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The idea of organizing this meeting was born at the 5th International Conference on Event Perception and Action, and could not have been realized without the enthousiastic and efficient help of Bill Mace and the International Society for Ecological Psychology.

The Workshop owes very special thanks to the efforts of the symposia organizers: Onno G. Meijer, Cees J. Overbeeke, Michelangelo Flückiger, Jens Rasmussen, John Paulin Hansen, John M. Flach, Reinoud J. Bootsma, Geert J.P. Savelsbergh, Jean-Claude Risset, Yves Guiard; everyone in Cognition & Mouvement and Cheryl Frenck for invaluable help in preparing and assisting the workshop.
The Workshop proceedings have been prepared by Françoise Joubaud.

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Program

THURSDAY, JUNE 7

8:30 Pick-up of participants at the subway station "Vieux Port"

9:00 Registration and pick-up of conference materials, coffee

9:30 Introductory remarks and comments

Problems in direct perception

Symposium organized by Onno G. Meijer and Cees J. Overbeeke

The symposium focuses on some theoretical and empirical problems which, in the opinion of the organizers, have to be resolved with some urgency in order to further develop direct theories of perception.

9:40 **Target Presentation** by Claire F. Michaels "Much more than a space odyssey: Toward an ecological psychology of 2001"

Reactions

10:10 Fons C. M. Blankendaal: "Who benefits from a meaningless world: Preliminaries to a problem history of direct perception"

10:30 Onno G. Meijer: "The fallacy of intrinsic meaning: Prerequisites to a physical and biological theory of meaning"

10:50 Cees J. Overbeeke & Gerda J.F. Smets: "Spatial versus temporal resolution in pattern recognition: Theoretical aspects and technological implementations"

11:10 General discussion

11:40 Lunch (buffet style) and Poster session

THURSDAY, JUNE 7

Vision, motion and action

Symposium organized by Michelangelo Flückiger and Daniel Mestre

The transformations over space and time of the ambient optic array constitute a prime source of information for a perceiving and acting subject. Visually, perceived motion can be caused by moving visible objects in the environment or by a moving observer. This basic approach to ambient and ambulatory vision can be applied to classical phenomena, such as so-called "optical illu-sions". Indeed, the perception of the characteristics of objects in the environment are dependent on the subject's movements and manipulations. A priori, the environment can be perceived on the basis of velocity and illumination invariants. Understanding the precise optical bases of adaptive behaviors such as the control of self-motion and collision avoidance is hence a major issue. Furthermore, spatial activities involve cross-modal perception and a hierarchical organization of environment-driven affordances and modes of action may help to understand variability in subject-environment interactions, including phenomena such as motion sickness.

13:00 Introduction

Part I: Object motion

13:10 Rainer Guski & Thomas Schinauer: "The vertical-horizontal illusion functionnally revisited"

13:25 Mario Zanforlin: "Stereokinetic phenomena and real objects perception"

13:40 Sten Sture Bergström, Karl-Arne Gustafsson & Torjbörn Jakobsson: "Induced 3-D Shape as support to a vector model for perceived illumination, colour and depth"

THURSDAY, JUNE 7

Part II: Self-motion

13:55 Klaus Landwehr: "Methodological and pragmatic problems in so-called time-to-collision studies"

14:10 Michelangelo Flückiger & Bernard Baumberger: "The effect of an instantaneous acceleration of optical flow on walking speed"

14:25 Daniel Mestre: "Information in optical flow"

Part III: Ecological analyses of spatial activities

14:40 Lawrence Warwick-Evans: "Cognitive versus ecological analyses of motion sickness"

14:55 Théophile Ohlmann: "Affordances and vicariousness involved in spatial activities"

15:10 General discussion

15:30 Coffee break

THURSDAY, JUNE 7

The ecological interface

Symposium organized by Jens Rasmussen, John Paulin Hansen & John M. Flach

Many complex human-machine systems are designed to function as "sensory systems". The interfaces in these systems characteristically have an abundance of data but a paucity of information. What would be required to design a human-machine system that functions as a "perceptual system," where information, rather than data is communicated across the interface? A framework for building "perceptual systems" will require a theory of affordances and a theory of information pick-up. The theory of affordances will specify what information should "be about." This addresses the issue of display content. The abstraction hierarchy will be presented as a formalism for addressing this question. The theory of information pick-up will be about display geometries and their relation to the natural intelligence within human perceptual systems and to the affordances they represent. This addresses the issue of display form. The literature on perceptual organization and optical flow fields will be discussed and several hypotheses about the nature of the relation between display geometry and perceptual intelligence will be offered. Several interfaces will be presented and evaluated with regard to the principles and hypotheses that are offered with regard to content and form.

15:45 General presentation

15:55 Jens Rasmussen: "Ecological interfaces: A technological imperative in high tech systems?"

16:15 John Flach: "Perceptual organization in ecological interfaces"

THURSDAY, JUNE 7

16:35 John Paulin Hansen: "Means, Scenes and methods for ecological interface design"

16:55 Gerda Smets & Cees J. Overbeeke: "The legibility of industrial design products: The importance of man-product interaction"

17:15 Gunnar Jansson: "Tactile graphics for visually impaired computer users"

17:35 General discussion

18:00 Shuttle to Marseille Vieux-Port

20:00 Banquet

FRIDAY, JUNE 8

8:00 Pick-up of participants at the subway station "Vieux-Port"

Control in reaching and grasping

Symposium organized by Reinoud J. Bootsma & Geert J.P. Savelsbergh

In the literature on manual prehension a qualitative distinction has been suggested between transport ("reaching") and grasping components. Major research attention has been devoted to the control mechanisms subserving (mainly) the reaching component and the coordinative mechanisms responsible for the attunement of the reaching and grasping components. In the symposium, research emanating from different theoretical perspectives will be presented. In order to ensure a fruitful discussion all speakers have been asked to specifically address the following question at the end of their presentation: "What is the origin (in terms of control mechanisms) of the trajectories of hand and arm in manual prehension?".

8:45 Introduction by Geert Savelsbergh & Reinoud Bootsma: Perspectives on control reaching and grasping"

9:00 Claude Prablanc: "Fast on-line corrections of a trajectory in hand pointing tasks"

9:25 Sylvie Athenes: "Grasping: Fitts' law or not Fitts' law"

9:50 Patrick Haggard: "State-space coordination in human prehension"

10:15 Coffee break

FRIDAY, JUNE 8

10:30 Audrey van der Meer: "Waving or reaching?"

10:55 Louise Rönnqvist & Claes von Hofsten: "The organization of arm hand movements in the neonate"

11:20 Reinoud Bootsma & Geert Savelsbergh: "Different perspectives on control and coordination"

11:30 General discussion

12:15 Lunch and Poster session

Ecological acoustics

Symposium organized by Jean Claude Risset

13:30 Jean Claude Risset: "Computer synthesis forces us to consider Gibson's view of ecological acoustics"

13:55 Yves Guiard: "Radiant and ambient sounds: Gibson's view of ecological acoustics"

14:20 Rainer Guski: "A primer in ecological noise research"

FRIDAY, JUNE 8

14:45 C. Cadoz: "Synthesis of sound by simulation of physical vibrations"

15:10 Stephen McAdams: "Perceptual organization in hearing"

15:35 General discussion

16:00 Coffee break

16:15 **Perspectives/Business meeting** coordinated by Yves Guiard

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17:30 Shuttle to Marseille Vieux-Port

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POSTERS

(Posters are displayed throughout the workshop)

Patrick Péruch & Alain Savoyant: "Spatial knowledge involved in goal-directed displacement: possible conflicting frames of reference"

Wolf D. Heine & Thomas Schinauer: "Exploring the nature of order preferences"

Jorma Putaansuu, Sten Sture Bergström & Claes von Hofsten: "Motion in depth induced by illumination"

Christopher Lynch & Margaret Hagen: "Toward an affordance based event grammar for two actor events"

Mireille Bonnard, Madeleine Durup & Jean Pailhous: "How can the natural coupling of cadence and amplitude in human gait be intentionally dissociated?"

