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Research Report 1999 - 2001

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MAX PLANCK INSTITUTE
FOR PSYCHOLOGICAL RESEARCH

Research Report
1999 - 2001

Max Planck Institute
for Psychological Research

Editors: Dr. Monika Nißlein and Dr. Frank Halisch
Assistance: Heide John
Stylistic Revision: Jonathan Harrow

Design: ARTelier Munich; Daniel Schwarz

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Franz Emanuel Weinert
1930 – 2001

The period covered by this report was overshadowed by the early and sudden death of Franz Emanuel Weinert. After a short but serious illness, Franz Emanuel Weinert died on March 7, 2001 at the age of 70 years. Through his death, the Institute has lost its highly esteemed founder and director of many years. For more than 18 years – from 1981 to 1998 – he shaped the fate of the Institute. We shall not forget him.

When the Department for Behavioral and Cognitive Development closed down in 1998 with Franz Emanuel Weinert's retirement, two of its longitudinal developmental studies were not finished completely: LOGIC (Longitudinal Study on the Genesis of Individual Competencies) and GOLD (Genetically Oriented Lifespan Study on Differential Development). A continuation of both studies is now assured under the scientific supervision of former students and colleagues of Franz E. Weinert. The continuation of LOGIC has been placed in the hands of Prof. Dr. W. Schneider at Würzburg; that of GOLD, in the hands of Prof. Dr. E. Hany at Erfurt and Dr. U. Geppert at Munich.

When Prof. Weinert retired, the Institute had already committed itself to caring for the samples of participants associated with these studies, looking after the data sets, and, as far as possible, supporting the implementation of further follow-ups. The death of Franz Emanuel Weinert has made this obligation even more important than before. At the present time, a final study within the framework of the GOLD project is being performed at the Institute, where it is being financed by the Max Planck Society. External funds are being sought for a further follow-up in the LOGIC study.

Brief Overview

The interval covered by this report (July 1999 to June 2001) is characterized by a series of events that have made lasting changes to both the internal and external situation of the Institute.

- September 1999 saw the long-awaited move to the Institute's new home at Amalienstraße. Thanks to careful preparation, the move went without a hitch, and the unavoidable disruption of scientific work was kept to a minimum.

- In December 1999, the opening scientific symposium was held at the new Institute building under the title »Cognition & Action on the Move.«

- In January 2000, the President, in agreement with the Institute, decided to postpone the search for a new Director (to succeed Franz Emanuel Weinert). Instead, the resources allocated for this should be spent temporarily on setting up independent junior research groups.

- In the summer of 2000, the President of the Max Planck Society appointed PD Dr. Edmund Wascher (Tübingen) and Dr. Ralf Möller (Zurich) to head the independent junior research groups at the Institute.

- In January 2001, the independent junior research groups *Cognitive Psychophysiology of Action* (headed by E. Wascher) and *Cognitive Robotics* (headed by R. Möller) started work at the Institute. Parallel to this, a research unit on *Infant Cognition and Action* was set up under PD Dr. G. Aschersleben.

- In the spring of 2001, the President appointed Dr. Rafael Laboissière (Grenoble) to head a further independent junior research group as part of the exchange program between the Max Planck Society and the *Centre de la Recherche Scientifique* (CNRS). The group has started work at the Institute in September 2001.

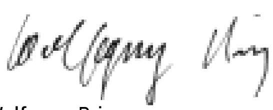
The outcome of these developments has been a far-reaching change in the structure of the Institute. Two complete departments (or even three up until 1997) have been replaced with a structure consisting of one department and several smaller research units. The functional division of research fields is currently as follows:

Department:	*Cognition & Action* (Wolfgang Prinz)
Research Units:	*Infant Cognition and Action* (Gisa Aschersleben)
	Cognitive Psychophysiology of Action (Edmund Wascher)
	Cognitive Robotics (Ralf Möller)
	Moral Development (Gertrud Nunner-Winkler)
	Differential Behavior Genetics (Ernst Hany and Ulrich Geppert)

At first glance, the new structure may seem less transparent than the old one. However, as the following report shows, the research programs of the new research units are not only closely related to each other but also exhibit clear overlaps with the research program of the *Departments for Cognition & Action*. The forthcoming establishment of a further unit *Sensorimotor Coordination* (R. Laboissière) will strengthen this association even further. We anticipate that this focus on issues in action control and action perception will encourage reciprocal impulses and exchanges and lead to lasting synergies.

In order to make the new focus of research visible, we have initiated a new series of symposia over the last year: *the Munich Encounters in Cognition and Action (MECA)*. Twice a year, in spring and fall, we are organizing one-day meetings on specific topics at which three to four leading international scientists will present papers from different perspectives. The first two symposia addressed *Motor Theories in Perception and Action* and *Cognition and Action in Social Life*. In this year's fall, there will be a third meeting on *Early Development of Action Control*. The brief but intensive exchange over these topics does not only stimulate research questions and research issues but also serves to promote integration across different research perspectives. Conferences focusing on specific topics, the research colloquium, and our program for guests and scholarship holders serve the same purpose. The title of the opening symposium after our move to the new building continues to be characteristic for our agenda: *Cognition and Action on the Move!*

Munich in June 2001



Wolfgang Prinz

Cognition & Action

Section 1: Perceiving Actions and Events
Section 2: Coordinating Actions and Events
Section 3: Interference Between Actions and Events
Section 4: Control of Actions and Events
Section 5: Acquisition of Action-Event Structures

Introduction

Our research addresses relationships between cognition and action. The focus of our agenda is on the cognitive processes involved in action planning, action control, and action perception as well as on mutual interactions between cognitive and action-related functions. One of our guiding ideas is that cognition and action are related to each other much more intimately than most theories of perception, cognition, and action believe. Notably, we hold that perception and action (or, perceived events and intended events) share common representational resources.

Systematic explorations at the interface between cognition and action can be viewed from two perspectives: In one perspective, we adopt a functionalist stance on cognition, that is, we view cognitive functions in the service of action and study them in relation to the planning, execution, and perception of actions. In the other perspective, we adopt a cognitivist stance on action, that is, we view actions in the service of cognition and study their impact on cognitive operations. An overview of our approach and the supporting evidence is given in a forthcoming target article in BBS (Hommel, Müsseler, Aschersleben, & Prinz, in press).

Separate Coding

The traditional way of conceptualizing relationships between perception and action is in terms of two distinct processing systems: one for input processing; another, for output processing. On the input side, processing proceeds in a bottom-up manner. It starts with stimulus events in the world that lead to certain patterns of stimulation in sense organs, which, in turn, generate sensory codes in the brain. On the output side, processing takes a top-down direction. It starts with motor codes in the brain that lead to certain patterns of excitation in the muscles, with the effect that a physical movement is generated in the world.

The logic of separate coding implies that sensory codes and motor codes cannot communicate with each other directly. Instead, because sensory codes represent patterns of stimulation in sense organs and motor codes represent patterns of excitation in muscles, their contents are incommensurate. Accordingly, rule-based translation is required between the two. Over the past 40 years, the concept of translation has indeed become one of the most prominent notions to account for the mapping of responses to stimuli.

The philosopher René Descartes has provided us with a beautiful pictorial illustration of the logic inherent in separate coding. According to Descartes, perception meets action in the pineal gland where input mechanics is translated into output hydraulics. Descartes' view illustrates, in a nutshell, that perception and action are considered to be two separate and distinct functions of mental life.

Figure 1: *In Descartes' view of perception and action, the incommensurability between the input and the output side is stressed in two ways: First, Descartes uses different metaphors for afferent and efferent conduction. Afferent conduction is based on mechanical movement (pulling at certain nerve fibers), whereas efferent conduction is based on hydraulic pressure (dispensing neural liquid). Second, he stresses the indirect nature of the mapping between input and output. This mapping occurs in the pineal gland, which moves in response to afferent mechanics, thereby discharging a specific pattern of neural liquid, which, when fed into the efferent hydraulics, eventually causes a specific movement.*

Common Coding

Though separate coding has been the dominant view of relationships between perception and action, it has occasionally been challenged. The philosopher Ernst Mach has provided us with another famous illustration on perception and action. In Mach's perspective, actions are represented in the same way as external events, the only difference being that they can be controlled by will. Accordingly, since external events and actions are made of the same stuff, the planning of actions requires no translation between incommensurate entities. It rather implies the modulation of certain types of events within a common representational domain for perception and action.

The common-coding approach holds that this notion applies not only to phenomenal experience (as Mach was claiming) but to functional mechanisms as well. Yet, common coding is not meant to replace separate coding, but rather to complement it. Accordingly, we propose to introduce, beyond and on top of separate systems for input and output processing, an additional common system for both in which output coding is commensurate with input coding; that is, actions are represented in the same format and dimensionality as any other event. For the sake of convenience, we call these representations action codes and event codes, respectively. Yet, from a more functional perspective, we consider them tokens of the same type, that is, codes for events that are perceived and codes for events that are produced.

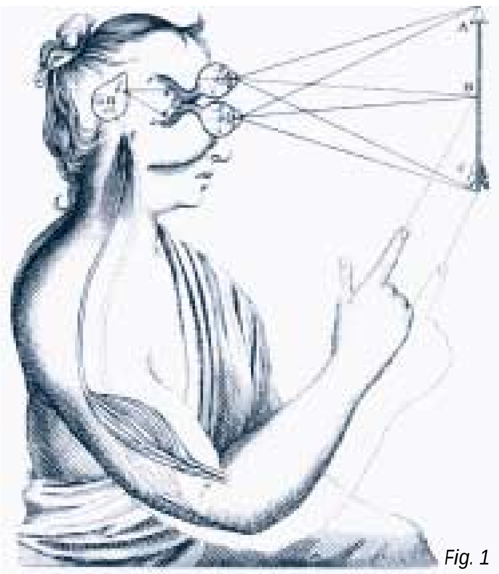


Fig. 1

Issues

Our research agenda is, of course, not meant to give full coverage to the fields of cognition and action in toto. Instead, we focus on their intersection: on cognitive antecedents and consequences of action and action-related antecedents and consequences of perception and action. Our current research is organized around a small number of theoretical issues that we address in a much larger number of experimental projects.

- From perception to action: Action planning and control
  How is perceptual information used for action planning and control? How are actions coordinated with environmental events? How is action planning affected by similarity between stimulus events and actions (as in stimulus-response compatibility, imitation, sensorimotor synchronization etc.)?

- From action to perception: Perception of actions and events
  How is perception affected by intended or ongoing action? What is the role of similarity between perception and action? Does it help or hurt? To what extent does action perception rely on action production? Do action perception and production draw on common resources, as ideomotor theory would suggest?

- From actions to goals: Anatomy of action codes
  How are cognitive representations of actions formed? What is their informational basis and how are they assembled? What role do body movements and more remote action effects play in these representations? How do action effects become integrated into action codes? How can representations of action effects take the role of action goals?

- From goals to actions: Mechanisms of voluntary action
  How is intentional control of action instantiated, and how does it interact with perceptual control? How are conscious intentions related to nonconscious mechanisms? How are task sets represented and maintained? How do tasks interact that follow each other (task switching)? How do tasks interact that address the same information at the same time (task interference)?

Neither of the two frameworks has ready-made answers to offer for any of these questions. What the frameworks offer are broad heuristic principles, not theories. Accordingly, the principle of common coding does not provide an explanatory theoretical principle in itself. However, it does serve the function of a heuristic guideline for constructing more specific theories that help answer specific questions for specific task environments.

Projects

Though most of our projects focus on one of these basic issues, there can be no simple 1:1 mapping of projects to issues. Instead, as will become apparent below, most projects address more than one of the issues. Further, most tackle not only the issues raised so far but also more specific paradigm-related issues in their respective research traditions.

Accordingly, we have organized the report of this department in terms of *projects*, and we have let *issues* play the role of recurrent themes to which we return time and again. It is divided into the following five sections:

- Perceiving actions and events
- Coordinating actions and events
- Interference between actions and events
- Control of actions and events
- Acquisition of action-event structures

Fig. 2

Figure 2: *Ernst Mach's view on perception and action. In discussing this picture, Mach stresses that visual perception does not provide us with an a priori distinction between body and environment. In principle, the body is perceived in exactly the same way as the environment, and the distinction between the two needs to be based on a nonvisual criterion. Mach's suggestion was that we do it by voluntary control, attributing to the body what we can control by will and to the environment what we cannot.*

Section 1: Perceiving Actions and Events

Figure 1.1: *When putting a flower into a coffee mug, we focus on attributes that are different from those when we drink coffee from it.*

Introduction

The traditional view of incommensurable codes pertaining to perception and action is challenged by research showing that past, current, or upcoming actions leave traces in our perceptual experience. A common-coding perspective, in contrast, predicts that all different stages of an action may have repercussions in perceptual tasks and vice versa. An example from everyday life may illustrate this point: Typically, we drink coffee from a coffee mug. However, when we are holding a bunch of flowers in our hands and looking for a vessel to put them in water, a coffee mug that happens to be within our reach may be turned into vase (see Figure 1.1). Importantly, what we intend to do with the object may change the object properties that we attend to. Instead of focusing on the handle of the object – which is what we usually do when we drink coffee from the mug – we focus on its aperture – which we need to do when we put the flowers' stems into the mug. Thus, intended actions determine which object attributes are selected. Further, our intended actions may well change the way we judge the attribute. In the case of coffee drinking, the aperture may be judged as large. In contrast, when trying to put the bunch of flowers into the mug, the aperture may seem rather small. This suggests that intended or executed actions change the way we perceive the world.

The idea that action is important for perceptual processes is not entirely new. In the late 1980s, researchers in the field of attention proposed an alternative explanation for our inability to process large numbers of items in a parallel manner. The new idea at the time was that our motor behavior would turn into chaos if it was fed with all the available information. Attention was thought to select information for action. The »selection-for-action« hypothesis was groundbreaking, because it provided a functional reason for a property of vision that was related to the motor system. Previously, the two systems had been treated as if they were independent. Here, we make the much more radical claim that perception and action are functionally dependent because they share mechanisms and representational codes.

Projects

Starting with the intention to perform the action and ending with motor programs representing a previously performed action in memory, event codes are expected to modulate motor performance and perceptual awareness. In particular, the ongoing planning and execution of an action may change the perceived location of events, the perceived features of events, and the perceived timing of events. The projects are roughly organized in terms of processing stages involved in human motor performance.

Before executing an action, the intention to perform it has to be established. For saccades, this may be an automatic process triggered by the abrupt onset of a stimulus. However, saccadic planning often errs in that the amplitude of the saccade is shorter than the actual distance to the target. This undershoot is mirrored in perceptual judgments; that is, a target is perceived closer to the fovea than it actually is. To explain these similarities, the project »Localizing Briefly Presented Stimuli« pursues the hypothesis that the distorted metrics of saccade programming underlie perceptual judgements. Not only the preparation of eye movements but also their execution affects perceptual judgments. In a well-known illusion referred to as representational momentum, observers mislocalize the final position of a moving object in the direction of motion. Previous theorizing attributed this error to mental processes continuing the stimulus motion in memory. The project »Representational Momentum« makes the alternative suggestion that eye movements executed after the disappearance of the moving target account for the illusion.
Similarly, hand movements have been shown to affect our perception. The project »Intention-Dependent Perception of the Direction of Ambiguous Apparent Motion« shows that the ambiguous rotation of a number of dots may be influenced by the direction of a hand movement. The perceived direction of the ambiguous motion sequence follows the direction of the hand movement. Interestingly, the intention to perform the action is sufficient to induce this perceptual change.

Further, the project »Task-Dependent Timing of Perceptual Events« asks whether identical stimulation can influence perceptual judgments and actions in different ways. A direct route between stimulus identification and action produces fast responses in simple responses, whereas more complex choice reactions and synchronization performance are based on later integrative processes. These findings may sharpen our understanding of differential links between perception and action.

In the project »Perceived Timing of Events«, we investigate the perceived timing of actions and associated stimulus events. We demonstrated that the ongoing planning and execution of an action changes the perceived timing of a related event. Similarly, we were able to demonstrate the reverse phenomenon: The perceived timing of a performed action is influenced by an associated event preceding or following the action.

In addition, the building of an action plan requires the integration or binding of multiple features of an event. Hence, features that are part of an action plan may be temporarily unavailable for perception. The project »Feature Binding in Event Perception« addresses these issues. Its main focus is to provide a principled account of the temporal dynamics of feature binding to explain why features that are part of an action plan are sometimes perceived better and sometimes perceived worse than features that are not.

A further consequence of the common-coding assumption is that the perception of actions and events will activate the common representations as soon as an observed event is »doable« by the action system. Hence, relevant information residing in the motor system may be made available for the perceptual system through common event representations. The project »Perception of Self- and Other-Generated Action« is concerned with one implication of this assertion: The similarity between external events and the common event representations should be higher when observing actions and events produced by oneself (e.g., on a video displaying one's own rather than a friend's actions). The project is investigating whether one's own actions have a special status in action perception.

The project »Action Comprehension« addresses the issue of whether the common-coding assumption also has implications for the comprehension of action sequences. This is in line with recent neurophysiological results pointing to the possibility that action-related structures contribute to the understanding of the meaning and the order of action sequences. In addition, similarities and differences between action comprehension and language comprehension are explored in order to determine whether the same functional principles underlie both faculties.

In sum, the projects in this section provide evidence for the view that (1) perception can be affected by ongoing action, (2) action perception and action production draw on common resources, and (3) action perception, at least in part, relies on action production. This suggests that a linear stage model that draws upon a clear-cut distinction between perception and action cannot be upheld.

The ongoing planning and execution of an action may change the perceived location of events, the perceived features of events, and the perceived timing of events.

1.1. Localizing Briefly Presented Stimuli[1]

Dirk Kerzel
Jochen Müsseler
Sonja Stork

The present subprojects are concerned with how accurately participants are able to localize briefly presented stimuli. The projects address several perceptual phenomena with stationary and moving stimuli and try to demonstrate whether and how these phenomena are – at least in parts – influenced by the perception-action interface.

Localizing Stationary Stimuli

This project is studying the ability to localize successively flashed stimuli with a *relative* judgment task. When observers are asked to localize the peripheral position of a probe with respect to the mid-position of a spatially extended comparison stimulus, they tend to judge the probe as being further out than the mid-position of the comparison stimulus (cf. Figure 1.2; Müsseler, Van der Heijden, Mahmud, Deubel, & Ertsey, 1999). This relative mislocalization seems to emerge from different *absolute* mislocalizations; that is, the comparison stimulus is localized more foveally than the probe in an absolute judgment task. Comparable foveal tendencies in absolute localizations are known from eye movement studies (Van der Heijden, Van der Geest, De Leeuw, Krikke, & Müsseler, 1999).

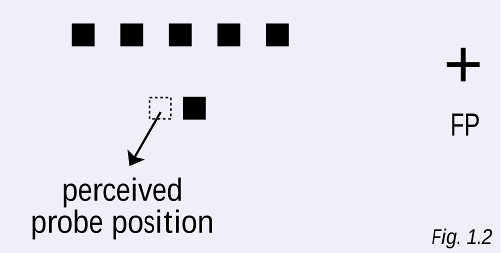


Fig. 1.2

Figure 1.2: *The relative positioning task. Participants fixated a cross in the middle of a screen, and a single lower square (probe) and a spatially extended row of upper squares (comparison stimulus) appeared successively to the left (or to the right) of the fixation point (FP). The task was to judge the position of the probe relative to the mid-position of the comparison stimulus.*

Further experiments revealed that this mislocalization emerges with both a bilateral and a unilateral presentation mode – with the latter mode, however, only when probe and comparison stimulus are presented in succession. Among other dependencies, the size of the mislocalization is influenced by the eccentricity of presentation and by figural features of the stimuli. The results are related to comparable tendencies observed in eye-movement behavior, and it is concluded that the system in charge of guiding saccadic eye movements is also the system that provides the metric in perceived visual space (Van der Heijden, Müsseler, & Bridgeman, 1999).

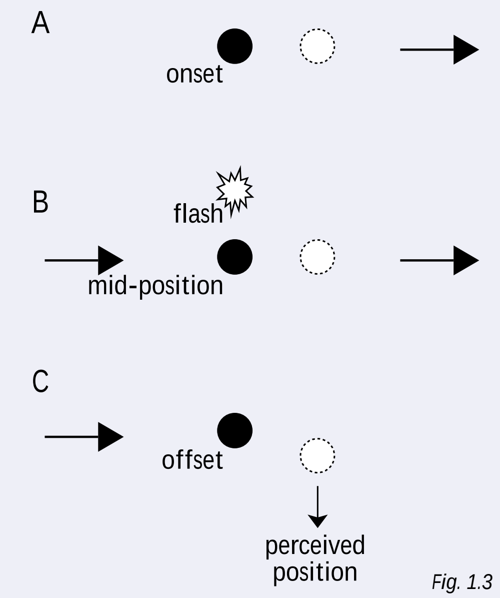


Fig. 1.3

Figure 1.3: *When observers are asked to localize the position of the onset (A) or the offset (C) of a moving target, they typically make localization errors in the direction of movement. Similarly, when observers judge a moving target that is presented in the mid-position in alignment with a flash (B), the target appears to lead the flash. These errors are known as the Fröhlich effect, representational momentum, and flash-lag effect, respectively.*

Localizing the Onset of Moving Stimuli

In the *Fröhlich illusion*, judgments on the onset position of a moving object are typically displaced in the direction of motion (cf. Figure 1.3). In previous studies, we developed and found evidence for an attentional account according to which the onset of the stimulus initiates a focus shift toward it and – while this shift is under way – the stimulus continues to move. The stimulus was assumed to be perceived at some later position, because the end of the focus shift determines the first consciously perceived position.

[1] *Parts of this research were supported by the Deutsche Forschungsgemeinschaft (DFG Grant AS 79/3).*

So far, the Fröhlich illusion has been obtained with linear motion of a small target (see, for an overview, Müsseler & Aschersleben, 1998, Percept Psychophys, 60, 683-695,) or with rotary motion of a spatially extended line (Kirschfeld & Kammer, 1999, Vis Res, 39, 3702-3709). In a recent series of experiments, we compared localization judgments of the onset of linearly and circularly moving stimuli directly and found that the Fröhlich effect disappeared with circular movements. Further experiments revealed that the mislocalization reappeared when (1) circular target movements were de-centered, and thus contained changes in eccentricity; or when (2) circular target movements were paired with an identification task involving a stimulus presented contralateral to movement onset. This pattern of results allows for an account of the Fröhlich effect that is based on attentional and oculomotor mechanisms and how they differ for circular and linear movements (Müsseler, Stork, Kerzel, & Jordan, submitted).

Another series of experiments compared judgments of the initial orientation of a small rotating dot directly with a line that rotated around the point of fixation. Again, the illusion was absent with the dot, whereas it was obtained reliably with the line. When the density of the line was reduced to two dots, the illusion persisted. However, the illusion was absent when a half-line extending to only one side from fixation was presented. We interpret the results in terms of attentional accounts of the Fröhlich illusion: The single dot attracted focal attention, whereas the line did not. Also, localization performance may differ between tasks requiring judgments of stimulus amplitude and of stimulus direction (Kerzel & Müsseler, submitted).

