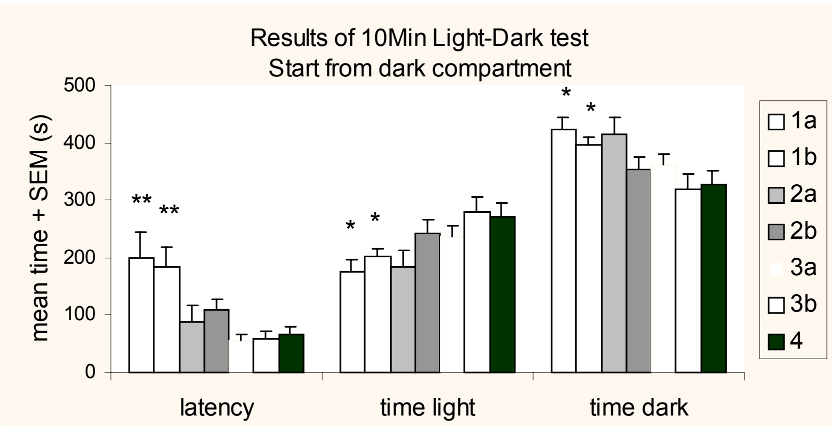

*__Figure 2.__ Results of 10 min light-dark experiment. Group 1: Corticotropin-releasing factor (CRF) transgenics with functional CRF construct (1a and 1b represent progeny from two different founders); Group 2: CRF transgenics with non-functional CRF construct (2a and 2b represent progeny from two different founders); Group 3: non transgenics after transgenesis (3a, injected with DNA construct, no integration; 3b, transgenic procedure, but no construct injected); Group 4: control animals (no transgenic treatment). Latency to first entry in dark compartment, total time spent in light and dark compartment (mean sec plus/min SEM) are shown. Test period was 10 min. * $p < 0.01$, **$p < 0.001$, significant difference compared to the control group).*

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Factors affecting lying and elimination areas in fattening piglets

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Although pigs tend to separate lying and eliminating areas, one of the problems of intensive pig production is the occurrence of dirty lying areas in fattening pig pens resulting in a higher labour input and lower technical results. Slatted floors are hygienic and require less maintenance. The main disadvantage is that they offer little comfort since the requirements of a lasting, clean floor are incompatible with the requirements of a soft lying area. Furthermore, the development of welfare-friendly housing systems requires a better knowledge of the factors influencing a clear elimination/lying separation. This study's aim was to assess some factors that could encourage pigs to structure their environment in an hygienic manner i.e.: shelter, a mat and proximity of a trough, and further how these should be combined as to optimize the separation.

Two adjacent fully-slatted pens (3.70 x 2.30 m) housing three piglets each were used. Subjects were 13 weeks old when introduced into the pens and had been group-housed. Food (trough) and water (nipples) were available ad lib. Social behaviour and spatial distribution of the pigs were recorded. Defecation sites, room and foreseen lying area temperature, were recorded daily. A colour CCD camera, connected to a Panasonic AG-6730 time-lapse video cassette recorder, was aimed sideways at the pen. The VCR recorded 4 one-hour periods spread over the entire day (09.00, 12.00, 18.00, 21.00) during twenty days. A focal sampling analysis was carried out using The Observer Video Pro software (Noldus Information Technology).

In the first experiment 3 piglets had a roof shelter (1 x 2.30 m) while the control group was housed in the barren pen. In a first period the trough was situated at the opposite side from the shelter close to the nipple. In the second one it was moved under the shelter. A new group of 2 x 3 piglets was used in the second experiment. Experimental piglets had a mat (1 x 2.30 m) instead of the shelter, the control group staying in the barren pen. In the second period the trough was moved on the mat.

A first analysis of the results showed that the pigs did not lie in the sheltered area. Instead they favoured to sleep close to the trough and kept that area clean. During the second period, the trough was moved under the shelter. This resulted in an immediate switch between the lying and dunging area. In the second experiment the piglets lied partly on the mat, partly on the slats. During the second period, the trough was placed on the mat, which resulted again in a switch between the former lying and dunging areas.

Regular registration of the temperature indicated that it had no influence on a relocation of the lying area. We conclude that, under the present conditions, the separation between lying and elimination area was essentially determined by the location of the feeding trough and not by the presence of a shelter or a mat.

Influence of nonconvulsive seizures induced by pilocarpine on spontaneous behaviour in adult rats

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Nonconvulsive limbic status epilepticus was induced by means of pilocarpine (15 mg/kg) in 10 LiCl-pretreated rats with implanted electrodes. The animals were exposed to an open field three times – just before pilocarpine injection, at the time when pathological EEG activity was unmistakably present in hippocampi (40-50 min after the pilocarpine), and when EEG activity turned to normal (120 min after treatment), each time for 10 min. Behaviour of the rats was monitored and 12 behavioural patterns were evaluated. Exploration (walking, rearing, sniffing) interrupted by periods of immobility and grooming prevailed in the pretreatment test. During pathological EEG activity, changes in both the total frequency, the total duration of behavioural patterns and the sequence of patterns and their expression were found. Furthermore, pathological patterns (head bobbing, chewing, staring spells) typical of nonconvulsive seizures appeared. Upon the postseizure test, pathological patterns disappeared. However, locomotor-exploratory activity of animals significantly increased. The activity corresponded to that of the first test. This finding suggests that habituation potency of animals with prior limbic seizures was impaired. In conclusion, limbic seizures induced by a low dose of pilocarpine resulted in changes in the structure of spontaneous behaviour and disturbed the processes related to the most elementary form of learning and memory.

Towards a research methodology for assessing command team performance

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Over recent years, there has been a vast growth in technological systems that aim to enhance human performance. For example, military command teams are being provided with digital support tools that automate numerous processes, and provide access to an almost unlimited amount of information. The introduction of these systems into what has previously been a manual process has the potential for significant impact. A variety of tragedies have demonstrated that one of the largest influences on system performance remains the human factor. Human error has been found to be responsible for 60% to 80% of fatal aviation accidents, and communication issues were found to be involved in more than 70% of accidents (Brannick *et al.*, 1995). The suggestion is that a large influence on effective performance is the interaction between information technology and team processes. In addition, research has suggested that not all aspects of digitisation improve performance. For example, Bowers *et al.* (1998) found that automating certain tasks was associated with improved team performance on only 1 in 4 measures.

Given the increasing emphasis on digital systems, it is important that research be conducted that will assess the impact on the performance of the command team. This creates a requirement for research that investigates and establishes techniques for analysing command team tasks and processes. In particular, techniques are required to identify and delineate the teamwork and the taskwork processes. Taskwork consists of behaviours that are performed by individual team members and are critical to the execution of individual team member functions. Teamwork, in contrast, consists of behaviours that are related to team member interactions, and are necessary to establish coordination among the individual team members to achieve team goals (Gregory & Kelly, 1998).

The focus of this paper is on observational methodologies that have been developed to collect behavioural data on command team processes. The *Team Behaviour Index* is used to determine team performance, while the *Objective Taskload Index* is used to determine command team taskload and structure. The techniques are currently being used within the Australian Army to collect empirical data on the information flow among the team, the team dynamics, the task characteristics, and the overall workload. The methodology has been found to be useful at multiple headquarters levels, demonstrating a high degree of cross-situational generality. The paper will describe these indices, and will present a sample of data that can be generated using this approach.

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Automated system for tracking and behavioral analysis

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The goal of the present work is automation of the Morris water pool test [1, 2] that is one of the most adequate and frequently used behavioral methods for study of memory and cognition functions in animals models of neurodegenerative disorders. In our specific experiments, aimed at testing of performance of various neuroprotectors, white rats are placed in water in round black pool 1.8 m in diameter and must find an invisible platform using visible landmarks around. Thus, an original system for tracking of the animal's trajectories in time and their analysis was developed.

The system consists of video hardware and a computer program. The hardware was chosen so as to provide high resolution, sufficient tracking speed, capability to create a video archive and adjust the video path parameters for optimization of the tracking conditions. The software should provide fast and qualitative tracking, storing the results in the database and video archive and their behavioral analysis. The detection and tracking of the object on a water surface is rather difficult due to multiple flashes (reflection) from the water. The construction of the unit and a special algorithm of processing of the image make it possible to solve this problem successfully, so the tracking process is practically insensitive to illumination and never crashes. The program automatically detects borders of the pool and other analyzed zones taking into account perspective and geometric distortions. Each track is automatically recorded on videotape during the experiment. All information about the experiment including the track position on the videotape is stored in the specially developed database and can be played back or repeatedly digitized (if required). A "streaming" mode of the experiment where tracking is started automatically at appearance of an animal in the pool and stopped at certain conditions is available in our system as well being very convenient for tests of a large number of animals.

Single tracks or experiments or any of their combinations can be analyzed using our software. A primary statistical analysis of the data obtained can be carried out directly in the program. The data can be exported into other programs such as Microsoft Excel, Statistica, etc. Currently the program is designated for tracking and analysis of animal behavior in a round pool, about 10 parameters being analyzed. However, it is object-oriented, so it can be easily modified for arbitrary pools and mazes of different shape and we can introduce any desirable criteria. The program operates under Windows 9x/NT/2000 and has a user-friendly interface. It has a comprehensive help system and detailed documentation. We will continue development of this software.

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Automated measurement of tonal bird vocalisations: a methodological approach and examples of its application

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Vocal signals can be regarded as special building blocks of behaviour. In most cases, such signals occur boutwise and in a clear serial organisation. Depending on the composition of signal series, one can distinguish between homotype and heterotype building blocks. In this paper, we present software designed to analyse rules of both the organisation and the dynamics of series of acoustical behaviours.

In the study reported here we investigate aspects of the vocal repertoire of the Arabian Babbler (*Turdoides squamiceps*). Similar to other birds, its repertoire comprises several highly distinctive and easy recognisable call types, though calls of the same type often show considerable variation (Figure 1). Beneath investigations of the phenology of call type usage in different situations, we particular focus on this variation in calls and call series, and the possible relation between this variation and, for instance, the context or the caller's social status.

Most of the calls concerned are more or less tonal with much emphasis on the fundamental (or sometimes the first harmonic). So far, only few attempts have been made to analyse the acoustic structure of such vocalisations in detail, and, probably due to the difficulties of (objective) measuring, in most studies mainly straightforward parameters such as maximum frequency or call duration were used. Since in the current study we wanted to quantify call parameters in more detail we developed software for that purpose. This program analyses spectrograms with a particular focus on the course of the fundamental.

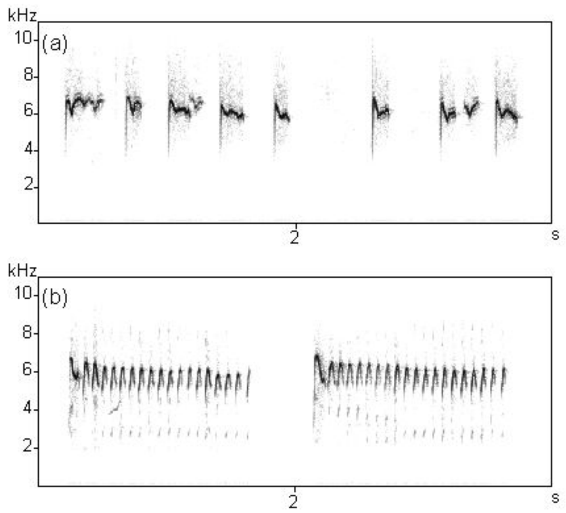

***Figure 1**. Spectrogram of call series of an Arabian Babbler: (a) call type 'tzwick', (b) call type 'thrill'. Note especially the variation within series.*

At the moment, the program allows to analyse spectrograms containing either a single call or a regular call series. If call series are analysed, it measures each call separately. Measures of call properties mainly focus on the fundamental's shape, and, besides straightforward parameters, include parameters that describe the fundamental's course in more detail or indicate features like its regularity. Since the general shape of signals may vary according to the type of the vocalisation, we vary the set of parameters according to the general structure of vocalisations. Additional parameters describe the energy distribution across time and frequency. Since we mainly analyse field recordings that may contain considerable amounts of background noise we also included measures that indicate the reliability of the analysis. Also an optional export of files containing the amplitude distribution over time, the location of the detected signal, and the detected course of the fundamental allows for a later validation of the values calculated.

We use the program in studies of mobbing vocalisations, long range vocalisations and call ontogeny. First results indicate that the microstructure of vocalisations was clearly related to several parameters of the context. For instance, parameters of mobbing calls were related to the kind of predator and its distance to the caller. Interestingly, a presumed increase in the danger of the situation had similar effects on different call types. The application of the developed software thus proved to be useful for elucidating variation in serial acoustic behaviours and its relation to other variables, e.g. the context.

The study was supported by funds of the GIF and the DFG (To 13/30-1).

SignStream: a tool for linguistic and computational research on visual-gestural language data

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Research on recognition and generation of signed languages and the gestural component of spoken languages has been held back by the unavailability of large-scale linguistically annotated corpora of the kind that led to significant advances in the area of spoken language. A major obstacle to the production of such corpora has been the lack of computational tools to assist in efficient analysis and transcription of visual language data.

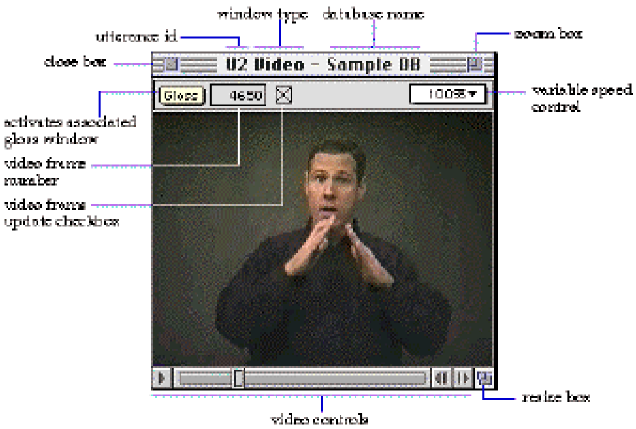

Figure 1a*. SignStream: video and gloss windows.*

The first part of this talk will present SignStream™, a computer program that we have designed to facilitate the transcription and linguistic analysis of visual language data. SignStream provides a single computing environment for manipulating digital video and linking specific frame sequences to simultaneously occurring linguistic events encoded in a fine-grained multi-level transcription. Items from different fields are visually aligned on the screen to reflect their temporal relations, as illustrated in Figure 1.

We will describe the capabilities of the current release – which is distributed on a non-profit basis to educators and researchers – as well as additional features currently under development.

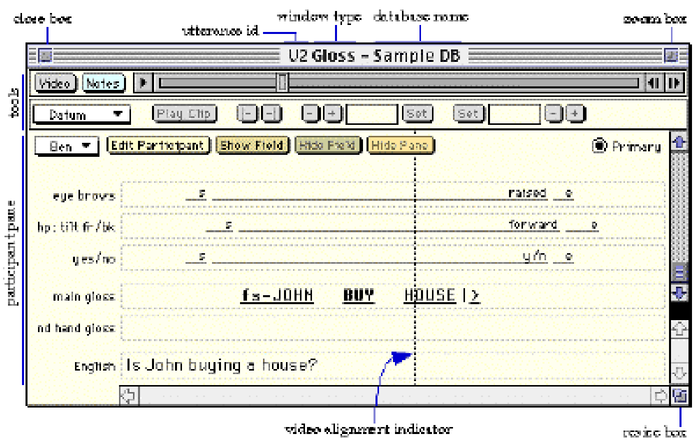

Figure 1b. *SignStream: video and gloss windows.*

Although SignStream may be of use for the analysis of any visual language data (including data from signed languages as well as the gestural component of spoken languages), we have been using the program primarily to analyze data from American Sign Language (ASL). This has resulted in a growing corpus of linguistically annotated ASL data (as signed by native signers). In the second part of this talk, we will discuss the ways in which the annotated corpus is being used in the development and refinement of computer vision algorithms to detect linguistically significant aspects of signing and gesture. This research is being conducted within the context of the National Center for Sign Language and Gesture Resources, which has established state-of-the-art digital video data collection facilities at Boston University and the University of Pennsylvania. Each lab is equipped with multiple synchronized digital cameras (see Figure 2) that capture different views of the subject (see Figure 3).

The video data collected in this facility are being made publicly available in multiple video file formats, along with the associated linguistic annotations.

Figure 2. *National Center for Sign Language and Gesture Resources: data collection facility at Boston University.*

Figure 3. *Three views of a signer.*

The projects described here have been supported by grants from the National Science Foundation.

Analysis of behavioral patterns in hypoglutamatergic mice: Implications for autism and cognitive deficits in schizophrenia

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NMDA receptor antagonist-induced hyperactivity in rodents has become a popular model of schizophrenia. Apart from hyperactivity, many other behavioral effects, such as defects in attention, hypersensitivity to outer stimuli and a general primitivization of the behavior can be observed after administration of NMDA receptor antagonists. It is likely that some of these behavioral changes correspond to cognitive deficits seen in disorders like schizophrenia and childhood autism. The aim of this study was to characterize and quantify changes in behavioral pattern in hypoglutamatergic mice treated with different types of antipsychotic compounds, using automated video tracking (EthoVision 1.95 – Noldus Information Technology).

The glutamate antagonist MK-801 induces a severe primitivization of the animals' tracks. We have tested four different psychotropic compounds in the MK-801 model, i.e. the classical neuroleptic haloperidol, the atypical antipsychotic agent clozapine, the DA D2/5-HT2A receptor blocker and antipsychotic agent risperidone, and the highly selective 5-HT2A receptor antagonist M100907, which has recently in phase III trials of schizophrenia been shown to have mild antipsychotic effects and be virtually devoid of side effects.

The tracks show that each receptor blocker has a unique effect on the movement pattern, with haloperidol being unable to affect the monotonous behavior induced by MK-801, while i.a. risperidone causes a movement pattern of high intricacy, albeit different from controls. This is an interesting finding in view of 1) the increasing number of reports showing beneficial effects of risperidone in autism 2) the observations that risperidone seems to improve cognitive functions, such as attention and working memory in schizophrenic patients, effects that may be mediated via 5-HT2A receptor blockade

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Intracranial recordings and word recognition in the human brain

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Non-invasive methods to image activity in the human brain are improving steadily, but still suffer from considerable shortcomings in terms of spatial and temporal resolution. Under special clinical conditions, it is possible to measure directly the neuronal activity from regions of the human brain. Electro-physiological recordings can be made chronically from electrodes placed in the depth or on the surface of the brain to localize the origin and spread of seizure-related activity in patients with medically intractable epilepsy. Investigations that piggyback on this clinically driven invasive methodology are particularly valuable in the study of higher cognitive functions for which animal models can be difficult and sometimes impossible. Intracranial recordings from epileptic patients have thus contributed substantially to our knowledge about language functions in the human brain. In particular, they have highlighted the involvement of non-perisylvian brain regions in the system of distributed brain regions that orchestrates language usage.

Two brain areas within the more densely sampled terrain of the inferior occipital and temporal regions have been identified – along the posterior and anterior portions of the fusiform gyrus. Both regions show specialization for processing verbal material, and are nearby to areas that are dedicated to processing face stimuli. The posterior region is not influenced by the semantic content or context of the stimuli, but is strongly affected by selective attention. The anterior region, in the anterior medial temporal cortex underlying the hippocampus, is sensitive to both the content and the context of word stimuli, and is also modulated by selective attention. The nearby face-selective areas show a parallel progression of sensitivity to semantic factors, with only the anterior region being sensitive to the familiarity and context of the face. The intracranial findings therefore support the existence of nodes that are functionally specialized for treating verbal material within the ventral object-recognition system.

Complementary methodology for studying the human brain has confirmed the involvement of these brain areas within the language network, and has helped constrain the interpretations regarding their contributions. The posterior node may subtend visual analysis of word shapes, participating in orthographic computations. The anterior node may provide an interface between language and associative long-term memory functions, weaving the word representations, perhaps multimodally, with the ongoing context. The discovery of these additional nodes specialised for verbal material has greatly enriched the formulation of language implementation in the human brain.

Mouse agonistic behavior data collected with The Observer and statistically analyzed with an add-on program differentiating three mouse categories: aggressive, timid and sociable individuals

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Agonistic behavior, occurring during intraspecific conflicts, refers to the spectrum of conflict-related behavior including not only aggressive behavior, but also the elements indicative of escape, defence, submission and other behavioral elements. Using the model of agonistic behavior of singly-housed male mice (outbred strain ICR) on dyadic interactions with non-aggressive group-housed partners in neutral cages, we have learned that isolates might be divided into three categories: a) *aggressive isolates* exhibiting at least one attack towards the opponent, b) *timid mice* exhibiting a lot of defensive-escape behavior but no attack, c) *sociable mice* exhibiting a majority of sociable behavioral elements, ambivalent locomotor activities and no defensive-escape or aggressive behavior.

For collection of behavioral data from videotaped 4-min agonistic interactions we are using the system The Observer 3.1 (Noldus Information Technology b.v., The Netherlands) which enables us to use a computer keyboard for recording, coding and analysis of not only frequencies but also time parameters of events observed from the videotape. Five time parameters can be evaluated: latency (amount of time elapsed from the start of the observation to a specific event), total duration (which can also be expressed as a percentage of the total observed time), mean duration, minimum duration (smallest duration of an element bout) and maximum duration (largest duration of an element bout). Recommendation is to transfer the summary data gathered with The Observer into Microsoft Excel for statistical analyses. While doing so we were facing to the problem of allocation of experimental animals into three individual categories, and furthermore, of evaluation of our ethopharmacological experiments in which we need to compare behavioral changes elicited by several different treatments: e.g. vehicle as a control + usually at least 2 or 3 drug treatments. The projects of experiments are randomized; thus, each animal passes all types of treatment during the experiment. The differences between the occurrence of acts in control and experimental interactions are evaluated by Wilcoxon matched-pairs signed-ranks test (pertinently by Mann-Whitney U test in the case of experiment with the repeated drug treatment requiring two independent singly-housed mouse samples).