Benoit G. Bardy, Bernard Baumberger, Michelangelo Flückiger & Michel Laurent: "Visual interactions between global and local information in locomotor positioning"

Walther Rikkert: "Phase-locking Farey hierarchy in human rythmic arm-movements"

Ruud van der Weel: "Effects of context on movement control in cerebral palsy: Implications for assessment and intervention"

Bernard Thon & Claude Bonneviale: "The coordination of finger movements: practice effects on 'natural' constraints"

Lothar Pickenhain: "On the significance of the intrauterine affordances"

Abstracts

Grasping: Fitts' Law or not Fitts' Law

Sylvie Athenes
CNRS-LNF, Marseille, France

One of the most important contributions to the motor control domain is probably the article published by Fitts in 1954 about the capacity of information transmission in the human motor system. In this paper, Fitts defined a measure of the difficulty of a task - the index of difficulty (ID) - as a ratio between the amplitude and the level of accuracy of a given movement. He predicted a linear relationship between ID and movement time, which is now known as Fitts' Law.

Since Fitts' original article, the measure of the speed-accuracy trade-off has been transformed and adapted (Welford, 1968; Schmidt et al., 1979; Meyer et al., 1982, 1988). Nevertheless, Fitts' Law has been by and large verified in most of the experimental situations, even if authors are still arguing about the exact limits of this phenomenon and the underlying mechanisms.

Among the movements studied are aiming movements or laboratory situation movements like the pin-transfer task or the disc-transfer task. The goal of the present study is to examine if Fitt's Law still holds when applied to *natural* movements. The chosen movement, grasping, has the advantage of being both natural and not too far removed from laboratory movements like the disc- or pin-transfer tasks. Whereas the rule of natural movements seems to be a very large reliance on compliance strategies, laboratory situations typically do not allow much room for the use of strategies. Indeed, the speed-accuracy trade-off is a constraint which could theoretically be overcome if the system is, in fact, the coordination of at least two devices: one device is responsible for the trajectory of the movement (i.e., taking care of the amplitude of the movement) while the other mechanism is in charge of the accuracy in achieving the goal of the movement. The grasping movement can be described in such terms: the arm is moving the hand to the vicinity of the object while the fingers, adapting the grip size to the object size, encompass and actually grasp the object.

Kinematic data is analyzed and discussed in terms of detailed strategies observable in natural situations.

Visual interactions between global and local information in locomotor positioning

Benoît G. Bardy,* Bernard Baumberger, Michelangelo Flückiger,** and Michel Laurent***
*** University of Aix-Marseille II, France**
**** University of Geneva, Switzerland**

The aim of the present study was to determine what interactions occur between the visual cues available to walking subjects in the global optic flow and those of a more local nature relating to the retinal expansion of a target. A locomotor positioning task was used in which the subjects were asked to stop spontaneously as near as possible to a stationary target. On the basis of previous data, this task is known to involve assessing the time-to-contact (Tc) with the target. The experiment was carried out in a special room, by means of a texture flow generator with which the velocity and direction of the optical flow arising from the ground were varied. Twelve experimental conditions were tested, involving various combinations of the target size and the texture velocity. The results show that, with both the targets involved, modifications to the global flow significantly affected the subjects' performances q(Tc), which confirms the idea that speed cues are among the main kinds of information used to assess Tc. The extent of these effects was found moreover to vary differentially depending on whether or not local information about an expanding target was available (large versus small target). The results are discussed as to what they reveal about the visual strategies used by an actively moving observer to assess Tc.

Induced 3-D shape as support to a vector model for perceived illumination, colour, and depth

Sten Sture Bergström, Karl-Arne Gustafsson, Torbjörn Jakobsson
University of Umeå, Sweden

A theoretical model for the perception of illumination, colour, and depth has been proposed by Bergström (1977, 1982) and by Bergström et al. (1984). It is assumed to explain the phenomenon of colour constancy (i.e., both constancy and lack of constancy).

The main postulate of the model is that the visual system performs *a perceptual vector analysis of reflected light into common and relative components*.

The common component is assumed to correspond to illumination and the relative components to reflectance. Modulations of the illumination correspond to the three-dimensional layout of the environment and modulations of the reflectance to variations of that which is illuminated. The common component characteristics of illumination is the distinctive feature which makes it possible for the visual system to distinguish between the two superimposed modulations.

A minimum principle as to the number of perceived sources of light is also assumed.

A series of experiments have been run to test the communality assumption. Critical experiments testing the assumption of a vector analysis are still missing but have been planned.

The experimental paradigm used so far is to illuminate flat surfaces by spatially modulated illumination. When the modulation is perceived as belonging to the illumination (i.e., there is coulour constancy) the surface is perceived as a three-dimensional object like a pleated blind (square-wave modulation) or a pile of pipes (sine-wave modulation).

Experiments have been run to explore some of the relevant illumination and display characteristics influencing the tendency of illuminated flat surfaces to appear three-dimensional (e.g., Gustafsson, 1987).

Examples of experiments testing the effect of crossings between illumination edges and reflectance edges on the perceived distinctiveness of the induced three-dimensional shape are given. Square-wave modulated illumination as well as an "O'Brien-effect illumination" have been used. The

results are discussed in relation to our theoretical model and in relation to traditional theories on depth perception.

REFERENCES

Bergström, S.S. (1977). *Scandinavian Journal of Psychology, 18,* 180-186.

Bergström, S.S. (1982). Ch. 18 in J. Beck (Ed.), *Organization and representation in perception* (pp. 356-378). Hillsdale, NJ: Lawrence Erlbaum Associates).

Bergström, S.S., Gustafsson, K.-A., & Punaansuu, J. (1984). *Perception, 13,* 129-140.

Gustafsson, K.-A. (1987). University of Umeå, Department of Applied Psychology (DAPS-), Reports, N° 21.

Who benefits from a meaningless world: Preliminaries to a problem history of direct perception

Fons C. M. Blankendaal
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In distinguishing between direct and indirect theories of perception, it is usually assumed that the central terms are unambiguous. This is not the case, as Cutting (1986) showed and Michaels (in this volume) confirms.

Cutting (1986) has suggested that the problem involved has a long history, going back to Locke at least. Although the history of perception has received considerable attention, also from an ecological perspective, it remains somewhat difficult to establish what it is that has remained the same during this history ('the problem') and what it is that has been allowed to change ('the context').

In earlier research we showed that the problem of motor control has a long history, going back to Locke at least. The persistent factor in that history has been, and still is, the tendency to think in strictly hierarchical terms: Laplace's (political) dream of an omniscient intellect ruling over a passive world.