Comparing Mislocalizations in Movement Direction

There are two further well-established illusions in movement direction (cf. Figure 1.3). They are observed when participants are asked to localize the *offset* position of a moving target (*representational momentum,* see also Section 1.2) or when they judge a moving target that is presented in alignment with a flash *(flash-lag effect)*. This study compared the size of the three mislocalization errors. In Experiment 1, a flash appeared either simultaneously with the onset, the mid-position, or the offset of the moving target. Observers then judged the position at which the moving target was located when the flash appeared. Experiments 2 and 3 were exclusively concerned with localizing the onset and the offset of the movin-g target. When observers localized the position with respect to the point in time when the flash was presented, a clear mislocalization in the direction of movement was observed at the initial position and the mid-position. In contrast, a mislocalization opposite to movement direction occurred at the final position. When observers were asked to ignore the flash (or when no flash was presented at all), a reduced error (or no error) was observed at the initial position and only a minor error in the direction of the movement occurred at the final position. An integrative model (cf. Figure 1.4) is proposed that suggests a common underlying mechanism but emphasizes the specific processing components of the Fröhlich effect, flash-lag effect, and representational momentum (Müsseler, Stork, & Kerzel, in press).

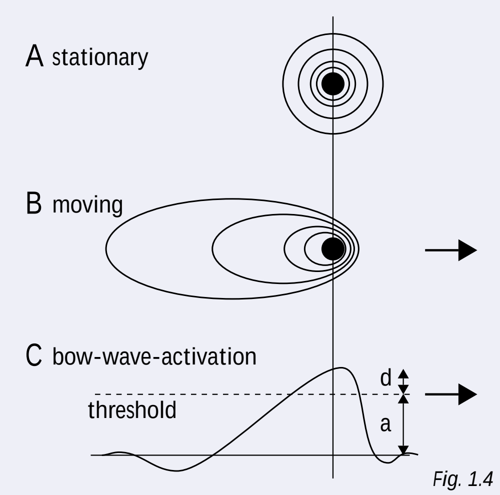


Fig. 1.4

Figure 1.4: *Schematic illustrations of the basic model assumptions. (A) The presentation of a stimulus elicits the build-up of an activation pattern that is not restricted to the area covered by the stimulus, but spreads its activation to and integrates contextual information from adjacent parts of the visual field (circles). (B) When a stimulus moves, the previously pre-activated stimulus positions contribute to and modify the activation pattern correspondingly. (C) The consequence is a stimulus-driven bow wave of activity traveling across the visual field. The Fröhlich effect is determined by the time taken to establish the bow wave above the perceptual threshold (a). The representational momentum effect is determined by the decay time of supraliminal processing after the target's offset (d). The flash-lag effect is determined by the faster processing time of the moving target compared with the stationary flash.*

1.2. Representational Momentum – A Case of Observer Action

Dirk Kerzel
Lothar Knuf
Jochen Müsseler
Sebastian F. Neggers
Sonja Stork

A Forward Shift for the Final Position of a Moving Target

When observers are asked to indicate the last position of a linearly moving object, they point to positions that are shifted in the direction of motion. Also, judgments are somewhat below the vertical position of the target.

How do current theories explain this phenomenon (see, for an overview, Hubbard, 1995, Psychon B & Rev, 2, 322-338) It has been suggested that the internalization of lawful invariants of the physical world accounts for the mislocalization. When we observe a moving target that vanishes at some random point, our mental apparatus may be incapable of immediately stopping the representation of motion. Consequently, the mental representation of motion overshoots the true final position (»representational momentum«).

Thus, the process accounting for the distortion was assumed to be localized at a postperceptual, cognitive stage. Implicitly, it was assumed that the raw sensory information provides an accurate representation of the physical world. In fact, a number of studies have attempted to rule out the possibility that low-level, sensory factors could account for memory displacement.

Effects of Observer Action on Perception

However, the rather passive role assigned to perception may be inappropriate given that moving objects were depicted. In everyday life, observers track moving objects that are of interest to them rather actively. However, current theories of representational momentum neglect observer action before, during, and after stimulus presentation.

Current theories of representational momentum neglect observer action before, during, and after stimulus presentation.

The notion of active perception can be applied easily to experiments employing smooth stimulus motion. In one typical experiment, target velocity and duration of the stimulus motion were adequate for smooth-pursuit eye movements. When observers tracked the target, the eyes had to be shifted very briefly after reaching a particular target location in order not to lose track of the target. Thus, when the target disappeared, a reorientation of the perceptual apparatus beyond the final position may have occurred, and the eyes were pointed at positions ahead of the vanishing point (see Figure 1.5). As it is known that the perceived position of peripheral objects is shifted toward the fovea (Müsseler, et al., 1999; Van der Heijden, Müsseler, & Bridgeman, 1999), and given that the fovea is directed at a position ahead of the final position, a foveal bias results in displacement in the direction of motion. A critical test of this idea would be a condition in which observers do not follow the target with their eyes. In this study, they were instructed to fixate a dot below the target's horizontal trajectory while the target moved in their visual periphery. In this condition, the judged final position was not displaced in the direction of motion when fixation was maintained (Kerzel, 2000a; Kerzel, Jordan, & Müsseler, in press; Jordan, Stork, Knuf, Kerzel, & Müsseler, in press).

When memory for the final position was probed at different retention intervals after stimulus offset, a factor separate from the above-mentioned foveal bias came into play. At very short time intervals after stimulus offset, an image of the target may have persisted in the visual system. As the eyes continued to rotate after stimulus offset, a persisting image of the target shifted beyond the final position, which may explain about one fifth of the illusion (Kerzel, 2000a).

Intentional Control

One may wonder whether a rather low-level explanation in terms of oculomotor overshoot is sufficient to explain the perceptual illusion. Because it has been demonstrated that some high-level cognitive factors affect the illusion, the answer is no. For instance, when a target oscillating between two eccentric position vanishes at one of the two reversal points, the remembered target position is not shifted in the direction of motion, but rather opposite to it. Therefore, expectations about the future trajectory of the target influence where the target's final position is remembered. However, there is also reason to believe that eye movements are influenced by high-level cognition. Kerzel (in press-b) found that the velocity of smooth pursuit eye movements decreased well before a reversal point, and Stork, Neggers and Müsseler (submitted) reported that the oculomotor overshoot as well as the mislocalization decreased when the disappearance of the target was controlled intentionally by a key press. In contrast, with fixation, the intention to stop the target motion biased judgments in the direction of motion, showing that binding the target in an action plan (stopping) produces a forward shift similar to that observed with overtracking (Jordan, Stork, Knuf, Kerzel, & Müsseler, in press).

Expectation

In addition to smooth linear motion, implied motion has been used to investigate representational momentum. In a sequence of pictures implying the motion of an object, different views of an object are presented, and successive views are separated by blank intervals. Such a sequence does not elicit smooth pursuit eye movements, yet a forward bias for the final position is readily observed. However, studies using implied motion often varied direction of target motion and the final target position between subjects. Thus, observers may have expected the target to travel in a particular direction or to vanish at a particular location before a given trial started. Kerzel (in press-c) treated direction of motion and final position as fixed or random factors. Surprisingly, the forward shift was absent when both factors were randomized. Thus, the forward shift with implied motion is restricted to repeatedly observed motion sequences that allow for pretrial motion prediction.

Purely Perceptual Factors

In addition to observer action and prediction, some perceptual factors may contribute to localization errors that have been attributed to memory distortions. It has been assumed that observers' judgements of the final position are biased downward due to mental analogs of gravity. However, when observers were asked to point toward the center of the stimulus, a clear downward bias was observed (Kerzel, in press-b). Thus, representational gravity may have its roots in perception. In a related fashion, shifts of attention may affect localization (Müsseler, Stork, & Kerzel, in press). For instance, when observers' attention was attracted by an abrupt onset at the time of target disappearance, the remembered position was shifted toward the distracting element (Kerzel, in press-a).

In sum, work on representational momentum shows that observer action and attention produce a mislocalization of the final position of a moving target. Thus action-related processes have an impact on where targets are seen or remembered in spatial vision.

Parts of this research have been conducted in cooperation with J. Scott Jordan, St. Xavier University, Chicago.

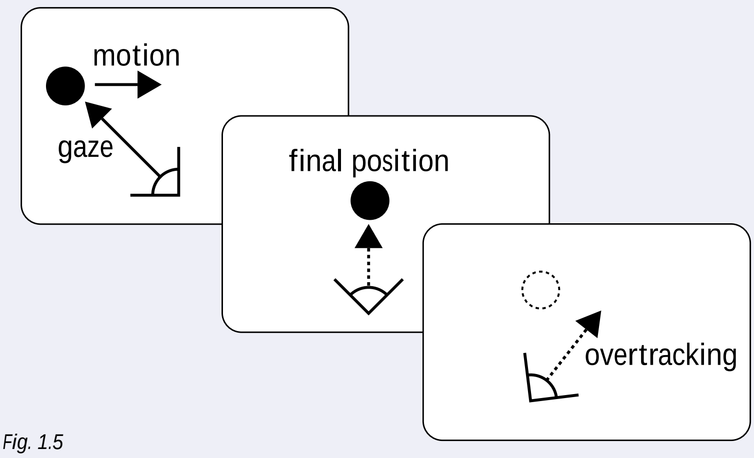


Fig. 1.5

Figure 1.5: *Schematic drawing depicting oculomotor overshoot. An observer tracks a moving target. When the target disappears, the eye movement cannot be stopped immediately, but the eye overshoots the final position. Fixation is directed at a position ahead of the final position.*

1.3. Intention-Dependent Perception of the Direction of Ambiguous Apparent Motion

Andreas Wohlschläger

The perception of »apparent« motion in a rapid succession of static images is based on the detection of picture elements that continue to correspond in one of several aspects despite their change in location. Which elements are perceived as corresponding is determined essentially by Gestalt laws. Alongside these perceptual factors, this project adds an intentional factor to the perception of apparent motion. It has been ascertained (Wohlschläger, 2000b) that directed hand movements influence the perceived direction of an ambiguous apparent motion, and that this influence takes the same direction as the hand movement. When executing rotational hand movements in parallel to a circular apparent motion display (see Figure 1.6), threshold functions for perceiving a given direction were shifted in the direction of the hand movement (see Figure 1.7). It was also shown that

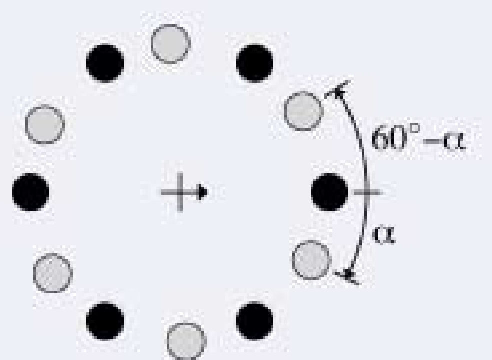


Fig. 1.6

Figure 1.6: *Experimental technique. The initial frame of each trial showed a circular arrangement of six white disks (here drawn in black), a fixation cross, and an arrow attached to the cross. The arrow cued the direction of the observer's hand movement. After performing the cued movement for at least 280 ms, the display was shifted clockwise (CW) about a constant angle a, resulting in a new angular position as depicted by the gray disks. The display kept on shifting repeatedly about a, and the observer reported the perceived motion direction by pressing a right (CW) versus left (counterclockwise, CCW) button. Note that a CW shift with the angular amount a could also be conceived of as α CCW shift with the angular amount 60° - α.*

even the intention to execute a purposeful hand movement sufficed to influence the perception of apparent motion. Perception was influenced before the hand movement was executed. Furthermore, it was demonstrated that the direction of the hand movement was actually of only secondary relevance for the direction of the effect. What was far more decisive was the direction with which the hand movement was linked cognitively. Hand movements that were usually ineffective exerted a definite influence on the perception of apparent motion when instructions were used to link up/down with left/right. In summary, findings reveal that it is the intention to act and not its execution that determines the perception of direction. A pilot study showed that left parietal patients do not exhibit an effect of hand movements on ambiguous apparent motion perception. Thus, an intact left parietal lobe seems to be a prerequisite for this type of action-perception interaction.

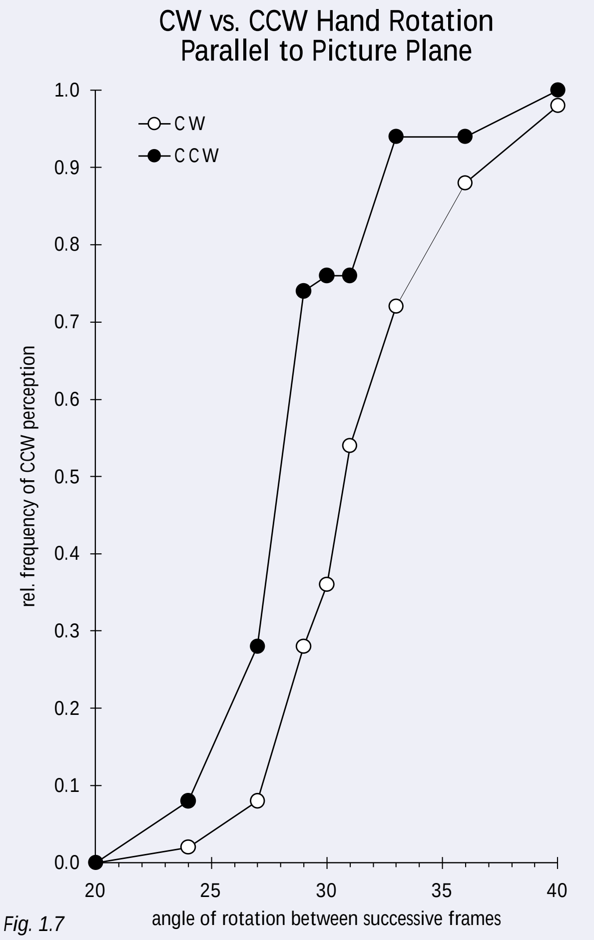


Fig. 1.7

Figure 1.7: *Results. Observed relative frequencies of CCW motion perception. Filled circles depict data obtained with CCW; open circles, with CW hand movements. The panel shows data from a condition in which rotational hand movements were performed parallel to the picture plane. A significant relative shift of the threshold functions for the two hand movement directions was observed only in this condition and not in a condition in which rotational hand movements were perpendicular to the picture plane.*

1.4. Task-Dependent Timing of Perceptual Events

Gisa Aschersleben
Lothar Knuf
Jochen Müsseler
Sonja Stork

Several visual illusions mislead perceptual judgment; nonetheless, these illusions have only a marginal influence on motor behavior like pointing or grasping. There are also a number of temporal dissociations, mainly observed between temporal order judgments (TOJ) and simple reaction time tasks (SRT; Aschersleben, 2000a, in press-b). The present subprojects extend these studies by applying various perceptual and motor tasks (localization judgment, TOJ, SRT, choice reaction (CRT), and synchronization tapping).

Task-Dependent Dissociations in the Timing of Moving Stimuli

The paradigm used in this project is one that elicits the Fröhlich illusion (see Section 1.1). This localization error (a mislocalization in movement direction) suggests a delay in the subjective timing of moving stimuli. In contrast, SRT is faster to moving stimuli compared with stationary ones. This dissociation was examined more closely in further temporal tasks (Aschersleben & Müsseler, 1999). In CRT, reaction times to dynamic features of the stimulus were shorter for moving stimuli. When participants had to react to structural features, longer reaction times for moving compared with stationary stimuli were found. In a synchronization task, the timing of the motor reaction was delayed when moving stimuli served as pacing signals. Finally, in TOJ, no difference in the timing of moving and static stimuli could be observed. These results show that identical stimuli can influence perceptual judgments and motor reactions in different ways. The outcome of earlier stimulus analysis processes seems to have a direct link to the motor system, whereas the representation used for the perceptual judgment, the TOJ, the CRT to structural features, and synchronization performance is based on later integrative processes (see Figure 1.8; Aschersleben, 1999a, 1999c).

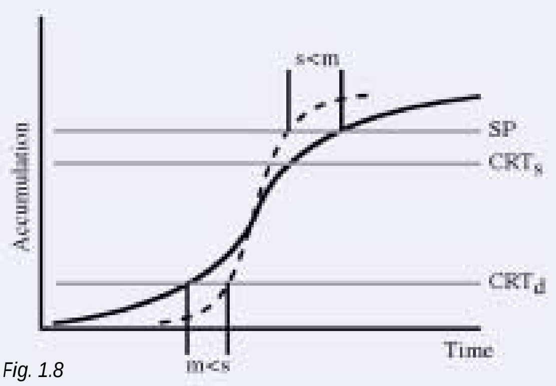


Fig. 1.8

Task-Dependent Dissociations in the Timing of Stationary Stimuli

A further temporal dissociation is being studied with the metacontrast paradigm. In metacontrast, the visibility of a stimulus (test) is reduced by a subsequent, spatially proximal stimulus (mask). However, the motor reaction remains unaffected by the masking (Fehrer & Raab, 1962, JEP, 63, 143-147). A series of experiments applied the metacontrast paradigm to present pacing signals in a synchronization task (see Section 2.1). Results indicated a predating of the mask by the previously presented test. When instructed to synchronize with the test, there was no dependence on SOA. Similar findings were observed for conditions in which the test was unmasked. Further experiments used TOJ to study the timing of the mask. Here as well, findings proved the predating of the mask to be independent of whether the test was masked or not (Aschersleben, 1999a, Aschersleben & Bachmann, submitted).

Task-Dependent Timing of Stimuli in the Kappa Effect

The Kappa effect is a perceptual illusion in which time estimates are influenced by the spatial context of the stimulus configuration. It occurs when a person has to judge the two intervals between a sequence of three stimuli presented at different spatial intervals. A greater distance between two stimuli makes the corresponding time interval also appear to be longer (Huang & Jones, 1982, Percept Psychophys, 32, 7-14). By applying the CRT, we were able to show that this effect is at least partly due to an influence of the preceding stimulus on the timing of the subsequent one while the timing of the first stimulus presented is not influenced by the subsequent stimulus (priming hypothesis). The results demonstrate that the attentional focus is not spatially limited to the position of the stimulus that elicits the attentional shift, although its position is relevant (spatial and temporal priming; see Aschersleben & Müsseler, 2000).

This research was partially supported by a grant from the Deutsche Forschungsgemeinschaft (DFG AS 79 3-1). Part of the project has been conducted in collaboration with Talis Bachmann, Tallinn, Estonia.

Figure 1.8: *Illustration of hypothetical accumulation functions for stationary and moving stimuli. Solid line: moving stimulus (m); broken line: stationary stimulus (s); gray lines: different thresholds for different tasks; SP: synchronization performance; CRT_s: choice reaction to structural features; CRT_d: choice reaction to dynamical features.*

1.5. Perceived Timing of Events

Gisa Aschersleben
Jörg Gehrke
Dirk Kerzel
Wolfgang Prinz
Andreas Wohlschläger

Effect Binding to Self-Generated and Other-Generated Actions

We are using the classical Libet paradigm (Libet et al., 1983, Brain, 106, 623-642) to investigate the perceived times of actions and of associated stimulus events. Results showed that the perceived time of events depended on whether these events were consequences of a self-generated action (action effects) or whether they occurred by themselves. In general, events were judged earlier if they were action effects, which is interpreted as a result of an efferent binding process that influences conscious awareness (Haggard, Aschersleben, Gehrke, & Prinz, in press). However, it remained to be clarified whether a sequence of two arbitrary events would lead to the same effects on perceived times of the single events. In the next series of experiments, the first event was always the visible execution of an action, whereas the second was a short beep. The action was either executed by the participant's hand, by the experimenter's hand, by a computer, or by a rubber hand. The perceived time was shifted toward action execution only in the participant and the experimenter condition. Thus, there was an efferent binding process that influenced conscious awareness, but it was not restricted to self-generated actions but also occurred for actions generated by others.

Asynchronous Perception of Motion and Luminance Change

This project extends previous research that demonstrated asynchronous perception of object features such as color and motion. In the present experiments, observers were asked to indicate when a moving target changed its luminance. The judged position of the luminance change was displaced from its physical position in movement direction, indicating latency differences between the perception of motion and of luminance change. The experiment showed that focal attention was not sufficient to bind features in the temporal domain. We then examined whether the latency difference could be accounted for by a general tendency to extrapolate the position of moving objects. Observers were asked to judge the position of a moving object when an auditory stimulus was presented. A slight bias to perceive the auditory stimulus before the visual motion was observed, thereby ruling out the extrapolation hypothesis. Finally, we found that when observers were asked to judge the first position of moving objects, a shift opposite to the direction of motion was observed. This result rules out the hypothesis that a delay in the perception of motion onset accounts for the results (Kerzel, submitted-a).

Crossmodal Interaction in the Perceived Timing of Events

In the well-known ventriloquist effect, auditory and visual events presented at separate locations appear closer together. The first part of this project ruled out the explanation that judgment errors are responsible for such effects by applying the staircase method. Moreover, strict synchrony between auditory stimulus and visual distractor was found to be a necessary precondition for the effect to occur (Bertelson & Aschersleben, 1998, Psychon B Rev, 5, 482-489). In the second part of this project, we considered the possibility of the converse phenomenon: crossmodal attraction on the time dimension conditional on spatial proximity. Participants judged the temporal order of sounds and lights separated in time and delivered either at the same or at different locations. By again using the staircase method, we were able to show that impressions of temporal separation were influenced systematically by spatial separation. This finding supports a view in which timing and spatial layout of the inputs play, to some extent, symmetrical roles in bringing about crossmodal interaction (Aschersleben & Bertelson, submitted). Converging evidence is also available from synchronization experiments in which participants were confronted with two pacing signals (one visual and one auditory), but had to pay attention to only one of them for the synchronization task. Whereas, with spatially discrepant stimuli, the distortion of the localization of auditory stimuli through discrepant visual stimuli was greater than vice versa, the temporal domain revealed a clear dominance of the auditory modality.

Parts of the project have been conducted in collaboration with Patrick Haggard, University College London, and with Paul Bertelson, Université Libre de Bruxelles, Belgium.

1.6. Feature Binding in Event Perception

Bernhard Hommel
Günther Knoblich
Jochen Müsseler
Wolfgang Prinz
Peter Wühr

Perceptual representations and action plans are not single, unitary codes but complex structures made up of separable constituents representing the various features of the respective event, that is, *feature codes*. In order to perceive a stimulus or to plan an action, the feature codes representing the particular event need to be activated. Several projects in our group are investigating how activation can spread between feature-overlapping event representations. However, to distinguish the features belonging to different perceptual events and/or action plans, the first *activation phase* of representation/planning needs to be followed by some *integration phase* in which features belonging to the same event are bound together (Hommel, Müsseler, Aschersleben, & Prinz, in press; Stoet & Hommel, 1999).