For the above-mentioned reasons an add-on program was developed enabling statistical analysis of pharmacologically induced behavioral changes in three differential categories of mice classified according to their behavior exhibited in the control agonistic interactions. It works under the Excel 97 and was prepared using macros in Visual Basic for Applications to make the program user-friendly. The operator just has to insert data informing about the sequences of experimental interaction types belonging to individual singly-housed mice during the whole experiment. The program counts the means and medians for each 'Observer parameter', and processes statistical evaluation for the levels of significance $p < 0.05$ and $p < 0.01$. From Excel the final data can be transferred to graphical programs or stored in a database. The present presentation demonstrates utilization of the described method for analysis of pro-aggressive effects of new anticonvulsants gabapentin and lamotrigine.

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Measuring and modelling learning success of African dwarf goats

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Learning is an important way of behavioural adaptation to improve future interactions between animals and their environment by individual acquisition and processing of information. Modern animal husbandry is increasingly characterised by automation in food and water supply, care, and even cow milking. Within this framework, cognitive capabilities gain importance in farm animals. Most of the systems that are offered, however, integrate the interactions between animals and technology only on a low level. One of the reasons for this could be an incomplete knowledge on farm animal cognition. The aim of our study, therefore, was to develop an effective and suitable method to test farm animals for their learning capabilities and cognitive abilities. In addition, the set-up was designed in such a way that it is possible to examine learning behaviours in larger, socially structured groups of animals. As a model, the African dwarf goat was used.

A general-purpose computer system for behavioral conditioning experiments, called "Feldermonitor", was developed. It consists of a 17" computer monitor with the screen covered by a clear acryl glass divided into four sectors each containing a switch in the middle. When an animal chooses the switch with a specific conditioned visual pattern, the computer delivers a portion of water (20-30 ml) into a bowl. By this way the animals are forced to retreat after the correct choice, drink the water, and then move back to the screen. Each goat is registered individually by a transponder system. Each pressing of a switch triggers the data collection. Automatically registered data are: animal number, time, position of the S+ stimulus, position of the S- stimuli, current state of the screen (active or black) and correct or incorrect choice. The data collected during an experimental day where written to disk.

This set-up allows flexible stimulus presentation and rewarding for different kinds of learning behavior of animals under group housing conditions. Using this device, up to now 160 African dwarf goats were tested in 14 groups for simultaneous visual discrimination tasks with four stimulus patterns (simple geometric figures) presented simultaneously. Each test consisted of a period of 14 days.

The learning ability of each goat and the mean learning ability of a group of goats can be modelled by using a non-linear model with four parameters. These parameters can be interpreted very well in the context of learning. A learning curve can be obtained for each goat. A future long-term experiment will include the genetic improvement of learning success by means of selection. The selection criterion will be derived from learning curves.

The modified hole board: a novel behavioral test for rodents

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To behaviorally characterize rodents and also to assess drug effects in these animals, tests of spontaneous unconditioned behaviors are often used. In these tests locomotor behavior plays a crucial role as it seems to be difficult for instance to reliably dissociate locomotion from indices of anxiety or exploration. To differentially investigate behavioral dimensions in rodents, behavioral data obtained from a series of different independent tests have to be correlated, resulting in cost-intensive and time-consuming procedures. Moreover, it has to be considered that an animal's behavior is context-specific and, thus, independent behavioral dimensions might be produced by different test paradigms themselves. Behavioral tests which allow to investigate a wide range of behaviors and which are focussed on a more detailed ethological analysis of experimental animals in a single complex paradigm may overcome these disadvantages.

We designed a modified hole board (mHB) paradigm which enables the investigator to perform more complex ethological observations than other tests of unconditioned behavior. The mHB comprises the characteristics of the classical hole board, which is especially used to evaluate exploration and activity, and the open field, which is used to investigate anxiety and locomotor activity. Additionally, by allowing visual and olfactory contact among the animals to be tested, the design of the mHB circumvents the stressful factor of social isolation during the test and enables the assessment of the social affinity among group mates. Therefore, this new test paradigm enables to investigate a wide range of behaviors, including anxiety-related behavior, risk assessment behavior, exploration, locomotor activity, and social affinity.

Wistar rats that have been selectively bred over the past decade for high anxiety-related behavior (HABs) show an increased innate emotionality and more passive stress coping strategies than the line of low anxiety-related behavior rats (LABs). Thus, HABs represent a unique psychopathological animal model of innate anxiety with face and predictive validity. In the present study the mHB behavior of untreated HABs and LABs revealed clear differences in anxiety-related behavior. Furthermore, HABs compared with LABs showed no differences in exploration of the protected area (i.e. rearings in the box) or social affinity. The same behavioral characteristics were found in vehicle-treated animals in two pharmacological experiments.

These results demonstrate that, using the mHB test, it is possible to differentially analyze the basal behavior in rodents and to evaluate behavioral effects induced by different pharmacological treatments under stress-reduced conditions. Behaviors such as anxiety, exploration, and locomotor activity can be dissociated and investigated by thorough monitoring and analysis of behavioral parameters obtained in this behavioral test. Hence, the mHb represents an alternative to the common practice, namely performing a series of more specific tests. Finally, due to its stress-reduced characteristic by avoiding social separation, the mHB test enables the investigator to evaluate subtle behavioral modulations such as mild changes in anxiety-related behavior or changes in the exploration of unprotected areas. Our results confirm that the mHB represents an effective tool for behavioral characterization in rodents and for high throughput-screenings for potential therapeutic agents in preclinical research.

Hierarchical coding of vocalization: computer-based training and reliability

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The study of development of vocalization behavior has long been dominated by two trends. In the first trend, interaction between infants or children and parents has been observed, usually by developmental psychologists. Categories of coding have been few, generally 2-5, in these interaction studies, and the paucity of categories has limited the interpretive power of the work. On the other hand, interaction studies have tended to provide sophisticated monitoring of observation reliability for the small number of categories employed in the work.

In the second type of research, infant or child vocalizations have been observed independent of interaction, in studies often performed by linguists or psycholinguists. The number of categories of coding has tended to be large. For some such coding schemes, each event can potentially be coded in terms of hundreds of possibilities. The complexity of linguistically-sophisticated coding systems inevitably complicates reliability assessment. In order to evaluate reliability quantitatively, much more effort is needed than in studies with few categories, and as a result there has been a lack of appropriate attention to reliability in linguistically oriented studies of vocalization.

Recently, the problem of reliability assessment has been intensified in linguistically-oriented studies of vocalization because schemes of coding for vocalization have been complicated even further in response to the recognition that patterns of infant vocal activity are organized hierarchically in syllables, utterances, phrases, and even higher order rhythmic units [1,2,5]. The prosodic characteristics of these higher order units is of increasing interest because it appears to reveal that infants even in the first months of life possess the core features of the rhythmic organization of prototypical mature speech. The infant capability is manifest, for example, in similar average durations of hierarchical units for infant vocal sequences and for clearly produced mature conversational speech, or for such prototypical rhythmic forms as nursery rhymes.

Computer-based observational coding and training offers new possibilities for the establishment of new coding schemes, the enhancement of reliability and reliability assessment and for development of more compatible cross-laboratory procedures. The authors of the paper have been working for years on the development of such improved procedures. In particular, the paper will report on efforts in which we are developing a library of digitized infant vocalizations, with coding recommendations to be utilized in interactive computer-based training. The examples focus on categorization at three levels in the rhythmic hierarchy of vocalization (syllable, utterance, phrase) as well as on many features of individual syllables and their presumed primitive segmental (consonant/vowel) substructure. The examples have been coded by two 'gold standard' observers, experienced coders of infant vocalizations and contributors to the literature on coding. For each utterance or utterance sequence in the database, reference codings are specified in terms of an infraphonological model [3]. The codings are explicated in accompanying documentation. In many instances binary categories of coding pertain to continuous variables, and consequently some utterances may represent clear examples of a categorical type (pertaining to an end of the continuum to which the type belongs, far from the boundary between types), while others may represent relatively ambiguous cases (pertaining to the middle of the continuum, near the boundary between types). Both clear and relatively ambiguous examples of various categorical types are available, clearly marked as such in the database, along with explication.

The training procedures are designed to enhance reliability and insure possible consistency in criterion setting for categorization. The method is based on presentation of examples in a systematic format within LIPP (Logical International Phonetics Programs) files [4], with automatic access to the database and the codings of the gold standard observers. After introductory training with each dimension of coding, learners are subjected to tests of their coding also conducted within LIPP. In this way it is possible to insure that the basic categories of coding are treated in the same way by observers in various laboratories. The LIPP system, with its specialized analysis language, offers automatic comparisons of coding data from various observers and so provides a basis for systematic tests of reliability. Changes in coding conventions can also be implemented conveniently within this software framework. The work is pursued in the attempt to integrate the sophistication of reliability assessment from studies in developmental psychology with the sophistication of linguistically-oriented vocalization coding schemes.

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Combining video observations with data files from an automatic milking system

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Today it is possible to milk cows virtually without human involvement in a fully automatic milking system (AMS). The main part in such a system is the automatic milking unit (AMU) or milking robot. Research on cow behaviour has been carried out touching this topic, especially in the Netherlands and in England. Ketelaar-de Lauwere *et al.* (1998) studied the effects of free and forced cow traffic in a simulated automatic milking environment. Time studies of dairy cows in an automatic milking system with a selection unit and one-way cow traffic was carried out by Stefanowska *et al.* (1997). Studying cow behaviour requires 24-hour surveillance during a longer period in order to obtain enough data. This means, in most cases, that video techniques are the only available method. By placing an appropriate number of video cameras in the loose house, time budget studies at, e.g., the feeding fence and cubicles can be made. However, identification at the animal level is not possible.

In an AMU all cows are automatically identified when they visit the AMU. After identification the system decides if the cow in question should be milked or not. Each cow carries a tag around her neck that is read on each visit in the AMU by a small ID-antenna. All data from a cow's visit to the AMU is stored in computer files: cow's ID, time and date of visit, milk yield, milk conductivity, etc. By using the same identification equipment used in the AMU, cows can be identified at the animal level on each location where such an ID-antenna is installed.

The methodological results of this study are that it is possible to combine existing computer files from the AMU with The Observer Video-Pro software (Noldus Information Technology). All data from the AMU is stored in computer files. With a special program, NEDAP dfquery, specific data can be retrieved from the AMU files. The data is then further processed in such a way that it has the same format as the ODF data files used in The

Observer. With The Observer Video-Pro software, videotapes can then be scored using the newly created ODF files containing date, time of visit, cow-ID and type of visit. The configuration file in The Observer should be designed in such a way that it recognises all cows and all possible behaviours (milking, failed milking, unqualified visit, passing through ID-antenna). It is important that the internal clock of the tape recorder is set on the same date and time as the internal clock of the AMU. Both systems should have synchronised clocks throughout the entire period.

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Repertoire size, song types and temporal pattern of song switching in a population of Ortolan Bunting from western Poland

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I analyzed song diversity and variability of the Ortolan Bunting *Emberiza hortulana* to help assess the function of multiple song types and switching between them during bouts. Because of their focus on song categories and repertoire size, earlier studies did not analyze temporal aspects of within-bout song variability, which must be known in order to plan more advanced experiments, e.g. with interactive playback. Therefore, in this study I concentrated also on the characteristic of song types production within song bouts.

The study was conducted near Poznan (western Poland), where Ortolan Bunting is still a common species in its typical habitats. Over 150 males were recorded in the springs of 1997-1999 with a Sony TCD-D8 DAT recorder and Sennheiser ME67 shotgun microphone. Spectrograms were computed with Avisoft-SASLab Pro 3.75 and temporal analyses were done using The Observer 3.0 (Noldus Information Technology).

Songs were typically two-part: an introductory phrase of 2 to 6, usually double-element syllables, followed by a terminal phrase, composed of a few short and identical elements forming highly amplitude-modulated whistle (Figure 1). Individual repertoire sizes varied between 1 and 5 song types, however over 80% of males sang exactly 2 song types. There were on an average 1.3 different song types per recorded male within the studied population. Consequently, many song types were shared by several males. Each song type was uttered by 6 to 25% of all recorded males. There was a high degree of stereotypy of song both within individuals and type. Infrequently, songs were shortened by deleting one or few initial syllables or the whole final phrase. Therefore, the variation in song length (min-max: 0.51-1.48 s, mean±SD: 1.48±0.20) resulted mainly from the differences between song types. Lengths of the following song renditions for a given male and type were almost equal (CV < 3%), which proves the high level of stereotypy. Between-song intervals varied between 0.60 and 21.85 s (7.1±2.77). Individuals usally sang less than 10 minutes without changing the place of singing. However, bout duration in this species might be easily shortened by the observer behaviour.

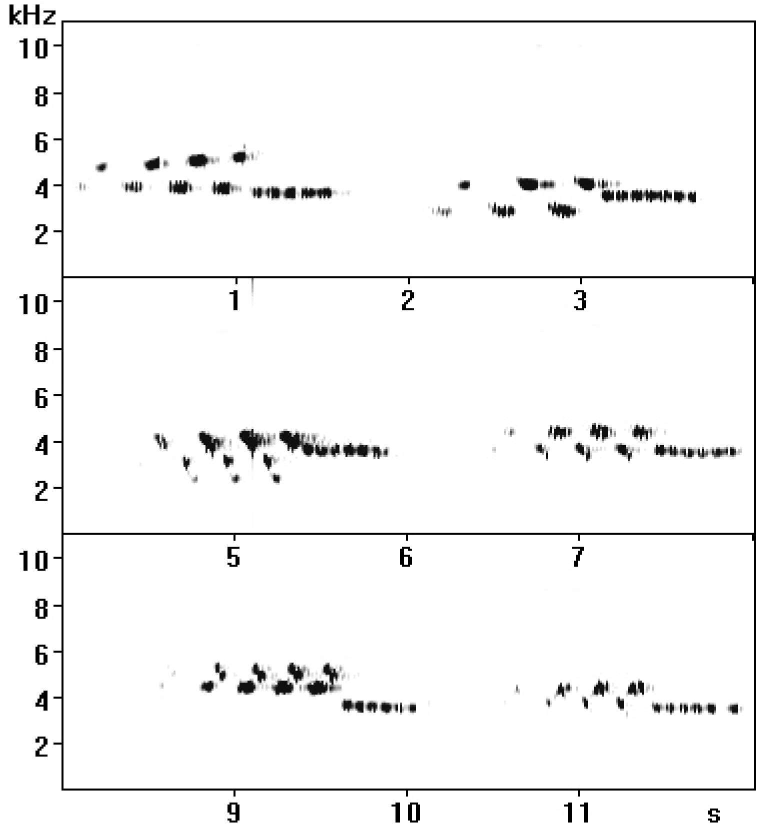

Figure 1. *Typical song phrases of Ortolan Bunting Wielkopolska region (W. Poland)*

Singing rate varied between 4 and 15.6 songs per minute (7.87±2.44). Series of one song types within a bout were very variable 1-31 (7.9±6.5), however rarely (<10%) exceded 15 songs. Song bouts can be divided into two classes: (i) with short series (3±2.6), and consequently, frequent switches – Figure

2A; (ii) with longer series (8.6±5.7) and less frequent switches – Fig 2B. Such different ways of using repertoires were not connected with an individual male's or recording's features (e.g. length), but with the context of singing (counteringing, male status etc.).

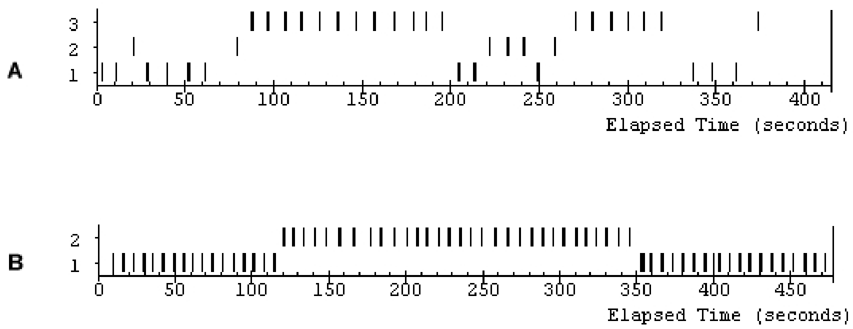

Figure 2. *Two categories of Ortolan Bunting song bouts: (A) – with short series of one song type, and frequent switches, and (B) – with long series and relatively rare switches. Each bar represents a song phrase; numbers on X-axis indicate different song types.*

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HTML viewer for synchronized video and kinesiological signal files

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Introduction

For a comprehensive assessment of walking disorders in a context of rehabilitation medicine, we developed a system for movement analysis based on multimedia technology, SYBAR [1,2]. This system synchronizes digitized video recordings of human behavior (e.g. walking) with digitized kinesiological signals (e.g. ground reaction force, EMG, joint angles). SYBAR is a Windows application written in C++. In order to make it possible to view the data sets of the SYBAR system with an Internet browser, we developed an HTML viewer based on a JAVA applet.

Method

The applet is started and receives input parameters in an HTML tag. Two of these input parameters are the URLs of the video (AVI format) and the synchronized data files. The format of the data files was taken from the SYBAR system. Video and kinesiological signals are coupled by means of a time code, which is written on the video frames as Vertical Interval Time Code (VITC), and is also stored in the data files. The graphical user interface of the applet contains a video player and figures with kinesiological data, in which a vertical time line shows the present video position (see Figure 1). Synchronization of video and kinesiological data is taken care of by regular updating of the time line of the figures to the time of the video player. The user can adjust the time of the video player not only with the control panel of the video, but also by mouse clicks in the figures.

Evaluation

The viewer was used to report the results of the analysis of the human movement lab to the referring physician over the hospital's computer network. A future use of the HTML viewer involves a client-server application suitable for multiple users across the Internet, which can be used for tele-consulation and tele-education.

Figure 1. *The graphical user interface of the HTML viewer as it appears in a web browser. The time lines in the figures with kinesiological data are synchronized with the video player. Video time can be set by mouse clicks in the figures.*

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Light-dark transition releases locomotor response in catfish, *Ictalurus* sp.

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Catfish, *Ictalurus nebulosus* and *Ictalurus melas*, seek shelter when light levels go up; they leave their hiding place and start swimming around when light levels go down. For a long time we have been using this locomotor response to control behavior in two-alternatives forced-choice experiments, without knowing precisely at what light levels the locomotor responses occur. We investigated and report here how much darkening was needed to induce the swimming response, i.e. to make the fish leave their shelter.

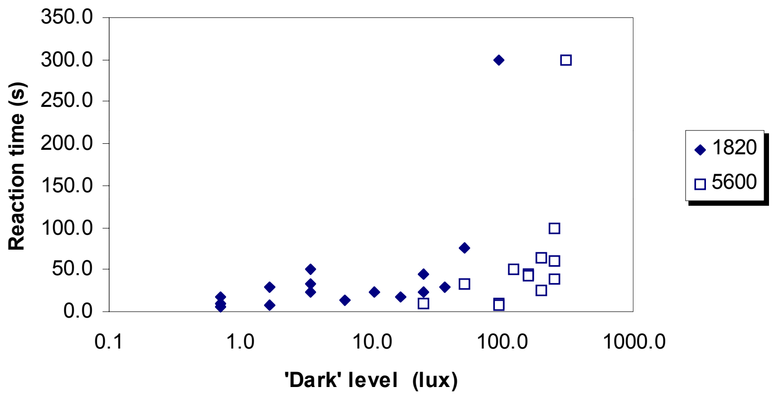

Figure 1. *Time between dimming the light and the moment a catfish leaves its shelter. The two sets of observations were made by lowering the light levels from 1820 and 5600 lux respectively to the values plotted on the X-axis in the graph above. It follows that the relative change in illumination controls the locomotor behavior.*

A single catfish, *I. melas*, was kept in a circular inflatable plastic basin of 1.2 m diameter, water height 30 cm, with a shelter at the periphery. The arena was illuminated by a 100 W Philips Astralux bulb. We used two different initial light levels, namely 1800 and 5600 lux. Light levels were changed by reducing the power supply of the bulb. At this stage we accepted the change of spectral composition when the light level was changed. A Grundig FA851 infrared sensitive video camera together with a simple black and white TV monitor were used to inspect the behavior of the fish. We made 6 observations per day, 52 in all.

It proved that at both initial light levels the fish responded to a relative reduction of light level from 100 to 5% in 5 s by leaving its shelter in less than a minute (Figure 1). At smaller reductions the response took more than 5 minutes to occur.

This study will be continued by an analysis of the neural connections involved.

Biotelemetry and behavior in the cynomolgous monkey

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A nonhuman primate model, in the cynomolgous monkey, has been developed for longitudinal monitoring of neurophysiological and behavioral parameters. With this model we are able to test the cortical brain activity simultaneously with the muscle tension and the spontaneous or controlled behavioral patterns. In this test system the electroencephalogram (EEG) and electromyogram (EMG) of the cynomolgous monkeys are registered telemetrically (implant TL10M3-D70-EEE, Data Sciences International). Furthermore, to induce a controlled alertness behavior, a coordination task has been developed. This test system consists of two variations: a static one and a dynamic one. The performance in this task is positively motivated by pieces of fruit. The rewards are placed horizontally at the left and right sides of the system. The animals can grasp the fruit rewards by using the contra-lateral hand at each side. Time and strategy (left or right hand first, easy or non-easy rewards first) were registered. In the static versions the easy reward takes less time to get. In the dynamic version, on the other hand, the more difficult reward is the fastest to reach. The strategy followed depends on the animal, but seems to be reproducible in time.

These techniques demonstrate that telemetry can be used for the monitoring of EEG and EMG in cynomolgous monkeys concurrently performing a motor-coordination task or, because the animals are monitored in their home cage, other behavioral patterns like sleeping. This gives the opportunity to get more inside in the neurological state of different types of behavior and to monitor the effects of psychoactive compounds.