By way of analogy, it may be *hypothesized* that the defenders of indirect theories of perception benefitted from conceiving an intrinsically meaningless world, with meaning being imposed by higher entities. Defenders of direct theories, then, were more 'democratically' inclined, with meaning emerging from below. If this, indeed, is the persistent factor in the history of 'direct perception', conceptual unanimity is not to be expected for some time to come.

Historiographical research is being carried out to test the above hypothesis. Some preliminary results will be presented. It will be concluded that an awareness of *why* people defended, or defend, indirect versus direct theories of perception, will help to sharpen the discussions.

How can the natural coupling of cadence and amplitude in human gait be intentionally dissociated?

Mireille Bonnard, Madeleine Durup, and Jean Pailhous
University of Aix-Marseille II & CNRS, Marseille

The links between cadence and amplitude are well known in human gait. For each walking speed, a preferred combination of amplitude and cadence is observed, which approximately corresponds to the minimum expenditure of energy (Cavagna, 1986). Since these parameters co-vary, it is often proposed that they result from the control of a more global parameter such as stiffness (Kay et al., 1987).

The purpose of the following experiments was to investigate how subjects can intentionally dissociate the natural coupling of cadence and amplitude. Both legs were in absolute coordination (same frequency), and in our conditions, a symmetrical work was necessary to walk in a straight line. A first experiment has been conducted to observe the preferred amplitude and speed associated with five different cadences, imposed to the subjects using a pacing metronome. In a second experiment, two different cadences were imposed in the same way, but the subjects were instructed to counteract the natural speed variation associated with the change in cadence; this requires to inversely vary the amplitude.

The results show that the subjects were able to dissociate the natural coupling of cadence and amplitude; the control of a single global parameter does not seem to account for our results. The informational basis which could be used to maintain the same walking speed despite important variations of cadence is discussed in reference to optical flow information.

Perceptual organization in ecological interfaces

John Flach
University of Illinois at Urbana-Champaign, USA

Many complex human-machine systems are designed to function as "sensory systems". The interfaces in these systems characteristically have an abundance of data but a paucity of information. What would be required to design a human-machine system that functions as a "perceptual system," where information, rather than data is communicated across the interface? A framework for building "perceptual systems" will require a theory of affordances and a theory of information pick-up. The Theory of affordances will specify what information should "be about." This addresses the issue of display content. The abstraction hierarchy will be presented as a formalism for addressing this question. The theory of information pick-up will be about display geometries and their relation to the natural intelligence within human perceptual systems and to the affordances they represent.

The effect of an instantaneous acceleration of optical flow on walking speed

Michelangelo Flückiger and Bernard Baumberger
University of Geneva, Switzerland

The question addressed in this experiment is how much a walker relies on the ambient optical flow to control his pace. So far this issue has only been investigated in back and forth motions of a visual scene on short paths. On the other hand, we used instantaneous speed changes of unidirectional and continuous texture flows on the ground during free walks of 8 m in length. This result was achieved in a special room equipped with a computer-controlled texture flow generator.

Previous research in our laboratory has shown that even without postural readjustment, subjects progressively change their walking speed according to different velocities of the optical flow.

It seemed that the use of instantaneous accelerations could evoke different locomotor responses, depending also on the direction of the flow and on its starting or stopping.

A 2 x 2 design was used in which the texture could be either on (and suddenly stop) or off (and suddenly start) in the middle of the walk. The texture could also either receed (RE) from the subject or approach (AP) the subject.

In a pre-test, the subjects were trained to walk at a constant speed of 5 km/h in a motionless texture. During the experiment, their task was to maintain exactly the same pace, regardless of texture speed. The speed of locomotion was recorded by a special cap worn by the subjects.

Results show that subjects accelerate when AP stops, and slow down when AP starts. As for RE, no effect was found in either condition.

We therefore concluded that a sudden change in optical speed has a strong effect on locomotion only when it corresponds to the direction of flows encountered during natural forward locomotion, that is when the projected texture is approaching the subject.

Radiant and ambient sound: Gibson's view of ecological acoustics

Yves Guiard
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In *The senses considered as perceptual systems*, Gibson (1966) attempted to systematically extend his radical reformulation of the problem of perception from vision to every other sense. Gibson, avowedly, had a limited expertise in the sound domain, but he outlined a highly consistent approach to auditory perception. Since 1966, attempts to investigate sound perception in a Gibsonian spirit have been quite promising, but surprisingly scarce (see Risset, 1988).

At the core of Gibson's ecological theory was the principle that to study perception, one should first stipulate the *environment*, the "what" of perception. To deal with the environment, Gibson offered two taxonomies. One was geometrical: The world can be decomposed, at various grains of analysis, into *surfaces*. The other was ontological: The world is made up of *objects*, *events*, and *places*. For an ecological study of audition, the next step should be to seek the laws whereby the *medium* (the air, for terrestrial animals) is structured acoustically by the environment. To the extent that properties of a vibratory field created in the medium by an environmental event are specific to (uniquely mapped onto) properties of this event, the former specify the latter, and acoustical information about the event can be said to be available, allowing audition.

From an ecological stance, a comparison between light and sound would suggest that, whereas vision typically amounts to the pickup of information about *light reflectors*, audition typically amounts to the pickup of information about *sound radiators*. Counterinstances like the nocturnal detection of a glow-worm (for vision) and echolocation (for audition) seem quite marginal. What happens at a light source, be it the sun or a candle, is generally of no interest at all to the perceiver: An efficient luminous source is one that emits light in a steady-state regime, thus radiating energy but no information. But light has so minute wavelengths that a reverberated optic array tells the visual system about every detail of the environmental layout. For the auditory system, in contrast, it is the behaviour of sound sources that counts most: The structure of the

wavetrain is information about both the mechanical disturbance undergone by the source and the identity of the bodies involved (e.g., collision: drum and stick). Radiant sound also provides information, both kinematic and dynamic, about the current state of the perturbed body (e.g., the configuration of the speech articulators of one's interlocutor, and the amount of strain imposed on them). And, finally, the orientation of the wavefront allows localization of the source. On the other hand, sound has large wavelengths, from about 2 cm to about 15 m: This characteristic is fortunate for radiant sound, for it allows the sound to pass around many obstacles; Gibson, however, judged it unfortunate for reflected sound: "Echos, he wrote, carry little information about the objects from which they are reflected" (*The senses*, p. 17).

There is something potentially misleading in this latter view of Gibson: What seems likely to be missed here is that, for organisms already equipped with a high-resolution visual system, the low spatial resolution of sound reflections may be their virtue. Indeed, it is about the layout and the material composition of the surrounding surfaces, not about the shape of objects, that reverberated sound is likely to provide information. This synthetic, large-grain acoustical information that Gibson apparently failed to consider is certainly valuable to living beings.

Clearly, the ecologically relevant structure of sound is due *both* to emission and reflection. Understanding the perception of ambient sound, a subject matter so far left to technologically-oriented research (see Blauert, 1974/1983), remains a stimulating challenge for ecological psychology.

REFERENCES

Gibson, J.J. (1966). *The senses considered as perceptual systems.* Boston: Houghton Mifflin.

Blauert, J. (1974/1983). *Spatial hearing.* Cambridge, Mass.: MIT Press.

Risset, J.-C. (1988). Perception, environnement, musiques. *Inharmoniques, 3,* 10-42.