Time Course of Feature Activation and Feature Binding

Using variants of the design developed by Hommel (1998, Vis Cog, 5, 183-216), we investigated the timecourse of stimulus- or response-feature repetitions (indicating activation) and of benefits of repeating feature conjunctions (indicating integration). With respect to stimulus features, we observed activation effects from very early on (less than 100 ms SOA) until about half a second. Integration effects set in much later (after about 250 ms) and they lasted much longer, sometimes more than 4 s (Colzato & Hommel, submitted). Similarly, effects of repeating single response features set in and were rather short-lived compared with effects of repeating conjunctions of stimulus and response features.

Side- and After Effects of Feature Integration

Integrating a particular feature into one event representation is assumed to decrease its availability for other integration processes and event representations (Hommel et al., in press). An obvious prediction of this assumption goes as follows: If feature X is already part of an integrated event code, be it an object representation or an action plan, forming another event code should be more difficult if it requires coding the same feature. Some aspects of this prediction were tested successfully in the project »Perceiving Stimuli During the Execution of Stimulus-compatible Actions« (Section 3.1) in which planning a left – or right-hand action made it more difficult to perceive a left or right stimulus, respectively. Reversing the perspective, we also found that perceiving and memorizing a left- or right-side object impaired the performance of a corresponding, that is, left- or right-hand action (Stoet & Hommel, in press). Taken together with the earlier observation that holding an action plan in preparation impairs the planning of a feature-overlapping action, there is now broad support for the assumption that feature integration in some sense occupies the codes of the integrated features, at least temporarily.

Activation and Integration in the Concurrent Processing of Visual Stimuli

The distinction between the activation and integration of feature codes during event perception (see above) can be applied to investigate the effect of distractor stimuli on the concurrent processing of similar or dissimilar target stimuli. In addition, we assumed that similar (i.e., feature-sharing) stimuli in different positions can activate the same feature code in parallel, whereas the integration of different feature codes belonging to one stimulus requires that spatial attention is directed toward the position of this particular stimulus. From these assumptions, the following predictions emerge: If observers process the target before the distractor, then a similar distractor in the display might provide redundant code activation and improve both accuracy and speed of target processing. If, however, observers process the distractor before the target, then the integration of a feature code into the distractor representation impairs the subsequent processing of a similar target that shares a feature with the distractor (code occupation). The results of a series of experiments confirmed these predictions (Wühr, Knoblich, & Müsseler, submitted). Moreover, our theoretical framework enabled us to explain seemingly discrepant results from the literature (e.g., Bjork & Murray, 1977, Psychol Rev, 84, 472-84; Eriksen & Eriksen, 1974, Percept Psychophys, 16, 143-49).

1.7. Perception of Self- and Other-Generated Actions

Rüdiger Flach
Günther Knoblich
Wolfgang Prinz

The main concern of this project is whether action perception relies on action production. More specifically, if action-related information is available to the perceptual system, by mediation of common event representations, self-generated actions should have a special status in action perception. The reason is that a currently observed stream of events, produced earlier by oneself, should be more similar to the common event representations than a stream of events produced by another person. In addition, the common event representations could also provide a platform for integrating currently perceived actions of another person with simulated actions one is imagining concurrently (Barresi & Moore, 1996, Behav Brain Sc, 19(1), 107-154). We have developed several experimental paradigms to address these issues.

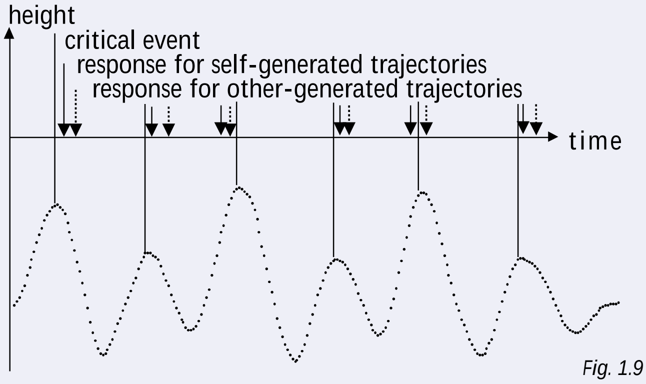


Fig. 1.9

Figure 1.9: *Participants pressed a key whenever the moving dot reached a peak. After some practice, they responded earlier when the trajectory was self-generated.*

In our earlier research, we used self- and other-generated kinematic displays of drawing to assess whether individuals could recognize their own actions (Knoblich & Prinz, 2001). In these studies, participants provided Self- or Other Judgments (SOJs) to indicate whether a kinematic display reproduced the products of their own actions. The main results were that self- and other-generated drawing could be distinguished, and that velocity information was crucial for the identification of self-generated drawing. These results provide support for the assumption that action-related structures contribute to action perception.

In a further set of studies, we investigated whether observation of self-generated kinematic displays also allows one to predict forthcoming strokes more accurately (Knoblich, Seigerschmidt, & Prinz, submitted). Findings confirmed this hypothesis. Hence, it is not only possible to determine whether one is observing the products of self- or other-generated actions but also to use the products of self-generated actions more effectively to predict future events. A third experimental paradigm was developed to determine whether the latter claim also holds when the perceptual input is richer than the kinematic information provided by a single moving dot. In this paradigm, participants watched video clips displaying either themselves or somebody else throwing a dart at a target board, and they had to predict the dart's landing position (Knoblich & Flach, in press). Predictions were more accurate when participants observed themselves acting. This result provides further evidence for the claim that perceptual input can be linked with the action system to predict future action outcomes.

Recently, we have developed a fourth experimental setup that allows us to investigate whether authorship also affects the timing of actions (Flach, Knoblich, & Prinz, submitted). The rationale behind this assumption is that the higher similarity between the products of self-generated actions and the common event representations should lead to a higher activation of the latter. This translates into the prediction that responses will occur earlier when individuals are instructed to synchronize with a critical event that is self-produced compared to one that is other-produced. In order to test this prediction, we asked individuals to press a key synchronously with a moving dot reaching a turning point in trajectories like those displayed in Figure 1.9. The results show that, under certain circumstances, the keypresses did indeed occur earlier for self-generated trajectories.

Taken together, the results of this project support the claim that action-related structures contribute to action perception by mediation of common event representations.

1.8. Action Comprehension

Patric Bach
Günther Knoblich
Wolfgang Prinz

The assumption of common event representations bears a powerful explanatory potential for addressing important issues in action comprehension. By action comprehension, we denote all processes that are involved in parsing sequences of actions and extracting meaning from them. The ultimate goal of this project is to find out whether the comprehension of action sequences relies on action-related structures. The rationale behind this claim is that common event representations might become organized into larger script-like chunks without becoming detached from the motor system. This would make action-related information readily available to support the analysis of the order and meaning of action sequences.

However, before these issues can be addressed, an adequate conceptualization of the processes of action comprehension has to be developed because there is virtually no literature on action comprehension proper. Luckily, the processes involved in action comprehension can be conceptualized in very much the same fashion as those involved in language comprehension (Bach, Knoblich, Friederici, & Prinz, 2001). Just like a single word can be meaningful or meaningless in the context of a sentence, a single action can be meaningful or meaningless in the context of an action sequence (semantics). Moreover, as grammatical rules impose constraints on the order of word categories (nominal phrase, verbal phrase) in a sentence, action rules impose constraints on the order of actions in an action sequence (syntax).

At this early stage of the project, we focused on the question whether similar patterns of processing can be found in both domains. Most theories of sentence processing assume that syntax and semantics are processed in parallel and automatically, and that syntactic categorization precedes the semantic analysis. This interpretation is supported by studies that recorded event related potentials (ERP). In order to test whether a similar pattern is found for action comprehension, we developed an experimental paradigm based on the game Paper, Scissors, Rock. The task is to detect violations of syntax, semantics, or both. Figure 1.10 shows examples for a correct sequence and the different type of violations that could occur. By measuring the time it takes to detect different types of errors under different conditions, one can determine whether the syntax and semantics of action sequences are processed in parallel and automatically, and whether the syntactic analysis is faster than the semantic analysis. A series of experiments demonstrated that all of the above said was the case. Hence, the pattern of results for action comprehension is quite similar to that observed in sentence comprehension.

In a further study, we recorded ERPs using the same experimental paradigm in order to determine whether the same components as in sentence comprehension are found after syntactic and semantic violations of action sequences. For semantic violations, there was a stronger N 400 component, and for syntactic violations, there was a stronger P 600 component. These components are also observed for semantic and syntactic violations in sentences. There was no clear evidence for the stronger ELAN (Early Left Anterior Negativity) observed after syntactic violations in sentence processing.

Taken together, these results suggest that there are close parallels between the processing of action sequences and sentences. Further research is needed to determine whether the action system is involved in the processing of action and word sequences.

This project is being conducted in cooperation with Angela D. Friederici and Thom Gunter at the Max Planck Institute of Cognitive Neuroscience, Leipzig.

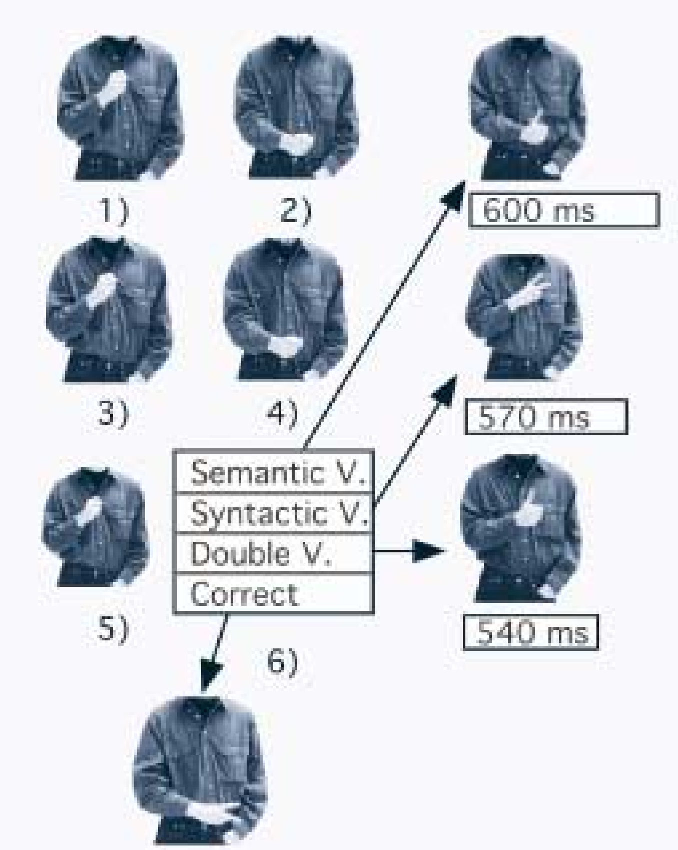


Fig. 1.10

Figure 1.10: *Action sequences of the game Paper, Scissors, Rock. The last frame determines whether the sequence is correct or contains a semantic (slowest reaction times), syntactic, or double violation (fastest reaction times).*

Section 2: Coordinating Actions and Events

Introduction

In order to act successfully, it is often crucial to coordinate actions with events occurring in the environment. Separate-coding accounts need to postulate informational transformations to explain how coordination between the action system and the perceptual system is achieved. Because timing is often critical for the coordination of actions and events, the complexity of such transformations would pose an enormous problem for the cognitive apparatus. The common-coding account tells a much simpler story: Event representations that are common to perception and action make transformations between perceptual and motor information unnecessary (at least on the level of functional analysis). As a consequence, they provide an ideal medium for the coordination of action-related and environmental information. This implies the opportunity to rapidly integrate changes in perceptual input resulting from earlier actions with the expected results of future actions.

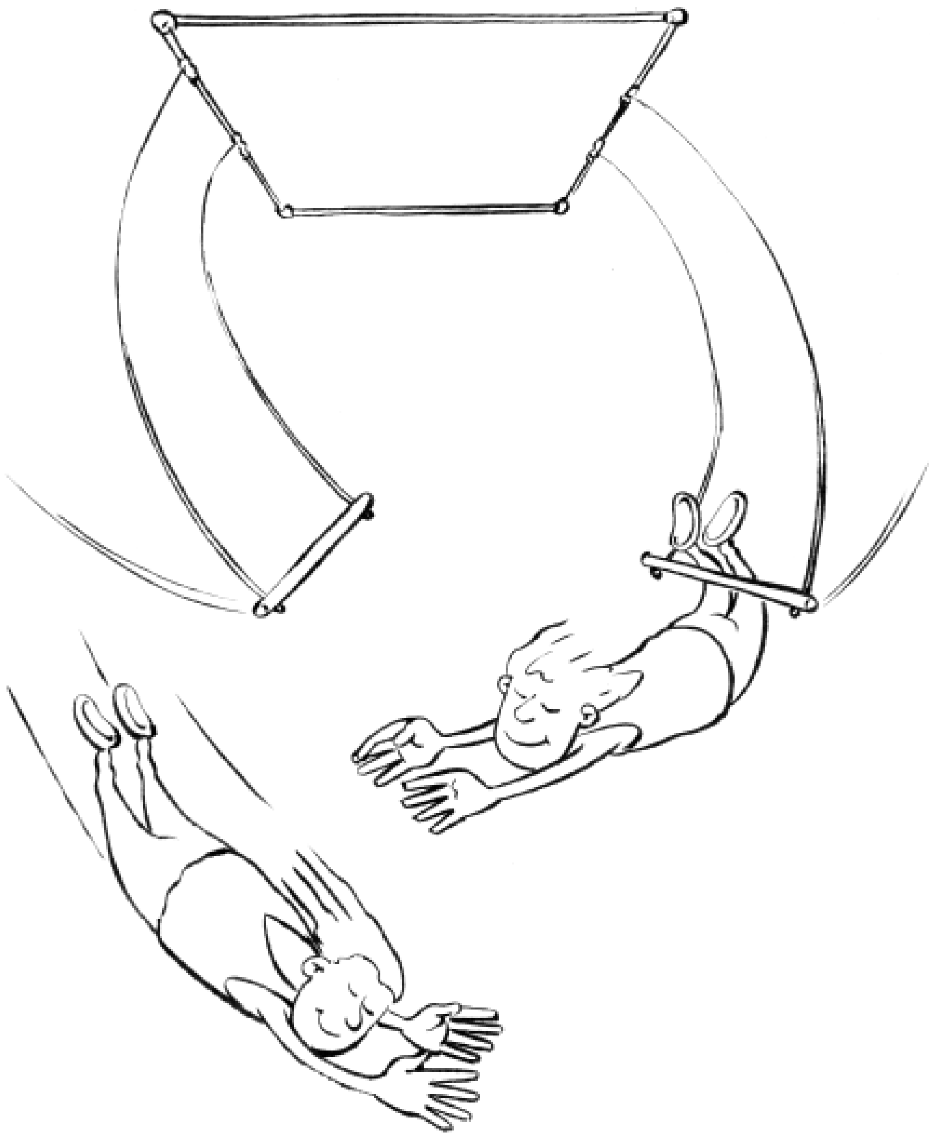


Figure 2.1:
Action coordination is ...
... working hand in hand.

Projects

The common-coding approach emphasizes the role of privileged relations between perception and action – in other words, relations in which either perceived features specify the characteristics of potential actions or in which characteristics of a prepared or executed action correspond with the features of a stimulus to be perceived. The project »Temporal Coordination of Actions and Events« is addressing the issue of the temporal coordination of actions with events. Based on the well-known effect that, in a synchronization task, actions precede the events to be synchronized, this project is investigating the role of sensory action effects in the temporal control of actions. In the common coding perspective, actions are represented and controlled by their (anticipated) action effects. Hence, the influence of manipulations of sensory action effects on the (temporal) control of actions is directly predicted by this approach.

The common coding assumption also generates a somewhat different perspective (compared with separate coding accounts) on the coordination of multiple action systems such as the eye and the hand system. It suggests that these subsystems are all linked to the common event representations that code the desired outcomes of a coordinated action. The project »Eye-Hand Coordination« is addressing these issues. Building on the well-established fact that eye movements normally precede hand movements, the project is pursuing the question whether planning reaching or grasping actions biases the eye movement system toward the object or event features needed to carry out the respective action. Such a result is to be expected if both systems are governed by the same action plan.

The assumption that common codes provide a medium for the rapid integration of different types of perceptual and action-related information also has implications for bimanual coupling. Whereas it is widely believed that constraints on the production of bimanual movements stem exclusively from the motor system, the assumption of common codes assigns an important role to the perception of the events that result from these movements (i.e., the action effects). In a sense, the hands are seen as the basic biological tool to produce desired events. This creates a natural connection to »artificial« tools. These are, in the common coding perspective, nothing other than extensions of the basic biological tools that simplify the production of certain desired events. The project »Bimanual Coupling and Tool Transformations« seeks to determine whether this perspective is supported by empirical evidence.

Another important issue addressed by the common coding account is the coordination of actions across individuals. This form of coordination is needed whenever two individuals engage in joint action. This is being addressed by the projects »Imitation« and »Joint Action«. For imitation, the common-coding assumption suggests that movements observed in another person are not imitated as a whole. Instead, different events the person produces in the environment should carry more or less information about this person's action plan. In addition, the imitator's common-coding system should be activated more strongly by goal-related aspects of an action. This should create a tendency to imitate goals rather than movements. Other forms of joint action, like rowing a canoe, require two or more actors to coordinate their actions in real time in order to obtain a jointly desired outcome. The common-coding assumption also provides hints on how this type of coordination can be achieved.

2.1. Temporal Coordination of Actions and Events

Gisa Aschersleben
Avner Caspi
Knut Drewing
Frank Miedreich
Katharina Müller
Bettina Pollok
Wolfgang Prinz
Prisca Stenneken
Andreas Wohlschläger

The common coding approach assumes that actions are represented and controlled by their (anticipated) action effects. In sensorimotor synchronization (see Figures 2.2 and 2.3), this *effect hypothesis* can be tied to the observation that participants regularly report subjective synchrony between the pacing signal and the response while producing an objective asynchrony. To explain why these asynchronies are always negative, in other words, why reactions have to precede the signals for the impression of synchrony to emerge, we have developed models that follow the basic assumption that the synchronization of signals and reactions is based on the timing of the central representations of both events (see, for overviews, Aschersleben, 2000b, in press-a). The timing of the central representation of the action is then determined by the specific (sensory) effects of the action performed. Thus, manipulations of sensory action effects should have a predictable influence on the temporal control of action. Some parts of the project are testing the *effect hypothesis* within the so-called continuation paradigm (see Figure 2.3) in which participants initially synchronize their finger movements with a set click, but then carry on tapping without a pacing signal.

Fig. 2.2

Figure 2.2: *Experimental setup used in the synchronization-continuation paradigm for hand and foot tapping tasks.*

Manipulating Somatosensory Feedback in Sensorimotor Synchronization

Various synchronization experiments confirm that manipulating auditory action feedback leads to a systematic change in negative asynchrony (e.g., Aschersleben & Prinz, 1997, J Motor Behav, 29, 35-46; Mates & Aschersleben, 2000). To clarify the role of somatosensory feedback in the temporal control of tapping movements, three different kinds of manipulations were tested: (1) enhanced, (2) reduced, and (3) eliminated somatosensory feedback. (1) Enhancing somatosensory feedback by instructing participants to tap with large finger amplitudes (leading to an increased tactile and kinesthetic feedback) resulted in a reduced negative asynchrony (Aschersleben, Gehrke, & Prinz, in press), whereas (2) reducing somatosensory feedback by applying local anesthesia to the tapping finger (i.e., eliminating the tactile component) led to an increase in negative asynchrony (Aschersleben, Gehrke, & Prinz, 2001). (3) Synchronization performance under conditions with a complete loss of somatosensory feedback can be studied only in deafferented patients. By manipulating the amount of extrinsic feedback (auditory feedback and visual control of movements), we could clearly demonstrate the influence of sensory feedback on the timing of actions in the deafferented patient IW (Aschersleben, Stenneken, Cole, & Prinz, in press). Further experiments in which the deafferented patient had to coordinate the timing of hand and foot movements support the interpretation in terms of an internal generation of the movements' sensory consequences (forward modeling; Stenneken, Aschersleben, Cole, & Prinz, in press).

Fig. 2.3

Figure 2.3: *In the synchronization-continuation paradigm, participants initially synchronize their finger movements with a sequence of isochronous clicks. In the continuation task, they then carry on tapping without the pacing signal. The asynchronies between click and tap and the intertap intervals, respectively, are analyzed as dependent variables.*

Neuromagnetic Correlates of Sensorimotor Synchronization

Central processes underlying performance on a synchronization task were analyzed with magnetoencephalography (MEG). Evoked responses were averaged time-locked to the auditory signal and the tap onset. Tap-related responses could be explained with a three-dipole model (see Figure 2.4): One source, peaking at 77 ms before tap onset, was localized in contralateral pri-

Fig. 2.4

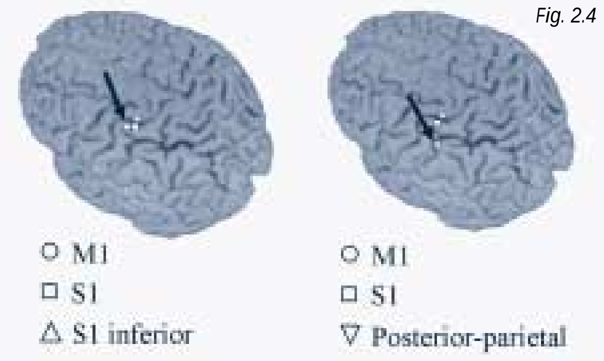


Figure 2.4: *The three tap-related sources superimposed on a representative brain surface. During auditory pacing (left) and tactile pacing (right), the same areas are activated in M1 and S1, whereas the second S1 source is located in the inferior S1 cortex during auditory pacing and in the posterior parietal cortex during tactile pacing.*

mary motor cortex (M1); the other two sources, peaking at tap onset and 75 ms after tap onset, in contralateral primary somatosensory cortex (S1). The analysis of the temporal coupling of these sources relative to different trigger points revealed the second S1 source to be equally well time-locked to the tap and to the auditory click. Analysis of time-locking of this source activity as a function of the temporal order of tap and click showed that the event occurring last was decisive in triggering this source. This finding suggests that it is mainly the sensory feedback that participants use for judging and evaluating »being in time« (Müller, Schmitz, Schnitzler, Freund, Aschersleben, & Prinz, 2000). Further support comes from a study comparing auditory with tactile pacing. No asynchrony was observed in these conditions. The localization of the two earlier sources seemed to be modality-independent, whereas location of the third source varied with modality (see Figure 2.4). Thus, the central data reveal modality-specific control units as being responsible for temporal precision in sensorimotor synchronization (Müller, Aschersleben, Schmitz, Schnitzler, Freund, & Prinz, submitted). Recent experiments have extended the paradigm to bimanual tapping and are studying the role of the second S1 source in the temporal coordination of actions.