A multimedia system for temporally situated perceptual psycholinguistic analysis

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Perceptual analysis of video (analysis by unaided ear and eye) plays an important role in such disciplines as psychology, psycholinguistics, linguistics, anthropology, and neurology. In the specific domain of psycholinguistic analysis of gesture and speech, researchers micro-analyze videos of subjects using a high-quality video cassette recorder that has a digital freeze capability down to the specific frame. Such analyses are very labor-intensive and slow. We present a multimedia system for perceptual analysis of video data using a multiple, dynamically linked representation model. The system components are linked through a *time portal* with a *current time focus*. The system provides mechanisms to analyze overlapping hierarchical interpretations of the discourse, and integrates visual gesture analysis, speech analysis, video gaze analysis, and text transcription into a coordinated whole. The various interaction components facilitate accurate multi-point access to the data. While this system is currently used to analyze gesture, speech and gaze in human discourse, the system described may be applied to any other field where careful analysis of temporal synchronies in video is important.

GSEQ for Windows: New software for the sequential analysis of behavioral data, with an interface to The Observer

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GSEQ is a general-purpose program that analyzes behavioral sequences. It reads sequential data written in SDIS (*Sequential Data Interchange Standard*) format, and provides a variety of sequential statistics, including tables of lag frequencies, chi-squares, and adjusted residuals. Several kinds of data modifications are possible, including recoding, lumping, chaining and time-windowing. GSEQ can also export results for further analyses using standard packages like SPSS. The program is useful for exploring both lagged associations in event sequences, and synchronic associations in time-based ones, and, generally speaking, for calculating sequential association statistics that reflect or characterize interaction processes in dyads or groups. The first versions of the software ran under DOS, and were published and presented elsewhere [1,4]. GSEQ for Windows 4.0 (GSW), a new version running under Windows 95 or later, is presented. Like previous versions, it includes a utility for composing commands that request specific analyses, and a function for plotting the data in time*behavior plots. A new utility for analyzing agreement between observers and for calculating kappa is also included. GSW compiles and reads data files written in the SDIS language, whose syntax has been updated and improved. GSW is multilingual English/Spanish/Italian, and provides results in HTML format if requested.

OTS, a utility external to GSW, which converts The Observer 3.0/4.0 ODF- to SDIS-formatted data is also presented [2]. The OTS program is useful for investigators who use The Observer [3] to collect data but who then wish to take advantage of the extensive data modification and analytic capabilities of GSW. OTS can convert either all the ODF files in a project, or a selection of them, into a single SDIS file, or into separate SDIS files.

GSW and OTS can be downloaded from www.gsu.edu/~psyrab/sg.htm or www.ub.es/comporta/sg.htm. GSW will not run unless a previous DOS version (distributed with Bakeman & Quera's 1995 book) is installed in the same directory.

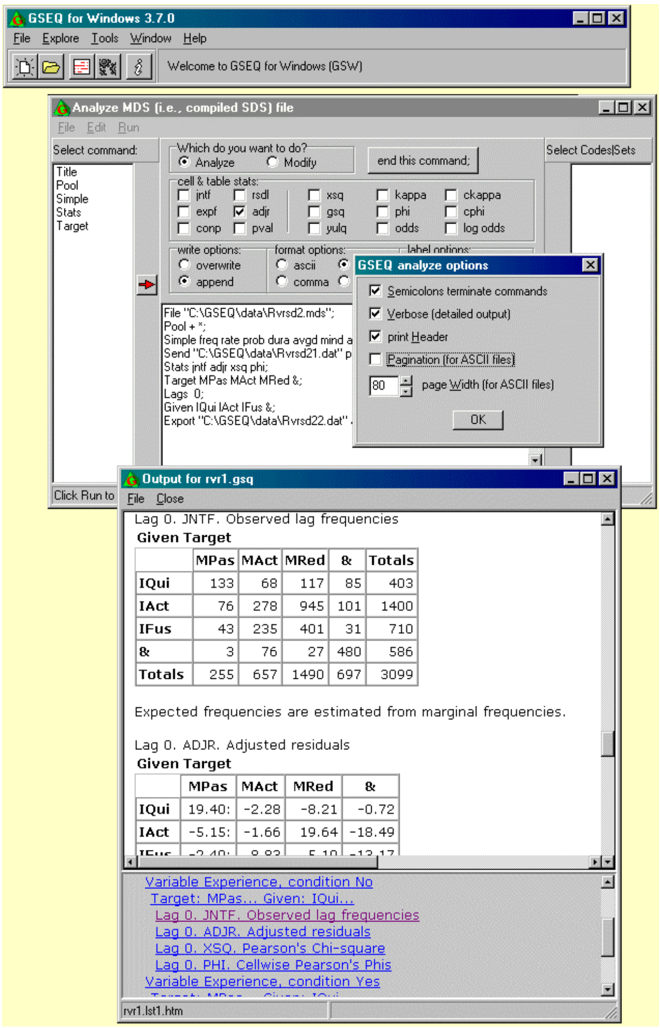

Figure 1. Sample screenshots from GSEQ for Windows.

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Effect of intrauterine growth retardation and hypoxic-ischemic brain injury on long-term memory and learning functions

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Introduction

It has been suggested that intra-uterine growth retardation (IUGR) does not affect the brain in the fetus and newborn because of a "brain-sparing phenomenon." That the head circumference of IUGR infants at birth is not affected and that the infants' neurological outcomes are relatively normal have been provided as arguments in support of the brain-sparing hypothesis.

However, we hypothesized that IUGR infants may suffer from subtle brain injury not obviously apparent; this is seen in such infants who manifest, with increased frequency, cognitive functional deficits in school age. The brain injury may be mediated by an increased vulnerability to hypoxic-ischemic (HI) injury in the IUGR fetuses.

Our study objectives were to: 1) test whether IUGR increases vulnerability of the brain to hypoxic ischemic (HI) injury; 2) see if long-term learning and memory functions are more predictive of such subtle brain injury than are standard neurological tests.

Methods

In time-mated pregnant rats, we ligated the uterine artery on day 20. After delivery, on day 7 of age, we induced hypoxic ischemic injury: Ligation of the right carotid artery was followed by 8% oxygen breathing for 2 hours (Levine-Vannucci Model). The pups were reared by their mothers. Outcome measures:

1. Structured CNS examinations up to day 60;
2. Morris water maze (MWM) testing, using the EthoVision (Noldus Information Technology) video tracking system, on days 27-32; 42-46; and 56-60; and
3. 8-arm radial arm maze (RAM) on days 70-73.

Results

The IUGR pups were predictably smaller. Data from MWM (mean and SD seconds to find the hidden platform) are shown below.

***Table 1.** Morris water maze: latency time to the hidden platform.*

MWM: Age tested	Sham (n=10)	IUGR (n=6)	HIE (n=11)	IUGR+HIE (n=7)
Day 28 Males	50 (43.9)	70 (40.0)	90 (0)	53.5 (42.4)
Day 28 Females	79 (18.3)	80 (14.1)	66 (32.1)	65 (43.3)
Day 45 Males	7 (3.3)	10 (7.0)	7 (3.6)	48 (47.8)*
Day 45 Females	13 (4.5)	16 (4.5)	13 (10.9)	32 (1.4)*
Day 60 Males	9 (1.3)	5 (2.6)	16 (15.3)	40 (36.1)*
Day 60 Females	11 (1.4)	9 (2.0)	6 (2.0)	41 (35.5)*

Pups in the IUGR plus hypoxic-ischemic group fared the worst, with significant impairment in learning and memory functions by day 60, compared to all other groups on respective days (*; $p<0.05$; two-way ANOVA).

The median days for achieving neurological milestones were similar in the four groups: 8 days for *cliff avoiding and surface righting*; 14 days for *walking*, and 16 days for *head lifting* and *eye opening*. Similarly, RAM tests results were similar in all groups (not shown).

Conclusions

With superimposed hypoxic-ischemic injury, IUGR impairs specific learning and memory skills. The "brain-sparing" effect of IUGR thus may be selective. Place-memory and learning tested in MWM were impaired markedly, but reward-based memory and learning tested in RAM were not. Such differential and selective vulneribility of neuronal pathways involved in learning and memory may explain the higher rates for cognitive deficits in school-age children, IUGR at birth.

Hypothermia, learning and memory in rats with perinatal hypoxic ischemic encephalopathy

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Introduction

There is evidence that hypothermia has neuro-protective effects in hypoxia-ischemic brain injury. However, the magnitude and duration of hypothermia necessary to produce the most benefit is unclear; similarly, the optimum therapeutic window for hypothermia to be effective is unknown. Whether hypothermia ameliorates brain pathology temporarily and delays the re-perfusion injury, or leads to long-lasting benefits needs to be shown.

We hypothesized: 1) early treatment with hypothermia after neonatal H-I injury is superior to later implementation; and 2) the effects of hypothermia can be demonstrated during infancy in the form of neurological deficit and learning and memory functions.

Methods

We used a modified Levine model of 7-days-old rat pups from two litters (total n=21) in which unilateral common carotid artery ligation was done under anesthesia and, one hour later, hypoxic breathing with 8% O_2 for 120 min was instigated.

Treatment groups: Group *I*: Controls with no H-I insult; Group *II*: HIE insult but no treatment; Group *III*: Early hypothermia [EH: 15 min following HI insult, the body temperature reduced to 32°C for 3 hrs; and *Group IV*: Late hypothermia [LH: 60 min following HI, the body temperature was reduced to 32°C for three hours].

Outcomes: 1) Daily neurological testing for 9 days; 2) Learning and memory tests (at 4, 6 and 8 weeks) using the Morris water maze (MWM) with a video monitoring and motion tracking computer system (EthoVision, Noldus Information Technology); and 3) Radial arm maze (RAM: trained at 9th week, and tested on the 10th week). The animals were killed 60 days after HI injury (~67 days of age).

Results

Table 1. Mean ± SD for various behavioral measures.

Task	Control (n=4)	No hypothermia (n=6)	Early hypothermia (n=5)	Late hypothermia (n=6)
Head lifting	13.00 ± 0	13.08 ± .20	13.00 ± 0	13.08 ± .20
Walking	9.50 ± .58	9.50 ± .55	9.40 ± .55	9.17 ± .41
Surface righting	8.50 ± .57	8.17 ± .41	8.20 ± .45	8.50 ± .55
Mid-air righting	14.00 ± .82	14.50 ± .84	14.40 ± .89	14.83 ± .75
Cliff avoidance	8.00 ± 0	8.33 ± .52	8.20 ± .45	8.33 ± .52
Morris Water Maze (time to find the platform in seconds)				
30-days	15.25 ± 12.80	73.29 ± 27.93	63.05 ± 35.02	60.75 ± 26.71
45-days	8.13 ± 5.97	15.58 ± 12.28	17.35 ± 27.19	30.04 ± 30.46
60-days	3.31 ± .77	8.92 ± 4.86	11.20 ± 10.97	15.13 ± 12.45
Radial Arm Maze				
Number correct of first 8 arms visited	6.00 ± 0	7.00 ± .63	6.40 ± .89	5.67 ± 1.03

Summary

1) Significant impairment in learning and memory was seen in our HI model, which was not due to neuromuscular dysfunction, 2) MWM tests revealed slightly improved long-term memory and learning at 30 days in the hypothermic groups, but the effects were modest and not sustained; no differences were noted on day 60 of age. 4) Considerable variability in outcomes was noted on learning/memory tests.

Conclusions

In this model of HI insult causes impairment of learning and memory, which was not due to neuromuscular dysfunction. Hypothermia might provide a transient benefit, however by 60 days these improvements are not sustained. 3) Early hypothermia may be more effective than late hypothermia; however, more studies should be done to evaluate the effect of the timing, duration and dosage of hypothermia on HIE.

Memory for spatial information

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It was hypothesized that spatial information was processed in dependence on the possible actions in a visual scene. The motor representations result from a viewpoint of observers independent of the real viewing position. The experiments reported here examine whether the different subjective positions mediate people's reconstruction of the spatial information they read about. To provide evidence the account that memory for spatial information implied an existing motor representation, different viewing positions are inducted in two experiments. The participants had to read two different narratives where the same spatial locations where conserved. In the first case it was described as an escape and in the second one it was described as a situation of relaxation. We proposed that these narratives generated the different potential sequences of actions. In the second trial the participants were asked to recall the narratives and to choose one of the 9 drawings that illustrated each of the narratives. The drawings were designed to reflect the different points of view according to a multiplication of the 3 horizontal and the 3 vertical positions. Configural-frequency analysis (KFA Package, 1994) revealed the strong relations between subjective viewers' positions based on implicit actions and spatial representations.

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Functional deficits in forelimb-using after phototthrombotic lesion in rats

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Following focal brain lesions in the rat, usually substantial alterations, e.g. in neuronal excitability and receptor density, are observed in the surround of the lesion as well as in remote brain areas. In the present series of experiments we used a series of behavioral tests to examine whether a persistent functional deficit can be monitored following lesions in the sensorimotor cortex of the rat. Focal brain lesions with a diameter of about 2 mm were induced in the forelimb area and a more caudal brain area (Occ2/Par1) of male Wistar rats. The rats had to perform three behavioral tasks at different time points in the two months following surgery.

In the first test the rat was placed in a glass cylinder and the rearing behavior was observed. The movements of both forelimbs along the wall were counted. In the second task the rat had to walk over a grid; we counted false steps defined as slipping with the forelimb through the grid, and related this to the total number of steps. In the third test we analyzed the motion of the forelimb when the rat was swimming a straight distance in a water basin. In all tasks we distinguish between the limb affected by the lesion (impaired) and the healthy limb. The results were determined as scores for the impaired limb compared to controls.

Compared to control, animals with lesions in the forelimb representation area of the sensorimotor cortex (FL-SMC) showed functional deficits for the impaired forelimb in all three tests. In the first week after surgery the rats use either the healthy limb or both limbs together for motion along the wall in the cylinder. They have a high score of false steps by walking on the grid. Also the swim test showed a higher score for the impaired limb in the first week. After two weeks of recovery, the deficit has considerably recovered. With lesions in the parietal area, walking on a grid or swimming were not impaired. However, a small impairment of limb use developed within the first seven days.

The investigations show that (i) clear motor deficits can be demonstrated with focal brain lesions in the sensorimotor cortex; (ii) these show considerable recovery within the first two weeks following lesion induction; (iii) animals with lesions in parietal areas may show some change of limb preference indicating that the lesion has some remote behavioral effects. The present studies will allow us to study the recovery from brain lesions and their pharmacological modification.

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Continuous assessment as a tool for monitoring temporal variations in subjective impressions

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Present-day technology begins to make it feasible to communicate complex information in a natural, dynamic way. Limitations in transmission bandwidth and memory are important reasons why system designers have to employ high levels of data compression. This often leads to content-dependent, temporal fluctuations in the quality of information presentation. When annoying to the end-user, such fluctuations can seriously threaten the acceptability of new media.

In this paper, continuous assessment is presented as a tool for monitoring temporal variations in subjective impressions. This method was originally developed for measuring time-varying image quality [1,2] and has recently been adopted by the International Telecommunications Union (ITU) under the name SSCQE (Single Stimulus Continuous Quality Evaluation) [3]. By this method, subjects continuously indicate the instantaneously perceived strength of a subjective impression by moving a slider along a graphical scale. As an illustration, Figure 1 shows the experimental setup for continuous assessment in case of evaluating visual information presented on a display. The observer looks at the screen and is asked to continuously adjust the position of a slider along a graphical scale according to his/her perception of a pre-specified attribute, e.g. perceived sharpness, depth or, at a more abstract level, quality or sense of presence. In general, the observer moves the slider upwards when experiencing an increase in perceived strength and downward when experiencing a decrease in perceived strength. The position of the slider is sampled at a fixed rate (e.g. 20 times per second) and the collected data are stored as files. These sampled positions can be plotted as a function of time to provide an impression of the temporal variation in the assessed attribute.

Continuous assessment has been employed to evaluate subjective impressions like time-varying quality of compressed video and speech material [2,4], perceived sharpness of blurred images [1], and perceived depth and feeling of presence in 3DTV [5]. The experimentally established relation between the results of continuous assessment and overall judgments indicate that human observers rely predominantly on the worst events in a sequence when determining their overall judgment [6].

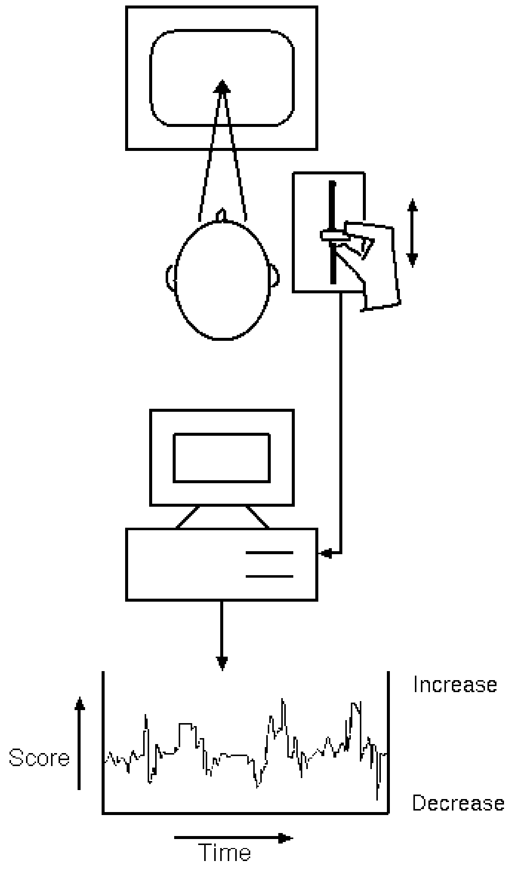

Figure 1. *Continuous assessment: experimental setup*

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A multiple species approach to sequential learning: are you a man or a mouse?

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We have developed a new method for studying list learning in animals and humans. We have used different variants of the task to examine list learning in rats, mice, and humans. This method was created as a functional analogue of human pattern learning tasks that requires subjects to press buttons in an array in the proper sequential order. Instead of buttons, our procedure requires subjects to respond in a circular array in a predetermined order. This method holds several advantages over other methods of studying list learning. This procedure has been found to be easily learned without lengthy pre-training. The data gathered with this procedure provide 1) a measure of correct response rates, 2) a measure of incorrect responses and the locations of these responses, and 3) a measure of response latency on a trial-by-trial basis. Subjects can receive numerous patterns each day without interruption between patterns.

The procedures used for mice and rats use an octagonal or hexagonal operant chamber equipped with a retractable lever or a nose-poke receptacle with an indicator lamp mounted on each wall. In the typical experiment, all levers/lights are presented/illuminated at the beginning of each trial, and the subject was allowed to respond to any of the manipuli. If the correct response is generated, all levers/lights excluding the correct lever/lights are removed/turned off and the subject is not reinforced until the correct response was performed. Upon responding correctly, all of the levers/lights are removed/turned off for an inter-trial interval ranging from 1 to 10 seconds and are then reinserted/re-illuminated to indicate the beginning of the next trial. An analogous procedure is used to examine list learning in humans, which requires subjects to respond to a circular array of circles on a computer screen. The response indicators are in a circular array. Thus, the patterns generated for the subjects to learn can be continuous, that is, composed of the endless combination of the eight choices to form patterns of any length and complexity.

We have examined mouse, rat, and human list acquisition of patterns ranging from 12 to 48 items in length. Organization of the items within the list can also be easily examined. We have required rats and humans to learn lists with organizations ranging from a very simple pattern, which could be expressed by two levels of rules, to patterns whose organization could be expressed by four or more levels of rules.

This procedure has also been used to examine other aspects of list learning such as: 1) the effects of the placement of phrasing cues which are either consistent or inconsistent with the structure of the list in rats and mice, 2) the effects of phrasing cues of differing modalities in mice, 3) the sensitivity of subjects to violations of list structure in rats, and 4) subjects abilities to "chunk" from non-adjacent serial positions in structured lists in rats. The procedure has also been used to examine the effects of numerous drugs on sequential learning. We have used variants of this procedure to examine the effects of MK-801, atropine, haloperidol, and clozapine on organized list learning and retention in rats.

The researcher as measurement device - On the dangers of 'coding' in gesture research

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In this presentation I will defend the thesis that with newly available technologies, measuring gesture is not a technical problem anymore. Rather, it is increasingly becoming a problem of creating meaningful categories from the raw measurement data. This problem is most likely to emerge when the temporal properties of gesture are studied.

First there is the problem of 'top down' theoretical bias. Certain theoretical assumptions lead to the use of certain categories, which are then sometimes used to falsify or verify these very same assumptions. For instance, how gestures are divided up in different phases is crucial, but to a certain extent arbitrary.

Second, there is a problem with intercoder reliability (Kita *et al.*, in press). When the human mind is used as a 'measuring instrument', the reliability and reproducibility of the results are often low. This is especially the case for spontaneous, iconic gesture, for these gestures are not conventionalized and therefore have an unpredictable shape. Although modern equipment (e.g. data gloves) have a significantly higher spatial and temporal resolution than video registration, this by itself does not reduce intercoder reliability.

Third, there is a risk of circularity. Because it is impossible to understand gestures without access to the speech, and because gestures can in turn change the meaning of the speech, one needs both to understand both because gesture and speech complement each other semantically (McNeill, 1992). This is especially noticeable when trying to establish the 'affiliate' of a gesture, which is the stretch of speech that is supposed to be semantically or pragmatically related to the gesture.

In certain limited contexts, automatic detection algorithms are possible, leading to higher reliability and well defined timing criteria. An example of automation in a limited context is De Ruiter (1998) where a fixed algorithm is used to distinguish phases (preparatory, stroke, retraction) in very simple and predictable pointing gestures. For a more general class of gestures, such as spatial gestures, a human coder is needed to distinguish these phases, for there the meaning of the speech is needed to distinguish single complex gestures from a series of smaller gestures.