A primer in ecological noise research

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The first part of this paper presents a short overview of established theories of noise and its effects. It is shown that the general activation theory, the distraction theory as well as the cognitive stress theory all neglect the stimulus information *specific* to environmental sounds. The well-known fact that environmental noise is annoying mainly in situations of disturbed activity (e.g., during communication, work, leisure, and sleep) is interpreted in the framework of an ecological approach to research on perception and action: The hearing system has evolved together with the other perceptual systems and together with action systems in a specific environment, and these systems are still working together with each other. In this perspective, the hearing system does not only contribute to the special acoustic part of the information contained in already visually perceived objects or events, in addition, it *must* also contribute to the acoustic information about objects and events which are *not* visually perceivable. It is of functional importance that the auditive system guides the whole organism to perceive objects or events which are not in the present field of view. This auditive information may interfere with the pickup of auditive or visual information necessary to guide the present activity of the organism: e.g., it may afford auditive masking, immediate cancelling of present activities, or it may afford actions in order to overcome the disturbance. The problem of interference of affordances, or of conflict between different affordances, seems to be new within the framework of ecological psychology. In the last part of this paper, several proposals for research on noise effects in terms of a body-scaled metric are made (e.g., the loudness of one's own voice as a referential dimension for measuring the loudness of environmental noise; or the speed of one's own running as a referential dimension for measuring the annoyance of the sound of moving cars, etc.).

The vertical - horizontal illusion functionally revisited

Rainer Guski and Thomas Schinauer
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The overestimation of the vertical -- resp. Vertical-Horizontal illusion, one of the better known geometrical optical illusions -- has generally been investigated via presentation of line drawings. In this connection, J.J. Gibson (1966) criticizes that only inadequate stimulus information entails perceptual illusions.

We adopt the view that overestimations of the vertical occur regularly even under unrestricted viewing conditions. This phenomenon can only have been developed and maintained during the process of evolution if it is of some functional value for actions of the perceiver.

Two experiments will be presented examining the functional relation between the possibility of observers to handle the perceived objects and the overestimation of the vertical. The first experiment examines the relation of perceived height and position of an object within or beyond reach by varying object size and form. The second experiment considers the estimation of height of tall objects by varying the degree of manipulation.

The results show the overestimation to be partially dependent both on the observers action facilities and some characteristic object properties.

State-space coordination in human prehension

Patrick Haggard
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Many researchers have observed a reliable relationship between hand transport and hand aperture in human prehension, with the hand opening to preshape a grasp as the hand moves towards the target.

Hand transport and hand aperture are therefore coordinated, in the sense that the two effector systems, while biomechanically independent, in fact work together - as in a master-slave relationship, for example. This hypothesised dependence of one effector system on the other generates a clear prediction: if the dominant effector system is perturbed during the movement, any effectors coordinated with it should show an appropriate response to the perturbation as well.

Experimental data are reported in which subjects' prehensile movements were disrupted by unexpected forces from a linear motor attached to the upper arm. On perturbed trials where a short, strong tug by the motor succeeded in temporarily reversing the approach of the subject's arm, a subsequent reversal of the preshaping of hand aperture was often observed: the hand continued to open for a short time after the perturbation, but then began to close again briefly before preshaping resumed. Representing the movement by plotting hand aperture against hand transport shows the relationship between the hand transport reversal and the hand preshaping reversal as a characteristic 'loop' in state space. The interval between the reversal of hand transport and the reversal of preshaping was remarkably constant, at around 180 ms. This result is consistent with the concept of a sensory feedback link responsible for coordinating hand preshaping with hand transport, so as to maintain an invariant relationship in state space.

In perturbed trials where these loops did not occur, a state space representation still reveals regularities in the response of the hand aperture to perturbation of hand transport. The implications of the resulting model of spatial coordination for human prehension are discussed.

Means, scenes and methods for ecological interface design

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While the necessary content of an ecological interface for complex industrial processes has been specified by the analytical approach of Jens Rasmussen and Kim Vicente, this paper discusses how the content can be implemented in an ecological display form. In real world perception, a lot of information units are nested within each other and form a kind of hierarchy without categorical bounds. This is the feature we want to capture, when we have to represent multi-level information simulations in a way that can be perceived directly. Some early and recent examples of ecological industrial interfaces will be given, forming the basis of a discussion on the general design principles behind ecological industrial interfaces. These principles are specified in a series of design criteria for ecological interfaces, providing a "cookbook" description of the design procedure and emphasizing the importance of using a combined analytical and empirical evaluation methodology.

Exploring the nature of order preferences

Wolf D. Heine and Thomas Schinauer
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Suggesting a mere paper-and-pencil strategy for studying population stereotypes, Smith (1981) demonstrated that most subjects prefer to label the quadrants of a circle by using a "reading convention" (from left to right, from top to bottom).

This procedure ignores that environmental properties (e.g., spatial position), anatomical-physiological properties of the organism (e.g., shoulder height), and the mutual constraint of both can determine the preference of certain configurations and the avoidance of certain display-control relationships at all.

In our first attempt to focus on this topic, we partially replicated Smith's procedure but we varied the areas of fourfold-tables from 16 to 64 cm to be filled up with four different symbols in a preferred order (n = 287).

In our second investigation, we chose the same fourfold-tables to be filled up with four small identical cylinders varying the plane of presentation (fronto-parallel versus horizontal). Also we enlarged the size of the whole configurations up to an area of 1 m with an adjusted size of the cylinders. 527 subjects participated in this task under the instruction to place the cylinders as fast and as precisely as possible into the centers of the quadrants. Accordingly, the order preferences were collected as byproducts of the performance task.

The results indicate not only a task dependent strategy between symbol writing and object placing but also that the anatomical-physiological properties of the organism are widely responsible for the selection of initial starting points and order preferences in discrete movement sequences.

Tactile graphics for visually impaired computer users

Gunnar Jansson
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The alphanumeric symbols of personal computers are now accessible also to the severely visually handicapped thanks to braille displays and synthetic speech. However, the increasingly used computer graphics is available only to a very limited degree in a non-visual way. This means that there are many computer programs that these computer users cannot utilise to say nothing of the informational content of visual graphics to which they have little access. The aim of the project to be described is to increase our knowledge about the usefulness of different alternative forms of tactile graphics. This is achieved by studying the possibilities and limitations of some important variants of tactile displays, such as swell paper, braille printer, and matrices of point stimuli (elevated pins, electrodes, or vibrators; the Optacon being a well-known example). The experimental problems include comparisons of the identification of forms and textures, determination of the maximal complexity that can be extracted tactually, and the possibilities of perceiving 3-D objects and scenes with these 2-D tactile displays. The different displays are explored separately in order to find optimum versions of them, but their relative usefulness in different contexts is also studied. The experimental results should, hopefully, suggest guidelines for the construction of tactile displays for computer graphics.