Bimanual Action Effects

In the continuation paradigm (see Figure 2.3), within-hand variability of intertap intervals is reduced when participants tap with both hands compared with single-handed tapping. This bimanual advantage can be attributed to timer variance (according to the Wing-Kristofferson model; Wing & Kristofferson, 1973, Percept Psychophys, 14, 5-12), and separate timers for each hand have been proposed for which the outputs are averaged (Helmuth & Ivry, 1996, JEP:HPP, 22, 278-293). Alternatively, we suggest that timing may be based on sensory movement consequences and the bimanual advantage due to the enhancement of these movement consequences. We were able to show that additional auditory action effects reduced timer variability for both uni- and bimanual tapping. Moreover, the bimanual advantage decreased when auditory feedback was removed from taps with the accompanying hand (Drewing, in press; Drewing & Aschersleben, submitted). These results indicate that the sensory movement consequences of both hands are used and integrated in timing. Further support comes from experiments manipulating tactile feedback. The bimanual advantage decreased when tactile feedback from the left hand's taps was omitted (e.g., by contract-free tapping; Drewing, Hennings, & Aschersleben, in press). To account for these effects, a reformulation of the Wing-Kristofferson model is proposed in which it is assumed that the timer provides action goals in terms of sensory movement consequences (Drewing, in press; Drewing & Aschersleben, submitted; Miedreich, 2000).

Alternative Approaches in Sensorimotor Synchronization

The Role of Attention in Sensorimotor Synchronization

One alternative account assumes that directing attention toward the tap or the click would minimize the asynchrony. Changing the allocation of attention between the auditory and the tactile modality reduced the asynchrony only in the auditory condition. Increasing either tactile or auditory attentional demands resulted once more in less asynchrony in the auditory condition alone. Further experiments tested a working model assuming that an attentional window opens around the moment of the click's appearance to perceive its presentation. While open, more attention resources are allocated to that particular moment, enabling better event perception.

Filled-Interval Reduced Asynchrony (the Raindrops Paradigm)

The effect of filled intervals on the asynchrony leads to an alternative approach using the time perception framework (Wohlschläger & Koch, 2000). This account assumes that the asynchrony is a mere product of misperception of the time interval between any two successive markers: An empty interval is underestimated, and therefore its (re)production is too short. Results showed that adding contact-free movements or regular versus irregular sounds between the interval reduced the asynchrony substantially. However, the number and the position of intervening elements played a crucial role in this finding.

2.2. Eye-Hand Coordination

Harold Bekkering
Sebastian F. Neggers

When humans interact with their environment, they often combine fast, ballistic, saccadic eye movements with goal-directed hand movements. Various eye-hand coordination studies have shown that, usually, saccadic eye movements were initiated about 50-100 ms before a goal-directed hand movement. However, this rather fixed order does not provide evidence that the two systems are linked by a common control mechanism. It could well be that, for instance, visual input is processed in parallel, and that the eyes are faster in motor processing because lower inertial forces act on the low-mass eyeballs. Alternatively, the oculomotor and manual motor systems could be coordinated in order to optimize performance.

Our earlier studies already provided evidence for such a coordination. Participants made rapid aiming movements (eye and hand) to suddenly appearing visual targets. We took advantage of the fact that saccadic eye movements are completed before the hand movement is started. In the control condition, the »static-trigger« trials, a second target was illuminated when the hand landed on the visual target. In the experimental condition, the »dynamic-trigger« trials, the second target was illuminated at peak velocity of the hand movement, at the same time when the eyes already fixated the first visual target. Both of these conditions were compared with eye-movements-only trials. Participants could not initiate saccades to a second target until the hand had reached the first target. That is, the saccade to the second target was severely delayed in the dynamic condition. Furthermore, the saccade could not be planned during the terminal phase of the hand movement. This observation was also stressed by a strong correlation between the height of the second reaction time and the length of the deceleration phase of the pointing movement (Neggers & Bekkering, 2000). More recent findings indicated that this ocular gaze anchoring mechanism was stabilized during the entire pointing movement. Moreover, the mechanism was related to an internally generated nonvisual signal, because the phenomenon also existed when vision of the arm was not available (Neggers & Bekkering, 2001).

In another series of experiments, we investigated the influence of action intentions on visual selection processes in a visual search paradigm (Bekkering & Neggers, in press). Participants either had to look and point to or look and grasp a predefined target object with a certain orientation and color among distractors (see, also, Figure 2.5). Results showed that target selection processes prior to the first saccadic eye movement were modulated by the different action intentions. Specifically, fewer saccades to objects with the wrong orientation were made in the grasp condition compared with the pointing condition, whereas the number of saccades to an object with the wrong color remained the same. Because object orientation is relevant for a grasping movement, whereas color discrimination is not, these findings support the view that the planning of motor action as a function of the required object features modulates the visual processing of relevant object features.

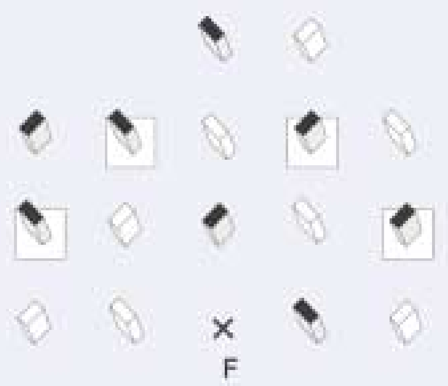


Fig. 2.5

Figure 2.5: *A schematic overview of the stimuli used in Bekkering and Neggers (in press). Participants had to search for a specific target conjunction among 0, 3, 6, or 9 distracters. That is, the target stimulus could be oriented either to the left or to the right and it could be green or orange.*

Overall, results demonstrate that the intention to perform an action results in a top-down modulation of visual processes favoring object features (e.g., orientation) that are related directly to the ongoing specification of parameters for action control (e.g., grasping characteristics).

2.3. Bimanual Coordination and Tool Transformation

Dirk Kerzel
Günther Knoblich
Franz Mechsner
Wolfgang Prinz
Martina Rieger

This project is investigating the role of – imagined or actual perceptual effects in movement organization. According to our general working hypothesis, which is derived from the common-coding approach, movements are organized functionally by way of a representation of their perceptual effects.

Perceptual Action Effects in Bimanual Movements

In periodic bimanual movements, there is a typical tendency toward mirror symmetry. Even involuntary slips from asymmetrical movement patterns into symmetrical patterns can be found. Traditionally, this symmetry bias has been interpreted as a tendency toward co-activation of homologous muscles. We provide strong evidence that challenges this traditional assumption (see Mechsner, Kerzel, Knoblich, & Prinz, in press).

In the classical bimanual finger oscillation paradigm, a person stretches out both index fingers and oscillates them in symmetry or in parallel. With increasing oscillation frequencies, a parallel pattern switches involuntarily into a mirror-symmetrical movement pattern. We varied the original paradigm by putting the hands individually either palm up or palm down. When both palms were up or both were down, the hand position was called »congruous«. When one palm was up and the other was down, it was called »incongruous« (see Figure 2.6). The critical condition was with an incongruous hand position. Given a bias toward the co-activation of homologous muscles, the parallel pattern should be more stable than the symmetrical pattern. However, our results showed that, independent from hand position, a symmetrical finger oscillation pattern was always stable, whereas parallel oscillations tended to disintegrate and switch into symmetry. Thus, the symmetry tendency observed in the bimanual finger oscillation paradigm can be described as a tendency toward perceptual, spatial symmetry without regard to processes in the motor system. Further support for this conclusion comes from studies using other bimanual oscillation paradigms including bimanual circling, bimanual pronation and supination, as well as bimanual multifinger tapping.

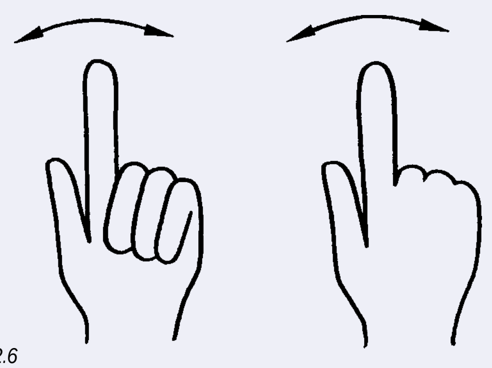


Fig. 2.6

Figure 2.6: *Illustration of the incongruous hand position in the finger oscillation paradigm.*

Perceptual Action Effects in Unimanual Movements

In a new project, we are investigating variations in the complexity of actions and the complexity of their perceptual effects in unimanual tasks. The studies are concerned with the problem regarding under which conditions performance depends on the complexity of the perceptual action effects, and how the complexity of the performed action interacts with this effect. In the experiments, participants draw on a graphic tablet, with their hands hidden under a blend. As one movement consequence, the action effect (i.e., a cursor trace) is made visible on a computer screen. The participants' task is to control the cursor trace. The relationship of the cursor trace and the hand trace is being manipulated systematically with the transformations ranging from simple to rather complex.

2.4. Imitation

Harold Bekkering
Andreas Wohlschläger

Part of the project has been conducted in collaboration with Dr. G. Gergely, Hungarian Academy of Sciences, Budapest.

Imitation, or performing an act after perceiving it, guides the behavior of a remarkable range of species at all ages. Imitation also serves an important function in human development, offering the acquisition of many skills without the time-consuming process of trial-and-error learning. The common view on how perception and action are mediated in imitation postulates that a matching takes place between the perceptual input and existing motor programs in the observer. We, however, have argued that this matching does not take place at the motor level; rather, we suppose it to take place at a goal level. That is, if we observe an action, we decompose the movement observed into its constituent components and later reconstruct an action from these components. Importantly, the decomposition-reconstruction process is guided by an interpretation of the movements as a goal-directed behavior with some of the goals being dominant over others (Bekkering, Wohlschläger, & Gattis, 2000; Gleissner, Meltzoff, & Bekkering, 2000).

More recently, we have tried to determine the nature of the goal hierarchy in more detail. In a series of experiments, adult subjects had to imitate a pen-and-cup action. The action modeled consisted of several components: There were two different objects, two possible locations, two treatments of what to do with the pen and the cup, two effectors (left or right arm), and two movements (clockwise or anticlockwise). Participants were fully informed about the aspect they needed to imitate. In another experiment, they were asked to imitate spontaneously the action observed. Results were basically the same: As predicted by the goal-directed theory of imitation, the category of errors observed most frequently was the type of movements performed. The second and third most frequent types of errors were the effector chosen and the treatment, respectively. Almost no errors occurred for location, and the best-imitated component was the object. Taken together, these observations indicate that imitation is not about copying movements. Rather, it is the goal of the action observed that we imitate. The organization of these goals seems to be very functional. That is, the ends of an action are more important than the means.

We also used the goal-directed theory to cast some new light on a patient group that is known to be impaired on imitation performance, that is, ideomotor apraxia. Typically, these patients have damage to the left hemisphere. Theories so far have used the principle of perceptual-motor matching in imitation, and the discussion has been whether the damage is located more on the perceptual side or the motor side. Using a paradigm similar to our previous study (see Figure 2.7), we were able to demonstrate that these patients also follow the functionality principle, for example, by ignoring the effector but choosing the correct object. These observations contradict earlier observations and demand a revision of present theories on the functional deficits in Apraxia.

In another recent study we analyzed the imitative learning in 14-month-old children. It demonstrated that while infants of this age can imitate a novel means modeled to them, they do so only if the action is seen by them as the most rational alternative to the goal available within the constrains of the situation, thus, supporting a »rational imitation« account over current »imitative learning« accounts (Gergely, Bekkering, & Király, submitted).

Figure. 2.7: *Stimuli in the apraxia study. Patients chose the correct object when asked to imitate, but did not use the same finger to point to the object.*

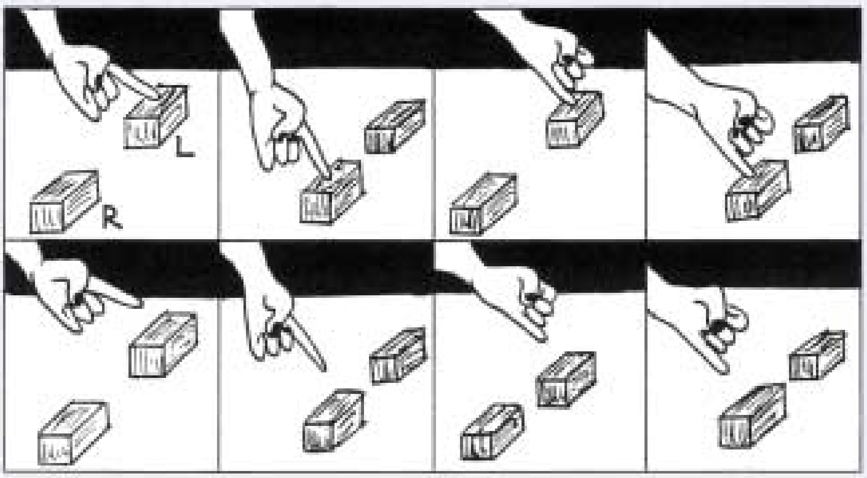


Fig. 2.7

2.5. Joint Action

Günther Knoblich
Wolfgang Prinz
Natalie Sebanz

When groups of individuals work toward a common goal such as paddling a canoe or playing a game of soccer, group members must engage in joint action. As a consequence, each must externalize his/her intentions, perceive the externalized intentions of the others, and plan his/her actions in relation to those perceived intentions in order to avoid action conflicts. It is very hard to conceptualize such processes within a separate-coding approach. In contrast, it is easy to see how action coordination could be achieved by integrating first- and third-person information on a level of common event representations (Knoblich & Jordan, 2000, submitted-b). In particular, we assume that common event codes are central for the coordination of actions across individuals, because they provide a medium for dealing rapidly with the actual and anticipated outcomes of self- and other-generated actions.

In a first series of studies (Knoblich & Jordan, submitted-a), we tested one implication of this assumption. In individuals, conflicts between different action alternatives can be resolved within a single cognitive system. In groups, such conflicts have to be resolved via the environment. As a consequence, it should be critical for groups whether perceived events can be attributed unambiguously to one's own or somebody else's actions. If the events are not ambiguous, group members should be able to resolve action conflicts just as well as single individuals. We tested these predictions with a tracking task that was highly likely to produce action conflicts that had to be resolved in real time. Figure 2.8 illustrates this task.

At the border, there is an action conflict between pressing the right and the left button, because if one wants to avoid large future errors, one has to increase the immediate error before the target turns (the target turns abruptly, whereas the tracker can be decelerated only step by step). We compared an individual condition in which an individual operated both keys with a group condition in which each person operated one key only. In addition, there was a condition in which an unambiguous auditory event signaled that a button had been pressed and a condition in which such a signal was not present. Performance and several other measures provided evidence for the claim that successful coordination of group action depends on unambiguous information about the actions of the other group member. If such information was present, groups behaved exactly as a single individual. If such information was not present, groups had much larger problems in coordinating their actions.

In another series of studies using a similar paradigm (Jordan & Knoblich, submitted), we tested whether perceptual space is transformed in an other-relative fashion when action coordination across individuals is required. This should be the case whenever somebody else might be interfering with the planned outcomes of one's own actions. Hence, perceptual displacements, as observed in the representational momentum effect (see Section 1.2), should be affected by the presence of another actor, because the anticipated effects of the other are part of a joint action plan. We developed a task in which individuals or groups move a dot as quickly as possible across the computer screen by pressing buttons that accelerated or decelerated the dot. At a certain point on each trial, the dot vanished, and participants were asked to indicate the perceived vanishing position afterwards. Again, participants worked on this task either individually or as a member of a dyad. The displacement was biased in the predicted direction in the group condition compared with the individual condition.

Taken together, results indicate that joint action plans can critically influence performance and perception. They are also consistent with our claim that the integration of first- and third-person information occurs on a level of common event representations.

This project is being conducted in cooperation with J. Scott Jordan, St. Xavier University, Chicago.

Figure. 2.8: *Participants used a circular ring stimulus (the tracker) to track a dot stimulus (the target). The target moved back and forth across a computer screen at a constant velocity and reversed its course upon reaching either edge of the screen. Left and right button presses increased/decreased the tracker's velocity.*

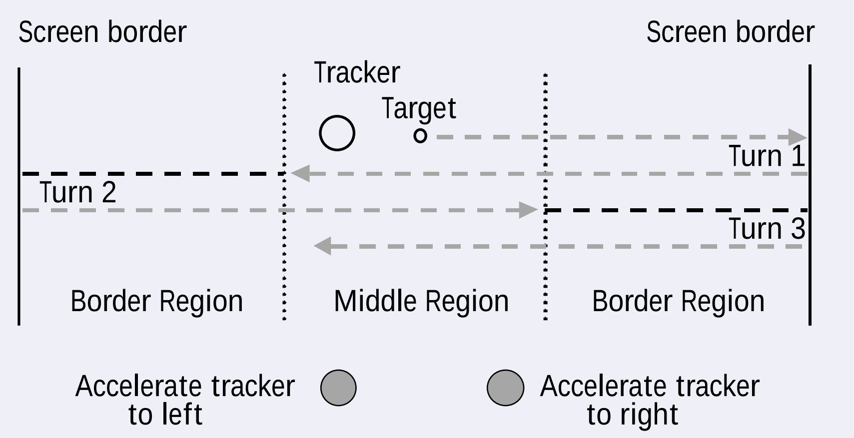


Fig. 2.8

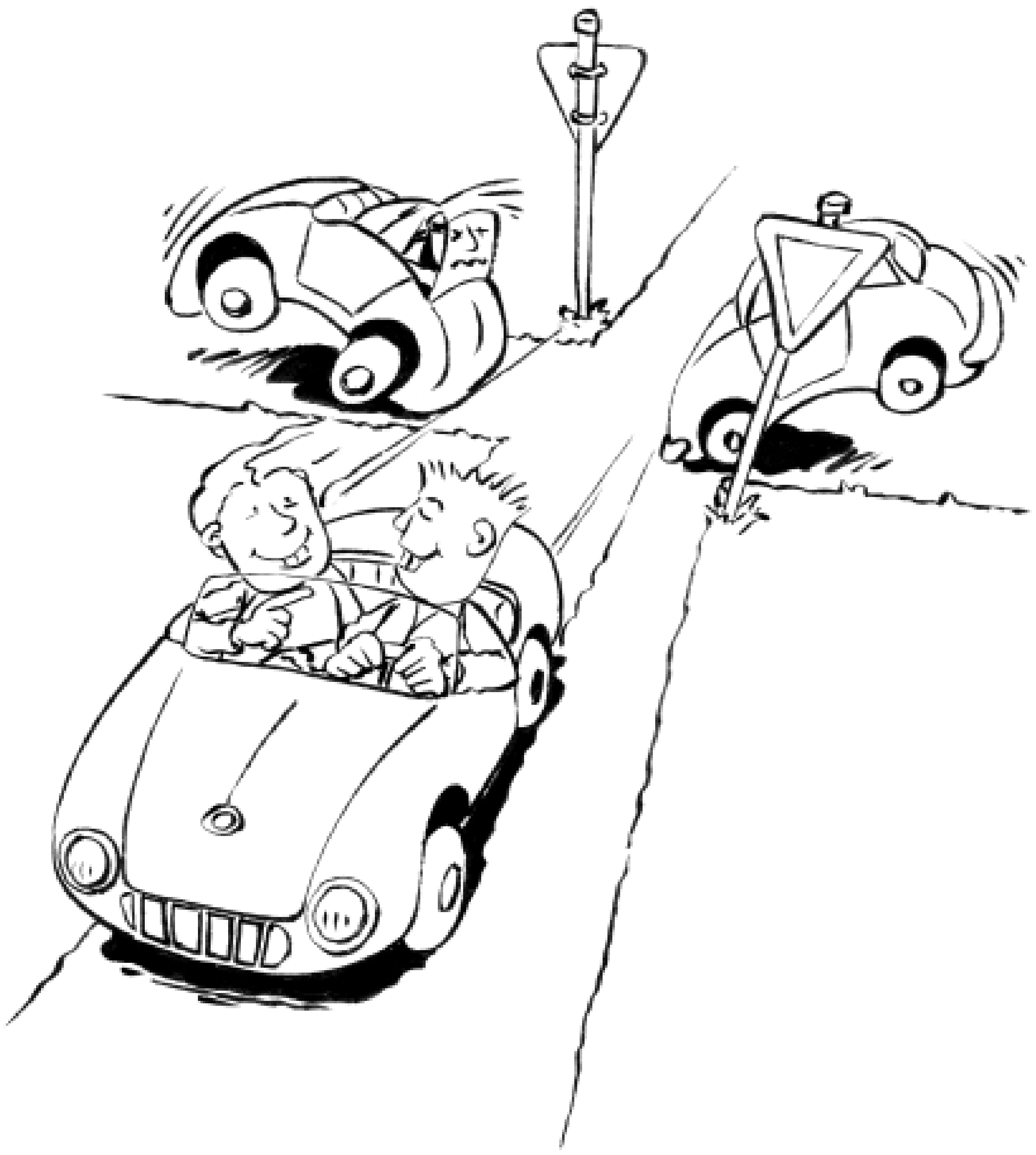
Section 3: Interference Between Actions and Events

Introduction

Research Questions

Introspectively, perception and action seem to fulfill different cognitive functions: Perception processes pick up and analyze events in the environment (mainly by afferent mechanisms), whereas action processes are generated internally and may produce and influence events in the environment (mainly by efferent mechanisms). Although perception and action processes are highly interactive under most ecological conditions (e.g., in sensorimotor tasks like pointing or grasping), they seem to operate relatively independently from one another. On the other hand, there are also observations from everyday life that give reason to doubt this independence. One well-known example is the driver who is engaged in conversation and therefore misses a stop sign. In this example, the act of conversation is obviously able to interfere with what is perceived.

Figure 3.1: *Control of proper action is often impaired when cognitive resources are drawn upon by competing actions and events.*



This section examines such interferences between perception and action. The theoretical starting point is the common-coding assumption (or the event-coding account, respectively) that action planning is controlled by representational structures that can also serve to represent the contents of perceptual events (see above; Hommel, Müsseler, Aschersleben, & Prinz, in press). In other words, action planning and perceptual encoding are assumed to operate on partially overlapping representations. Therefore they are prone to evoke interferences by each other.

Two different approaches are used to analyze these interferences: The first investigates in an unspecific manner (i.e., with no feature overlap between response and stimulus) whether and how the processing of a response task can exert an influence on the processing of a perceptual task and vice versa. The second approach examines specific relations between perception and action. Specific relations exist in situations in which either perceived features specify the characteristics of potential actions (stimulus-response compatibility) or characteristics of a prepared or executed action correspond with the features of a stimulus to be perceived (response-stimulus compatibility). For example, when stimulus and response correspond spatially (e.g., a right-hand reaction to a right-hand stimulus), better performance is observed than when they do not correspond (e.g., right-hand reaction to left-hand stimulus). However, spatial properties of stimuli also impact on the planning of actions when they are completely irrelevant to the task at hand. Even when instructed to react to nonspatial stimulus properties (e.g., with a right-hand reaction when an X is displayed), participants perform better when the stimulus appears on the same side as the reaction.