I therefore argue that, now that measurement hardware (e.g. data gloves) has reached a certain level of maturity, it is time to spend more energy on creating formal frameworks and definitions that are as precise, and as little theory-biased as possible. Measurement equipment alone will never be able to replace human interpretation completely in gesture research.

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EUDICO: an annotation and exploitation tool for multimedia corpora

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The EUDICO project started in 1997 at the Max Planck Institute for Psycholinguistics as an effort to make multimedia-related resources with linguistic content available to an as large as possible scientific audience. This has resulted in a powerful set of platform-independent software tools that operate over the Internet and thereby give researchers all over the world access to important linguistic resources with multimedia content. The essential design decisions making EUDICO currently a unique multimedia annotation and exploitation tool are: (1) distributed and Internet-capable operation; (2) resource format independent operation; (3) different fully synchronized viewers presenting the data to the user; (4) freely definable annotation structure; (5) central and local data storage; (6) central software management.

The resources that we support in the EUDICO project consist of media tracks and annotation layers that contain linguisticaly relevant descriptions of events that occur within the media tracks. These annotation layers are freely definable but all share as a common feature that they can be precisely located on the media time axis. To support as many existing corpora as possible, an Abstract Corpus Model (ACM) was designed that has the expressive power to describe all the linguistic annotation schemes that are currently in use. The ACM is implemented as Java objects and the software tools are designed to work with this ACM. Dealing with a new corpus within the EUDICO framework simply means to make a mapping from the specific corpus format to the ACM. All existing EUDICO tools are thereafter instantly available for the new corpus. Currently three important formats are supported, i.e. Childes, Gesture and Tipster.

The tools that are available to work with the multimedia corpora make it possible to analyze their content and to add new annotations to them. An EUDICO client can choose a subset of the corpus data he is interested in by browsing through a corpus tree or by giving some formal selection criterium. For such a data selection he can start viewer tools to show the multimedia data and annotation content. The audio data can be played along with a signal waveform.

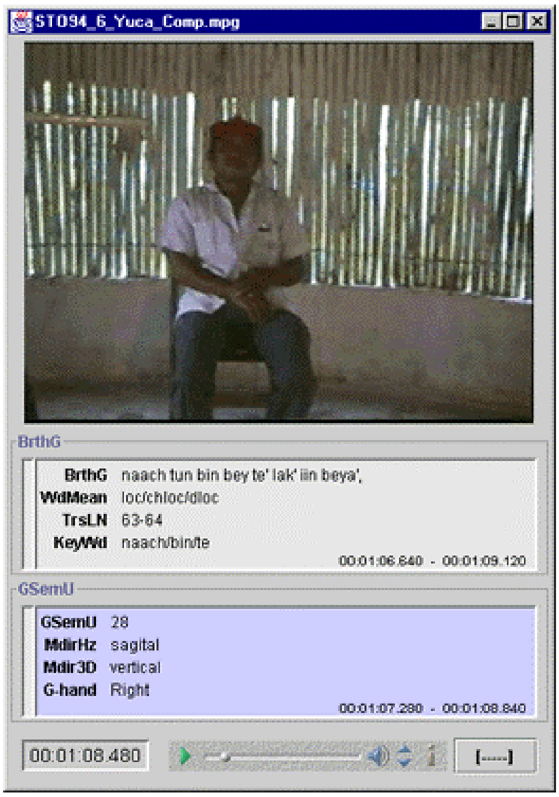

Figure 1. *The Video window is displayed simultaneously with the Viewer selector. In this case an MPEG-1 movie is shown. In case of audio-only media data the video component is just missing from this window. The controls on the bottom of the window are, from left to right: a running time code counter that can be used to jump to some specific time as well, the standard JMF video control bar, and a button that plays only the currently selected*

The video data can be played with the standard functionality as found on video recorders (Figure 1). The annotation data can be visualized in all kinds of special-purpose viewers that are fully synchronized with the media players. One view shows the annotation data as dynamic subtitles to the media data. Another view shows the annotation data as ordered lists. When the media data is being played the corresponding annotation data is highlighted within the list. By clicking an annotation in such a list the user can set the media time to the start time of the annotation segment. When visual information regarding the relative position of annotations to each other is needed, we offer a partitur-like view where the content of the selected annotation tracks are indicated along the time line. This makes it for instance possible to easily detect overlap of segments from different annotation layers.

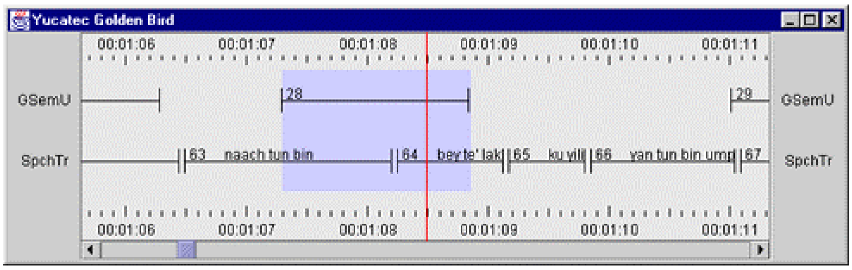

Figure 2. *Time line view is a bit different from other viewers in the sense that is represents tags from multiple tiers in one view. Each tag is shown as a bar, where the horizontal position and length of the bar indicates the tag's begin time and duration. The tag's values are only represented by the beginning of the value of the tag's first field. Pressing the 'popup button' (the right mouse button on most systems) displays a tag panel with all fields. The vertical order of the tiers can be changed simply by dragging the tier's name label to the proper position. The current time is represented by a red cross-hair in the middle of the view. When playing the tag bars scroll horizontally, always reflecting the proper media time. Scrolling in this viewer using the scroll bar changes the current time in all other viewers as well.*

The only requirement to work with the EUDICO framework is a computer that has a connection to the Internet supporting MPEG-1 streams and it must have the freely available Java runtime environment with the Java Media Framework software extension installed. All other software is sent to the client over the Internet in a completely transparent manner at the moment he starts a tool. This mechanism ensures that the client always works with the newest version of all available tools. The requested parts of the media data are streamed to the client's computer at the moment that they need to be rendered. There is no need for temporary storage of the media data on the client's machine.

EUDICO is an open software framework that will be extended continuously with many features making it a major tool during the coming decade. Because of the highly modular and object-oriented architecture of the software the set of tools is easily expandable if new functionality is desired.

Behavior as discourse: A structural analysis of the feeding behavior of laboratory rats

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Ethologists usually study feeding behavior of rats and animal behavior in general mainly at population level [1,2,3,4,5] and emphasize aspects of intra-colonial learning and inter-individual informational exchange. Therefore, studies of intra-individual strategies and inner structure of behavior are less frequent [10,12]. In most of such studies, classification systems and mathematical data processing of sequences as units of behavior, are based on the researcher's own operational system [5,6,8,9,11]. In our experiment on feeding behavior at laboratory rats, we first tried to adapt the taxonomic systems used by some authors [2,5,7,8,10], to a functional goal-oriented perspective. Secondly, we applied methods used in sociometry [13,14] and social psychology to the analysis of behavior sequential chains, which we have represented by transition matrices of dyad successions. We found parameters that reflect the dynamics of learning process and can be used as indicators of sexual behavioral dimorphism. On the other hand, these parameters support a 'structuralist' view of behavior. According to this view, one can consider a sequential chain as a 'syntagm' and therefore, look for its inner 'grammar'; i.e. its internal regularity that should transcend inter-individual differences of strategy.

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User model of information retrieval on the Internet: a cognitive psychological approach

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Information retrieval has changed considerably in the last years with the expansion of the Web (World Wide Web) and the advent of modern and inexpensive graphical user interfaces and mass storage devices. How does one find anything on the Internet? There are essentially four methods of information retrieval on Internet: browsing, consulting an index, word of mouth, or posting a request.

Problem in information retrieval

The key problems in Internet information retrieval, in particular concerned with ill-defined information requirements, concept interpretation in searching and text representation in indexing. The main objective of information retrieval is to facilitate the effective communication of desired information between a human generator of information and the human user. This communication takes place in an information system.

Aims

The present paper aims to analyse and suggest solutions to key problems in online information retrieval, in particular concerned with the search of information problems on Internet.

User model of information retrieval

Information retrieval research has developed in a fairly complex manner around the classic but effective vector space model, abstracting from single keywords to cluster of keywords and other increasingly abstract objects, in order to improve discriminating performance. User model from the psychological point of view represent the category of keywords with associated score according to the "mental representation" present in the model. We use conceptual graphs to model the user's search goal on Internet. The nodes represent keywords, annotated with frequency of usage; the links represent the distance between keywords in the model. The task is to transform user requests into queries by understanding the information problem or the underlying goal or problem.

Design and usability testing

Efficient usability testing involves choosing the most appropriate methods for the problem at hand. The purpose of testing is to provide design support and the emphasis should therefore be on obtaining the maximum design-related information for the testing effort. In the present discussion the research is reserved for that more general activity that is directed towards the accumulation of general principles. When specific answers to very specific questions are required the usability testing is more appropriate.

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An ultrafiltration-collection probe to remotely and continuously monitor blood glucose and lactate in broiler chickens

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To closely monitor physiological processes in blood or other body fluids it is important to frequently take samples for off line analysis. Such sampling techniques are often physically or psychologically stressful, or pose a severe restraint on the circumstances under which sampling can be done. Animals often need to be restrained to take blood or tissue samples. For small animals repeated sampling can imply a compromise of their physiological capacity to compensate for the loss. Even if samples can be taken stress-free, animals must often be housed individually in an experimental environment that allows easy sampling.

Recently we have developed an ultrafiltration-collection probe for the sampling of blood or (subcutaneous) tissue fluid that may be used for continuous, stress-free sampling in a naturalistic environment. The system is based on inserting into the relevant body compartment a semipermeable membrane, which is connected to a collection tubing that stores the fluid sample. Its small inner diameter (125 μm) prevents diffusion. A low, continuous sampling flow (50 nl/min.) is driven by a pulse-free vacuum pump (Figure 1) [2]. As only tissue fluid is stored, the ultrafiltrate always has 100% recovery. The membrane (cut-off point 20 kD) keeps out degrading components. The entire system is small and may be attached to the animal. Afterwards the ultrafiltration-collection probe is removed and the contents are analyzed in 20 nl fractions using a bi-enzyme reactor (glucose oxidase/horseradish peroxidase or lactate oxidase/horseradish peroxidase, using a ferrocene buffer as mediator) with electrochemical detection in a flow injection system [1], resulting high resolution glucose and lactate profiles.

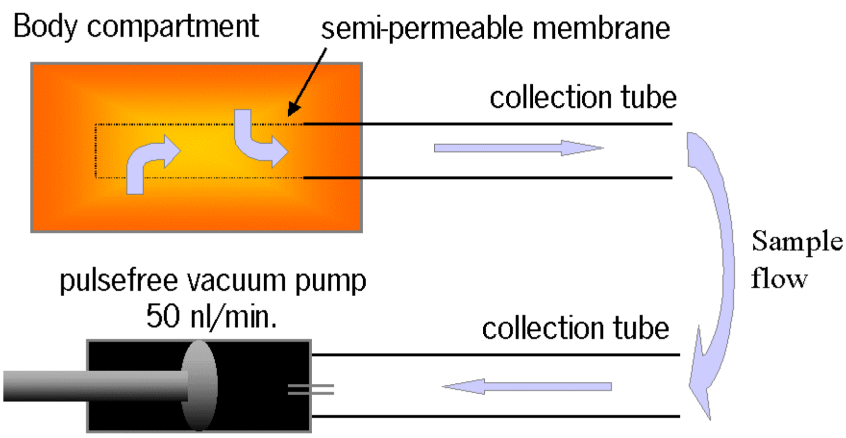

Figure 1. *Schematic diagram of the ultrafiltration-collection probe and sample flow.*

Recently this technique was applied to sample blood ultrafiltrate for 8 hours in 40 freely moving, group housed chickens to monitor glucose and lactate levels. A membrane was surgically inserted into the right wing vein. The collection tubing and pump were attached under the wing in a plastic bag. After recovery the birds were returned to their pens. The probe did not seem to hinder the chickens, nor attract unwanted attention from other chickens. At 3 days after surgery the pump was started, and the probe ran for 8 hours during which the birds were crated and transported for 1,5 hours. Afterwards the probe was removed and the collection tubing separated, sealed and stored at 4 °C until analysis. The sample was analyzed to give a 5-minute resolution profile of glucose and lactate (Figure 2).

Profiles of blood components are well suited for combination with behavioral observations. The high time resolution may provide data on fast transient effects, like increased glucose mobilisation during social conflicts, when combined with time-dependent behavioral observations of animal interactions. Circadian rhythmicity might give insight in the effects of with day/night activity or feed intake. The ultrafiltration-collection probe is an aspecific sampling system. In the future it may be further developed for sampling in different tissues, or different components, e.g. catecholamines, which will allow the study of behavioral and physiological stress responses in numerous experimental and naturalistical settings.

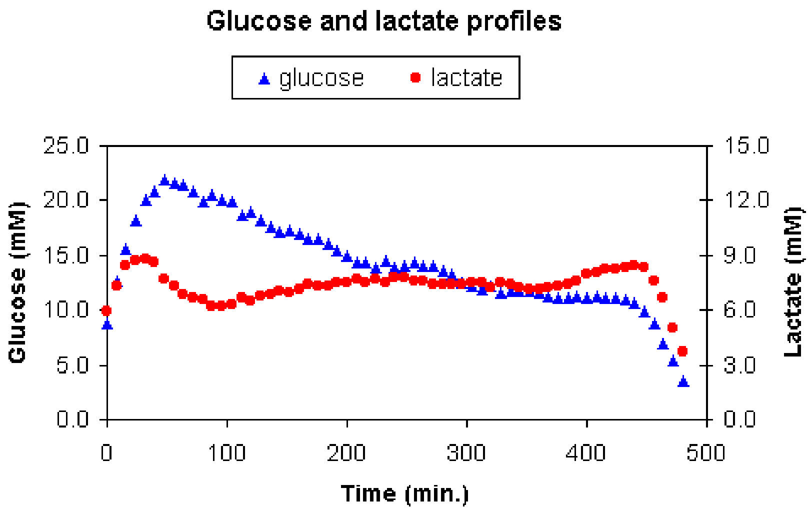

Figure 2. *An example 8-hour profile of glucose and lactate levels (in mM) in the ultrafiltrate, as measured in a group-housed chicken. Each point represents 1 measurement per 8 minutes sampling time (mean flow = 31.25 nl/min).*

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Behavioral measurements + Functional MRI brain activation measurements: the whole is greater than the sum of its parts

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Functional Magnetic Resonance Imaging (fMRI) can reveal important aspects of human brain function even in the absence of a measurable, observable, behavioral response. For example, the multiple visual areas of human cortex can be mapped while a subject passively views the appropriate visual patterns, with no required behavioral response. But overt behavioral responses can be used to make fMRI a much more powerful tool than it would be without them. For example, experiments in the formation of memory make critical use of behavioral data collected long after the subject is out of the MR scanner. Studies of the effects of cocaine on brain function depend on the subject's being able to report subjective experiences while being scanned. In these studies the behavioral data is required to analyze and interpret the imaging data. Meeting the practical challenges in the collection of various behavioral responses (e.g., overt speech) in the context of MR imaging is rewarded by more powerful and flexible experimental designs. The speaker will describe some of the accomplishments of the past and speculate on the future advances in measuring behavior during MR imaging, and using that behavioral data to increase the power of fMRI.

Evaluation of observational learning in captive European starlings in response to avian repellents

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Chemical repellents can protect agricultural crops from birds by inducing conditional food avoidance learning. Moreover, untreated "observer" birds can learn to avoid foods by imitating behavioral responses of treated "demonstrators." We measured behavioral responses of demonstrators (captive European starlings, *Sturnus vulgaris*) to aversive unconditional stimuli (chemical repellents). We also monitored feeding behavior of treated demonstrators and untreated observers in response to the conditional stimulus (a colored food cup), which was presented for 2 hours prior to treatment. We tested n=24 pairs of demonstrators and observers to four treatments (n=6 pairs/treatment): (1) methyl anthranilate (MA), an irritant to birds, that is considered to be an environmentally and toxicologically safe food flavoring; (2) methiocarb (MC), an effective repellent that is no longer considered to be environmentally safe; (3) propylene glycol (PG), a non-repellent carrier; and (4) control (no chemical). During the training phase, demonstrator starlings were presented with a colored food cup for 2 hours, and then were provided the respective treatments. Observers fed from their normal food cups and were not handled during training. During the 2-choice learning test, conducted daily for 14 days, we provided 20 g of food in colored and uncolored cups for 2 hours to both demonstrators and observers. We videotaped starlings during both the training phase and 2-choice learning test. We used The Observer (Noldus Information Technology) to quantify activity budgets and feeding rates of demonstrators during the training phase, as well as cup preference and feeding efficiency of demonstrators and observers during the 2-choice learning test.

Chemical repellents affected activity budgets of starlings. Specifically, the control birds spent more time feeding than birds from the respective treatment groups, but the feeding efficiency (n pellets eaten/min of feeding) of controls was less than among treated starlings ($p<0.05$). During the 2-choice learning phase, avoidance of the colored food cup for demonstrators occurred on 5 of 14 days for controls; 7 of 14 days for PG; 12 of 14 days for

MA; and 7 of 14 days for MC. Avoidance among observers occurred on 3 of 14 days for controls; 9 of 14 days for PG; 4 of 14 days for MA; and 12 of 14 days for MC.

Behavioral observations indicated that treated demonstrator starlings exhibited reduced feeding efficiency compared to controls or untreated observers ($p < 0.05$). The data suggest that environmentally benign and toxicologically safe chemicals such as MA can induce long-term food aversion learning when the peripheral senses are bypassed. Moreover, the detailed observational data obtained in this study provide valuable insights into behavioral mechanisms and subtle social interactions between birds.

Ambulatory measurement of upper limb usage and basic activities with an extended version of the Rotterdam Activity Monitor

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In a number of patient categories, problems in performing activities of daily living are expressed in upper limb (non)-usage. So far, there were no objective outcome measures available to determine functional problems during daily living of patients with diseases involving the upper limb(s) [1]. Therefore, we performed a feasibility study to extend the possibilities of the Activity Monitor (AM), which has been developed at our department. The AM consists of a number of piezoresistive acceleration sensors connected to a portable recorder. Reliability and validity of measuring basic activities (e.g. lying, sitting, walking) using the standard configuration of 3 or 4 sensors attached on thighs and trunk were found to be good [2]. To measure upper limb (non)-usage, however, this standard configuration was not sufficient.

The aim of this study was to develop a reliable and valid instrument, which can discriminate between upper limb usage and non-usage during performance of activities of daily living. Upper limb usage was defined as active displacement of (parts of) the upper limb(s) in relation to proximal parts, holding objects and/or leaning. We formulated several requirements that had to be met: measurement periods of minimally 24 hours, usage of small low power consuming sensors, quantifiable bilateral upper limb measurement for comparison, applicable for both healthy subjects and patients and comfortable wearing. Sixteen subjects performed an activity protocol while wearing the AM (for a picture of the standard configuration of the AM, see [4]; for this study we used two additional sensors on both forearms of the subjects). Video recordings were made as a reference. For analysis we synchronised the video recordings and the raw acceleration signals. We used Vitagraph Basic Software and the time-series oriented Signal Processing and Inferencing Language (S.P.I.L.). In the current method of signal processing, three feature signals are derived from each raw acceleration signal: the angular, motility and frequency feature [3]. It was found that the motility feature was most suitable to discriminate between usage and non-usage. This feature is created after high pass filtering, rectifying and smoothing and depends on the variability of the raw signal around the mean. The standard configuration to measure basic activities was maintained to support and improve the discrimination between usage and non-usage.

Preliminary results with two extra sensors on each forearm, just proximal to the dorsal side of the wrist, with their sensitive axis perpendicular to the body segment offer good perspectives. Use of the motility feature to detect upper limb displacement was almost without any problems, while detection of holding and leaning was clearly more difficult. Future research will be aimed at improving the discrimination between upper limb usage and non-usage during measurements in the patients' home environment.

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Automated non-invasive home-cage monitoring for detection of novel mutant mice

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The Jackson Laboratory has recently launched a large-scale mutagenesis program to systematically collect novel neurological mouse mutants. Beyond the logistics associated with screening large numbers of mice the greatest challenge lies in the need to detect *individual* deviant mice from a large population. Currently available behavioral and physiological paradigms are typically only used to reveal *group* differences. Automated methods for detection of a variety of phenotypes are required.

We have developed (in conjunction with Columbus Instruments, Columbus Ohio) a comprehensive cage monitoring system (CCMS) that monitors mice in specialized individual live-in cages. The system allows automated, non-invasive, simultaneous collection of 1) total, ambulatory and rearing activity; 2) food and water consumption; and 3) oxygen and carbon dioxide concentrations.

To validate CCMS as a tool for deviant detection we collected data from 29 known mutant mice – 4 *tubby* (obesity), 6 *mdx* (dystrophic), 7 *Drd3* (dopamine receptor knockout), 3 *Fmr1* (fragile mental X syndrome), 4 *sti* (ataxic), 5 *het* (inner ear defect) – and 13 mice from 2 additional strains (7 A/J and 6 129SV/J) and compared them to normal C57BL/6J mice. All mutants were on C57BL/6J backgrounds (except closely related B10 for *mdx)* and were selected because they had subtle, non-visible phenotypes. All mice were age matched (8 wk). Data were recorded continuously for three days.

To exploit the CCMS data set, we developed a multivariate statistical algorithm for mutant detection. Briefly, the algorithm first "trains" on a data set from normal mice and then computes the Mahalanobis distance [1] between subsequent individual mice and the training set. If this distance is "too" large, the mouse is flagged as an outlier. The cutoff distance for flagging can be adjusted for a desired rate of false positives (5% for these experiments).