Methodological and pragmatic problems in so-called time-to-collision studies

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"Time-to-collision", "time-to-contact", or "time-to-coincidence" (abbrev.: ttc) is *not* a self-contained, specialised field of inquiry, rather, it is part and parcel to *any* inquiry in human and animal behaviour, or so I suggest. Three experimental paradigms seem to have been developed to study the details of ttc-behaviour. The first paradigm might be called the Carel-paradigm (Carel, 1961). It is characterised by "blacking-out" available stimulus information, and having the subject "judge", or "estimate" ttc. It is usually preferred in applied psychology, especially by traffic safety researchers. The second paradigm might be called the Schiff-paradigm (Schiff, 1965 et passim). It is characterised by cancelling information about three-dimensional surface layout, or "shape", and "self-black-out" of stimulus information. It is usually preferred by animal psychologists, but has also been used by developmental psychologists, working with young children (e.g., Yonas et al., 1977). The third paradigm might be called the Lee-paradigm (Lee et al., 1977 et passim). It is characterised by looking at information-action coordination directly. It is usually preferred in the sports and motor-behaviour community. From an ecological, Gibsonian (Gibson, 1979) point of view, the Carel-paradigm might be criticised for asking possibly irrelevant questions (about the precision of ttc-"estimates"), and the Schiff-paradigm might be criticised for being rather limited in scope (avoidant behaviour). The Lee-paradigm might be considered to be just about all right, but it might not really prove what is at issue -- it demonstrates concomitant variation in two different domains -- optics and mechanics -- which can be described in terms of the same physical dimensionality (namely, *time*); but it does not really show *how* optical information actually controls behaviour, if it does at all.

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1. This paper was written while I was at the Psychology Department, College of Arts and Sciences, Chiba University, Chiba, Japan.

Toward an affordance based event grammar for two actor events

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The most basic distinction among the things of the earth is that between its objects and its beings. Essentially, the criterion for that distinction is locomotion. Objects do not locomote: objects do not move unless they are made to move by an external agent - either gravity or another object or being. Animate beings move by themselves but the movements they make are often influenced, if not determined, by the actions of other objects or beings. Most studies on the perception of movements and motions of objects have ignored the issue of "meaning". The perceived affordances of the events have remained largely unexplored. One factor that has hindered researchers is the lack of an adequate movement grammar that would permit descriptions of events and the potential information specified. It is our goal to develop a vocabulary and syntax that realistically constrains and describes all possible movements and interactions between two objects or beings as well as the affordances specified by the information in the interactions. We are applying this system to variations on Heider and Simmel (1944) animation sequences, manipulating the objects' shape and size, as well as temporal, spatial, and space/time parameters. In addition, we believe that it is a simple matter to exploit this event grammar in the development of graphical interfaces that are perceptually based and, hence, particularly easy to learn and use.

Perceptual organization in hearing

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Recent research has revealed a certain number of coherence cues constraining the perception of sound objects and a listener's capacity to follow an object's behavior through time. A set of cues for concurrent organization limit the ability of listeners to separate simultaneously sounding events. Another set of cues for sequential organization relegate events to source event streams. These mechanisms operate in everyday life as well as in such specialized situations as listening to music. The cues, when applied to the simultaneous and sequential dimensions of musical structure, appear to be relevant to higher levels of structuring as well as to the level of event and stream perception. An understanding and formalization of these mechanisms may eventually lead to more comprehensive theories of the perception, recognition and understanding of sound objects and events. They may as well lead to systematic theories of orchestration and instrumentation in music, which at present are merely represented by vast catalogues of specific instances rather than a true theory that allows extrapolation beyond already classified instances.

Waving or reaching?

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Reaching for an object requires 'knowing' the relation between the frames of reference of the eye and head, of the head and trunk, and of the trunk and arm. Vision plays an important role in linking the frames of reference of the different parts of the body. An experiment will be described which shows that early arm movements in neonates are involved in establishing a frame of reference for later reaching and grasping.

Having established a stable frame of reference for reaching, the infant can then tackle the problem of regulating actions to fit in with the spatiotemporal structure of (moving) objects. This requires predictive control and entails calibrating the perceptuo-motor system - i.e., scaling visual information in terms of action.

Reaching for an object moving at different speeds was investigated in infants from 16 weeks onwards. The object was occluded from view by a screen during the last part of its approach. The effect of velocity on the infants' reaching behaviour was measured to assess how predictive control and perceptuo-motor calibration of reaching and grasping develops over time.

The fallacy of intrinsic meaning: Prerequisites to a physical and biological theory of meaning

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Direct perception is said to be 'intrinsically meaningful' because it is not extrinsically so: in that sense, meaning is *discovered* rather than imposed (Gibson, 1979, p. 33). If, however, the *intrinsic* meanings of the environment (Gibson, 1979, p. 44) have to be discovered, they have to be there already-intrinsic (intri-nsik) referring to "1. situated within, 2. ... internal, 3. belonging to the thing itself ...". In this literal sense, intrinsic meaning precludes the emergence of novel relationships.

Unless, that is, one would want to say that the sellability of Berlin wall stones has been an intrinsic meaning of the wall all the time -- which may be a logical truism but fails to highlight the fact that such potential meaning is only recognized after the fact. This *post hoc* recognizability of meaning in evolution and development requires that the theory of direct perception be matched with a new theory of meaning.

In proposing a physical theory of meaning, Haken (1988) suggested that a message has meaning inasfar as it (co-)specifies the parameters of a system: already at a physical level, 'meaning' is defined in terms of 'action'. Modest as it is, this definition is sufficient to allow for "the *emergence of meaning* as the emergence of a new quality of a system, or ... the *self-creation of meaning*." (Haken, 1988, p. 23). In non-linear dynamics, a system as a whole (e.g., a periodic attractor) may be meaningful to itself, the system specifying its own parameters. This emergence of high-level meaning derives from 'self-simplification' (Pattee, 1972).

In biology, self-simplifications have solidified into structure, subject to random variation and natural selection. Some of the variations enhance reproduction, some are lethal, but most are neutral and thus quite meaningless. Recent developments in genetics have shown that a repertoire of meaningless variations may preadapt organisms to coming, unforeseeable change. The same must be true for the environment. Hence, new meanings usually (but not necessarily) emerge from within the repertoire of originally meaningless changes.

True, it is the organism which does most of the 'discovering' of new relation-ships, but neither is meaning intrinsic (in the sense of already being there) nor information specific (in the sense of allowing for one kind of action only). Thus, it is recommended to continue defining 'meaning' in terms of 'action', to refrain from proclaiming the 'intrinsicness of meaning' or the 'specificity of information', to start speaking of the 'self-creation of meaning' by organism-environment systems, and to pay more attention to structure (DNA, the immune system, the nervous system, language), playing the key role in the self-creation of biological meaning.

Information in optical flow

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One cornerstone of Gibson's ecological approach to visual perception (1979) is the concept of *optical flow*, being the continuously changing *ambient optic array* at a continuously moving point of observation. Gibson pointed out that the perception of the global flow pattern was the functional basis for ambulatory vision. He proposed that two types of information are currently available in optical flow: *Exteroceptive* information about the layout of the surfaces in the environment, and *proprioceptive* information about the movements of the observer and particularly the direction of locomotion (or *heading*). However, the precise optical bases for the control of locomotion remain to be determined. In the 70's Lee (cf. Lee, 1980) made a significant contribution to this question. He demonstrated that optical flow affords predictive *exproprioceptive* information about the movements of one's bodily actions *relative* to the environment. In particular, he formally demonstrated that time-to-contact to environmental elements was directly specified by optical flow; In that sense, optical flow can be conceived as specifying relative rather than absolute information (like the absolute distance to an obstacle or the absolute speed of self-motion). This basic conception can be applied to the control of locomotion in general. Using discrimination tasks, in which the subjects had to judge their direction of heading *relative to a target*, Warren and col. (1988, 1990) have found high heading accuracy on the basis of optical flow in a wide range of trajectories. In recent experiments, the perception of differences in the speed of self-motion was also found to be quite accurate from optical flow. These experimental analyses support the hypothesis that optical flow is a reliable source of information for visually guided action. They further suggest that information is available from optical flow in relativistic terms, from two points of view. First, it is about the movements of the self *relative to the environment.* Secondly, subjects are very sensitive to *changes* in optical flow, which lawfully specify *changes* in the subject-environment interaction. These relationships between changes in optical flow and changes in the subject's

action-forces constitute laws of control (Warren, 1988), and the study of these is a major issue in the ecological approach to perceiving and acting.