Our projects are using various versions of these interference paradigms. In the projects on »Perceiving Stimuli During the Execution of Stimulus-Compatible Actions,« the main research question is whether processes of action planning are able to exert an influence on perceptual processes, and, if so, how. This leads to research designs in which participants perform an unspeeded action at leisure while simultaneously having to perceive response-compatible or -incompatible stimuli.

In the second set of projects on »Interference with Speeded Response Tasks,« speeded responses are introduced with the consequence that the resulting dual task becomes similar to the well-known paradigm of the psychological refractory period.

Finally, in the projects on »Interference Studies on Imitation,« the research question is how humans and other species manage to copy other individuals' behavior by simply watching them. Facilitation or impairment is expected depending on the congruency between perceived and to-be-performed action.

3.1. Perceiving Stimuli During the Execution of Stimulus-Compatible Actions[1]

Bernhard Hommel
Jochen Müsseler
Wolfgang Prinz
Andreas Wohlschläger
Peter Wühr

Usually, approaches to human information processing examine and attempt to characterize those processes that transform sensory input signals into overt reactions. The present subprojects address the opposite question, namely whether and how processes of action control exert influences on perceptual processes. The method of choice employs dual-task paradigms in which participants plan or perform an unspeeded action while simultaneously perceiving and recognizing particular stimuli.

The basic design is depicted in Figure 3.2: When a reaction *R* is performed in response to a cue at leisure, a masked stimulus *S* is presented. The framework provided by the event-coding account predicts that simultaneous access to shared codes should reveal elementary interactions; that is, motor processes of *R* should influence perceptual identification of *S*. Thus, the critical empirical test is whether the identification of *S* depends on the execution of *R* and/or the relationship between *R* and *S*.

A typical result of previous experiments was that the perceptual task proved easier when the masked *S* was presented alone compared with when it was presented during the execution of *R* (see, for an overview, Müsseler, 1999a). Accordingly, perceptual single-task performance was better than dual-task performance, indicating a nonspecific impact of response generation upon perceptual identification. More important from an event-coding point of view was the finding that observers were less able to identify response-compatible *S* (e.g., left keypress, left-pointing arrow) than to identify response-incompatible *S* (e.g., left keypress, right-pointing arrow; *blindness to response-compatible stimuli*, cf. Figure 3.3).

Examining Alternative Interpretations of the Blindness Effect

Further studies tested various interpretations of this finding. For example, we found no evidence that the blindness effect depends on the relationship between response cue and masked *S* (i.e., in an *S*-*S* relationship, cf. Figure 3.2), or on the relationship between *R* and perceptual judgment (i.e., in an R-R relationship, cf. Müsseler & Hommel, JEP:HPP, 1997, 23, 861-872). Further, we were able to demonstrate the perceptual impairment both in terms of accuracy of identification and detection as well as in terms of the signal-detection parameter d' (Müsseler, Steininger, & Wühr, 2001). Consequently, it seems safe to conclude that R really affects the perception of S. An even more straightforward test of this conclusion was to omit the response cue and to use only responses that were triggered endogenously by the participants. Indeed, as a further experiment showed, it did not matter whether participants performed an arbitrarily selected left or right response or whether they responded to a response cue (Müsseler, Wühr, & Prinz, 2000).

Finally, evidence was obtained that feature overlap between the anticipated action effect and the to-be-identified stimulus contributes to the blindness effect. This was shown in a task in which proximal spatial feedback on responses was eliminated while adding other distal action effects (Steininger, 1999). On the other hand,

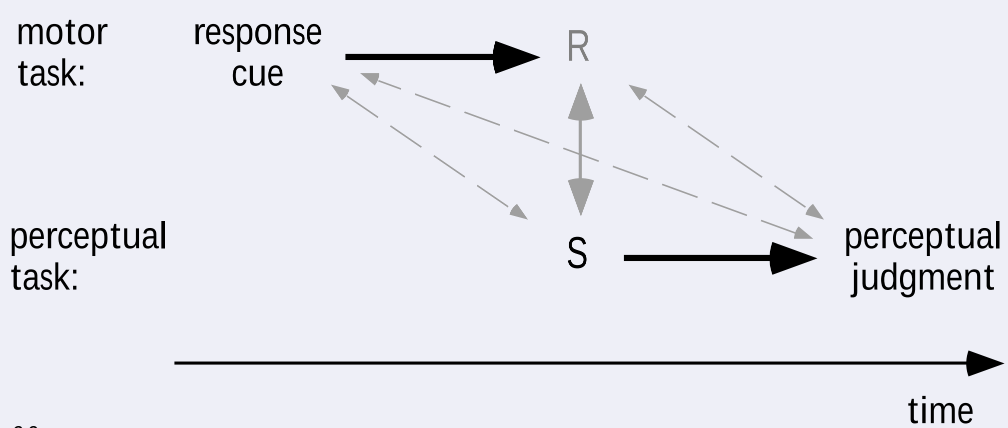


Fig. 3.2

Figure 3.2: *Basic dual-task situation devised to examine whether action control affects perceptual processing. Observers are engaged in a motor task* (R) *while, at the same time, they have to identify a stimulus* (S)*. The critical empirical test is whether the identification of* S *depends on* R *(straight line with double arrow). Dashed lines indicate other relevant S/R relationships that need to be controlled.*

[1] *Subprojects in this area were supported by the Deutsche Forschungsgemeinschaft (grant Mu 1298/2).*

when there was no intention to produce these action effects, the blindness effect disappeared (see also Müsseler, Wühr, & Prinz, 2000). Both findings are consistent with the effect-oriented view of the event-coding account (Hommel, Müsseler, Aschersleben, & Prinz, in press).

The Time Course of the Blindness Effect

This project examined the time course of the blindness effect and how to interpret it. In several experiments, participants performed a timed response, and the time a to-be-identified *S* was presented varied in respect to *R* execution. Experiments 1 and 2 examined an explanation of the effect in terms of a brief refractory period of action-effect codes. However, the findings provided more support for an account according to which the effect reflects a conflict of shared codes that are embedded in an action plan and therefore encapsulated from perceptual processing. Further experiments were designed to test this account against alternative interpretations. Experiment 3 controlled whether the effect emerged from a suppression of the response features. Results ruled out this hypothesis. Finally, Experiments 4 and 5 ruled out a retention-based explanation according to which the effect originated from an interference in the retention phase instead of a failure in stimulus encoding (Wühr & Müsseler, in press-a; see, also, Wühr & Müsseler, in press-b; Müsseler & Wühr, in press).

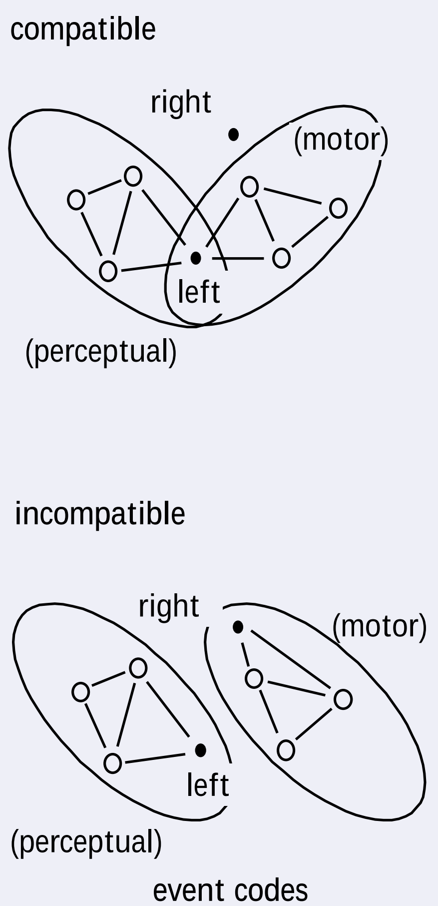


Fig. 3.3

Testing the Generality of the Blindness Effect

So far, the blindness effect was established with manual left- versus right-hand keypresses (*R*) and the identification of left- and right-pointing arrows (*S*). In three pairs of experiments, we tested the generality of this account by using other stimulus-response combinations than arrows and manual keypresses. Planning manual left-right keypressing actions impaired the identification of spatially corresponding arrows but not of words with congruent meaning. In contrast, planning to say »left« or»right« impaired the identification of corresponding spatial words but not of congruent arrows. Thus, as the feature-integration approach suggests, stimulus identification is impaired only when there is an overlap of perceptual or perceptually derived stimulus and response features, whereas mere semantic congruence does not suffice (Hommel & Müsseler, submitted).

Figure 3.3: *Assumed feature overlap and nonoverlap of event codes in a compatible and incompatible dual-task situation. The perceptual and the motor event code come into conflict over the overlapping feature code in the compatible condition, whereas they coexist in the incompatible condition.*

The Blindness Effect in Less Transient Actions

Keypresses as responses have the disadvantage of being very transient. Using a less transient everyday action as the response *(R)* allowed us to test the general validity and to analyze the time course of the blindness effect during action execution. We flashed probe stimuli of different orientations at different points in time during the relocation of a wooden block. The blindness effect, reflected by an impaired detection of probe stimuli matching the goal orientation of the wooden block, increased toward the end of the movement. After movement termination, the blindness effect quickly ceased. Thus, in less transient actions, the blindness effect reflects the anticipation of the action outcome not only in the spatial but also in the temporal domain (Wohlschläger, 2001).

3.2. Interference with Speeded Response Tasks[1]

Iring Koch
Jochen Müsseler
Wolfgang Prinz
Peter Wühr

In the experiments described in Section 3.1, *unspeeded* responses were combined with identification tasks to examine whether action planning and/or execution can exert an influence on perceptual encoding. In the projects described in the following, *speeded* responses were used in the primary task. The resulting dual task is similar to the well-known paradigm of the psychological refractory period (PRP paradigm): When two speeded tasks are performed in close succession, performance on the second task is impaired. Recently, an impairment has also been observed when the second task required only the visual encoding of a stimulus (Jolicoeur & Dell'Acqua, 1998, Cognitive Psychology, 36, 138-202). This finding and the blindness effect reported in Section 3.1 were the starting point for the present projects.

Examining the Blindness Effect in a PRP Task

This subproject (Wühr & Müsseler, in press-a) investigated the conditions under which the processing in a speeded response task interferes with concurrent processing in a visual encoding task. Three PRP experiments were designed in which a speeded left or right response to a tone was combined with the identification of a masked left- or right-pointing arrow that followed the tone at variable stimulus-onset asynchronies. Two additional experiments tested the impact of the presentation of tone on visual encoding.

There were four major findings: First, an unspecific decrease in identification accuracy was observed with decreasing stimulus-onset asynchronies. Second, a blindness to response-compatible stimuli was observed with speeded responses. Third, a specific interference was found between low- and high-pitched tones and left- or right-pointing arrows. Fourth, the specific tone-arrow interference modulated the specific response-arrow interference when the task allowed both to occur simultaneously. The present findings, which suggest both procedural and structural interference between response preparation and stimulus encoding, are interpreted in terms of a two-stage model of action planning (cf. Hommel, Müsseler, Aschersleben, & Prinz, in press; see, also, Müsseler & Wühr, in press-b).

Process Interference in a Response-Cueing Paradigm

In another series of experiments, Koch and Prinz (in press) further explored interactions between perceptual encoding processes and action planning and execution. The authors varied spatial cross-task compatibility in a response-cueing paradigm in which they used a stimulus movement for later report in a perceptual task and a finger movement as response in a logically independent reaction task. The movement direction of the target stimulus and the direction of the to-be-executed speeded response could be either the same (compatible) or different (incompatible).

For instance, in one experiment, Koch and Prinz (in press, Experiment 3) varied the interval between onset of the perceptual target and of the response go signal (target-go interval, TGI). In addition, in 25% of the trials, participants were informed prior to the start of the trial that they could ignore the visual target for the perceptual task (»no report« trials). Findings are shown in Figure 3.4. First, strongly increased RTs with short TGI were found, indicating unspecific dual-task process interference. Second, this interference was reduced in the »no-report« condition in general and in the short TGI condition in particular. This suggests that unspecific interference in the »report« condition was actually due to perceptual encoding processes and not to temporal information conveyed by the target onset, because this information was the same in »report« and »no-report« conditions. Moreover, RTs were shorter in compatible trials than in incompatible trials, indicating a cross-task compatibility effect due to code overlap between tasks. Furthermore, this cross-task compatibility was also present in »no report« trials, suggesting that stimulus movement direction is encoded automatically even if it is not needed to retain this information for later report.

[1] *Subprojects in this area were supported by the Deutsche Forschungsgemeinschaft (grant Mu 1298/2).*

Recently, these findings were also extended to a choice-RT experiment in which the speeded response was not cued prior to presentation of the visual target but rather by a reaction stimulus (high vs. low tone) occurring after the perceptual target (Azuma, Prinz, & Koch, submitted). Here, the authors found the same pattern of effects, indicating that the underlying processes are generalizable to different experimental paradigms. In general, we interpret the cross-task compatibility effect as resulting from overlap of code activation across tasks, whereas process interference seems to occur to prevent temporal overlap on the level of perceptual encoding and response retrieval processes.

Another question is why, in the present experiments, RTs were shorter in compatible trials, whereas, in the blindness experiments reported above, perceptual identification was impaired with compatible S-R relationship. This issue is addressed in more detail in Section 1.6 (cf. Wühr, Knoblich, & Müsseler, submitted).

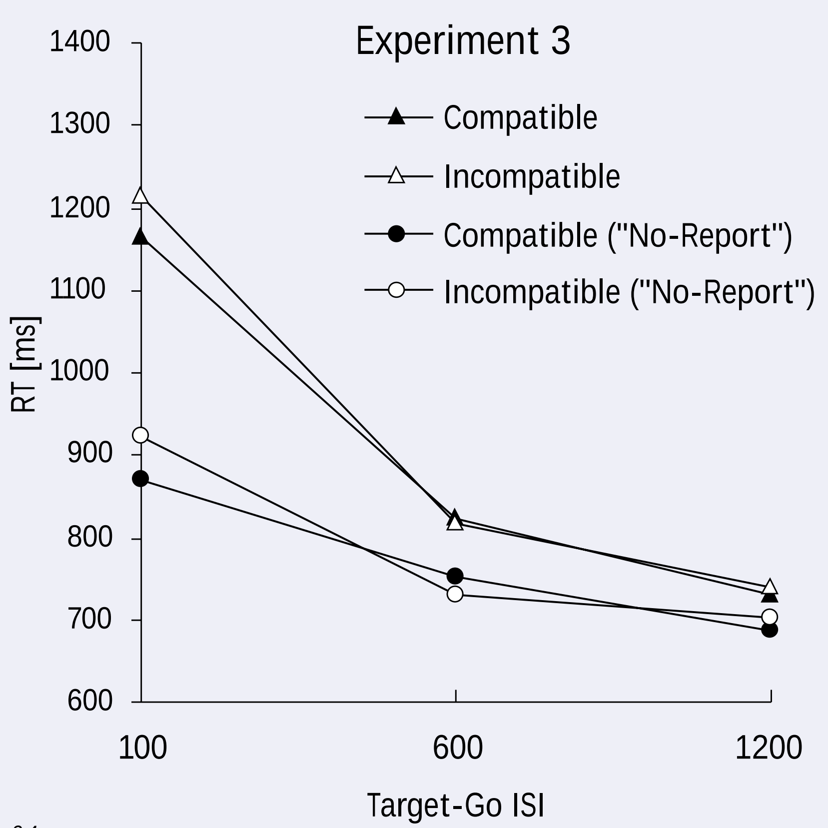


Fig. 3.4

Figure 3.4: *Findings of Koch and Prinz' (in press) Experiment 3. Reaction times (RTs) to go signal as a function of compatibility between direction of perceptual target movement and direction of manual response, interstimulus intervals (ISIs) between target and go signal, and of the necessity to report the target.*

3.3. Interference Studies On Imitation

Gisa Aschersleben
Harold Bekkering
Marcel Braß
Dirk Kerzel
Wolfgang Prinz
Anna Schubö
Andreas Wohlschläger

Research on imitation asks how humans and other species manage to copy other individuals' behavior by simply watching them. On the basis of perceiving an action, the imitating agent creates a motor program that may produce the same, or a closely resembling action.

Mirror Neurons

The traditional approach to the problem of imitation distinguishes between perceptual and motor processes and assumes a strict linear order between the two. In contrast, our approach builds on the assumption that perception and action are tightly coupled in a common representational domain. Neurophysiological evidence for such a claim comes from so-called mirror neurons in the Macaque prefrontal cortex (Area F5). These neurons fire when the monkey observes particular object-oriented actions, such as grasping, holding, or pulling an object. Importantly, these neurons also fire when the monkey performs a similar action. Each neuron codes a specific action and fires whenever such an action is either observed or performed by the monkey.

Interference Logic

To provide evidence for a human mirror system, we employed the following interference logic: If certain (neural) codes are in charge of identifying an action perceptually, and are similarly engaged in executing the same action, then perceiving the specific action should facilitate its execution, because the neural unit is already in an active state. On the other hand, perceiving an action different from the one to be executed is expected to impair performance, because the unit activated by the perceived action has to be inhibited, and the response-related unit has to be activated.

Empirical Evidence

Hand movements. The interference logic was applied to the execution and observation of manual gestures. In a series of experiments by Stürmer, Aschersleben, and Prinz (2000), participants were instructed to either close their hand, or to open it. The color of a videotaped hand on a computer screen told the participants which gesture was to be performed. In its resting position, the hand on the screen was in an intermediate position, and similar to the instructed hand movement, it could either close or spread while the imperative stimulus (color) was being presented. The interesting manipulation was the relation between the irrelevant hand gesture on the screen and the hand gesture performed by the participant. The presented and executed gestures were either the same (congruent) or different (incongruent). Results showed that the response latencies were shorter when the irrelevant gesture on the screen and the executed gesture were congruent.

Finger movements. Braß, Bekkering, and Prinz (2001; Braß, Bekkering, Wohlschläger, & Prinz, 2000) took the interference logic one step further. In the study of Stürmer et al. (2000), manual choice reactions had to be performed. Thus, it is unclear whether the interference from the visually presented manual gesture occurred at the level of response selection or response execution. If perception and motor programming share representational resources, then it should be possible to obtain interference from an observed action even when response selection is already complete, and only one step – response execution – has to be taken after stimulus identification. To confirm this rather radical prediction, Braß et al. (2001) instructed participants to either raise or lower one of their fingers in response to the onset of motion of a hand presented on a computer screen. Importantly, participants did not have to choose between raising and lowering. Instead, the response remained the same throughout a long run of trials. However, the irrelevant direction of the finger movement on the screen that triggered the response influenced reaction times. When the observed and the executed finger movement were congruent, responses were faster than in the incongruent condition. Additional brain imaging experiments revealed that the cerebral locus of the conflict was Broca's area, the human analog of Area F5 in the macaque (Iacoboni, Woods, Braß, Bekkering, Mazziotta, & Rizzolatti, 1999). Interestingly, however, mirror neurons in the macaque are tuned exclusively to object-oriented, whereas the above results were obtained with non-object-oriented actions. This fact qualifies the analogy of Broca's area and Area F5, unless it can be shown that human imitation is also tuned to object-oriented actions. Imitation research in children (Bekkering, Wohlschläger, & Gattis, 2000) showed that the presence or absence of objects plays a critical role for imitation. Children have a tendency to neglect the type of movement and the choice of the effector when imitating transitive actions. We replicated these finding in adults (Wohlschläger & Bekkering, submitted-a). Adults also occasionally choose the wrong finger, but only when they imitate finger movements that are directed toward objects and when the model's movement is approaching the object in an awkward, indirect way.

Fig. 3.5

Figure 3.5: *Stimuli used by Braß, Bekkering, and Prinz (2001). The index finger would either lift (bottom) or tap (top) from a neutral starting position (center). Participants had to execute either a lifting or a tapping movement. The type of response was blocked.*

Mouth movements. Although manual movements have been the focus of most studies on imitation, ideas related to mirror neurons can also be found in the literature on speech perception. The motor theory of speech perception holds that speech perception is accomplished by the same innate module that also contains the motor commands used in speech production. Evidence for such a close perception-action link was provided by investigating interference from visible speech gestures (Kerzel & Bekkering, 2000; Kerzel, submitted-b). The question was whether observing a visible speech gesture would lead to the activation of the corresponding motor commands. Participants in these experiments saw a male speaker's mouth pronouncing either /ba/ or /da/. Simultaneously, the written syllables »Ba« or »Da« were presented on the speakers lips, and participants were instructed to read the syllables. We observed that responses were faster when the observed and the instructed syllables were congruent. Again, these findings indicate that the perception of actions may directly activate the motor programs producing the same action in the observer.

Drawing movements. So far, studies using relatively simple actions have been described. But what about complex manual movements that take more than a few hundred milliseconds to execute? Schubö, Aschersleben, and Prinz (in press) investigated sinusoidal drawing movements on a graphics table. Participants had to copy the motion of a dot on the computer screen. However, on a given trial, they had to copy the dot's motion on the preceding trial. Thus, perceptual encoding of the trajectory occurred at the same time as imitation of the dot's trajectory on the previous trial. Results showed mutual interactions between perceptual encoding and motor performance: Watching a small motion while performing a medium-sized movement increased movement size, whereas watching a large motion led to a decrease. The same contrast-like impact was observed from action to perception. Thus, a contrasting mechanism acts to increase the distinctiveness of perception and action codes in a common representational domain. Nonetheless, further projects showed that similarities between perceived motion of a single dot and the direction of a hand movement facilitate responses (Nattkemper & Prinz, in press; Kerzel, Hommel, & Bekkering, in press).

Section 4: Control of Actions and Events

Figure 4.1: *Task intentions need to be shielded against interfering intentions that can be evoked by stimuli associated to them.*

Introduction

Actions serve to fulfill intentions. That is, the functional role of action is to achieve an intended or desired goal in a specific situation. This holds for even the most simple reaction time (RT) experiment, because task instructions must induce, prior to the experimental task, the participant's intention to act (e.g., by pressing a response button) when a specific stimulus event occurs.

In general, actions and events are organized in terms of intentions and tasks. To accomplish this organization, the cognitive system must be able to establish a relatively permanent representation of a task. It is this task representation that determines how stimulus events and actions are to be bound together in a given, prespecified situation. In this sense, task instructions serve to establish the appropriate cognitive representation of the task at hand, and this is a necessary prerequisite for psychological experiments. However, although such cueing of intentions by way of explicit instructions often occurs outside of experimental contexts as well, it is clear that intentions can also be activated endogenously, that is, without being triggered by explicit cues. Analyzing and understanding how such task representations are established and maintained is a major goal of cognitive psychology.

Recent developments in cognitive psychology see task representations as serving the role of higher-order, »executive« control structures. In a rapidly growing literature, such executive control structures have been termed »task sets.« These are action-related memory structures that specify which out of a potentially large range of stimulus events in a situation are relevant, how these are to be interpreted, and which action should be executed to achieve the intended goal.