Initial development of the algorithm used only 3 variables (ambulation, rearing and CO_2/VO_2 ratio) and divided each of these into light and dark period values for a total of 6 parameters. The algorithm was applied to three data sets: a "training" set including 32 C57BL6/J mice, a "control" set including 19 C57BL6/J mice, and a "test" set including the mutants and the different strains. The outlier scores for the training and control sets were approximately evenly distributed between 0 and 1 (Figure 1a,b respectively). In contrast, for the test set the outlier scores were concentrated near 0, indicating that some mutants were flagged (Figure 1c). The algorithm flagged 1/19 in the control set (~5% as predicted) while in the test set 12/29 mutant mice and 12/13 mice of a different strain (not in figure) were flagged.

These results demonstrate that CCMS can detect a variety of mutants and can provide an interpretative foundation for subsequent focused tests. Ongoing work is aimed at increasing detection by including more variables (43 summary variables are currently derived from raw CCMS data sets) and determining if subsets of these variables can be grouped to target specific phenotypes.

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Competition of alternative paths in behaviour

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The task of the choice between alternative options may be difficult for an animal if there is equality of alternatives. We tested the behaviour of rats in the Y-maze that consisted of a starting room with initially closed starting gate and a 'centre' (hall) with two identical outlets, guiding into safe shelters. There was an electrical floor in the starting place and in the 'centre'. The rats (n=7) were trained to forsake the starting place by the opening the starting gate and to go into one of the shelters. Usually, an animal preferred one of the safe shelters (left or right). Next, tests were accomplished with switching off the current. Every test was finished by the rough handling of the rat from the 'safe shelter' and returning it into the starting room. Thus the safety of the preferred shelter became less obvious for the rat, and after several tests the rat remained in the 'centre', looked into the outlets, and looked round its choice. In this critical test the time of the action became extremely long: up to 45 s, while in the previous and consequent tests it was no more than 8 s. The significance of the result was 0.01. Sometimes after choosing one of the shelters the rat left for the other safe shelter. One of animals couldn't decide the delivered task and returned to the starting gate, searching it.

Alternative paths of the active avoidance are the elements of the object contents of motivation. Our experiments allow us to evaluate the competition of the object components of motivation.

Using GPS to study the ranging behaviour of wild red deer stags

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Introduction

The incorporation of Global Positioning System (GPS) units into animal telemetry collars [1] has greatly increased the potential for studying ranging behaviour of large herbivores. By enabling the collection of positional data over large areas, at any time of day or night and without disturbance to the animals, it is possible to build a complete picture of their movements throughout the year. GPS has been used in a 2-year study of the ranging behaviour of wild red deer (*Cervus elaphus*) stags in and around a 30,000 ha sporting estate and nature conservation area, in a mountainous region of the north-east of Scotland. The aim of the study was to provide information to assist in the management of deer and vegetation and to increase understanding of the behavioural ecology of the animals. Questions are being addressed at three different scales: (1) which areas are used by the deer at different times of year, (2) whether deer movements are influenced by disturbance from recreational walking within the estate, (3) to what extent deer movements are related to environmental factors, such as vegetation, topography and climate.

Methods

In each of 2 consecutive years, 9 GPS 1000 tracking collars (Lotek, Canada) were fitted to stags from the beginning of April to the end of January the following year. Each collar collected around 4500 records during the year, each consisting of a position fix and integrated activity measure. The collars were programmed to take fixes at 4-h intervals in year 1 and at 2-h intervals in year 2, with fixes every hour on Sundays and Wednesdays. In year 1, fixes were also taken every 15 minutes on 2 days each month, from June to November. Data were retrieved from the collars, via a remote radio link, every 3 to 4 months.

Analyses

1. Deer positions have been plotted on maps of the area [2], using GIS software [3], allowing the animals to be tracked over time. The information will be used to determine management strategies to promote the regeneration of native woodland within the estate, in line with conservation aims for the area.
2. Hourly totals from automated people-counters, beside popular tracks on the estate, show consistent patterns of activity within days, weeks and over the year [4]. In order to determine whether deer movements are affected by human disturbance, comparisons will be made between the distances of collared animals from these tracks during busy and less busy periods, for example Sundays and Wednesdays.
3. Environmental factors which determine deer movements will be investigated by comparing deer positions with GIS information on the topography [2], land cover [5] and weather data [6] for the area.

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EthoVision color identification: A new method for color tracking using both hue and saturation

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Tracking animals using pattern analysis of a monochrome video image which distinguishes objects by their size is a technique that has its limitations. In practice many systems using that method only track a maximum of two objects (unless one is not concerned with distinguishing individuals), and if both objects are the same size, it can sometimes even be difficult to track more than one. Color tracking (that is, identifying an individual by its color, or the color of a marker attached to the object) can be used to track more animals simultaneously, for example up to 16 per arena using EthoVision® Color-Pro 2.0. EthoVision's color tracking can be used to track a variety of different species, and has been used successfully with a number of animals, including rats [2,4], pigs [5] and fish [6].

In this paper we outline the advantages of using color tracking, and the theoretical framework on which it is based. EthoVision Color-Pro 2.0 can use both the *hue* and *saturation* components of the hue-saturation-intensity (HSI) color space model (Figure 1) to track objects. Previous versions of EthoVision (EthoVision for DOS 1.95 [1]) only used the hue component; the new method gives significantly better results. If both hue and saturation are used to define the objects' color, EthoVision can distinguish objects which are more similar in color to each other than if only using hue (for example objects with the same hue but differing saturation values), which is why the system can cope with as many as 16 objects (under appropriate conditions). In addition, the use of these two complementary detection descriptors makes the object identification more robust, so that, for instance, objects can be tracked more reliably if the light intensity (brightness) is uneven across the arena.

The new version of EthoVision also has a redesigned user interface (Windows 95, 98, 2000), making it much easier to train the system to identify an object by its color. During the presentation, the user interface will be explained, and there will be a demonstration of how to carry out color tracking using the EthoVision program. Finally, practical aspects of color tracking, will be discussed, including methods of marking animals, difficulties with lighting and similar technical aspects of setting up an EthoVision system for use with color tracking.

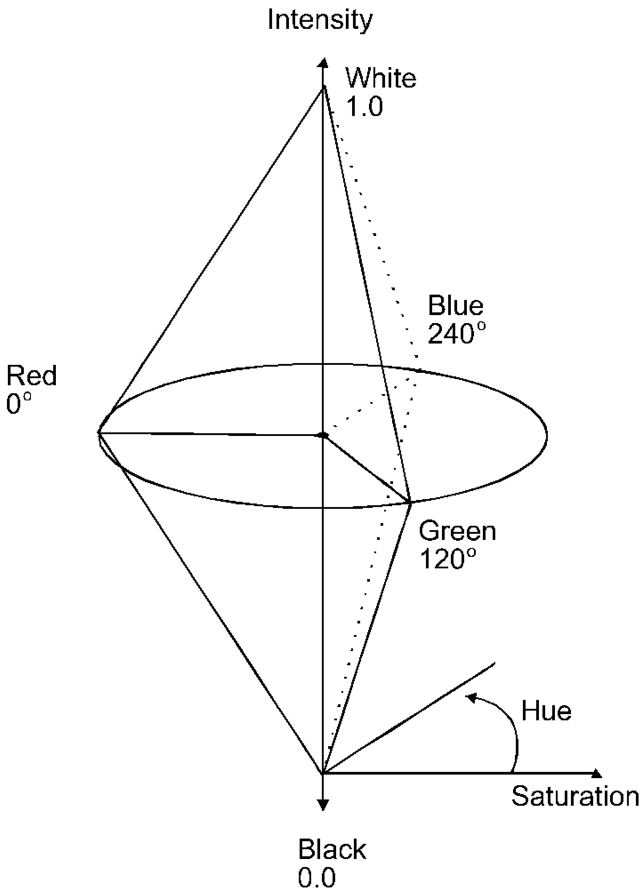

Figure 1. *The HSI color space model. The horizontal distance from the center of a horizontal plane to its outside represents a color's saturation (fullness), the angle on that plane its hue (color) and the vertical distance (z-axis) its intensity (brightness).*

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Integrated measurement of motility and energy consumption in fish larvae and daphnia

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Many behavioural patterns or reactions in fish seem to be energetically determined or at least linked. In previous experiments on behavioural thermoregulation [3,5], decreased motility during starvation periods [2] and changed behavioural patterns in chemical stress situations [1] were repeatedly observed and theoretically explained by energetic mechanisms. Especially larvae and juveniles normally forage with a strongly limited metabolic scope. To get additional physiological information further to our previous and continuing behavioural investigations in fish, we decided to design equipment for the joint registration of motility parameters and oxygen consumption of small fish, fish larvae and daphnia in a single aquarium system. The device consists of a small observation unit (whereas different aquarium sizes are possible) with a constant water flow and a recirculation (cleaning, heating and aeration) system. The animals can be fed during the experiments, so experimental periods from days to some weeks are possible. The behavioural parameters motility, turnings, swimming height, horizontal distribution and individual distances are registered and calculated by the video recognition system BehavioQuant® (first presented at *Measuring Behavior '96* [4]. A controlling unit driven by a second program simultaneously running on the computer regulates the temperatures and measures the oxygen content of inlet and outlet water of the fish chamber. Time intervals between measuring in and out values are destined by the flow-through time of water. The instantaneous temperature and oxygen values as well as the movement of registered objects can be observed on screen without disturbing the animals. Registered data are transferred to a desktop computer where recalculation and evaluation goes on.

In our first experiments with carp juveniles we got a strong correlation between motility and oxygen consumption as well as some influences of chemical stressors. A subsequent analysis of fish body composition (proteins, lipids and carbohydrates) and detoxification enzymes before and after the experiments will give us some more information about the metabolic pathways of dissipated energy.

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The mouse as a subject in operant studies

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Operant techniques have been extensively used in behavioural pharmacology and behavioural neuroscience since they offer precise control over behaviour, allowing quantitative assessment of the effects of an experimental manipulation. The availability of a vast literature characterising behaviour on many different operant schedules allows the consequences of the experimental manipulation to be readily interpreted. Furthermore, the experimenter is readily able to manipulate the behavioural contingencies, thus allowing detailed analysis of the sensitivity of the experimental manipulation to changes in reinforcement schedule, to the provision of discrete and contextual cues. Such an exquisite control over experimental conditions offers major advantages for the precise analysis of behavioural changes.

Recently, with the advent of transgenic technology, most easily applicable to mice, there has developed a need for operant models for use with this species. Although operant equipment for mice has been available for some years, it has not been widely used, partly because it was not very suitable for this species, being simply scaled down from rat equipment. As a result, a laboratory myth developed that mice were unable to learn lever pressing as an operant response, and that the use of a hole-poke operant did not conform to the general descriptive laws of operant behaviour derived from other species. Several manufacturers now supply specialist mouse equipment, with levers sensitive enough for mice to operate, or with alternative manipulanda such as nose-poke detectors.

Although experience with mouse operant techniques is not as extensive as that with rats, it has become clear that mice perform operant tasks readily. The presentation will show data from mice performing complex schedules such as differential reinforcement of low rates of responding, and compare such data with that from rats. The application of operant methodology to study cognitive functions, and in studies of drug abuse will be will be described.

Behavioral responses to in and out of phase communication between 2-3 months old infants and their mothers

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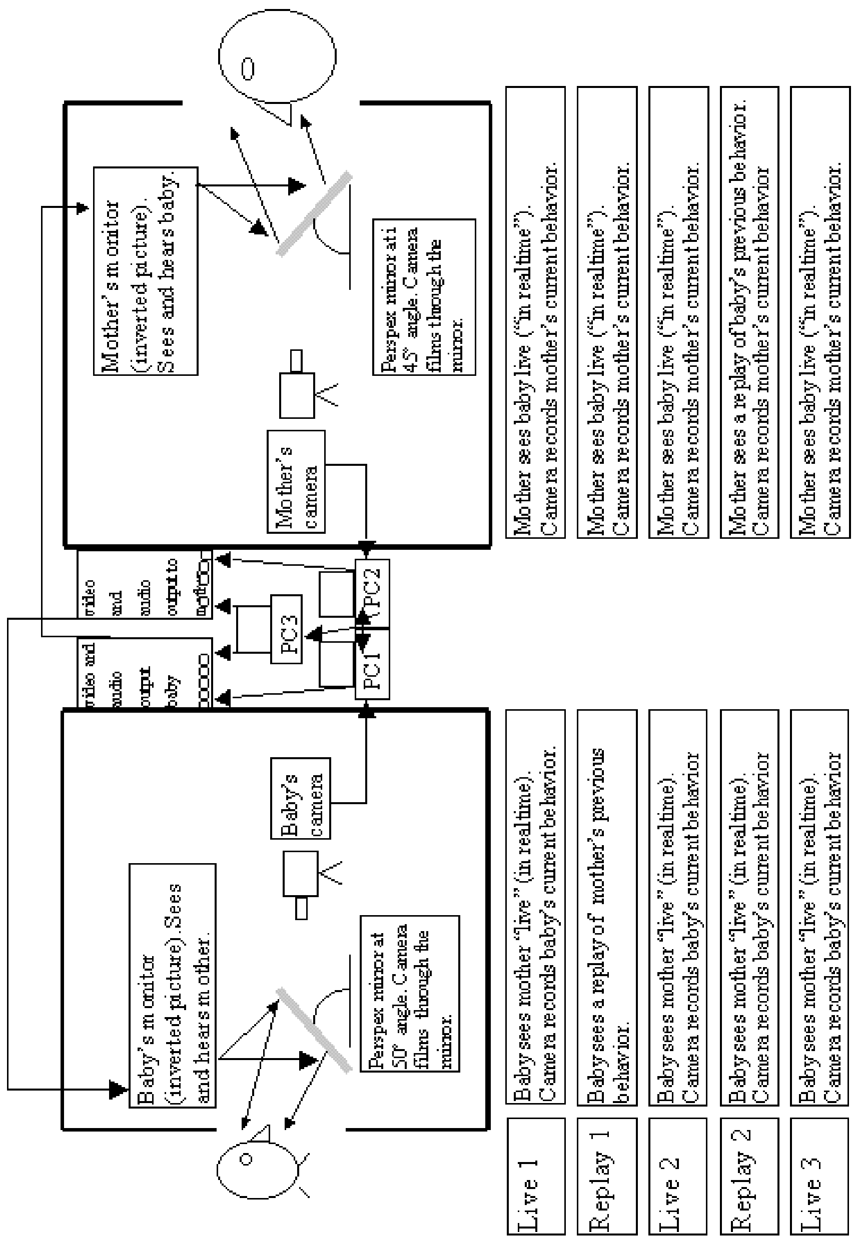
Recent studies point to the importance of early mother-child interaction for affect regulation and emotional development in infants. The purpose of this study was to assess face-to-face communication between 2-3 month old infants and their mothers. The study utilized a "double video" system that enabled the mother and the infant to see a full-face, life-size image of the other. The infant and the mother were presented with live real-time video sequences of the partner, where communication was mutually responsive (Live condition), or set out of phase (Replay condition). The study consisted of five sequences: Live1 – Replay1 – Live2 – Replay2 – Live3. In Replay1 the child viewed a replay of the mother's behavior at an earlier stage while the mother was presented with live sequences of her infant. In Replay2 the mother viewed a replay of her infant's behavior at an earlier stage while the infant was present with live sequences of the mother. Video recordings were digitized with a Miro DC30+ video capture board and analyzed with The Observer Video-Pro (Noldus Information Technology).

On all three live conditions, the infants looked significantly longer at the mother's face than all other foci combined. However, during Replay1 & 2, there was no such difference: The infants looked equally much at the surroundings and their own body as at their mothers' face. This suggests that the infants identified the difference between sequences with mutually responsive communication and sequences where communication was set out of phase. The mothers looked almost exclusively at their infant's face in all sequences. However, still there was a significant reduction during the Replay2 condition compared to both the subsequent (Live2) and the following (Live3) video sequence.



Mother's monitor (inverted picture). Sees and hears baby.
Perspex mirror at 45° angle. Camera films through the mirror.
Mother's camera
video and audio output to mother
video and audio output baby
PC1
PC2
PC3
Baby's camera
Baby's monitor (inverted picture). Sees and hears mother.
Perspex mirror at 50° angle. Camera films through the mirror.
Live 1
Baby sees mother "live" (in realtime). Camera records baby's current behavior.
Mother sees baby live ("in realtime"). Camera records mother's current behavior.
Replay 1
Baby sees a replay of mother's previous behavior.
Mother sees baby live ("in realtime"). Camera records mother's current behavior.
Live 2
Baby sees mother "live" (in realtime). Camera records baby's current behavior
Mother sees baby live ("in realtime"). Camera records mother's current behavior.
Replay 2
Baby sees mother "live" (in realtime). Camera records baby's current behavior
Mother sees a replay of baby's previous behavior. Camera records mother's current behavior
Live 3
Baby sees mother "live" (in realtime). Camera records baby's current behavior
Mother sees baby live ("in realtime"). Camera records mother's current behavior.

Figure 1.

The finding that infants looked more at their mother in sequences with mutually responsive communication than when communication was set out of phase suggests that infants are sensitive to social contingencies. Secondly, the fact that the mother only looked less at her infant only during Replay2, while the infant looked less at her mother during both Replay situations, suggests that the mother's looking behavior was less influenced by the responses of the child than vice versa. This may reflect the important role the mother play in regulating the infant's behavior during early mother-infant interaction.

Exploring accelerometry as an objective method to assess daily functioning in migraine

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Background

Migraine is a chronic disabling disorder, with paroxysmal attacks of unilateral, pulsating headache associated with symptoms such as nausea and vomiting. Dependent upon the intensity of the pain and the duration of the migraine episode, migraine significantly reduces quality of life and leads to impaired functioning (emotional, social, behavioral) both at home and at work. The impact of migraine on daily functioning has presently only been quantified by means of repeated subjective assessments before, during and after migraine attacks, using daily logs and/or questionnaires.

Aim

We explored whether ambulatory accelerometry (e.g. [1,2]) by means of a portable digital recorder (Vitaport2; Temec Instruments b.v., Kerkrade, The Netherlands) can be used as an objective method to quantify the behavioral aspects of migraine-related disability.

Methods

Four body mounted uni-axial piezo-resistive accelerometers were used to quantify the time spent in different body postures (lying, sitting, standing), physical activities (walking, cycling) and a general index of body motility during 8 migraine attacks and subsequent recovery periods of 6 female migraine patients (mean age: 39.8 years, range: 29-49) in their habitual environment. The length of each recording period was approximately 3 days. Two patients used no drugs for the acute treatment of their migraine attack; the other patients used their habitual medication. In order to quantify the influence of a migraine episode on daily activities, we also performed measurements during a headache-free baseline period (2 days) of the same patients.

Results

Within the context of the time required to travel to the patient and attach the sensors (approximately 60-75 min in this study), the migraine attacks and recovery periods were monitored. Overall, the procedures functioned well, indicating that ambulatory accelerometry measurements before, during and after a migraine attack are feasible to perform. All recorded migraine attacks influenced daily physical activities as quantified by means of ambulatory accelerometry. A bed rest-requiring moderate or severe migraine attack showed the following behavioral changes: the number of postural transitions and the time spent in the standing position and as movement were reduced, whereas the time spent in the lying position was increased, versus a corresponding headache-free baseline period. Total body motility was always reduced during migraine, also in those patients who were able to continue their daily activities.

Conclusions

Our data suggest that migraine always influences behavior by reducing motility and that, dependent upon the severity of the attack, effectiveness of acute treatment, and the time of day, the time spent in various body positions, dynamic activities, and number of postural transitions are affected. Therefore, ambulatory accelerometry may provide the objective behavioral effect parameters for the evaluation of migraine and its treatment on daily functioning in the habitual environment.

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Automatic computer analysis of pig play

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We designed an experiment in which we wanted to assess the importance of pre-weaning social experience for later social behavior. The testing involved 4 pigs (either all from the same litter or two pairs from two litters) interacting in a 2x2 m arena. We knew that in pig fights and play fights, mutual spatial positions of the two contestants are important. For a human observer, it is impractical to score these positions directly as the mutual orientation of the opponents may change several times within a single second. We took advantage of the ability of EthoVision® Color-Pro (Noldus Information Technology) to follow several differently colored objects at a time (Figure 1). For further analysis of basic position data from EthoVision we wrote a FoxPro program for cleaning data and mutual position analysis.

Figure 1. *Four pigs in a pen with color markers applied to their back.*

The first task, cleaning the data, is achieved in three steps. First, the system identifies invalid data points based on a combination of different criteria. Next, it replaces these invalid data points by interpolations calculated from the nearest correct positions of the object. Third, it checks once more whether the interpolated values meet a criterion of a reasonable distance between the two markers on the same piglet.

After the data are cleaned in this way, an algorithm is applied that finds out, in three runs, what is the mutual position of the two pigs. First, the positions of the snouts and the tails of the two colored pigs are calculated by extrapolating the "head marker - back marker" vectors into the appropriate directions. For this purpose, the relative lengths "snout - head marker", "head marker - back marker" and "back marker - tail" were measured for each pig individually from the screen and put into the program as parameters. In the second run, it is determined how close the pigs are to each other and which of them is "active" at the moment, i.e. has its snout nearer to the body of the second one. The whole two-pig configuration is rotated in the second run so that the passive pig has its snout at $x=0$, $y=0$ point and its body falls on the negative half of the y-axis. Finally the angle of the two bodies and the point of contact is calculated. For the purpose of our study, we classified all possible positions into contact - non contact, 3 basic orientations (parallel, anti-parallel and perpendicular) and two classes according to whether the active piglet was snout-contacting the other either in front or behind the ear base.

Recording of behavioural responses after unilateral injection of MSM peptides into the rat left ventral tegmental area

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Our studies are focused on detailed examination of behavioural responses induced by alpha-, gamma$_1$- and gamma$_2$-MSH administered into the *ventral tegmental area* (VTA) in rats by use of the registration system The Observer with the Psion Workabout handheld computer (Noldus Information Technology, The Netherlands).