REFERENCES

Gibson, J.J. (1979). *The ecological approach to visual perception.* Boston: Houghton Mifflin.

Lee, D.N. (1980). The optic flow field: The foundation of vision. *Philosophical Transactions of the Royal Society of London, Series B290*, 167-179.

Warren, W.H. (1988). Action modes and laws of control for the visual guidance of action. In O.G. Meijer & K. Roth (Eds), *Complex Movement Behavior: The motor-action controversy.* Amsterdam: Elsevier Science Publishers B.V.

Warren, W.H., Morris, M.W., Kalish, M. (1988). Perception of translational heading from optical flow. *Journal of Experimental Psychology: Human Perception and Performance, 14*, 646-660.

Warren, W.H., Mestre, D., Morris, M.W., Kalish, M. (1990). Perception of curvilinear heading from optical flow. Manuscript submitted to publication.

Much more than a space odyssey: Toward an ecological psychology of 2001

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This paper examines the current state of the ecological psychology and its prospects for the decade to come. First, it is acclaimed that a coherent ecological science must be based on a few well-conceived scientific and philosophical principles, shared by the ecological community; right now, that basis is *not* shared. I take the key-tenets to be: 1. realism, i.e., the idea that animals can be said to perceive an environment that exists independent from perception; 2. animal-environment mutuality, i.e., that the environment as an object of perception must be measured using animal-referential terms; 3. perception-action mutuality, i.e., theories of perception and coordinated activity must be formulated as a package; and 4. the specificity of information, i.e., information specifies the environment and perception/action is specific to particular information.

The key advances in the last 15 years are in four areas: 1. the discovery of particular invariants in structured light and sound used to guide activity (e.g., Lee's *tau*); 2. the combined articulation of the information, biomechanics (or biodynamics), and perception of affordances (e.g., Warren's stair-climbing); 3. the concept of 'smart perceptual mechanism' (Runeson); and 4. the discovery that many of the 'degrees of freedom of motor activity' are, in fact, constrained by self-organized dynamic systems.

With respect to the current weaknesses of the approach, some relate to our successes. We need to identify *more* invariants, investigate the basis of *more* affordances, and elaborate the dynamics of action. With respect to 'smart devices' that can guide our theorizing, we need a 'smart perception/*action* mechanism' -- a metaphor that captures the entire perception-action cycle. Finally, we need to give attention to two areas that have received too little in the past. First, we need a fully developed account of the development of perception and action, noting as well that development provides a rich database for studying how perception and action co-evolve. Second, it is time also to address the issue of how neural processes that subserve perception and action might be understood and how they might arise both at the evolutionary and somatic time scales.

Affordances and vicariousness involved in spatial activities

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Affordances (Gibson, 1979) and vicariousness (Reuchlin, 1978) share the same goal: to reduce concurrent processes trigerred by the interaction between the subject and his/her environment. Affordances are driven by the environment, the loop action/perception for a given situation and the properties of a given organism. Affordances are said to describe general activity. Vicariousness is driven by individual differences, each person has several processes allowing him/her to adapt to a given situation but in a given individual some of these processes are more easily evoked as compared to others. Vicariousness is said to describe individual differences. Vicariousness and affordances are complementary: when several affordances are involved in a given situation, individual hierarchy in vicarious processes could choose between concurrent affordances. Conversely an important modification in the subject's environment could generate new affordances and alter the individual vicarious hierarchy. Two experiments show the heuristic value of a combined approach using both Gibson's and Reuchlin's views. Postural activities are of importance to understand spatial activities (Paillard, 1974, 1987, 1988; Riccio & Stoffregen, 1988; Stoffregen & Riccio, 1988). It is well-known today that postural activities give negative and positive affordances to cope with spatial environment. Elementary postural conducts are always interacting with high level spatial processes because the spatial activity always needs a spatial invariant which can be gravity itself or its derivates: visual array or Z axis. However the individual sensitivity toward one of these three frames of reference is well-established. This sensitivity appears only in a regular environment. We can show (i) that a strong postural modification triggers new positive affordances *for some subjects only*, these new affordances cancel the given hierarchy of frames of reference in a given individual: some types of spatial processing are strongly improved; (ii) that, *for some subjects only*, the intermodal matching of convex curvature is linked to postural information, this link disappears when the curvature is concave. This approach to selection/control of frame of reference by crossing affordances and vicariousness may lead to deeper understanding of difficulties - like motion sickness - exhibited during extreme spatial activities.

Spatial versus temporal resolution in pattern recognition: Theoretical aspects and technological implementations

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When an observer looks at a screen with a low resolution (say, 32 x 32 blocks) and a limited amount of grey values (say, 3), there will be no spatial insight nor recognition of objects. The observer cannot see what is shown nor where it is.

How can this pattern be recognized? In classical approaches, pattern recognition will be enhanced by increasing the spatial resolution. A Gibsonian approach will concentrate on making the image move (the temporal resolution) without changing the spatial resolution. It will be shown that this allows for excellent pattern recognition.

The importance of movement for spatial insight has been shown for example in studies on babies. Gibson (1988) writes:

> "An infant's visual acuity for static two-dimensional displays is poor for the first several months and increases only gradually during the first year ... This handicap was long thought to incapacitate the young infant almost to the point of blindness and prevent it from learning much about the world. We know that this is by no means the case; not only are other perceptual systems functioning, but the baby picks up information from motion in the optical array as it regards events taking place before it... ."

An experiment will be reported in which spatial resolution is played off against temporal resolution. An implementation (a reading device for people with poor eyesight), based on low spatial and high temporal resolution, will be described. Theoretically, it will be concluded that research into direct perception will have to take the organism's movements more seriously.

Spatial knowledge involved in a location task: possible conflicting frames of reference

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Several studies on the use of cognitive or real maps in way-finding tasks have shown that subjects have some difficulty due to the contralignment of the map with the field. In order to investigate the source of these difficulties and the mental operations involved in solving them, we proposed an analysis of contralignment rather in terms of conflicting frames of reference: it was no longer the map and the field that were aligned (or contraligned), but the viewpoint (a location and an orientation) on the map, and the viewpoint in the field.

Accordingly, some aspects of the coordination of spatial frames of reference are reviewed here, for a location task carried out in a computerized space presented on a graphic screen. The subject was asked to find the position and orientation of a viewpoint on a map by moving a cursor on the map via a mouse. This viewpoint was aligned or contraligned with respect to the subject's position in front of the screen. Moreover, the type of information available to the subject was manipulated: presence or absence of egocentric information (the subject could perceive the dynamic evolution of the scenes corresponding to his/her successive positions and orientations on the map), and of exocentric information (layout of objects). In all cases the subject had dynamic feedback on his/her own displacement in an exocentric space (that is, he/she could follow the displacements of the cursor on the map corresponding to the successive viewpoints he/she occupied).