Research Questions

This fairly general characterization of the role of task sets in the control of actions and the interpretation of events leads to a number of more specific research questions. Examples are: What is the temporal dynamic of establishing or changing a task set? Which components of task sets can be activated in memory prior to actual stimulus presentation in order to prepare for the task in advance? What is the microstructure of a task set; that is, does it comprise specific stimulus-response (S-R) »bindings« that may be re-activated upon presentation of that very stimulus? How can task sets be shielded from such interference in order to perform the intended task properly? Can task sets lead to involuntary persistence of actions, although the situation has changed, making the action no longer functional? These questions have been addressed in different classes of experimental paradigms that will be described briefly below.

Projects

A major experimental approach for investigating »executive« control of task sets is the »task-switching« paradigm. Here, a condition in which a task is repeated is compared with one in which the task (i.e., the intention) is switched. In the »cueing« paradigm, the task sequence is random, but each stimulus is preceded by an instructional cue (see Figure 4.2). Alternatively, tasks can be presented in a simple and predictable order (e.g., AA BBAABB, etc.), so that explicit cues are not necessary. Notwithstanding the specifics of the paradigm, the typical finding is that RTs and error rates are higher in the task switch condition than in the task repetition condition, thus demonstrating »switch costs.«

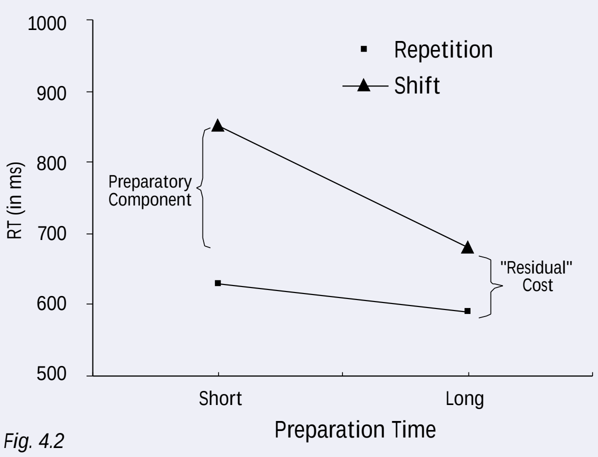


Fig. 4.2

Figure 4.2: *Illustration of typical data in the task-switching paradigm.*

Recent research has shown that these »switch costs« possess different components. One is a »preparatory« component that is commonly understood as reflecting the processing demands on »executive control functions« to configure the cognitive system for the new task (i.e., to maintain or shift the »task set«). The other component of switch costs is a »residual« component that may be due to a variety of processes such as involuntarily persisting activation or inhibition of the respective task set(s) or episodic retrieval of S-R bindings leading to interference effects. Several projects using the task-switching paradigm attempt to differentiate these processes and, thereby, to extend our knowledge about how cognitive processes are controlled. These projects are described in more detail below.

Whereas research on task-set switching is primarily concerned with the moment-to-moment reconfiguration of task sets and the maintenance of task sets over relatively short periods, intentions often have to be postponed for longer periods of time until an adequate opportunity for their execution occurs. One hypothesis, already suggested by theorists of the older German »will psychology« such as Ach and Lewin but revived in more recent models of voluntary action control, holds that uncompleted intentions facilitate the processing of intention-related information for extended times, even when participants do not think about the intention consciously. There is indeed evidence that representations of uncompleted intentions persist in memory in a state of heightened activation or accessibility (»intention-superiority effect«; Goschke & Kuhl, 1993, JEP: LMC, 19, 1211-1226). In order to investigate whether such intention-priming effects are independent from conscious retrieval, experiments were performed in which simple intentions (e.g., laying a table) were induced and had to be postponed until some later point. Prior to the execution of the intended activities, participants received an indirect memory test in which they had to complete word stems (e.g., KNI__) with the first word that came to mind. We expected that intention-related words (e.g., »knife«) would come to mind faster and/or with higher probability than equally well-learned neutral contents, even when participants were not instructed explicitly to retrieve the intention, and even when selective encoding or rehearsal of the intention was prevented.

Furthermore, task sets may, under certain conditions, be activated involuntarily by contents of perception. This conclusion can be drawn from the results of our ideomotor action research (Knuf, Aschersleben, & Prinz, in press). Our participants could only observe, but not manipulate, the course of a ball on a computer screen. Although instrumentally completely ineffective, the participants moved their bodies as if to exert some kind of magical influence on the moving ball – a classic example of ideomotor action. Although the majority of these induced movements could be shown to be intentionally guided, weaker effects of perceptual induction were found as well.

4.1. Endogenous Preparation in the Control of Task Sets

Thomas Goschke
Bernhard Hommel
Iring Koch
Bianca Pösse
Stefanie Schuch
Florian Waszak

This project is investigating the role of preparation in task switching by varying the cueing interval. Like other researchers (e.g., Meiran, 1996, JEP:LMC, 22, 1423-1442), we found that prolonging the cueing interval reduced shift costs, indicating that task sets can be activated in advance. Furthermore, we also observed that prolonging the time for the decay of task-set activation reduced shift costs, presumably because less residual activation needed to be overcome when switching to a different task (Koch, in press).

Another way to explore task preparation is to vary the response-stimulus interval (RSI) in a predictable alternating task sequence such as ABABAB. Using such a paradigm, we (Goschke, 2000) tested the specific hypothesis that advance preparation consists, in part, in the *retrieval of a verbal task representation* into working memory. In task-repeat blocks, participants consistently performed only one task, whereas in task-switch blocks, they alternated between two tasks (responding to the identity or color of letters). Lengthening the predictable RSI from 14 to 1500 ms reduced the switch cost. In a second experiment, the RSI was always long, and participants were instructed either to verbalize the next task (»letter« or »color«) prior to the stimulus or perform a verbal distractor task during the RSI. Whereas task retrieval led to a reduction of the switch cost, no reduction of the switch cost was obtained when task retrieval was prevented by the distractor task (see Figure 4.3). This indicates that the retrieval og a verbal task representation (»self-instruction«) is an important component of advance task-set reconfiguration.

Figure 4.3: *Task-switch cost as a function of the response-stimulus interval (RSI) and the intervening activity during the RSI (verbal distractor task vs. verbal self-instruction). Data from Goschke (2000, Exp. 1 and 2).*

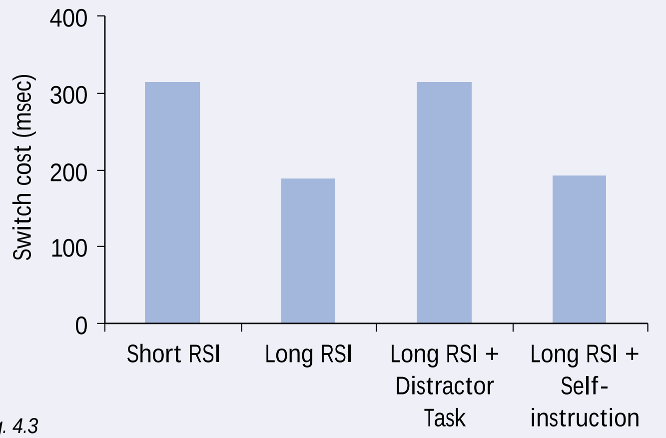


Fig. 4.3

In other experiments, we observed that preparation in simple, predictable task sequences is based primarily on external cues if these are available. For instance, in one experiment (Koch, submitted-b), two groups of participants switched between two tasks. One group could rely only on the predictable sequence; the other group received redundant external task cues. Longer preparation time had much stronger effects with external cues compared with only the predictable sequence, suggesting that endogenously preparing for a task switch is difficult if it is not triggered by an external cue.

This conclusion is supported by experiments exploring whether incidentally learned task predictions help to prepare a task (Koch, in press). Participants performed a complex repeating task sequence. When this learning sequence was changed, negative transfer occurred, indicating task preparation based on task sequence learning (see Figure 4.4). However, the preparation effect did not differ for task shifts and repetitions, suggesting that self-generated cues are used primarily for *task-specific* preparation, but not for specifically preparing a task *switch*. In another study, we attempted to rule out the possibility that the switch unspecificity of the preparation effect was due merely to the fact that task sequence learning was incidental and preparation was therefore based on »implicit« learning. An easy alternating runs sequence was used, and participants were informed explicitly about its existence. Nevertheless, once again, the negative transfer effect due to a sequence change did not differ between task shifts and repetitions. This indicates that the shift unspecificity is due to the nature of the cues and not to whether learning is incidental or intentional. In conclusion, self-generated cues, based on task sequence information, lead primarily (but not necessarily exclusively) to task-specific preparation.

Involuntary Carryover Effects of Previous Task Sets and Residual Switch Cost

Another series of experiments (Goschke, 2000) investigated whether part of the »residual« switch cost (see Figure 4.2) is due to persisting inhibition of task sets. More specifically, we assumed that inhibitory processes, which serve to reduce crosstalk by suppressing competing task sets and/or distracting stimulus information, are triggered selectively when a stimulus elicits a response conflict (»conflict-triggered control« hypothesis; Goschke, 2000). This prediction was tested by investigating response-congruency effects. On response-incongruent trials, a response conflict was induced by mapping two stimulus dimensions to incompatible responses (e.g., the identity of a stimulus required a left keypress, whereas its color required a right keypress). On response-congruent trials, the two stimulus dimensions were mapped to the same response. Response times increased significantly on task-switch trials that were *preceded* by response-incongruent (compared to congruent) trials, indicating persisting inhibition of the previously distracting stimulus dimension. As anticipated, no such effect was present on repeat trials. The carryover effect of incongruency on the previous trial was not attenuated by increasing the preparation interval (Goschke, 2000), indicating that inhibition was released only when the next stimulus was processed. In conclusion, part of the residual switch cost appears to reflect persisting inhibition of competing task sets or distracting stimulus dimensions. This suggests that the cognitive system continuously monitors the strength of response conflicts in order to adjust inhibitory control processes in a context-sensitive manner.

The point in time when inhibition is triggered was explored further in a series of experiments using a no-go methodology (Schuch & Koch, submitted). As in the above-mentioned study, we hypothesized that inhibition is primarily due to the need to select a response. To test this idea, participants always had to prepare for the next task, but occasionally and unpredictably they had to withhold their response. On such trials, task preparation was not accompanied by response selection. We found that shift costs disappeared after no-go trials, whereas there were clear shift costs after go trials, suggesting that inhibition of competing task sets occurs only when a response must be selected.

Finally, in cooperation projects, we are investigating the neurocognitive basis of stimulus-set and response-set switching using brain imaging techniques (functional magnetic resonance imaging, fMRI.[1] A further cooperation project with the MPI in Leipzig is planned for this October (principal investigators are Iring Koch, Munich, and Marcel Brass, Leipzig). Finally, Thomas Goschke will start another project together with Oliver Gruber (MPI for Cognitive Neuroscience in Leipzig).[2]

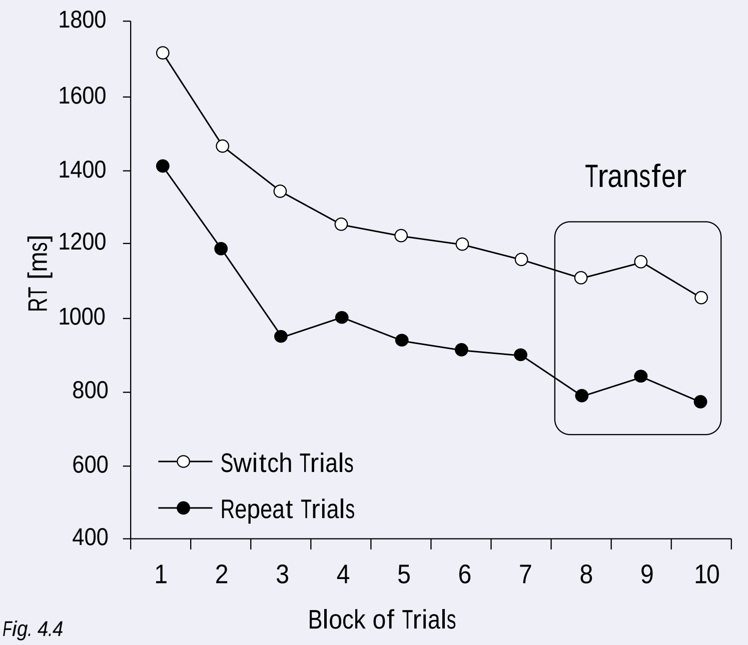


Fig. 4.4

Figure 4.4: *Mean RT (in ms) in Experiment 2 of Koch (in press) as a function of trial type (switch vs. repeat) and blocks of trials. The task sequence presented in Block 9 was different from that in the other blocks.*

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[1] Supported by the German Israeli Foundation (GIF). Participating institutions (counseled by Hommel, Leiden, Netherlands) are the MPI for Cognitive Neuroscience in Leipzig (von Cramon & Brass), the Ben Gurion University at Beer Sheva, Israel (Meiran), and our institute (Prinz & Koch).
[2] Supported by the Deutsche Forschungsgemeinschaft (DFG SPP 1107 »Exekutive Funktionen«).

4.2. The Role of Episodic S-R Bindings in Task-Switch Costs

Bernhard Hommel
Iring Koch
Bianca Pösse
Florian Waszak

As described above, task-switch costs (TSC) have been proposed to reflect a kind of »task-set« reconfiguration that is needed to prepare the cognitive system for the new task (Rogers & Monsell, 1995, JEP: General, 124, 207-231). However, other interpretations are also possible: Allport, Styles, and Hsieh (1994, A & P, 15, 421-452) attributed TSC to the involuntary persistence of the previous task set, this leading to proactive interference (task-set inertia). More recently, Allport and Wylie (2000, A & P, 18, 35-70) have suggested a retrieval account of TSC that goes beyond the inertia hypothesis. It assumes that previously appropriate task sets may be retrieved from memory automatically when stimuli recently associated with these sets are presented, thereby creating conflict with the currently appropriate set. This approach differs from others in emphasizing the role of stimulus repetition and of the bindings between stimulus and task set. It predicts that TSC should be largely reduced or even eliminated when the stimuli used have not yet occurred in the context of another task.

We examined this prediction in a series of experiments (Hommel, Pösse, & Waszak, 2000; Waszak, Hommel, & Allport, submitted). Participants named pictures and read words in response to incongruent picture-word stimuli (see Figure 4.5), switching task on every second or third trial. Some of the stimuli were presented in both tasks, picture-naming and word-reading (set PW), whereas other stimuli were presented for word-reading only (set WO). Figure 4.6 shows the results of Experiment 1 from Waszak et al. (submitted): Stimuli presented in word-reading only (WO) showed a TSC of about 100 ms; stimuli presented in both tasks (PW), in contrast, showed a TSC of about 230 ms. Thus, switching tasks in response to stimuli appearing in both task contexts more than doubled the switch cost. Further experiments (Waszak et al., submitted, Experiments 3 and 4) revealed that this effect survives a large number of intervening trials. In these experiments, stimuli were presented in such a way that the mean lag between the occurrence of an item for picture naming and the subsequent presentation of the same item for word reading was 100-200 trials. Furthermore, we found that presenting an item several times in picture naming (before the occurrence of the same item in word reading) yielded a larger cost of task switching than presenting the item once in picture naming and later on once in word reading (Waszak et al., submitted, Experiment 2).

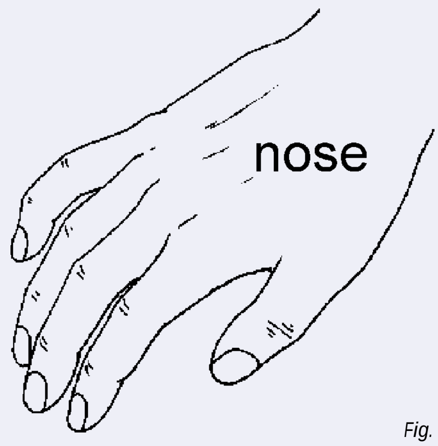

Fig. 4.5

Figure 4.5: Typical picture-word Stroop stimulus.

These results cannot be explained in terms of a preparatory mechanism setting up the appropriate task set of the upcoming task. Rather, they suggest that the cognitive system stores a memory trace combining item-specific information with information about the particular task context (in this case, picture naming). When the stimulus appears again, it retrieves the associated task set, which then competes with the currently selected and/or actually needed set. The more traces involving one task (picture naming) accumulate in memory or the stronger they are, the more impaired the performance when the stimuli are presented during the other task (word reading).

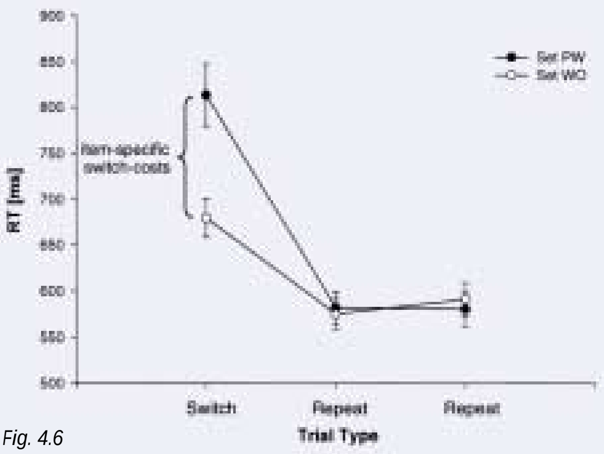

Fig. 4.6

Figure 4.6: *Data from Waszak, Hommel, and Allport, submitted, Experiment 1: Mean RTs for word reading as a function of trial (switch, two repeats) and item set (set PW/picture-naming and word-reading and set WO/word-reading only).*

In another series of experiments, Iring Koch and Alan Allport explored item-specific effects in task switching using a pair of numerical judgment tasks (to decide whether a digit was odd vs. even, or whether it was higher vs. lower then 5). Some digits were mapped consistently to only one task (consistent mapping, CM), whereas there was a variable mapping for the remaining digits (variable mapping, VM). In one experiment, participants practiced task switching with both CM and VM stimuli (see Figure 4.7). After six practice blocks, the mapping for the CM digits was reversed. Results showed a clear RT benefit for CM items. Furthermore, the CM mapping reversal produced strong negative transfer effects for both congruent and incongruent CM stimuli. The effect for congruent stimuli, for which only the task but not the response changed, indicates the influence of stimulus-task associations. Nonetheless, this interference effect did not influence the amount of shift costs. Similar experiments with partially comparable results were obtained using alphabetic arithmetic tasks. Currently, we are exploring the boundary conditions for the shift specificity of item priming that we found for word reading with incongruent picture-word stimuli.

In a further series of experiments, we found that task-related information is not only associated with stimuli but also integrated with whole stimulus-response episodes (Pösse, 2001). Under single-task conditions, benefits due to response repetition have been found to depend on stimulus repetition, which indicates that co-occurring stimulus and response features are associated automatically. The same effect can be demonstrated in task-switch situations, yet its size is reduced in switch compared with repeat trials (Hommel, Pösse & Waszak, 2000; Pösse, 2001). Apparently, under these conditions, stimulus-response bindings are mediated by the task context, which suggests that their representations include information related to the task under which they were formed.

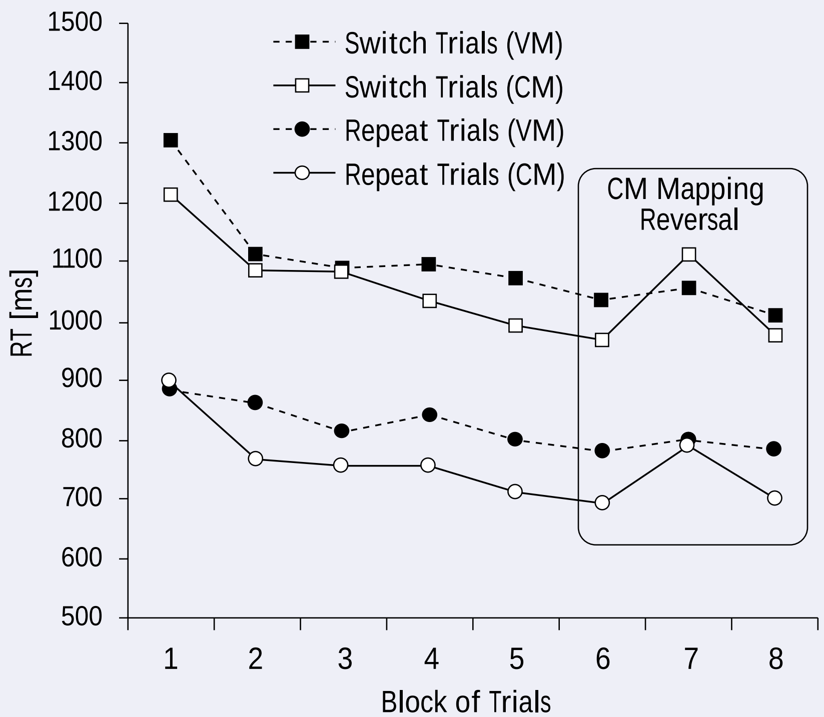

Fig. 4.7

Figure 4.7*: RT as a function of trial type (switch vs. repeat), mapping (Consistent stimulus-task mapping, CM vs. variable mapping, VM), and mapping reversal for CM items in Block 7.*

4.3. Priming of Control Structures in Memory: Costs and Benefits of Persisting Activation of Intentions

Thomas Goschke

In this project, Goschke in collaboration with Kuhl (University of Osnabrück) is investigating whether representations of intentions in long-term memory are characterized by special functional properties. Whereas research on task-set switching focuses on the moment-to-moment configuration of cognitive sets in response to changing task demands, it is often the case that intentions have to be maintained through longer delays until an opportunity for their execution occurs. Thus, maintenance of stable goal representations is as essential for action control as flexible goal switching. For instance, it has been suggested that intentions are shielded against competing action tendencies by specific control processes (Goschke & Kuhl, 1993, JEP:LMC, 19, 1211-1226), or that representations of intentions are tagged by *relevance* markers that facilitate the detection of intention-related cues (Prinz, 1990, in Spada (Ed.), Lehrbuch Allgemeine Psychologie, 25-114), or that goals are sources »of high and constant activation ...« in memory (Anderson, 1983, The Architecture of Cognition, 156).