Since the VTA represents the brain region containing A10 mesolimbic dopaminergic neurons, increased dopamine release from their projections in the *nucleus accumbens* and *tuberculum olfactorium* can be taken as essential to provide manifestation of intensified behavioural responses, such as stereotypic ones. Our previous data [1] showed that MSH peptides are capable to alter locomotor responses after intra-VTA administration in rats.

In the present studies attention was payed to the following responses: face washing (FW), body grooming (BG), ano-genital grooming (AAG), tail licking (TL), scratching (SCR), head shakes (HS), wet-dog shakes (WDS), also rearing or vertical activity (VA), locomotion or horizontal activity (HA), rotations (ROT) and catalepsy (CAT). The total observation was performed during 1 h. To find out the dynamics, these responses were summarized in 15-min intervals during the whole observation period and calculated as mean $\pm$ SEM.

The Observer allowed us to record the full spectrum of behavior events. So, the alpha-MSH and gamma$_1$-MSH in comparison to saline induced excessive stereotypic responses, such as grooming (particularly FW, BGF, SCR), as well as increased VA. The observed intensified grooming responses were maintained for 30-45 min after peptide injections, whereas VA only for 15 min. In contrast, gamma$_2$-MSH lacked these activities, but it caused a moderate (5 scores from 10 as maximum) CAT. In addition, only gamma1-MSH elicited slight ROT.

One may conclude that The Observer registration and analysis system combined with the Psion Workabout handheld computer as a mobile tool for behavioral data collection gave a good possibility to obtain a clear picture of the quantitative and qualitative changes in MSHs-induced behavioural repertoire in rats.

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What are the units of song imitation?

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It is generally difficult to decide if two performances of a behavior are of the same pattern and what are the natural units of a behavioral process. Assessment of song imitation raises both issues. First, comparing the song of a tutor-bird with the emerging song of its pupil: it is difficult to decide if (and at what stage) the two performances are similar enough to be considered as 'imitation'. Second, although it is relatively easy to divide a mature song into 'syllable units', during the imitation process the acoustic structure of syllables is vague and is constantly changing. Therefore even the first step of partitioning a developing song into distinct sounds is a difficult task. To address those subjects we developed a fully automated procedure that measures parametrically the similarity between songs. The procedure uses an analytical framework of modern spectral analysis to characterize the acoustic structure of a song.

This analysis provides a superior sound spectrogram that detects frequency traces even during early stages of vocal ontogeny, when sounds are vague and variable. The procedure then reduces the spectral image to a set of simple acoustic features. Based on these features, it detects similar sections between songs automatically as illustrated in Figure 1.

This technique allows us to analyze the process of song imitation as it occurs from moment to moment: We induced the rapid onset of song changes leading to song imitation in zebra finches and used our automated procedure for tracking trajectories of these changes from the initial untutored sounds and until a model match was achieved. We found that exposure to a song model induced marked generation of structured sounds during the second day of training. The temporal pattern of sounds then slowly transformed from repetitive to serial production of syllables.

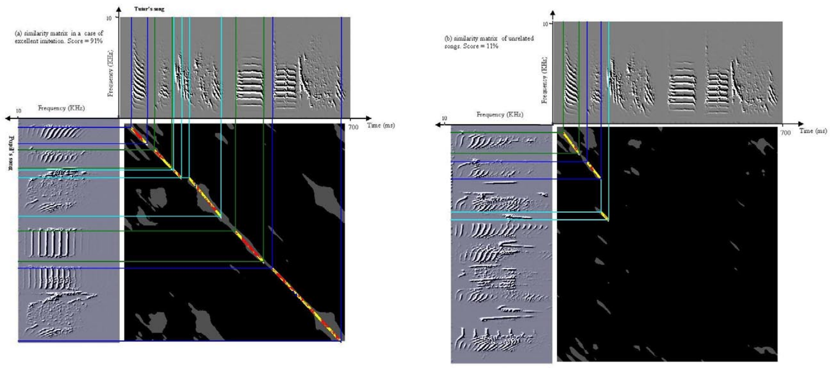

Figure 1*. Our automatic procedure examines the similarity between two sounds by constructing a similarity matrix that combines four acoustic features: pitch, Wiener entropy, FM and spectral continuity. The algorithm sets a statistical threshold to distinguish between non-similar (black) and similar (gray) sections of the similarity matrix. It then selects the most-similar sections (colored lines), and examines fine-grained assessment of the similarity across the acoustic features.*

Tracking this transition revealed that different sounds of the song model were not copied separately, but often differentiated, through stereotyped trajectories, *from successive renditions of the same prototype sound*. We suggest that song imitation is a process of generation and differentiation of primitive prototype sounds. The natural units of the process are therefore the *operations* that the bird performs on sounds so as to match them to the model.

Analysis of imitation trajectories in terms of such operations allows us to text hypotheses regarding the underlying mechanism of vocal imitation: Importantly, there were several cases where imitation did not proceed by gradual reduction of acoustic differences between the sounds of model and pupil. We explain those deviations by synthesis of our findings with previous analysis of the non-linear dynamics of song production in the bird's vocal organ. Based on those findings, we present a framework for a new theory of song imitation.

EthoVision for Windows: a new video tracking system for automation of behavioral experiments

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The EthoVision video tracking system has become a standard instrument for automation of behavioral experiments in hundreds of laboratories around the world. Since its introduction in 1993, the functionality of the software has been expanded with every new release. Since the last major DOS upgrade in 1997, we have completely redesigned and rewritten the original EthoVision software, resulting in a robust 32-bit application optimized for Windows 95/98. In this presentation, the most significant new and enhanced software features in EthoVision 2.0 will be reviewed.

One of the novelties in EthoVision for Windows is the Experiment Explorer. This new tool allows you to organize your experiments according to your own specific needs and wishes. EthoVision 2.0 introduces the concept of a workspace, a folder holding one or more experiments (Figure 1, left pane). For example, you can create a different workspace for each user or place all experiments belonging to the same research project in the same workspace. The Experiment Explorer will keep track of all experiments and associated profiles and data files. This way you can increase the efficiency with which you set up new experiments, by simply copying the necessary profiles from previous experiments.

In the experimental design you can now easily predefine the independent variables in a comprehensible spreadsheet. The number of variables you can define is unlimited, allowing an elaborate experimental design. With the available copy and paste functionality and the automatic sort options any experiment is quickly set up.

In EthoVision for Windows the signal from the video camera is directly displayed on the computer screen. This way the definition of arenas and zones or points of interest is much easier (Figure 1, right pane). During the actual data acquisition the live video images, arena definition and tracks are visible on the computer screen.

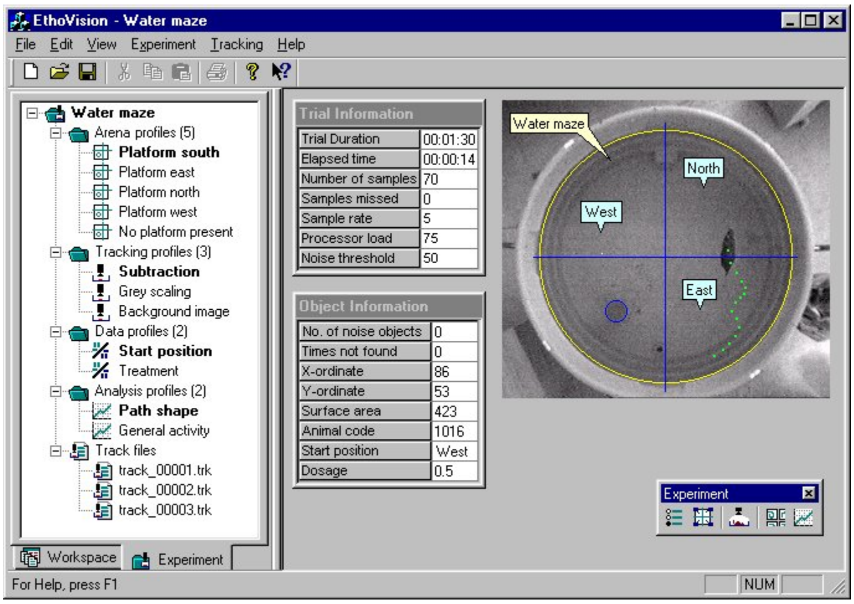

Figure 1. *This screenshot gives an overview of the EthoVision desktop. In this example, the left pane (Experiment Explorer) shows the structure of a Morris water maze experiment. To define the arena and zones of interest, the right pane displays the video image of the experimental setup.*

To fine-tune data visualization and analysis, EthoVision allows you to construct specific data sets at several hierarchical levels. The selection criteria are saved in a data profile, which is applied during the visualization and analysis of the data. You can plot a selection of tracks on a single screen for direct visual comparison of for instance different experimental groups. Track plots can be displayed with or without the arena definition or the background image of your setup. You can customize the plot layout by changing colors and line styles of the tracks. Track plots can be saved as bitmaps or copied to the clipboard for inclusion in reports or web pages.

The analysis report of the DOS version has been replaced by a spreadsheet with the results of the analysis. You can manipulate the layout of this table for optimal presentation: just reorder the rows and columns to fit your needs. The analysis results can still be exported in different file formats to other spreadsheets or statistics packages for further analysis, but an easier and faster way is to copy and paste the data directly.

Automatic production of video compilations with The Observer Video-Pro

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Since the introduction in 1990, The Observer has found its way into many areas of research as a supporting tool for collecting, managing, analyzing and presenting observational data. The integration of video and observational data has offered the user major benefits with respect to validity and reliability of observations. Here we present the latest addition to The Observer Video-Pro [1]: the Video Highlights Module, an add-on package that allows the user to automatically select episodes of video according to observed events, to be placed in a Video Play List (VPL). With the VPL once can produce highlight CDs, multimedia presentations, web sites, etc.

Synchronization of observational data with video stream

If one codes a digital video file, event timing is based on frame numbers in the media file. However, if one collects data while the video is being digitized (i.e. one is scoring 'live'), time stamps in the observational data file (ODF) are based on the computer clock. As a result, the events in the data file are not anchored to the corresponding images in the media file. The same happens if one digitizes a videotape that had already been coded: the events in the ODF will be out of synch with the video file. The Video Highlights Module solves this problem: with one button click one can synchronize the observational data with the corresponding video file.

Automatic creation of Video Play Lists

Within The Observer Video-Pro one can search for actors, behaviors and modifiers. Each time a particular combination is found in the Event Log, the associated video episode can be added to a Video Play List (VPL). With the Video Highlights Module one can do this automatically in a fast and easy way: one defines a filter for events of interest, and the program will automatically add all episodes in which those events occur to a Video Play List. It is also possible to create a VPL with episodes from different video files. Besides these automatic features, one can still change the order of the VPL and add or remove clips manually.

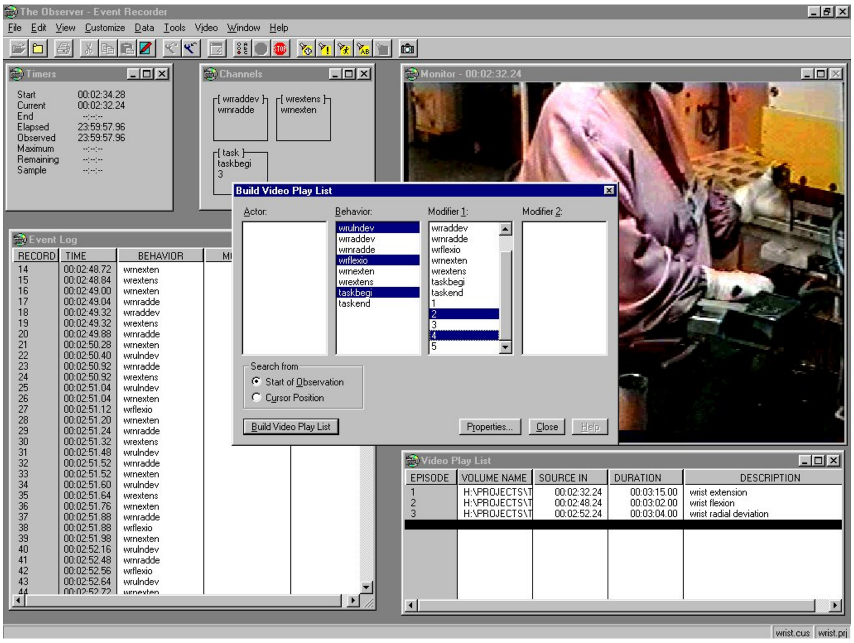

Figure 1*. This screenshot gives an example of the creation of a Video Play List. Once the user has made a selection of Actors, Subjects and/or Modifiers, the Video Highlights Module automatically builds the Video Play List.*

Presenting video highlights

After creating the Video Play List, one may want to show the highlights to colleagues or students. The fastest way to do this is by playing a VPL within The Observer Video-Pro. For many users, however, it is often desirable to use the video clips outside The Observer, for example in a Word document, a PowerPoint presentation, a web page, or simply stored on a CD. The Video Highlights Module allows one to export the VPL to an MPEG editor (that comes with the Video Highlights Module), which automatically extracts the selected clips from the video archive and saves them as MPEG files that can be viewed outside The Observer Video-Pro.

Video file formats

The Video Highlights Module provides full support for MPEG-1 as well as MPEG-2 media files. The main advantage of MPEG-2 is the much higher quality than MPEG-1. Of course this requires substantially larger storage capacity and the hardware configuration has to meet the specifications for supporting MPEG-2, including a DVD writer for storage of video files and an MPEG-2 encoder for creating video files in MPEG-2 format.

Reference

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Assessing agreement among markings of behavioral events

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In a four-minute sequence from a videotaped dialogue between a psychotherapist and her patient, a number of clinical raters are given the task of searching for conspicuous events (verbal and nonverbal) and marking them accordingly. The assumption is that neither information about marking preferences (characteristics of the rater) nor information about the occurrence of conspicuous events worth marking (characteristics of the material) should exist, thus leading to very spontaneous and subjective marking. To avoid any kind of distraction and disturbance of the rater's imagination and spontaneity, an untypically rigid, 'menu-less', extremely simple touch screen realization for setting and working with events had to be designed.

The freedom of marking means that, as a result from superimposition of all the raters' markings, complicated configurations of reciprocal overlapping intervals emerge (Figure 1). A new definition of the concept 'marking agreement' is required, basing only on relational, not on metric considerations. Intervals of a subset of a marking configuration are declared as agreeing if (1) each interval overlaps with each other interval of the subset and (2) the intervals are not distinguishable from each other regarding their overlapping relation to the remaining intervals of the marking configuration. Such subsets are called 'nuclei'.

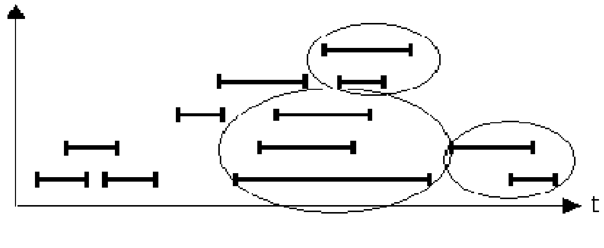

Figure 1. *Superposition of events. The circled markings constitute 'nuclei'.*

The number of 'nuclei-markings' in the whole marking configuration of the raters indicates the degree of agreement. To be able to compare different configurations regarding a significance concept, a standardization on the basis of random configurations is made using Monte Carlo simulation.

The temporal aspect of marking is another topic of the study. The same material is given repetitively to the raters in several sessions. The focus is on the changes in the rater's marking. By accumulating the sessions on one hand and the raters on the other, marking configurations appear, growing in two dimensions. The analysis of this growth process tries to determine the variance of the characteristics of the raters and of the material, respectively.

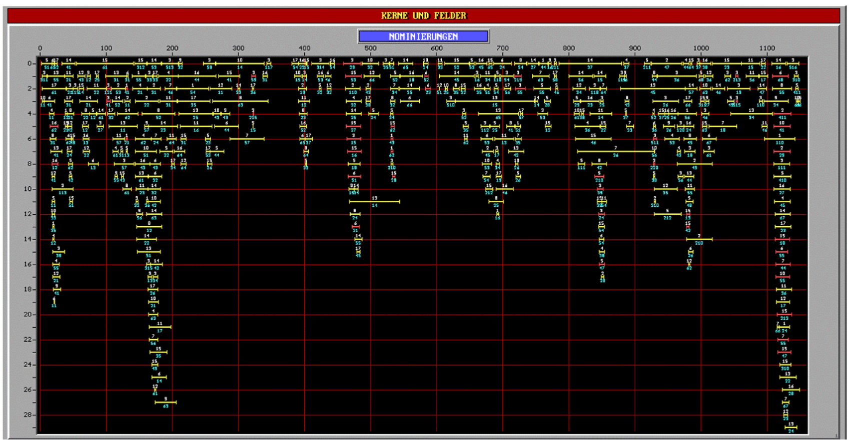

Figure 2. *The taped sequence is divided into 1150 units of .2 sec (x-axis). 17 raters have set a total of 409 nonverbal markings. 181 markings are organized in nuclei, according to the law of Figure 1, thus constituting an overall agreement of approx. 44%.*

The statistical analysis of about 400 nonverbal (Figure 2) and 500 verbal markings, given by 17 raters in 6 sessions, yielded the following main results. There are distinct differences marking verbal and nonverbal behavior: Agreement in verbal markings is significantly higher. A majority of the raters vary their comments in the course of the sessions markedly. Effects of convergence (raters mark the same events in different sequences) and effects of divergence (raters tend to mark more individually at the end) occur at the same time. Raters who mark much more events than others do not mark more individually than others, but concur with a proportionally larger number of other raters. The higher the agreement regarding single events (strong nuclei) the more convergent the given comments. Rating verbal behavior is mainly guided by observable events, whereas rating of nonverbal behavior is influenced by rater stereotypes. Comparing 'many raters × few sessions' with 'few raters × many sessions', the first product leads to much higher agreement than the second.

Development of a selective adaptation design for determining the nature of free-field auditory localization aftereffects

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Department of Psychology, University of Ballarat, Wallinton, Australia

Existing psychophysical evidence supports the proposal that underlying neural mechanisms coding for sound localisation in the horizontal plane achieve fine discrimination through the summation and comparison of neural 'channels'. Using a system of automated data collection that measured and recorded the accuracy of subjects' ability to localise sound in the free-field, the present study developed and refined a selective adaptation design, which subsequently enabled recording of participants' change in localisation accuracy in pre- vs. post-adaptation trials. Additionally, through manipulation of the adapting stimulus, the present study was able to demonstrate that the adaptation aftereffects experienced by listeners were not consistent across differing adapting locations. The techniques devised in the present design refined those employed by previous researchers and have enabled a platform for further psychophysical research that may provide additional insight into the neural mechanisms that underlie human sound localisation.

Development of a technique for identifying central auditory pathway neuropathology in people with multiple sclerosis

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Evidence surrounding localisation of sounds in the horizontal plane indicates that whilst interaural intensity differences (IIDs) undoubtbly play a significant role, fine discrimination is achieved primarily through the summation of responses of neurons selectively tuned to differing temporal disparities. The accuracy and reliability of such localisation processes, however, reliant as they are on temporal processing, are likely to be disturbed by the blocking or slowing of conductance of impulses in affected neurons through the demyelinating effects of Multiple Sclerosis (MS). Despite a paucity of reported auditory disturbance, emerging evidence suggests the experience of auditory localisation deficits in people with MS may be more common than previously realised. Subsequently, localisation tasks that create a demanding environment for binaural temporal processing may carry particular future diagnostic significance in the paraclinical assessment of MS central auditory pathway neuropathology. Through the utilisation of both high-pass filtered noise and the precedence effect, the methodology and system of automated data collection specifically devised for the present study has created complex 'free-field' and 'virtual' binaural temporal processing localisation tasks that may identify previously undiagnosed central auditory pathway neuropathology in people with MS.

Continuous telemetric measurement of heart rate, temperature and activity in the cow under stable conditions

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Oestrus detection in cows requires not only technical skill from the farmer but also a lot of labour investment. This points to the development of new devices aiming to improve oestrus detection.

Telemetric monitoring of temperature and activity in the cow was accomplished by the implantable capsule *Capt alpha* from ESAT-MICAS and IMAG-DLO. This capsule, 60 mm by 17 mm, transmits every second by RF three data bytes: an identification code of the animal and information from three sensors, a piezo-resistive accelerometer and two thermistors. The transmitter frequency is 30 MHz, FSK being used for data modulation. The expected battery duration time was 45 days. An RF receiver and a decoder were connected to a PC for continuous data recording.

A *test capsule* was implanted in an adult Frisian cow to follow inflammatory response, biocompatibility and *in vivo* electronics insulation from humidity. This capsule was inserted in the connective tissue lateral to the anus. A *Capt alpha capsule* was implanted in a Brown-Swiss cow, whose reproductive cycle was monitored during 45 days, with observation of the animal's behaviour in the exercise park and hormone level determination to test the feasibility of the new telemetric monitoring system as a helping tool to oestrus detection in the cow, without interfering with the stable routine. The animal's daily activity was video recorded. Heart rate monitoring was performed with the *PCG capsule* from University of Tras-os-Montes and Alto Douro (UTAD). *PCG* was implanted subcutaneously in the mitral area of the Frisian cow to detect S1. Heart rate in the Brown-Swiss cow was followed during 2-hour periods, placing the *PCG capsule* on the mitral area.

The *test capsule* was recovered 45 days after implantation showing no signs of damage or fluid invasion. The *Capt alpha capsule*, also removed 45 days after implantation, was in a similar condition. These results account for *in vivo* preservation of the battery and the circuitry.

Oestrus was confirmed by observation of excitement and mounting behaviour in the females in the exercise park and also by a fall in progesterone levels.

Data records show a different activity pattern during oestrus in the housed animal, with lower total activity, but with localised peaks of intense activity, never reached during control days. Temperature records show an increase of *circa* 0.5 °C when compared to a control day, reaching an increase of up to 1.0 °C in some night periods. Telemetric heart rate records during control and oestrus days were within the physiological range, heart rate being slightly lower during oestrus. However, the animal showed a higher rise in the heart rate, which took longer to stabilise, when the researchers approached during oestrus.