Characterisation of the possible contralignment conflicts between the spatial reference systems and that of their solutions in the different conditions is given through analysis of the time required and the strategies (translation and/or rotation components) involved in the task.

On the significance of the intrauterine affordances

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Nearly exclusively, the scientists working in the field of Ecological Psychology treat the affordances of the human being as if they start to exist from the day of birth. However, the affordances influencing the ontogenetic development before birth are equally or more important than the postnatal affordances. Nowadays, we know that the epigenetic use of the genetic inheritance is the crucial point for the actual ontogenetic development, and each step of the in-utero-development may be decisive for the future of the whole organism. The lack of the adequate, necessary affordances during the prenatal stage may block the correct and complete expression of the inherited possibilities. Therefore, we need a deeper understanding of the influence and the efficiency of the prenatal affordances.

The moment of birth is a catastrophic event for the developing organism, because the previously existing affordances suddenly undergo a complete change. The genetic program is prepared for adapting to this new situation. However, under the real social living conditions most of the normal epigenetic influences are artificially changed in such a way that a great amount of the necessary affordances is lacking, or they are so distorted that they cannot facilitate the optimal development of the self-organizing organism-environmental system. This lack of the adequate, necessary affordances during the development of the newborn baby not only may hinder his optimal development, but also lead to lasting damages in the behavioral sphere. Therefore, their study must be looked upon as being of top significance.

Fast on-line corrections of trajectory in hand pointing tasks

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The goal of this study was to show that a quick hand pointing movement towards a visual target is under the control of a sensorimotor loop comparing the instantaneous visual information relative to the target and the non-visual position sense of the hand (kinaesthetic or/and efferent).

In order to show the existence of such a mechanism, we have randomly altered the retinal feedback resulting from the orienting saccade toward the target. The amplitude and the time of perturbation were chosen in such a way that the subject could not detect it.

Subjects were simultaneously looking and pointing toward targets appearing within their peripheral visual field. These targets were randomly displaced at the instant of the saccade orientation.

The results show a smooth modification of the whole trajectory of the hand motion and a duration of the movement which is not significantly increased with respect to movements towards unperturbed targets.

By looking at the acceleration profiles in space, the acceleration vectors of perturbed trajectories seem to diverge early from those of normal trajectories (80 to 180 msec from movement onset), and not only in the homing phase.

From a global point of view, the final effector (here the index finger) has a trajectory which seems to be automatically locked to its final goal (hitting the target), without interfering with the perceptual processes, which here do not reach the level of a conscious detection of the perturbation.

Motion in depth induced by illumination

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In demonstrations made by Bergström (1982) adult subjects reported a flat coloured surface moving in depth when the surface was illuminated with cyclic temporal modulation of illumination. The purpose of the present experiment was to study the size of the perceived object motion in depth 1) when a static surface and 2) when an object moving in depth was illuminated with cyclic variation of illumination. Nine adult observers judged the size of object motion in three experimental and in one baseline condition under both monocular and binocular viewing conditions. The stimulus display consisted of two flat coloured surfaces. The left one (20 cm x 20 cm) was always static and evenly illuminated and the right one (15 cm x 15 cm) was either static or moving back and forth. In the experimental condition it was illuminated with a cyclic variation of illumination. In the baseline condition, the rigid surface was moving back and forth and both surfaces were evenly illuminated from a common source. The results indicated that cyclic variation of illumination projected onto a flat surface is perceived as object motion in depth during both monocular and binocular viewing conditions and not as a stationary object in varying illumination. During the monocular viewing condition, the induced motion was estimated to be of the same magnitude as real object motion in even illumination. The results also indicated that perceived object motion is largest when the cyclic illumination is in phase with the real object motion. These results support the assumption made by Bergström (1982) that the spatial and spatio-temporal modulation of illumination gives important information about illumination, three-dimensional shape, position, and movement of an object in space. The same experimental conditions but without a baseline condition will be used to test 3½-month-old infants sensitivity to the information provided by spatio-temporal modulation of illumination.

REFERENCE

Bergström, S.S. (1982). Illumination, color, and three-dimensional form. In J. Beck (Ed.), *Organization and representation in perception, Ch. 18.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Ecological interfaces: A technological imperative in high tech systems?

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Ecological interfaces are characterized by representing the interior functional structure and states of the actual work content in the human-machine interface in a way that matches the immediate task and the cognitive characteristics of the user. It is argued that the present trend in technological development towards large, complex, and rapidly changing socio-technical systems makes this kind of interfaces important for economic as well as reliability and safety reasons.

At present, metaphor based interfaces appear to be promising for certain kinds of personalized information environments for the general public, whereas ecological interfaces making visible internal systems processes are mandatory for industrial process systems. Between these categories we find decision support systems and work stations for most other modern environments. The aim of the paper is to evaluate the theoretical foundation for metaphor-based and ecological display design and to characterize those work environments for which the two approaches are appropriate.

Computer synthesis of sound forces us to consider Gibson's view of ecological acoustics

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Computer synthesis of sound, introduced by Mathews in 1957, allows one to manufacture sounds in arbitrary ways, with unprecedented precision and reproductibility, from the specification of their physical structure. However the first attempts to use computer synthesis of sound for music were disappointing: the synthetic sounds lacked variety, richness and identity. To take advantage of the potential of computer synthesis, one had to develop a better understanding of the psychoacoustics of musical sounds: their physical structure and how they are perceived. Hence the exploitation of the medium - synthetic sound - is at the same time an exploration of auditory perception, and specially of robust psychoacoustic effects which can remain salient in a musical context.

Thus, in 1965, the author could assess the aural significance of various features extracted from the analysis of brass instrument tones by submitting them to the foolproof synthesis test: this "analysis by synthesis" method provided information about the cues for sound identity and naturalness. It appears that those cues are more robust than the structure of a frequency spectrum, which was previously believed to characterize the timbre. For instance, the "brassy" timbres are characterized by the existence of a relation between spectrum and intensity: the spectrum is enriched in high frequencies when the intensity increases.

Synthetic sounds can be contrived so as to yield acoustic paradoxes or illusions, which make possible novel and strong musical effects. Chowning has demonstrated powerful illusory movements of virtual sound sources. The author has extended Shepard's "stairway to heaven" to produce endlessly ascending glissandi, or sounds going up in pitch but ending lower than where they started. He has also generated sounds that seem to go down in pitch when their frequencies are doubled, and beats that seem to slow down when one doubles the speed of the tape recorder. As Purkinje stated, illusions are deceptions of the senses but truths of perception. Clearly pitch is not a scaled copy of frequency, as classical phychoacoustics seems to imply.

Synthesis experiments demonstrate that auditory perception is highly specific. Its oddities do not seem to make sense unless one adopts an "ecological" point of view, as proposed by Gibson: hearing has evolved so as to extract, from sound signals, useful information about the environment. Experiments by Chowning, Bregman, McAdams, Cadoz and myself confirm this point of view. For instance, the ear is very sensitive to frequency aspects, which are generally well preserved between the source and the listener, more so than intensity aspects to which the ear is much less sensitive. The cues for source identity relate to features of the sound which are robust under the conditions of sound propagation. The ear can make complex inferences to evaluate the distance of the sound source and the loudness at the source, rather than perceiving a single loudness at the ear. Specific mechanisms of hearing help the listener to parse the incoming stream of sound events into different sources located in different directions at different distances and to infer hypotheses about the way the sounds were produced.