In previous experiments, Goschke and Kuhl (1993, JEP:LMC, 19, 1211-1226) found faster recognition latencies for words related to a later-to-be-performed activity compared with control items, indicating that representations of intentions persist in memory in a state of heightened activation or accessibility (*the intention-superiority effect*). Our current research (Goschke & Kuhl, submitted-a) is investigating whether the intention-superiority effect is independent from conscious retrieval attempts and can be found in indirect memory tests in which participants are not instructed to consciously recall intentions. Participants memorized »scripts« describing two action sequences (e.g., setting a dinner table and clearing a desk). After studying them, they were instructed that they would have to execute one of the activities later, whereas the second activity only had to be remembered. In a subsequent word-stem completion test, they had to complete word stems with the first word that comes to mind. All word stems had several possible completions, but one third of them could be completed in particular with words from the to-be-executed script (intention-related items), another third could be completed with words from the neutral control script (neutral items), and the remaining stems could be completed with words from a third script that had not been presented in the study phase (baseline items). To minimize effects of voluntary retrieval attempts on completion performance, only word stems for which the solution word came to mind within the first second after presentation of the word stem were analyzed. As shown in Figure 4.8, we obtained a typical repetition-priming effect: Word stems were completed more often with script words when the script had been studied compared with when the script had not been studied. More important, we also obtained an intention-priming effect: Word stems were more often completed with script words when the script had to be executed compared with when the script had only to be remembered. This effect was independent from whether participants rehearsed the scripts after study, or whether rehearsal was prevented by a distractor task. Thus intention-related memory contents came to mind with a higher probability, even though participants were not instructed to recall them, and even though only »spontaneous« solutions were analyzed that came to mind within the first second, making it unlikely that the effect was mediated by an extended controlled memory search. In conclusion, intentions appear to modulate subsequent information-processing without a conscious recollection of the task or the instruction.

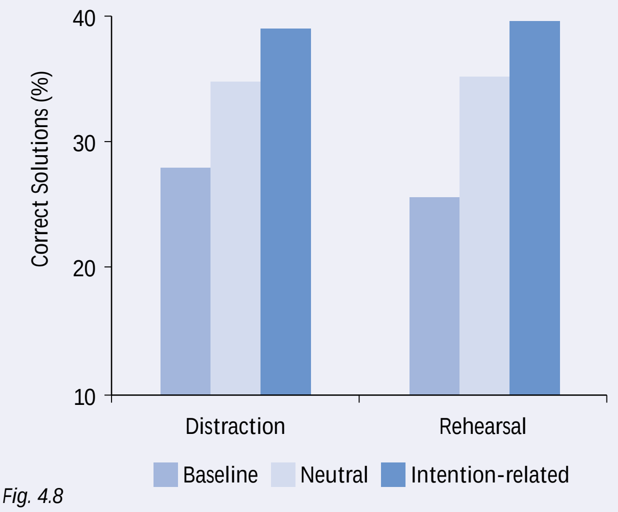

Fig. 4.8

Figure 4.8*: Proportion of word stems completed with words from an action script when the script had to be executed (intention-related), had to be remembered (neutral), or had not been presented before (baseline).*

In a related study, we tried to show that sustained activation of intention-related memory contents can also produce increased *interference* when intention-related items serve as distractors (Goschke, Dibbelt, & Kuhl, submitted). Participants again memorized two action scripts and were then instructed to execute one of them later. Next, participants had to memorize an additional study list of 6 words, all of which were taken from either the to-be-executed or the control script. Then, they completed a recognition test containing positive probes from the 6-item study list and distractors that had not been in the study list but were taken from the same script as the study-list words. Participants thus had to discriminate positive probes, which had been in the study list, from distractors, which had not been in the study list, but in the corresponding script. Assuming that distractors from the to-be-executed script would exhibit more sustained or heightened activation, lists containing intention-related distractors should produce larger recognition latencies, because the difference between the activation levels of positive probes and distractors is smaller compared with test lists containing distractors from the neutral script, which are subject to stronger decay and thus can be rejected more easily as foils. As shown in Figure 4.9, this is exactly what we found.

If one considers these results together with the findings from task-set switching research summarized in Section 4.1 and 4.2, it is obvious that the control of intentional action involves various subprocesses, including maintenance of intentions in long-term memory, retrieval of verbal task-representation from memory, proactive interference from recently activated task sets, persisting inhibition of distracting stimulus dimensions, and retrieval of episodic stimulus-response bindings. From a more general theoretical perspective, one can conceive of these processes as serving complementary requirements in the control of action (Goschke, 2000, in press-e): On the one hand, the cognitive system must be reconfigured from moment to moment to meet changing task demands; on the other, cognitive configurations must be maintained over time and in the face of distractions. Whereas persisting activation of intentions in memory may promote the maintenance of intentions in the face of distractions, it incurs a cost when flexible goal switching is required. Thus the seemingly dysfunctional residual task-switch cost discussed in Section 4.2 may be an unavoidable side effect of an adaptive tendency to shield intentions from distractions and to avoid crosstalk by suppressing competing task sets (Goschke, 2000). This perspective raises the important question of how the balance between maintaining and shifting goals is regulated in a dynamic and context-sensitive way. This question will be addressed by Goschke in collaboration with Gruber (MPI for Cognitive Neuroscience) in a collaborative project[1] that will combine behavioral and neuroimaging methods to investigate interactions between complementary control operations.

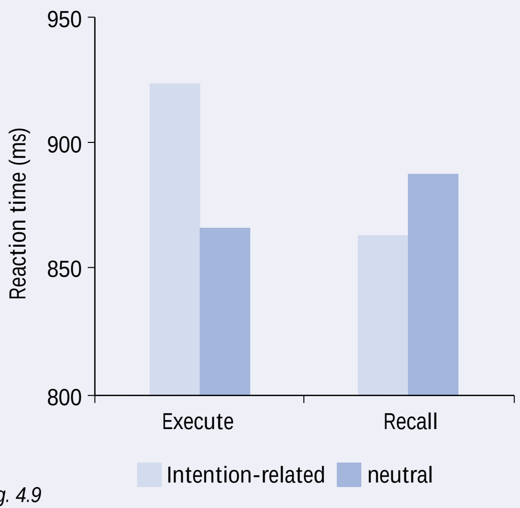

Fig. 4.9

Figure 4.9*: Mean recognition latencies for test lists with intention-related and neutral distractors in the execution and recall condition.*

[1] *Supported by the Deutsche Forschungsgemeinschaft (SPP 1107 »Exekutive Funktionen«).*

4.4. Ideomotor Action

Gisa Aschersleben
Lothar Knuf
Sara de Maeght
Wolfgang Prinz

Ideomotor actions may, under certain conditions, arise in a person who is observing the course of certain events. The classic case refers to body movements induced by watching other people's actions or by watching the course of physical events. Consider, as an example, an observer who has just launched a bowling ball and is now following its course. As long as it is open whether it will reach its intended location or not, she can hardly prevent herself from moving her hand or twisting her body as if to exert some kind of magical influence on the ball. This involuntary, or even countervoluntary nature of ideomotor actions has placed them among the curious phenomena of mental life. Moreover, the fact that they are instrumentally completely ineffective makes them even more mysterious (Prinz, 1987, in Heuer & Sanders (Eds.), Perspectives on Perception and Action, 47-73).

This mystery may be unraveled at least partially if one discusses ideomotor phenomena in the present context, that is, as some kind of involuntary activations of task sets. This view is supported by a number of our studies that investigated how the pattern of body movements is induced in the observer relative to the course of events that induce them (Knuf, Aschersleben, & Prinz, in press). Two answers to this question have been suggested: Perceptual induction (we perform movements that would lead to the effects we see), and intentional induction (we perform movements that would lead to the effects we would like to see). Both hypotheses have been tested within a paradigm modeled after the logic of the bowling ball example (see Figure 4.10): On each trial, a ball would move toward a target, either hitting or missing it. This journey was divided into two phases, instrumental and induction. During the instrumental phase (which lasted about 1 s, and was terminated by the ball crossing an invisible horizontal line on the display), participants could influence one of the two display components by corresponding joystick movements. In the ball condition, joystick movements would shift the *ball* to the left or the right. By this means, participants were able to correct the ball's trajectory and gain a chance of hitting the target. In the target condition, joystick movements would shift the *target* to the left or the right, in an attempt to give it a chance of being hit.

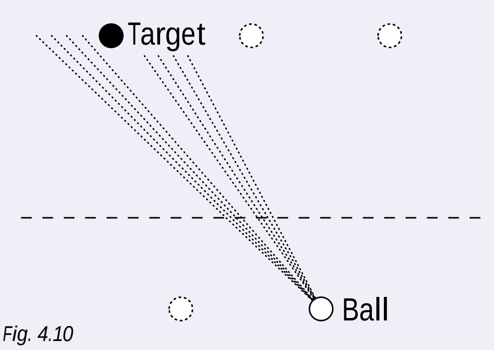

Fig. 4.10

Figure 4.10: *A paradigm for the study of ideomotor movements (Knuf, Aschersleben, & Prinz, in press). In the example shown, the ball leaves from one of two possible starting positions (at the bottom) and travels toward one of three possible target positions (at the top). Dotted lines indicate the set of eight preprogrammed trajectories, one of which is chosen randomly for presentation on a particular trial. The horizontal line indicates the transition from instrumental phase (below) to induction phase (above).*

This task allowed us to study ideomotor hand, head, and foot movements occurring during the induction phase and to examine how they related to the events on the display. Perceptual induction would predict that movements occurring during the induction phase would always point in the same direction as the ball motion. Intentional induction predicts a more complex pattern: First, it leads one to expect that joystick movements occur on misses but not on hits (if the observer interpolates that the ball will eventually hit the target, no further instrumental activity is required to achieve the goal). However, if the observer sees that the ball will miss the target, this should induce ideomotor movements performed in a (futile) attempt to affect the course of events. These futile attempts should always depend on the side on which the ball is expected to miss the target. In the ball condition, body movements should act to push the ball toward the target, whereas, in the target condition, movements should act to push the target toward the ball.

Using this paradigm, we were able to demonstrate the existence of ideomotor movements under controlled experimental conditions (Knuf, Aschersleben, & Prinz, in press). The results support both intentional and perceptual induction, even though effects were differently pronounced between effectors (for an example of hand movement data, see Figure 4.11). In the case of intentional induction, hand movements were guided clearly by ball-related intentions in the ball condition and by target-related intentions in the target condition. The noninstrumental effectors were not dependent on task conditions. Instead, induced head and foot movements were guided by ball-related intentions in both conditions.

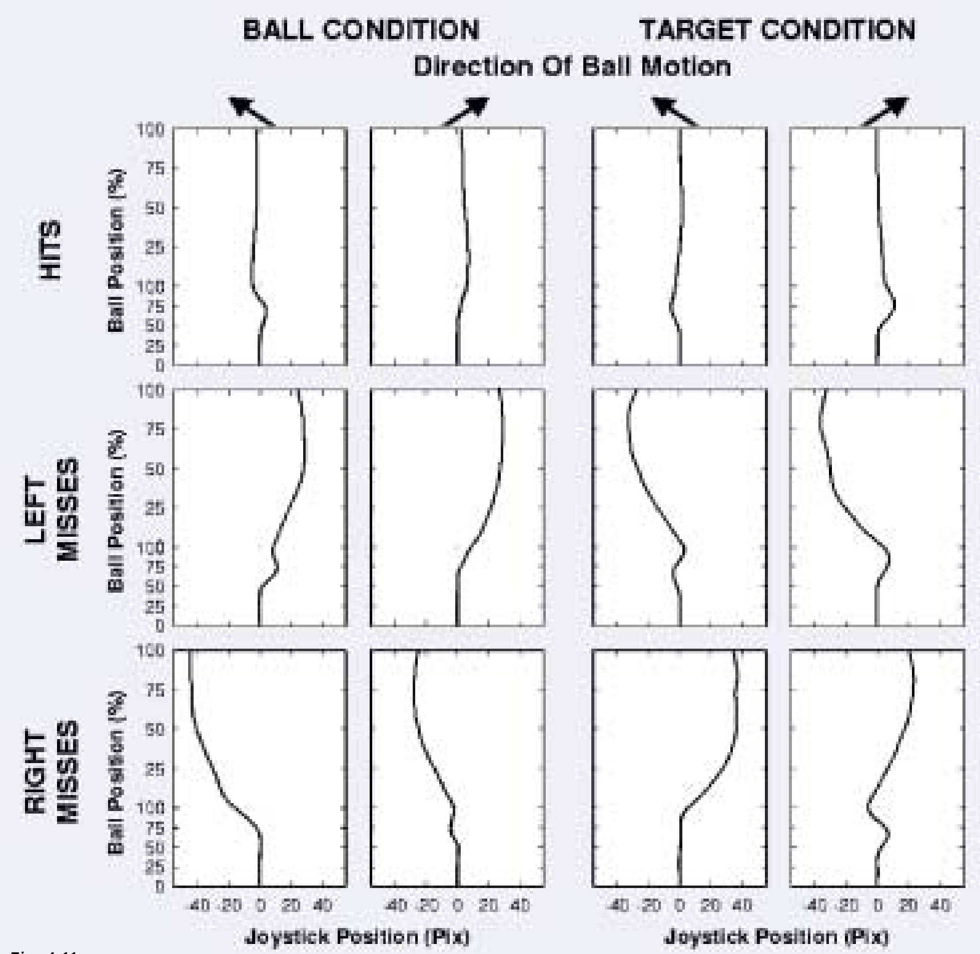

Fig. 4.11

Figure 4.11: *Mean trajectories of joystick positions on trials resulting in hits and left and right misses for two conditions (Ball vs. Target) and two directions of ball motion (↖ vs. ↗). The ordinate indicates the relative vertical ball position on the display for the instrumental and the induction phase (separated by the horizontal line). Positive and negative pixel units depict joystick shifts to the right and the left relative to the joystick's home position. Data taken from Knuf, Aschersleben, and Prinz (in press).*

Though participants in our experiments were well aware that their movements were instrumental only during a short initial period on each trial, the task did not permit a clear separation between induced and instrumental activity. In experiments performed by De Maeght, Knuf and Prinz, the paradigm was extended with a condition in which the participants' movements were entirely non-instrumental. All events on the screen were computer controlled (including a simulation of ball or target shifts during the instrumental phase, which were explained as being produced by a virtual teammate). To ensure that the participants always observed the events on the screen, they worked on a tracking task in which they had to track the *vertical* ball position with corresponding *vertical* joystick movements. It should be noted that tracking movements did not produce any effects on the screen (only the tracking quality was fed back at the end of each trial). Horizontal shifts, in contrast, were interpreted as induced movements and treated in the same way as in the original paradigm. Results confirmed most of the previous findings. However, although evidence for intentional induction was still observed in all effectors, they were always ball-related in this case. Currently, we are investigating possible reasons for these results.

Section 5: Acquisition of Action-Event Structures

Figure 5.1: *Actions are performed to produce particular events by intention. Thus, the cognitive system has to learn the contingencies between movements and their effects: At first, a piano player has to learn that each keypress produces a certain tone. After that, he no longer needs to think about the keypressing movements, but can play a melody just by imagining the tones.*

Introduction

Research Questions

One important aspect of the relationships between cognition and action is that actions are performed to attain desired goals, hence, to intentionally produce particular events. These events may differ in their remoteness from the agent's body: An action can be performed to produce events in one's own body *(proximal action effects)*, like feeling one's arm moving toward a light switch, or to produce events in the environment *(distal action effects)*, like seeing the light going on. Additionally, action goals may also differ in their complexity: Some action goals are simple, such as moving a finger to press a key, whereas others are rather complex and require the combination of several actions, such as driving an automobile.

By definition, an action goal can be attained only after the action has been completed. But in voluntary action, a representation of the goal seems to be involved before the action starts, that is, in the early stages of action planning. This anticipatory representation of the action goal has at least two functions: First, we plan and execute our actions in such a way that they are likely to lead to the desired goal, and hence, an anticipatory goal representation is involved in *action control*. Second, after performing the action, we compare the attained goal with the desired goal, and hence, an anticipatory goal representation is involved in the *evaluation of action success*. Yet, both functions require the presence of a representation of the goal that controls the selection and execution of appropriate movement patterns. According to this logic, intentional action is controlled by some anticipatory representation of the intended and expected action effects. This idea is usually referred to as the »ideomotor principle.«

From this perspective, the performance of goal-directed actions may become very difficult, because the relationships between actions and their effects tend to be rather complex: On the one hand, one action may lead to several different effects, whereas, on the other hand, one effect may be produced by several different actions. Thus, the cognitive system has to *learn* the contingencies between movements and their effects in order to perform voluntary actions. Through this, the system can learn to anticipate certain action effects when it performs certain movements. Afterwards, anticipatory goal codes can be derived from the learned relationships between movements and their effects and used to control goal-directed actions.

Projects

The projects in this section deal with the issue of how the representations of action effects are acquired and how they are then used to control the selection of voluntary actions. The major common feature of the projects is the underlying idea that actions are triggered and controlled by thinking about their distal action effects. As we shall see, this »action-effect principle« helps to interpret data (1) on the control of simple, discrete actions, but also (2) on the combination of simple actions into more complex action sequences, and (3) on how people learn to perform continuous motor skills in, for example, sports.

The project »Acquisition of Action-Event Structures for the Control of Discrete Movements« shows how representations of action effects are acquired and how they are used to control simple, discrete actions. The underlying assumptions are incorporated into a two-stage model of action control. The general notion is that in Stage 1 of the model, given sufficient contingency, distal effects become associated with the movements that elicit them. Hence, actions are represented cognitively by codes providing information about the sensory effects a given motor program is likely to produce. Stage 2 of the model refers to the selection of goal-directed movements. When the learned associations attain a certain strength, presentation of the action effects leads to an activation of the motor program assigned to the movement. Thus, movements can be selected by anticipating (i.e., activating the codes of) their consequences.

The project »Acquisition of Action-Event Structures for the Control of Sequential Movement« shows that associations between movements and their effects also impede the learning of action sequences. This learning plays a central role in action control, because it allows people to predict upcoming events and to prepare their corresponding responses. The major experimental paradigm for investigating sequence learning is the serial reaction time (SRT) task (Figure 5.2). Usually, participants in the SRT task show a practice-related improvement in performance, but they have no conscious recall of what they had learned before (implicit learning).

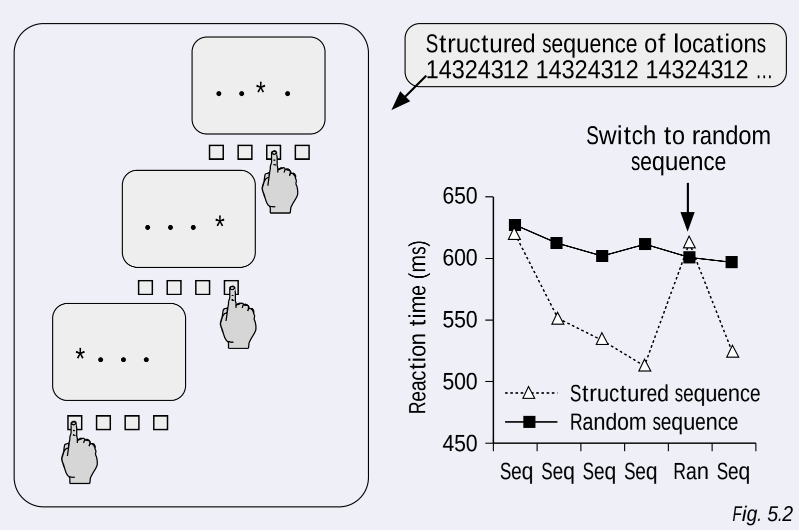

Fig. 5.2

Figure 5.2: *The serial reaction time task (SRT task). A shift from a structured sequence to a random sequence typically leads to an increase in response time indicating that the structure of the sequence has been learned.*

One of the topics that has received much attention is whether sequence learning is mediated mainly by the *perceptual* or by the *motor system*. Although there is evidence that sequence learning is based on learning relations between the stimuli of the sequence (S-S learning), the results obtained in the second project imply that the structures of the response sequence (R-R learning) or the structures of both stimuli and responses (S-R or R-E learning) are also important for learning action sequences.

The project »Acquisition of Action-Event Structures for the Control of Motor Skills« shows that some initial practical implications of the action-effect principle may be found in sports motor processes: Alongside the positive effects of self-control over learning processes, focusing attention on the distal effects of a motor action in sports leads to better learning than focusing on the course of the movement. Moreover, learning associations between movements and their effects also has implications on perception: As action effects are just certain classes of environmental events, they will also become activated when these events are perceived independently from one's movements. As a consequence, the perception of such events will include the indirect activation of codes for movements suited to produce these events.

5.1. Control of Discrete Movements

Birgit Elsner
Bernhard Hommel
Iring Koch

The Acquisition of Associations Between Actions and Their Perceivable Consequences[1]

The main question in this project was how anticipatory representations of the intended and expected action effects are acquired, and how they are then used to control the selection of voluntary actions. Some predictions derived from the two-stage model of voluntary action were tested successfully in several experiments (Elsner, 2000; Elsner & Hommel, 2001).

Each experiment was divided into two phases: In the first phase, the acquisition phase, participants performed a free-choice left or right keypressing response, and each keypress was followed contingently by a low or a high tone (see Figure 5.3). According to the two-stage model, the experience of several co-occurrences of a response and a tone should lead to an association between the motor pattern underlying the keypress (i.e., the action) and the cognitive representation of the tone (i.e., the action effect). If so, presenting one of the tones (e.g., the high tone) should prime the associated response (e.g., the left keypress). This was tested in the second phase, the test phase of the experiments, in which the tones were used as imperative stimuli requiring a left or a right keypress.

Figure 5.3: *Experimental design testing the two-stage model.* (Top) *Acquisition phase: Each keypress is followed consistently by a certain tone* (Bottom) *Test phase: Action-effect tones are presented as imperative stimuli. Typically, acquisition-consistent responses are executed faster and selected more often than acquisition-inconsistent responses.*

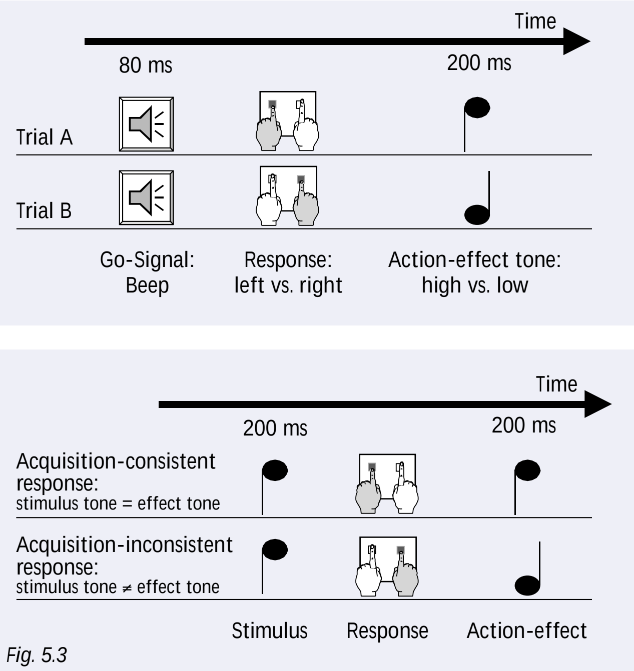

Fig. 5.3

The results obtained in the test phase were consistent with these expectations. Both reaction time (RT) and response frequency (RF) data supported the idea of action-effect integration and response activation through stimuli corresponding to learned action effects (Elsner & Hommel, 2001). As this was true even when participants were distracted strongly by another, attention-demanding task, automatic response priming through previously acquired associations is the most likely cause of the obtained results. Moreover, the RT and RF differences were still reliable when effect tones were no longer presented in the test phase. Thus, the acquired response-effect associations seem to be resistant to extinction.