Results suggest that combining data from continuous temperature, activity and heart rate telemetric monitoring improves oestrus behaviour characterisation and detection.

Effect of morphine on air-puff-induced hyperalgesia measured by 22 kHz ultrasonic vocalization following intracerebroventricular administration of *E. coli* lipopolysaccharide in the rat

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Human pain is characterized by an important affective component that has not been modeled by animal studies. Vivian & Miczek (1998) suggested that 22 kHz ultrasonic vocalization (USV) in rats might communicate affective states. This could be used to measure complex animal behavior such as pain. The goal of the present study was to develop a model of hyperalgesia in which USV could be used to quantify pain. We have demonstrated that the USV pattern of naïve animals can be modulated by hyperalgesia/allodynia and that this state can be reversed by analgesics such as morphine.

In our study, animals were rendered hyperalgesic by the intracerebroventricular (i.c.v.) administration of 2.4 μg of *E. coli* lipopolysaccharide (LPS) [2]. Four hours following LPS injection, each animal was isolated in a sound attenuated chamber (BRS-LVE Tech Serv) and USV was elicited by the presentation of 10 standardized air-puffs (intensity=75 psi; duration=0.2 s) aversive stimuli. USV was detected with a 1.20 cm microphone (G.R.A.S. VedBaek) and the recording period lasted for 10 minutes starting with the first stimulus presentation. A commercial automated signal-detection system (Leuven Measurement System, CADA-X 3.5B) was used to analyze the recordings for each animal and to perform statistical manipulation of the data for the characterization of the USV.

Compared to naive rats, rats injected with LPS had a lower threshold for activation of USV as shown by the number of air-puff stimuli needed to induce USV and a shorter latency to obtain the first USV signal. When animals vocalized, the rate of USV as well as the number of USVs produced, increased in LPS-injected animals compared to naive rats. Also, morphine (2.5-10 μmol/kg) injected subcutaneously reversed the USV response. In summary, air-puff stimulation reliably evoked USV in pre-treated animals with LPS. This provided a robust background of distress signaling which was interpreted to be aversive and possibly hyperalgesic. In keeping with this, the opioid analgesic, morphine, attenuated USV at doses reported to be analgesic by more conventional measures of motor reflex behavior.

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The Observer 5.0: preview of new software for collection and analysis of behavioral data

R.J.H. Trienes, A.H.M. Hendriksen, R.G. Jansen, J.J.M. Theuws and L.P.J.J. Noldus

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Since its introduction in 1990, The Observer has become a standard tool for collecting, managing, analyzing and presenting observational data, with thousands of users worldwide. The current implementations, The Observer Basic 3.0 and The Observer Video-Pro 4.0 [1,2], are heading for an extensive upgrade in version 5.0. At the conference, we will present a preview[1] of the most important new functionality that will become available in The Observer 5.0 as compared to the current versions.

Configuration
With respect to study design, version 5.0 will offer a substantial number of new features. The most important are:

- It will be possible to define *successive focals*, i.e. to have a number of observations for a series of focal subjects within a single observational session, without delay between the various observations. This saves a lot of time if one needs to observe individual subjects in turn for a specified amount of time, e.g. people in a group, pedestrians crossing a street, or chimpanzees in a colony.
- It will be possible to define a *recording method for each behavioral class*. Thus one can combine e.g. continuous recording with interval sampling, convenient if one wants to make an ongoing record of all behaviors of a focal subject, while recording the activity of other individuals at fixed intervals.
- In version 5.0 one will be able to define *multiple simultaneous modifiers*, i.e. modifiers that do not mutually exclude each other. This is particular useful for studies of spatial behavior (one individual being in proximity with a varying number of other individuals in a group) or interactions

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[1] The Observer 5.0 is still under development. Technical specifications are subject to change without notice.

(people in a discussion group talking to a varying number of other people).

- It will become possible to define *numerical scales*, which can be analyzed accordingly. Thus one can calculate the level of aggression, or the average number of toys a child is playing with, if one defines these variables as a numerical class of behaviors or as numerical modifiers.
- Scoring and analyzing action-reaction dyads will become more flexible by defining a particular behavioral element as *triggering*. This will split up a record of the actor-action-receiver-reaction type into two separate record actor-action-receiver, and receiver-reaction-actor, thus allowing for a more accurate recording and analysis of this type of social behavior.
- In version 5.0 one can decide to which behaviors a comment can be added. This is especially convenient if one has a large number of activity categories but only one element of verbal behavior for which one wants to transcribe the utterance in an additional comment field.

Observation

All new features in the Configuration module will be supported in an intuitive way in the newly designed Observation module. In order to be able to score successive focals in a number of observations within a single session we have discarded the concept of predefined 'channels' (combinations of focal subjects and classes of behavioral elements). It was obligatory to do so, because one may not always know the number of focal subjects or their identity in advance. In version 5.0, there is no longer a limitation with respect to the number of focal subjects or behavior classes that can be scored simultaneously. It will also be possible to score behaviors occurring in bouts, i.e. repetitive series of events such as pecking for chickens, allogrooming for monkeys or ruminating for cows. A lot of new functionality will be integrated into a single Event Log, preventing many distracting windows and dialog boxes from cluttering up the screen.

Analysis

The most important enhancements with regard to data analysis are as follows:

- We plan to have a unified data selection method for selection and filtering of observations, scope (session/observations), time intervals, subjects, behaviors, and modifiers in an integrated view instead of in a large number of separate dialog boxes.

- The time-event table and time-event plot will be integrated into a single viewer, and will allow sorting of output by observation groups, subjects and behavioral classes.
- The Elementary Statistics module will offer a number of new statistics, including median and quartiles, confidence interval, frequency rate, statistics for bouts, statistics for numerical values, and statistics for multiple simultaneous modifiers.

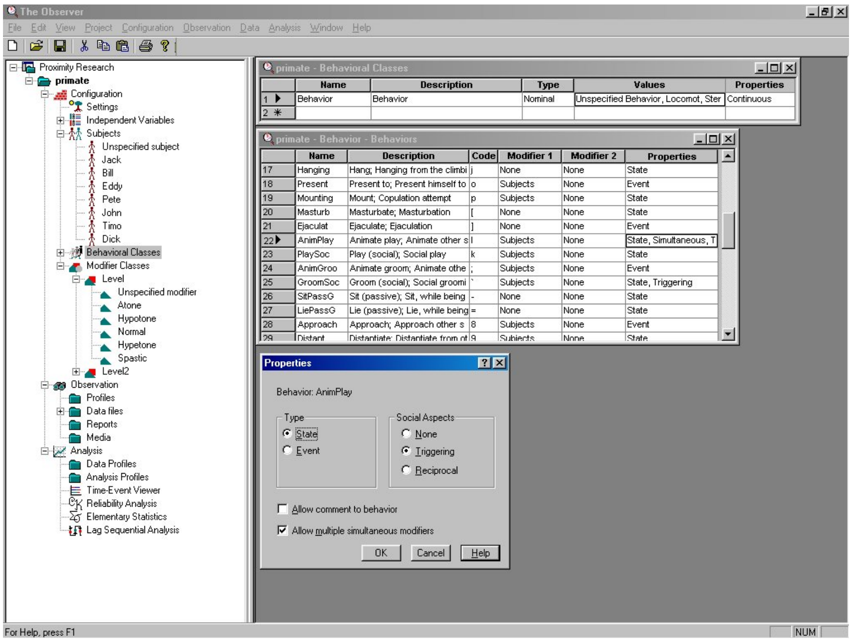

Figure 1*. Preview of the user interface of The Observer 5.0, compliant with Windows 98/NT standards, showing a tree view of all items in a single project and some views that allow you to define the properties of behavioral elements.*

- The Reliability Analysis module will provide four methods for calculation of inter-observer agreement, based on frequency, duration, time-sequence, and duration-sequence. It will also compute a confusion matrix, Cohen's Kappa and Pearson's Rho.

- Lag Sequential Analysis will support higher order transitions, up to 10 transitions forwards and backwards in time, and will generate transition matrices for each subject, combination of subject-behavioral class, and for each behavioral class.

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A program for the design and analysis of drug self-administration studies according to a novel pharmacokinetic/pharmacodynamic model

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We have recently proposed a quantitative pharmacological model of maintained cocaine self-administration that states that the intervals (T) between self-administrations are described by the equation:

$$T = \ln(1 + D_U/D_{ST}) * t_{1/2} / 0.693$$

where D_U is the cocaine unit dose, D_{ST} is the minimum maintained level of cocaine (the satiety threshold) and $t_{1/2}$ is the cocaine elimination half-life [1]. In Sprague-Dawley rats the satiety threshold was calculated to be approximately 2.0 mg/kg. Moreover, a direct method for the measurement of cocaine priming threshold determined was developed. It was determined that the reinstatement of cocaine self-administration requires the level of cocaine to be at or above that produced by an i.v. injection of 0.2 mg [2]). Therefore, the cocaine level in the body appears fundamental in the regulation of responding for cocaine.

We have developed a software package that permits:

1. Flexibility in the self-administration sessions. Sessions are typically divided into five distinct stages: 1) extinction of cue-induced presses, 2) reinstatement, 3) loading, 4) maintenance and 5) extinction of cocaine-induced presses.
2. Present drugs or food and signals according to any desirable schedule: fixed, proportional, variable or progressive.
3. Calculate the cumulative levels of cocaine at any time during a self-administration session. Particular emphasis is placed on the reporting of the calculated levels of cocaine at the time of each cocaine injection.
4. Record the absolute time of every event (events are: any lever presses, pumps or signals activation and deactivation, etc.).
5. Export the data to a database.

6. Present the cumulative record of drug administration events and the corresponding cocaine levels graphically immediately after the session.
7. Calculate the priming threshold, the satiety threshold, the intervals at any unit doses of cocaine used in the experiment etc.

Using this software package we have demonstrated that the cocaine levels rise rapidly following reinstatement, corresponding to the drug-loading phase of a session. Approximately 5-15 min after reinstatement, the inter-injection intervals abruptly become longer, but remain regular. During this maintenance phase of a session the calculated cocaine levels at the initiation of each injection are observed to remain constant at all unit doses. Extinction responding is related to the declining cocaine levels.

Hardware and software requirements are:

- Operant chambers and interfaces from Med-Associates, Georgia, VT, U.S.A.
- Med-PC software for Windows from Med-Associates.
- IBM compatible PC with Windows 95 or 98.
- Database (for example InterBase or Microsoft Access).
- Sigma Plot or similar graphics program.

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Objective quantification of head movements and tics in patients with the syndrome of Gilles de la Tourette

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Background

Recurrent and involuntary motor and vocal tics constitute the typical characteristics of patients with the syndrome of Gilles de la Tourette (GTS). Objective quantification of the frequency and intensity of tics in Tourette patients can contribute much to improvement of diagnostic criteria and evaluation of therapy efficacy. The difficulty of developing reliable methods for the assessment of tic severity relates to the variable presentation of tic symptoms, comprising aspects of localisation, frequency, intensity, complexity, and noticeability. Furthermore, there are time- and situation-specific variations within and across subjects in tic severity. At present, several clinician-based rating scales exist to assess the multiple clinical features that contribute to overall severity of Tourette's disorder, whereas videotape-based tic countings have been used to obtain a more quantitative index of tic severity and the temporal dynamics of tics. Much can be gained from objective tools that can describe the temporal and situational characteristics of tics in controlled and ambulatory situations.

Aim

In this study, we explored accelerometry as a novel tool to objectively quantify the frequency and intensity of motor tics and (non-)specific movements during period of rest and performance of various tasks in GTS patients.

Methods

Nine Tourette patients (2 females; mean age: 37.6 years, SD: 12.9) and 14 controls (7 females; mean age: 31.8 years, SD: 14.3) participated in a 1-hour session during which a video camera recorded the movements of the head during two pre-task periods of rest (5-min periods) and during performance of two tasks, e.g. a conversation of 5 min during which the subject talked with the researcher about his/her hobbies and the watching of a 15-min video of an entertaining program. Objective registration of head movements and head tics occurred by means of three uni-axial 5-g piezo-resistive accelerometers (IC-sensors 3031) that were attached to an elastic band, placed above the eyes of the subject. With these sensors both the position of the head in the lateral, sagittal and transaxial plane could be documented, as well as the actual acceleration of the head during movements in the three planes. The accelerometer signals were stored at a sample frequency of 64 Hz on a digital portable recorder. Two typical movement patterns were analysed: a) fast oscillatory head movements (about 3-4 per sec) which occurred in both patients and controls, and b) isolated fast head movements, primarily corresponding to isolated motor tics of the patients (head jerking). A head motility index was computed for each plane (lateral, sagittal, transaxial) in order to obtain a general motility measure: each of the 3 signals was high-pass filtered (0.5 Hz) and rectified, the resulting signals were integrated over 1-min intervals.

Results

Head motility levels in the lateral, sagittal and transaxial plane were significantly higher in the patients than in controls during all procedures ($p<0.05$). Both patients and controls showed a significant increase in head motility levels during conversation ($p<0.05$); both groups also showed a similar significant increase in specific oscillatory head movements during conversation ($p<0.05$). The number of isolated fast head movements was significantly higher in patients than in controls ($p<0.05$); these movements showed no increase during conversation but increased significantly while watching the videotape ($p<0.05$).

Conclusion

Our findings illustrate the potential of accelerometry to provide objective quantitative parameters of spontaneous movements in Tourette patients. In both standardized and ambulatory research, accelerometry may be used as an objective tool to quantify the severity and temporal dynamics of tics or (non-)specific movements in neuropsychiatric disorders.

Characterising behavioural phenotypes using automated image analysis

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The aim of our project is to automate the analysis of studies of rodent behaviour, for use in drug discovery and functional genomics. Systematic behavioural studies have become important in creating animal models of psychiatric and neurological disorders and in investigating their response to pharmacological agents. Recent advances in mouse genetics have created a similar need to characterize the behavioural phenotypes of transgenic mice.

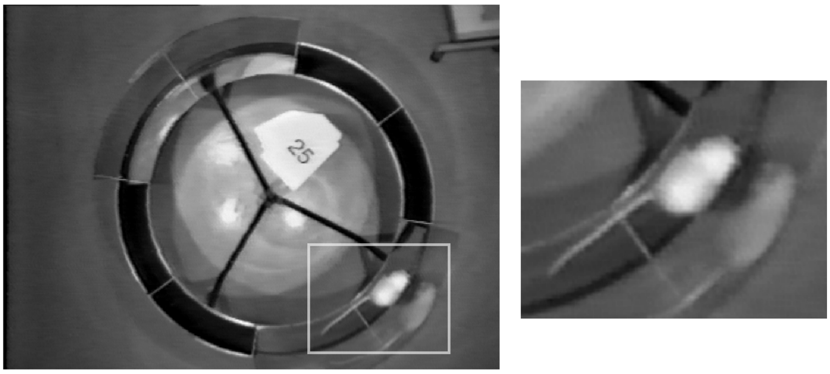

Figure 1. *An example monochrome video frame (768x576 pixels) showing an adult Sprague-Dawley rat in the zero maze.*

There are a number of well-validated test paradigms such as the elevated zero (Figure 1) and plus mazes, water mazes, dark/light boxes, social interaction analysis, etc. Various automated systems are available which record motion/movement patterns, but the most versatile approach is the analysis of video recordings/live video images of animals in these standardized environments. Many automated systems can track animals and provide position/time data. However, in many cases, behavioural analysis is also required; this commonly involves an experimenter observing and recording data via a computer interface. But this is subjective, qualitative and extremely time-consuming.

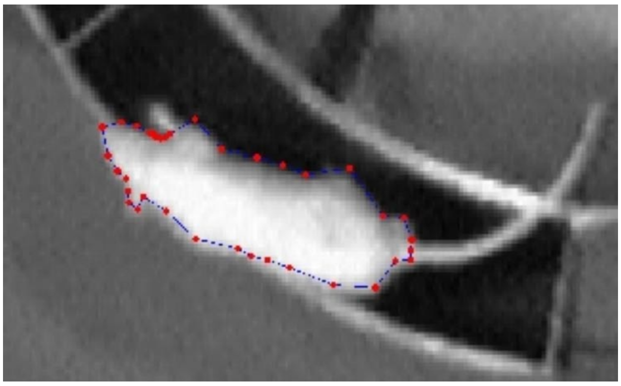

Figure 2. *Close-up of an example marked-up image from the training set.*

We are developing a system that uses Active Shape Models (ASMs [1]); these are deformable models of shape, which are learnt from example images (see Figure 2). The set of shapes seen across the training set is analyzed to extract the modes of variation, providing a compact mathematical description of the shape of the animal and the way it changes. We also model the image profile across the shape boundary. These features allow robust tracking of the explicit object of interest; rather than just detecting movement or changes-from-background in the image, we can focus explicitly on objects that are of the correct shape. The modeling of the profiles also allows us to distinguish, say, between the actual animal and reflections.

The allowed modes of shape variation also provide a compact way of recording the shape variation seen as an animal is tracked. We have found that many characteristic postures can be differentiated using only the first two modes of shape variation (see Figure 3); other postures require more modes, but still a small number. As well as this static recognition of posture, the statistical analysis of shape change over time provides an indicator of behavior.

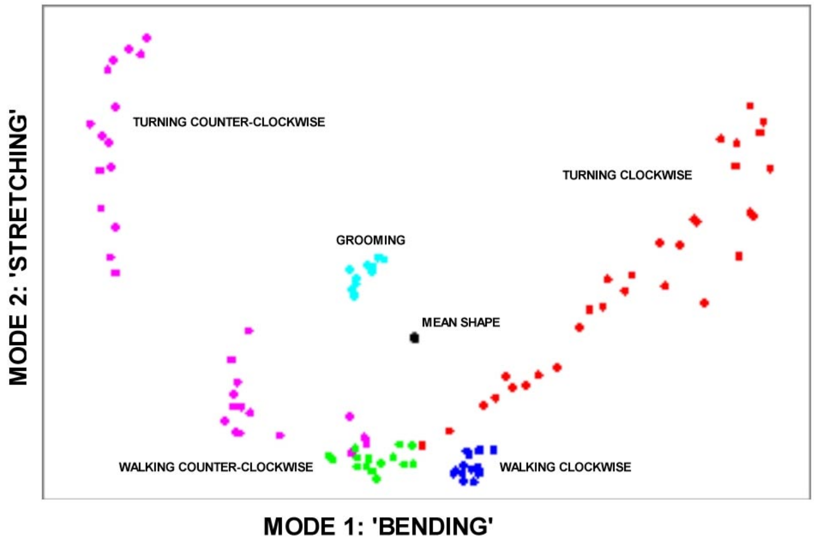

Figure 3*. The values of the first two modes of shape variation plotted for a set of examples of various postures.*

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An ethological observation of a collaborative behaviour setting: some technical aspects

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Modern observational research implies many technical questions about the right tool use. In this work we aim to introduce the application of ethological procedures of observation to the complex social interaction of the human species (*Homo sapiens*). Given computerized methods of data like The Observer Video-Pro [4], the major goals of this eco-ethological study are: to report the interactions of a small group at work during a collaborative learning task; to construct an ethological catalogue of student-student socio-cognitive interactions; and to analyze the temporal structure of sequences of student-student behaviors.

As we are interested in collaborative learning settings, we provide illustrative material from student-student interactions of a behaviour setting using categories of observation taken from our exploratory study. From this viewpoint, 4th grade university students were encouraged to explore collaboratively the software Biota [1], a BioQUEST Library Collection [2] module, which permits them to experience Biology as a problem solving activity [7] in a new social learning environment. The method of sampling was that of focal sampling and the method of recording was that of continuous recording [3]. Videos of student-student acting out during the problem solving cooperative activity were obtained with The Observer Video-Pro system [5,6].

In this exploratory study, we establish a first approach to a category system of the students' collaborative learning strategies. With this qualitative picture obtained from our partial ethogram, we have quantified those social interactions. The Observer provides a highly efficient tool for the exploratory analysis of observational data. The data was first analysed with the "time-event plot" which gave us a graphic layout: learning behaviours were plotted against elapsed time. Secondly, through elementary statistics we search for (a) percentage of frequently occurring learning behaviours; (b) percentage of co-occurring events. Finally, in order to calculate frequencies of transition between pairs of learning behaviours, we used a lag sequential analysis method.

We discuss how The Observer, a menu-based software package, can be helpful to collect behavioural data in educational behaviour settings such as a classroom. It can be used to record interactions in a "focus group" of co-operative learning during a problem-solving activity.

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Evaluation of motor behavior and sleep/wake pattern in depressed patients by wrist-actigraphy

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Background

Alterations in psychomotor behavior and sleep/wake pattern are characteristic features of a major depressive disorder. To evaluate these features, wrist-actigraphy can be applied as a method to assess 24-hour patterns of spontaneous motor activity for prolonged periods of time in a natural environment.

Aim

In this study, wrist-actigraphy in combination with sleep logs was utilized to evaluate in severely depressed patients disturbances in motor activity levels (retardation), sleep latency, sleep duration and motor activity characteristics of the sleep period.

Methods

Participants were 71 depressed patients (26 males and 45 females, mean age= 52.7, sd=8.7) and 96 healthy subjects (51 males and 45 females, mean age=41.2, sd=8.7). The patients were free of psychopharmaca for at least one week and had a mean score on the Hamilton Rating Scale of Depression of 27.7 (sd=5.0). The healthy subjects were medication-free for at least three months prior to the study, they were not under any medical treatment and had no personal history of psychiatric illness. Motor activity was monitored by a wrist-actigraph (Gaehwiler Electronic) which contains a piezoelectric accelerometer (sensitive to 0.1 g and above) that records both intensity and frequency of movements per 30 second. The actigraph was continuously worn on the non-dominant wrist for 3 consecutive 24-hour periods. In addition, a sleep log was kept in which participants recorded their sleep/wake times, sleep latency time and the periods the actigraph was taken off.