The presentation will be illustrated by sound examples.

The organization of arm and hand movements in the neonate

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This study deals with the early organization of infants' arm, hand and finger movements and how they are controlled. What kinds of arm and hand movements are the neonates able to perform? The motor system of the neonate is rather undifferentiated, which is reflected in coupling of arm and hand movements in various ways. Questions related to these synergistic properties and their immaturities will be addressed and discussed in relation to the development of the motor pathways. How are the movements of the neonate controlled? In terms of the neural organization of hand movements, the immaturity of the pyramidal tract is one of the most striking differences between adults and neonates. Behavioral data indicate that this system, which is responsible for the control of the pincer grasp and other relatively independent finger movements, matures during the second half of the first year of life in humans. The relative absence of cortico-motoneuronal connections in the neonate only implies absence of precise spatial control of fractionated finger movements as needed for manual actions. Grasping in neonates, when it occurs, is a gross movement of the whole hand as observed in the grasp reflex. However, closer inspection of spontaneous finger movements in newborns actually reveals a large variety of them. The fact that fractionated finger movements do not combine into skillful movements in the neonate does not mean that they lack function altogether. Our study showed systematic and qualitative differences of newborns' hand movement patterns in different conditions. Many of these movements will play important roles in later appearing manual skills.

The legibility of industrial design products: the importance of man-product interaction

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The central theme of industrial design engineering is the conception and planning of the artificial. It provides the thought which guides the making of products, whether by individual craftsmanship or mass-production techniques. Design theory is *reflection* in the conception and planning of the artificial. Design theory is directed toward two goals: improved design practice and knowledge.

The *first part* of this presentation is about how direct theory of perception can contribute to enhance the legibility of the artificial and thus to improve design practice. This comes about in three ways:

1. In the field of prosthetics: grafting patterns carrying specific behavioural meaning onto a new carrier as a means to develop new technological solutions as an aid for the sensory handicapped.
2. Training perceptual skills: enhancing the students sensitivity for patterns that specify the behavioural meaning of objects, e.g., to learn how to consider the perceptual system as the system it is, including, a.o., its nonlinear as well as its cross modal properties.
3. In the field of expressiveness: using patterns carrying specific emotional meaning (e.g., arousal patterns belonging to certain emotions) to convey to products the same experience, e.g., in building a small size, low speed roller coaster, giving the same perceptual experience as a full size high speed roller coaster.

The *second part* of this presentation is about how this kind of research (making products that work in the technical-utilitarian sense as well as in the affective sense) improves our knowledge about the perceptual system as such, and leads to more and new fundamental research about the perceptual process. Examples will be given.

The coordination of finger movements: practice effects on 'natural' constraints

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When a subject has to perform two simultaneous finger-keypress responses, the performance is strongly dependent on the relationship between the two fingers involved in the chord. We examined these performances (reaction time, errors) for all possible two-finger chords as a function of practice (4 successive trial blocks) in skilled and unskilled pianists. Overall, reaction time is longer and errors are more frequent for chords played with non-homologous fingers of both hands when compared to within-hand or symmetric-finger chords. Simultaneous activation of two fingers reflects the well known 'homologous coupling' or functional linkage between symmetric effectors.

Trial repetition results in a shortening of reaction time and a decrease in error rate. Piano practice has a significant effect on the two performance indexes, the differences between the two groups being more marked for the most difficult chord. In unskilled pianists, substitution errors depend on finger pairing, being more frequent for chords played with non-homologous fingers of both hands. On the contrary, in the skilled pianist group, substitution errors appear at the same (and rather low) rate whatever the type of finger pairing.

These results suggest that extended piano practice allows to break from 'natural' constraints of the motor command system of the hands, and frees simultaneous finger movements from the functional linkage between symmetric effectors.

Cognitive versus ecological analyses of motion sickness

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Motion sickness (MS) may be defined as pallor, cold sweating, nausea and vomiting in response to real or illusory self-movement. The capacity to be motion sick is not limited to the unhappy few but is a universal characteristic of people with an intact vestibular system.

Explanations of MS in terms of overstimulation or even novel stimulation of the vestibular system have been conclusively disproved, leaving as the only explanation the "Sensory Conflict" theory. Based on the classical view of separate sensory systems the theory rests on the following central ideas: *the visual, vestibular and other proprioceptive systems normally provide concordant information about self-movement, but when one system provides discrepant or conflicting information then, provided the conflict is sufficiently intense and long lasting, MS will develop. There is however, said to be a second layer of conflict in which the current pattern of sensory inputs are in conflict with the pattern which is expected on the basis of one's recent exposure history. Moreover, in the case of active self-movement there is said to be a third layer of conflict - that between the current relationship of efference to reafference and the expected relationship of efference to reafference*. This analysis is undeniably successful in terms of 1) identifying those situations which are potentially nauseogenic and 2) suggesting how MS could, always in theory, and often in practice, be prevented. But the theory has remained stagnant since the 1970's and has conspicuously failed to explain 1) why there is so much individual variation in susceptibility to MS and 2) how people acquire immunity (habituate) to MS and in particular to which situations this immunity will generalise.

More fundamentally the theory is couched in terms of concepts of information processing, mental representations and manipulative rules. It ignores *ecological concepts of cross-modal perception, active use of perceptual systems, higher order invariants and affordances*. The whole area is an open invitation to ecological psychologists and offers many opportunities for both theoretical and experimental investigation. Stoffregen and Riccio have initiated

this by trying to demonstrate the relative insensitivity of the otoliths and the relative importance of dynamic interaction with the surface of support in maintaining equilibrium.

Their ideas and results are considered further; a brief attempt at a new theoretical analysis is explored; and preliminary results from two experiments on adaptation to MS, and on individual differences in susceptibility to MS, are presented.

Stereokinetic phenomena and real objects perception

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Stereokinetic phenomena arise when 2-D patterns are set in slow rotary motion. For example, a white disc with an eccentric black dot appears as a three-dimensional solid cone of a well defined height. Even a simple stripe of white paper, a bar, appears as a solid rod tilted in depth and 50% longer when moving than when it is stationary. Neither phenomenon can be explained under the current theories of depth-from-motion, that are all based on a "rigidity assumption". In fact, the disc with the eccentric dot is not one of the possible two-dimensional projections of a rigid real cone; i.e., it is the projection of an elastic or deforming object. The bar is, by definition, a rigid object when moving on the frontal plane, as it maintains constant over time the relative distances among all its points; so, there is no reason why it should appear tilted in depth. Another striking example of what types of invariances the visual system can extract from the optical flow is given by a rotating ellipse. This pattern can appear alternately as three different objects: a deforming disc, a rigid disc tilted in depth, a rigid and solid egg-like object tilted in depth of constant height. Zanforlin (1988) has recently proposed that the visual system can extract all these various invariances by means of velocity differences minimization. The hypothesis allows quantitative predictions of the apparent depth of the various 3-D objects arising from 2-D moving patterns. Theoretical predictions are in good agreement with the experimental results when subjects are asked to estimate the size of the perceived objects or to open their hands as if to grasp them. The hypothesis and results are discussed in relation to the perception of physical (rigid) or biological (non rigid) objects in the environment.

REFERENCE

Zanforlin, M. (1988). The height of a stereocinetic cone: A quantitative determination of a 3-D effect from a 2-D moving pattern without a "rigidity assumption". *Psychological Research, 50,* 162-172.

List of Participants