Results
Table 1 shows, for patients and healthy subjects separately, the motor activity levels during wake (Act. W) and sleep (Act. S), the total wake and sleep time (TWT and TST, respectively), sleep latency time (SLT) and the immobility index during the sleep period (Imm. S). Differences between patients and healthy subjects were studied by t-tests or non-parametric Mann-Whitney U-tests, dependent on the distribution of data.

Table 1*. Mean (sd) motor activity and sleep parameters.*

	Patients	Controls	Difference	P
Act. W (movements / 30 s)	17.7 (8.9)	30.4 (12.7)	-12.7	<.001
Act. S (movements / 30 s)	1.8 (1.5)	1.3 (0.8)	0.5	ns
TWT (min)	848.5 (60.8)	944.7 (58.4)	-96.2	<.001
TST (min)	375.1 (95.5)	420.6 (51.5)	45.5	<.01
SLT (min)	72.4 (44.3)	22.8 (21.5)	49.6	<.001
Imm. S	0.91 (0.06)	0.92 (0.03)	0.01	ns

Depressed patients were found to be significantly less active during wake than healthy subjects, but no difference in motor activity level was observed during the sleep period. Both total wake and sleep time were significantly decreased in the patient group. Additionally, the patients demonstrated a significantly larger sleep latency time than healthy subjects. No alteration was observed in depressed patients regarding the immobility index during the sleep period.

Conclusions
Our findings underline the presence of disturbances in motor activity during daytime (psychomotor retardation) and sleep patterns in depressed patients.

In future actigraphy research, we will focus on the clinical relevance of wrist-actigraphy as a useful tool to evaluate treatment effectiveness and to predict treatment response in this patient group.

Multimodal interaction in virtual reality

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This contribution reports work carried out in Bielefeld in the context of interacting with virtual reality environments. Three things are important in our work toward incorporating gestures as a useful tool in virtual reality:

- Measuring gestures as articulated hand and body movements in the context of speech.
- Interpreting them by way of classifying features and transducing them to application commands via a symbolic notation inherited from sign language.
- Timing gestures in the context of speech in order to establish correspondence between accented behaviors in both speech and gesture channels.

The things we have learned from investigating these issues help us to advance natural interaction with 3D stereographic scenes in a scenario of virtual construction. In the first place we have dealt with pointing and turning, etc., often classified as deictic and mimetic gestures. In the DEIKON project, we have now started to investigate more sophisticated forms of deictics in construction dialogues that include features indicating shape or orientation, which leads us into iconic gesture. Another issue in our work is the synthesis of lifelike gesture from symbolic descriptions for an articulated virtual figure where natural motion and timing are central aspects.

Inter- and intra-individual variation in resting behaviour in dairy cows

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Interpretation of lying behaviour of dairy cows in terms of welfare is difficult because reliable information on parameter values is lacking. This applies to information such as the variation between and within animals, changes in lying time and the relevance of it, the number of lying bouts, and the interaction between lying behaviour and management. It has been realized that these parameter values can only be reliably estimated by automated 24-hour recording. Therefore, a system has been developed at ID-Lelystad that enables continuous recording of lying behaviour of dairy cows.

In a free stall barn, 16 cubicles were equipped with commercially available electronic cow-identification receivers, supported by two photoelectric cells in each cubicle to identify the posture of cows. Around the neck cows were wearing transmitters, which had been slightly adjusted for use in this system. Cubicles were automatically scanned for transmitter number and photoelectrical output one after the other twice every minute, and data was stored in computer.

The system was validated by means of video observations (72H time-lapse mode), with a single camera overlooking 16 cubicles. After (automated) correction for double identifications by adjacent receivers in empty cubicles, 93.7% of the 4203 lying periods could be reliably recorded. Missing cow-identification (3%) was restricted to lying bouts of less than 5 min only. To study intra- and inter-individual variation in lying behaviour, 16 Holstein Friesian dairy cows (days in lactation: 156) were housed in the system for 6 weeks. After habituation, the last 19 days were used for the analysis. On average (19 days) cows spent 723 min/day (16 cows; s.d. between cows: 115) lying. Individual cow means (19 days) ranged between 483 and 985 min/day. Lowest and highest standard deviations within cows were 44.6 and 97.6 min/day. Corresponding values for the number of lying bouts were 12.1 (±

2.37); cow means ranged 7.7-16.4 and standard deviations within cows ranged 1.12-2.49.

The large differences between cows together with the low standard deviation within cows suggest that lying behaviour (time and bouts) is consistent over time and characteristic for the individual cow.

Temporal patterns in children with a disorganized/disoriented attachment

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Disorganized/disoriented attachment

Within the field of mother-infant studies the development of a category of disorganized/disoriented attachment ("D") has received much attention. More than 60 studies involving more than 5,000 infant-parent dyads have proved the validity of D and its importance for developmental psychopathology [1]. Studies on adrenocorticol responses and cortisol levels support the idea that children with D lack a coherent behavioural strategy for coping with stressors.

Research question

In the current classification system, one occurrence of a particular behaviour – lasting only a few seconds, within an observation period of 30 minutes – can be sufficient for the assignment of D (e.g. "while in apparently good mood, infant strikes against the parent's face or eyes"). We wanted to investigate whether children with a D-classification show an overall pattern of disorganized social behaviour with their parent.

Temporal patterns

The software package Theme, developed by M.S. Magnusson, recognises temporal behaviour patterns based on consistencies in [2,3]. Some temporal patterns may consist of behavioural event types that all belong to the same actor but in this study we were especially interested in the so-called dyadic patterns. In the dyadic patterns both parent and child are present as actor at least once.

Results

When children with a D-classification (n = 13) were tested against children without a D-classification (n = 13), no significant differences were found in separate social variables. However dyads with children with a D-classification had a significantly lower percentage of long dyadic temporal patterns (percentage for D-children 0.6 ± 1.1, for non-D children 4.5 ± 6.2). Significant differences in the effect of separation from the parent on heart rate were found between children with a D-classification and age and IQ matched children that had not received a D-classification [4].

Conclusion

The low number of long dyadic patterns in the children with a D-classification may be indicative of an overall pattern of disorganized social behaviour. Optimal social behaviour may involve achieving the right balance between variation and predictability; the optimal amount of patterns being dependent on many different variables like social environment, age of the child, and identity of interaction partner. We speculate that the number of patterns found in children with a D-classification is below this optimal number of patterns. More research is clearly needed on the important aspects of sequence and timing of behavioural elements.

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Infrastructure to support gesture research

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In the field of psycholinguistics, the Max Planck Institute was one of the first to make consequent use of computer-based audio and video material. This opened completely new types of research questions. A gesture project was established relying fully on the availability of multimedia technology at the desktop. Also, anthropologists and linguists who want to study language usage in real-life situations and to document the rich context of language acts as well are digitizing the raw data systematically to make use of the new opportunities.

The major technological problems that had to be solved were:

- The development of multimedia annotation and exploitation software.
- The establishment of a network infrastructure allowing to handle many Mbps datastreams.
- The setup of media servers to store terabytes of multimedia data and to provide enough capacity to pump video across the network.
- The decision for a couple of standards to ensure the investments.

A first-generation multimedia program developed specifically for the Mac platform is actually in use [1]. It is flexible enough to allow the user to define an almost infinite number of annotation tiers and to describe the complex time relationships typical for independent streams of data such as speech and gesture. Nevertheless, this tool has a couple of limitations which we want to overcome with the two second generation tools called EUDICO [2] and Browsable Corpus [3]. These tools are based on modern software design methods and programming languages such as UML [4] and Java, respectively, and APIs such as Java Media Framework. EUDICO supports streaming of the relevant media fragments across the Internet and can operate in distributed environments. Browsable Corpus defines a browsable and searchable universe of meta-descriptions and offers appropriate tools such that users can easily find appropriate resources to work with. Since this technology is intended to be available in the Internet the meta-descriptions are based on XML.

The software handles Cinepak, MPEG-1 [5], and in the future certainly MPEG-2 [5] video encoding formats. For MPEG-1, streams of 3 Mbps constant bit rate are typical. A fast switching network with a Gbps Ethernet switch in the center and dedicated 100 Mbps connections to the media desktops is the basis for multimedia delivery. It was decided to rely on overcapacities in the LAN and not to apply complex technologies such as ATM offering mechanisms to reserve certain bandwidths. The media servers will be coupled with Gbps connections to be able to support several users in parallel. Separate digitization stations have been set up which now create MPEG-1 streams in real-time and in doing so making utterly time-consuming conversions from for example M-JPEG to MPEG-1 obsolete.

The success of the video setups and tools at the institute led to the fact that more and more audio/video material is digitized. Currently, the servers have to store and offer about 400 Gb video data. A new project carried out by one researcher will imply an increase of about 40 Gb per month. This leads to great organizational challenges, since the data has to be organized in maintainable structures, to be backed up, and to be made on-line available. With respect to the latter, two possibilities are given: (1) using large RAID systems or (2) using hierarchical storage management systems where only part of the data is available on disk and the larger part is migrated to a tape library. Both possibilities have been compared at the institute. The decision about which possibility to choose depends on a number of criteria such as total amount of data, robustness of hardware and software, price per Gb to be stored, and accepted latencies.

All aspects of setting up an adequate multimedia infrastructure will be discussed in detail. The focus of the talk will not be on specific tools, but discuss technological alternatives, the experiences made at the institute, and explain the choices for the coming years.

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Measuring effects of different temperatures on swimming activity and social behavior in groups of Mediterranean marine fish with the EthoVision Color-Pro video tracking system

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In nature, fish are continuously submitted to various external environmental factors (biotic, abiotic) affecting their behavioral responses. We have already conducted studies to determine the effect of environmental variables on sexual behavior in fish. However, other behaviors involved in reproduction, like swimming activity, are also influenced by the environment. Temperature is almost certainly one of the most important environmental effectors influencing swimming activity. In laboratory (aquariums) we used EthoVision® Color-Pro 1.96 (Noldus Information Technology), a computerized video tracking system based on digital imaging techniques, to quantify and take into account variables that cannot be measured accurately by usual methods of direct observation.

In a first approach conducted in three experimental aquariums (L100 x W50 x D48 cm) equipped with 2x30W neon tubes, reduced in an arena of L68 x W30 x D48 cm with blue plastic plates), three different temperatures (16 °C, 21 °C, 26 °C) were tested in the Mediterranean damselfish *Chromis chromis* (length: 9 cm). To track several individually identified fishes, we used color markers (fluorescent color plastic pearls of 1 centimeter) attached under the dorsal fin of the fish. In theory, the color tracking system can detect up to eight colors, but in practice we only found two colors (fluorescent green and pink) detectable simultaneously in a water environment. Placing the camera in front of the arena, we measured in two individual damselfish (2/4 fishes tracked at each trial) the distance moved (DM), the velocity (V), the social interactions reflected by the distance between the two animals (DO) and the time spent in the defined zones (IZ) of the aquarium (sandy bottom, middle water, near surface), according to water temperature and fish density at 21 °C (1, 2 and 4 fishes). It is worth noting that we have tested the potential impact of the pearl on the swimming activity with trials using one fish with and without color mark (monochrome tracking). Each session (track) lasted 1 hour with an image sample rate of 5 samples/s (18000 samples/h).

The pearl has no significant effect ($n=6$) on swimming behavior (DM, V) and time spent in the defined zones (IZ). Density does not significantly affect the DM, V, IZ, except for the density 4, where the fish swims faster near the surface ($n=12$, $p=0.01$). However, densities 2 and 4 influence the DO (larger for density 2) in the arena ($n=12$, $p=0.05$) and when a fish is alone, it stays longer on the bottom ($n=6$, $p=0.04$). The three temperatures tested do not influence the DM, V, IZ, except for 21 °C, where fish swims faster near the surface ($n=12$, $p=0.01$), probably an adapted behavior to escape from birds in nature. An interesting result concerns the DO on the bottom that is inversely proportional to the increase of temperature and highly correlated with this factor ($n=12$, $r=-0.984$). This measure could reflect the increase of social interactions observed with reproductive behaviors in nature, which appear with the elevation of water temperature in June.

Our study illustrates the new possibilities of digital imaging techniques for the understanding of the relations between fish and their biotic and abiotic environment.

Comparing sequential associations within a single case

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This paper compares the type I error rate and computes the kappa for agreement on significance decisions using a new application of sampled permutation tests and log linear analysis to examine whether two sequential associations are different within a single dyad (e.g., a teacher and a student). We used the sample permutation test and log linear analysis to test the significance of the same pairs of behavior streams. Within each set of behavior stream pairs, the behavior streams were generated from the same algorithm to create a distribution in which the mean difference between sequential associations was zero. Using generated behavior streams allows us to estimate the type I error rate and to create the sampling distribution needed to understand the conditions under which the techniques provide different results. However, the algorithm is based on an actual mother-child interaction session that yielded moderate positive sequential association. Because past work has found that permutation and asymptotic tests produce different results most often when sample sizes are small, we generated sets of behavior pairs with relatively small number of events. Each member of a pair had the same (i.e., 100 vs. 100, 50 vs. 50, and 25 vs. 25) and different (100 vs. 400) number of event pairs to simulate designs that use time-based (typically producing equal-length comparisons) and event-based (typically producing different-length comparisons). In the 100 vs. 100 event pairs condition, the amount of agreement on significance decisions was extremely high (kappa = .92) and the type I error rate was about approximately the same for both methods (.059, .066 for shuffle-the-cell and log linear, respectively). In the 50 vs. 50 and the 25 vs. 25 event pairs conditions, the degree of agreement reduced and the difference in type I error rates increased as length of session decreased. In all equal-length cases, the shuffle-the-cell method was slightly more conservative than the log linear method. In the different length condition, the type I error rates for the two methods (.044 and .061, for shuffle-the-cell and log linear, respectively) were similar but there was almost no agreement above that expected by chance regarding significance decisions (kappa = .07). Cases in which the results differ are those that violate the assumption that the data are sampled from a Poisson

distribution. It appears that when sample sizes are small and the behavior streams to be compared are of very different lengths, permutation tests may be preferable over log-linear analysis, at least for comparing 2 x 2 tables.

A comparative approach to the early behavior development in mice

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Recent development of transgenic and knockout technologies stimulates new interest to comparative studies of mouse postnatal development. In order to provide a background for the analysis of the effects of targeted mutations on mouse behavioral development, we have designed a battery of tests that characterize maturation of a set of sensorimotor functions, behavioral traits and learning abilities in mice from birth to weaning. The main criterion for the selection of tasks into this battery was the postnatal age- and behavior-specific validity of the experimental tasks that were recruited from developmental neurobiology and psychobiology.

In its present form, the battery includes:

- eight parameters of somatic maturation;
- thirteen standard tests from the Fox battery which were expanded by several modifications from the Altman's tests;
- analysis of development of thermo- and homing preferences in two-way discrimination tasks used at different postnatal ages;
- tests for nest seeking behavior; and
- tests for descending from an elevated platform under different conditions.

Learning models of one-trial olfactory conditioning and social transmission of food preference where mother was used as a demonstrator are also included in the battery. Additionaly animal behavior patterns under conditions of isolation and social interactions are recorded and analysed. The role of maternal care is estimated by the pups transfer test.

The proposed battery allows researchers to evaluate the developmental contribution of different components of the pre- and postnatal environment including gender, individual experience, social environment and maternal behavior. Our application of this battery for a number of tasks demonstrates its validity and sensitivity for comparative analysis at the individual, population and inter-strain levels.

Quantitation of operant nose press force maintained in CD-1, BALB/c and C57BL/6 mice

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Measurement of operant behavior in laboratory rodents is usually accomplished with a lever-switch ensemble that detects lever depressions of sufficient force to close the switch. These manipulanda only register the occurrence of a response, thereby ignoring many of the motor features of the response itself, such as the force applied to the manipulandum during the response. We have constructed a manipulandum that uses an isometric force transducer to measure the force of operant response as the mouse presses it nose against a smooth, flat disk.

The force-sensitive disk is serviced by a computerized data collection system, allowing on-line, real-time measurement of the applied force at a 100 Hz sampling rate. In-house software permits the force data to be used in real-time to provide auditory or visual feedback or to be used to control other environmental events (e.g. food delivery). Data stored on the computer can be reviewed in its original integer form or can be transformed to text for importation and processing by graphics (see Figure 1) or statistical packages. Combining this manipulandum with an operant-conditioning chamber has allowed us to measure nose presses directly reinforced with food presentation (Fixed Ratio 1), as well as anticipatory nose presses made during signaled conditions prior to the reinforcement period. With these methods we have observed mouse strain differences in capacity to emit appropriately high force as force requirements for reinforcement are increased. Specifically, force production by the C57BL/6 mouse was lower than that seen for the other two strains (CD-1, BALB/c). Our preliminary neurochemical analyses have suggested that the low force production in the C57BL/6 strain is associated with lower levels of brain dopamine and lower dopamine turnover in this strain compared to the other two strains studied.

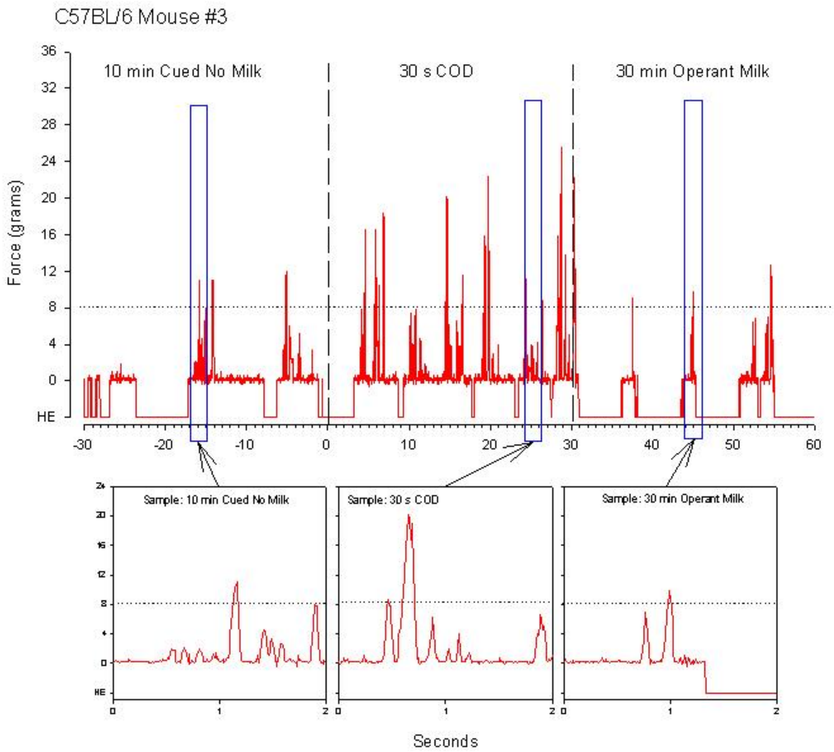

Figure 1. The top panel shows a sample record of the transition from two non-reinforcement conditions ("10min Cued No Milk" and "30 s COD to a reinforcement condition ("30 min Operant Milk", Fixed Ratio 1,8 gram requirement). The three bottom panels show 2 s samples from each of the conditions shown in the upper panel highligthed by the blue squares, expanded to show real-time in seconds. Head Entries (HE) into the feeding hopper are shown by the deflection of the signal line (red) below the zero value. The vertical dashed lines (upper panel) show changes in conditions. The horizontal dashed line (all panels) shows the force requirement for reinforcement in the last condition.

The force-sensitive manipulandum provides an additional quantitative level of analysis that can be incorporated into current operant-conditioning paradigms to yield measures reflective of the dynamic nature of motor responses in laboratory mice.

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Measurement of emotional involvement in spontaneous speaking behavior

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Measurement of vocal indicators of emotions - in laboratory settings - is typically done by computing the deviation of emotionally charged speech patterns from a neutral pattern (Banse & Scherer, 1996; Simonov *et al.*, 1980). However, measurement of genuine emotional reactions occurring spontaneously poses the problem of comparison with a base-line level. We investigated two methods of measurement involving spontaneous speaking behavior. Both use intra-subject comparisons but they do not require a "neutral" condition. They were applied in two research projects and proved adequate for the assessment of emotional involvement in spontaneous speech.

Method 1

The subjects were 39 diabetic patients presenting different levels of impairment of the autonomic nervous system known to be related to emotional arousal. The latter was induced through the subjects' verbal recall of their emotional experiences of joy, sadness and anger. At the end of each episode they said a standard sentence on the emotion congruent tone. The standard sentence was acoustically analyzed. Upon extraction of basic vocal parameters (Zei & Archinard, 1998), we computed a *Vocal Differential* index, i.e. the ratio between the value obtained in high arousal conditions (anger and joy) and that in low arousal condition (sadness). This resulted in two additional variables per vocal parameter: *Anger/Sadness Differential* and *Joy/Sadness Differential*. The results showed that emotional involvement as reflected in the Vocal Differential index is positively correlated with the functioning of the autonomous nervous system. We also computed a cumulative score consisting of the acoustic parameters significantly related to the differentiation of the three emotions. The score was composed of Z values and called *Vocal Arousal* index. It reflected the degree of emotional involvement for each emotion.

Method 2
This pilot study involved 10 breast cancer patients whose coping with illness was assessed through an interview, which allowed us to assess the coping style as well-adaptive or ill-adaptive. It was hypothesized that confrontation with emotional contents during the interview would cause the subjects to encode their emotional reactions into their voices.

In order to establish an individual base line range of vocal arousal, the whole interview was screened for passages of high and low vocal arousal. For each arousal condition the Vocal Differential index was calculated. Vocal Arousal was measured for the passage where the subjects talked about their coping with illness. The position of the Vocal Arousal index inside the base line range was indicative of the coping style. The results also showed that relatively narrow Vocal Differential index was related to coping difficulties.

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