In line with the two-stage model, the results suggest that (1) response-tone associations are actually formed; (2) these associations are bidirectional, so that activating one associate tends to activate the other; and (3) these associations have an impact on, and thus are likely to mediate, response selection.

By assuming an associative basis of action control, we place our approach in the context of associative learning theory. To further explore this assumption, we investigated whether variables that are known to influence associative learning also affect the strength of learned action-effect associations (Elsner, 2000). To this end, we systematically varied the temporal delay between *(i.e., temporal contiguity)* or the probability of co-occurrence of the keypress and the tone *(i.e., contingency)* in the acquisition phase, and examined whether these variations would have a systematic impact on the participants' performance in the test phase. Results showed that the RT difference in the test phase increased with increasing temporal contiguity and increasing contingency in the acquisition phase. This supports the hypothesis that the amount of response activation in the test phase is dependent on the strength of the response-effect associations learned in the acquisition phase, and hence, lends further support to the notion of an associative basis of action control.

Investigating the Neural Basis of Learned Action-Effect Associations

The behavioral studies reported so far suggest that voluntary action is goal-directed and depends on the ability to learn associations between movements and their perceivable consequences. In cooperation with H. R. Siebner (Klinikum rechts der Isar, Munich), we investigated the neuronal substrate linking the perceivable outcome of an

[1] *Supported by the Deutsche Forschungsgemeinschaft (DFG: SFB 462).*

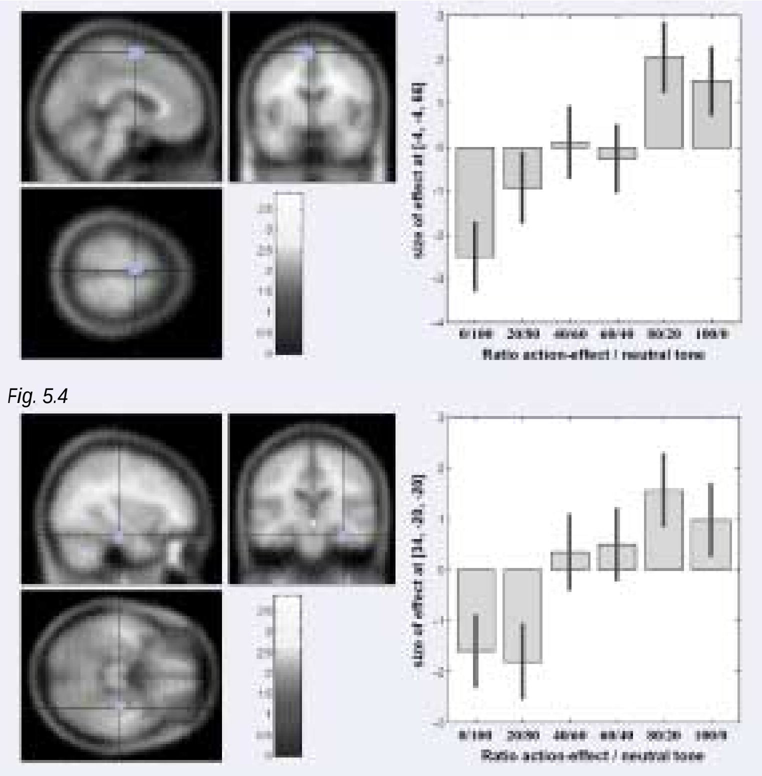

Fig. 5.4

Figure 5.4: *Brain regions showing a linear relationship between functional activation and the proportion of perceived action-effect tones.* (Top) *Activation in the supplementary motor area (SMA).* (Bottom) *Activation in the right hippocampus. The bar charts represent the activations as a function of the proportion of perceived action-effect tones.*

action to the action itself with $H_2^{15}O$ positron emission tomography (PET) (Elsner et al., submitted). Healthy adults first learned that self-initiated keypresses (i.e., actions) were followed consistently by certain tones (i.e., action effects). During PET imaging, participants listened to varied ratios of (response-related) action-effect tones and (not response-related) neutral tones without performing any movement.

As depicted in Figure 5.4, the caudal supplementary motor area (SMA) and the right hippocampus showed a graded increase in functional activation as a function of the frequency of action-effect tones, suggesting that both cortical areas play a role in binding the outcome of an action to the action itself. The activity of the hippocampus may be interpreted as representing the retrieval of previously learned action effects from memory, whereas the activation in the SMA most likely reflects the automatic generation of the motor act even in the absence of a movement. Hence, both brain areas are involved in a highly flexible binding process that helps to promote the learning, automatization, and control of voluntary actions.

The Anticipation of Action Effects Guides Response Selection

In a project in cooperation with W. Kunde (University of Würzburg), we varied response-effect (R-E) compatibility to pursue the idea that effect representations guide response selection (Koch & Kunde, submitted). Participants vocalized a color word in response to a visually presented digit. The vocal response resulted in the presentation of a visual response effect that was either a color word printed in congruent color (Experiment 1) or colored nonword letters (Experiment 2). The effect could be compatible or incompatible with the vocalized color word. A clear compatibility effect was found in Experiment 1, but not in Experiment 2 (Figure 5.5), suggesting that R-E compatibility pertains primarily to the abstract meaning of the effect word, but much less (if at all) to the color of the letters. This »conceptual« R-E compatibility effect extends previous findings in the spatial and intensity dimension (Kunde, 2001, JEP:HPP, 27, 387-394; Kunde, Koch, & Hoffmann, submitted). The results are consistent with the prediction in ideomotor theory that anticipated response effects activate corresponding responses automatically.

Figure 5.5: *Mean RT as a Function of response-effect (R-E) compatibility and Effect Type. R-E compatibility pertains primarily to the abstract meaning of the effect word, but much less to the color of letters.*

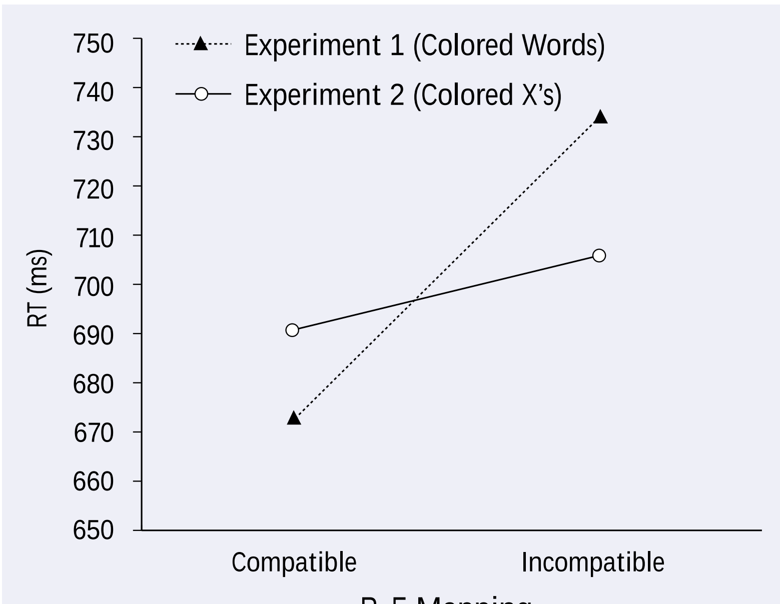

Fig. 5.5

5.2. Control of Sequential Movements

Annette Bolte
Thomas Goschke
Iring Koch

This project is investigating the learning of different kinds of sequences that underlies the ability to anticipate upcoming events and/or actions.

Variations of Structures in Stimulus and Response Sequences

In one series of experiments, *structures* in stimulus and response sequences were varied independently from each other (see Koch & Hoffmann, 2000-a), and the *spatial versus nonspatial nature* of both the stimulus and the response sequences was varied (Koch & Hoffmann, 2000-b). The variation of structure was most effective in spatial structures, irrespective of whether they had been in the stimulus or response sequence, suggesting that motor response learning is indeed a special case of spatial learning. Another series of experiments (Koch, submitted-c) showed that spatial S-R incompatibility facilitated sequence learning. Presumably, the formation of associations among consecutive responses was enhanced by the stronger response-code activation necessary to overcome S-R incompatibility, suggesting that motor response learning plays an important role in sequence learning. In ongoing experiments, we are investigating the effects of response modality on sequence learning (Zirngibl, 2001, MA thesis).

Figure 5.6: *Mean RT for location and phoneme sequences (S = structured sequence; R = random sequence). The RT decrease with training and the RT increase in the random sequence indicate that location and phoneme sequences were learned independently.*

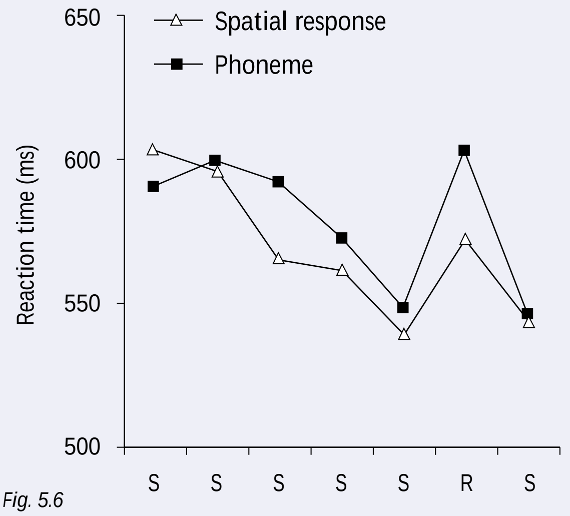

Fig. 5.6

In a collaborative project, Koch and Kunde (Würzburg) are investigating whether redundant response effects influence learning. The underlying theoretical framework is ideomotor theory, according to which actions are initiated by anticipating their effects. First results show stronger learning with compatible than with incompatible effects.

Acquisition of Spatial and Nonspatial Sequences

In a further project, Goschke (1998, in Stadler & Frensch (Eds.), Handbook of Implicit Learning, 401-444); Goschke, submitted-a) investigated whether *spatial response* and nonspatial stimulus sequences are learnt independently. In a *serial search task*, four letters were presented (e.g., DACB), followed by an auditory target letter (e.g., »B«). Participants signaled the location of the target letter in the visual array by pressing one of four response keys. Either the sequence of target locations or the sequence of phonemes followed a repeating pattern (in both conditions, the other sequence was random). In both conditions, RTs decreased with training and increased reliably when the repeating sequence was replaced by a random sequence (Figure 5.6), indicating that location and phoneme sequences were learned independently.[1]

Evidence that learning of spatial and phoneme sequences may involve separable brain systems was obtained in a collaborative study with the MPI of Cognitive Neuroscience (Leipzig), in which patients with Broca's aphasia and left-frontal lesions showed intact learning of location-response sequences, but were unable to learn phoneme sequences, presumably reflecting impaired phonological working memory (Goschke, Friederici, Kotz, & van Kampen, 2001). In an ongoing event-related potential study, we are investigating electrophysiological correlates of spatial and nonspatial sequence learning (see Eimer, Goschke, Schlaghecken, & Stürmer, 1996, JEP:LMC, 22, 970-987). In a further project, we showed that not only sequences of *specific* stimuli but also rule-based sequences of gestures are learned (Öllinger, MA thesis).

In conclusion, learning of sequential structures occurs in different domains and modalities and presumably forms the basis for the ability to anticipate actions and events.

[1] *Funded in part by the Deutsche Forschungsgemeinschaft (DFG grant 60720/1-2).*

5.3. Control of Motor Skills

The Automaticity of Skill Learning as a Function of Attentional Focus[1]

Wolfgang Prinz
Andreas Wohlschläger
Gabriele Wulf

In previous studies, we have demonstrated that motor skill learning can be enhanced considerably by directing learners' attention to the distal effects of their actions (i.e., external focus of attention) rather than directing attention to proximal action effects (i.e., internal focus of attention; see Wulf & Prinz, in press). In this project, we tested the predictions of the »constrained action hypothesis« (Wulf, Shea, & Park, in press) that an internal focus of attention interferes with the automatic control processes normally regulating the movement, whereas an external focus allows the motor system to self-organize more naturally.

A dynamic balance task (stabilometer) was used with participants instructed to focus on their feet *(internal focus)* or on markers attached to the balance platform *(external focus)*. The external focus group produced generally more effective balance performance than the internal focus group and responded at a higher frequency, indicating higher confluence between voluntary and reflexive mechanisms. In addition, the external focus group demonstrated lower probe RTs than the internal focus group, indicating a higher degree of automaticity and less conscious interference in the control processes associated with the balance task.

In further studies, we investigated the helpful effects of distal focus on basketball players and neurological patients. In launching, basketball beginners profit more from a distal than from an internal focus both with respect to their hits and with respect to their technique as estimated by independent judges. A rehabilitation training for left-parietal patients with a posttraumatic deficit in mental rotation showed that focusing on the visual effects of rotating an object *(distal focus)* led to a more promising reestablishment of the mental rotation ability than focusing on the hand movements *(proximal focus)*. Thus, focusing on distal action effects has clear learning advantages, maybe because it allows for more automatic control processes.

[1] *Supported by the Deutsche Forschungsgemeinschaft (DFG PR 118/18-2).*

Feedback and Attentional Focus: Enhancing Sport Skill Learning

Following up on the benefits of instructing learners to focus on distal effects, we examined the effectiveness of feedback as a function of the focus of attention induced by it. In addition, we wanted to examine the generalizability of the distal-focus advantages to the learning of a complex motor skill (volleyball »tennis« serve). While similar in content, the feedback statements given to the *internal-focus* participants referred to the coordination of their body movement, whereas the feedback provided to the *external-focus* participants referred to more distal action effects. Whereas movement quality was not affected differentially by the type of feedback, external-focus feedback resulted in a greater accuracy of the serves than internal-focus feedback after a 1-week retention interval – independent of the level of expertise. This supports the view that the learning benefit of focusing on distal rather than proximal action effects is a robust phenomenon that generalizes to the feedback provided to the learner as well as to different skill levels.

The Impact of Motor Learning on Perception

If perception and action share the same codes, it has to be anticipated that changes in these codes caused by motor learning will be reflected in changes in perceptual skills. Two experiments have shown that motor practice actually does affect perceptual skills (Hecht, Vogt, & Prinz, 2001). These experiments involved motor practice of timed two-cycle arm movements without visual feedback, and visual judgments of similar patterns. Transfer from perception to action and, more importantly, from action to perception was found. Furthermore, transfer from action to perception was equally pronounced not only in participants who had actively practiced movements during training but also in participants who had received merely kinesthetic feedback about the movement. This kinesthetic-visual transfer is probably achieved via visuomotor-kinesthetic matching or via timekeeping mechanisms that are involved in both motor and visual performance.

Motor skill learning can be enhanced by directing learners' attention to the distal effects of their actions, rather than to proximal action effects. If actions are controlled by anticipating their distal effects, focusing attention on proximal effects may interfere with the automatic movement-control processes.

Research Units

Unit 1: Infant Cognition and Action
Unit 2: Cognitive Psychophysiology of Action
Unit 3: Cognitive Robotics
Unit 4: Moral Development
Unit 5: Differential Behavior Genetics

1. Infant Cognition and Action

The research unit »Infant Cognition and Action« is investigating the early development of the cognitive mechanisms of action control. More specifically, it aims to investigate (1) the cognitive aspects of infant action control and how they develop, (2) the development of infant understanding of actions performed by other persons, and (3) how these two aspects of action control are related to each other during early development.

Gisa Aschersleben (Head)
Birgit Elsner
Bianca Jovanovic

Background

An important precondition for answering questions about action control and action understanding is a clear definition of what constitutes an action – as opposed, for example, to a movement. Actions differ from movements in their intentional character, that is, actions are goal-directed. As a consequence, it is important for both theoretical considerations and practical experimental planning to distinguish the two constituents of an action: the movement and the goal. This distinction corresponds to the well-established distinction between means and ends. One important consequence for the research questions outlined above is that infants have to be able to differentiate means from ends, and they need this discrimination not only to interpret the actions they see but also to perform their own goal-directed actions. The basic idea that these action goals correspond to action effects, which play an important role in both action production and action perception is rather new in the developmental literature.

The assumption that action-related effects play an important role in action control is based on theoretical assumptions developed in the *Cognition & Action Group* at our institute: the common coding approach. The core assumption of the common coding approach is that perceived and to-be-produced events are represented in a common domain in which both actions and events are represented in an abstract format. As a consequence, both types of codes (perceived events and to-be-produced actions) can communicate with each other directly, and there is no need for a translation process to mediate between the perceptual side and the motor side. In the last 10 years, *the Cognition & Action Group* has gathered quite a lot of evidence supporting such a general framework (for an overview of the theoretical account as well as empirical evidence, see Hommel, Müsseler, Aschersleben, & Prinz, in press). One central aspect of this account is that the format of these codes is a distal one. That is, actions are represented in terms of the distal effects they produce in the world and not, for example, in terms of muscular innervation patterns. These action-generated effects include effects at several levels including body-related afferent information, visual information about, for example, the position of the arm during and/or after a movement, and, eventually, the auditory pattern resulting from that movement.

The general approach underlying the projects in the unit *Infant Cognition* and *Action* is motivated by the common-coding approach and by the extensive empirical support for the idea that actions are controlled by their (anticipated) distal effects. In more detail, two important aspects frame our projects: First, we assume that action-generated effects play an important role not only in adults' but also in infants' action control. If this assumption is valid, we should be able to demonstrate an influence of action-generated effects on how infants control their own actions and, moreover, on how infants interpret actions performed by others. It might even be that a rather obvious action effect is a necessary precondition for very young infants to interpret actions as goal-directed. Second, we assume an abstract representation of events. Starting from this assumption, one can draw some interesting conclusions on the relation between the two aspects of action control we are interested in, namely, active performance and the interpretation of other persons' actions. In principle, three conclusions are possible:

1. The traditional view, already proposed by Descartes, is based on the assumption that people have privileged access to first-person knowledge, whereas knowledge about other persons is mediated and transformed via perception. As a consequence, most infant researchers think that infants understand themselves first – in our case, they understand that they are able to produce goal-directed actions, and this understanding is based on personal experience – and it is only then that they are able to transfer this knowledge to an understanding of actions performed by other people.

2. The second view assumes the opposite: Infants first understand other people – and that people in the outer world perform goal-directed actions – and it is only then that they are able to transfer this knowledge in order to understand themselves and to perform goal-directed actions. One in no way trivial precondition for this view is that the representation of knowledge about *me* does not differ from the way knowledge about other persons *(you)* is represented.

3. A third view assumes that action perception and action production are based on the same codes at a representational level. Like the second view, this view also assumes that the representation of knowledge about *me* is similar to the representation of knowledge about *you*. Moreover, the concrete assumption would then be that even very young infants have an abstract representation of actions in terms of action-generated effects, and that this representation is used by both the motor system (to perform goal-directed actions) and the perceptual system (to interpret observed actions as goal-directed). Developmental differences in the age at which one might observe the capability of infants to either perceive or perform goal-directed actions would then be based on limitations in the development of the perceptual system and of the motor system.

This third view is the one that will serve as a starting hypothesis for the projects being conducted in our unit, mainly because it is a direct deduction from the common-coding approach. However, this view does not give an answer to the important question as to when and how these abstract representations emerge. A first answer would be that they develop very early in infancy, that is, during the first three months of life. At this age, infants produce a great amount of rhythmic movement with their legs and arms, which at least do not seem to be goal-directed. During this phase, infants perceive and learn contingencies between their movements and the effects they produce (in their own body as well as in the world, e.g., proprioceptive, tactile, visual, and auditory). Finally, after 2 or 3 months, they establish abstract representations of these action-generated effects that allow them to control their actions in terms of their anticipated effects.

The projects in this unit serve mainly to demonstrate the important role of action-generated effects in infants' perception of goal-directed actions and in self-performed actions. As a consequence, we study preverbal infants, that is, those aged approximately 6-18 months. The main methods applied are the habituation paradigm, the preferential looking paradigm, and the imitation paradigm.

Methods

As our group studies mainly preverbal infants, the typical way for us to collect data will be through observing their behavior, for example, looking behavior or imitative behavior. One classic method in infant research is the *habituation paradigm*. When infants are presented with the same object or sequence of actions repeatedly, they lose interest and looking time decreases. On the other hand, if they are presented with new objects or actions, looking time increases. This looking pattern can be used to examine which features of an object or an action sequence are perceived as differing from the ones with which the infant is habituated. Another classic method that also relies on the measurement of infants' looking behavior is the *preferential looking paradigm.* Here, infants are presented with (e.g., two) different objects (either at the same time or in succession) and looking times are analyzed. If the infants look at each of the two objects in a different way, this behavior is interpreted as evidence that the infant is able to perceive the difference between them. A third method that we shall use in our projects relies on the infant's imitation behavior. In the *imitation paradigm*, a sequence of actions (e.g., object manipulation) is demonstrated to the infant. Then, either immediately afterwards or after a delay, the object is handed over to the infant to see whether he or she produces the demonstrated action sequence more often than infants in a control condition who have not been exposed to the sequence of actions.


Fig. 1

Figure 1*: Experimental set-up for habituation and preferential looking studies.*

1. Infant Cognition and Action

Project Area:

Infants' Perception of Goal-Directed Actions

Parts of the Project Area Infants' Perception of Goal-Directed Actions *have been conducted in collaboration with Dr. G. Gergely, Hungarian Academy of Sciences, Budapest.*

This project focuses on infants' perception of goal-directedness in other persons' actions. Using the habituation paradigm, Woodward (1998, Cognition, 69, 1-34; 1999, Infant Behav Dev, 22, 145-160) demonstrated that 6-month-old infants pay more attention to changes in the goal objects of grasping actions than to changes in the motion path. She interpreted this finding in terms of an early sensitivity to action goals. However, when infants were presented with an allegedly »nonpurposeful« action – a hand falling backwards onto one of two objects – there were no signs of the distinctive looking pattern described above. According to the author, this is evidence for an early capacity to distinguish between purposeful and nonpurposeful actions. Furthermore, Woodward considered several possible bases (e.g., dynamic and featural cues, familiarity with specific actions) by which infants could discriminate between these actions. However, this finding has been criticized, because Woodward was able to demonstrate the effect only with grasping.

Using the Woodward paradigm, we tested the hypothesis that a salient action effect is one important feature young infants use to interpret actions as goal-directed. We argue that infants probably are quite familiar with the grasping motion and its consequences, namely, object manipulation. It might then be this expectation of object manipulation (an object-directed effect) that makes infants encode the target object in a specific way. In contrast, the unfamiliar nonpurposeful action is less likely to be associated with object-directed effects. Following this rationale, the introduction of an action effect after the same nonpurposeful action should transform this into a goal-directed action and produce similar results as the grasping study. Consequently, we modified Woodward's nonpurposeful condition by adding an effect to it (see Figure 3). The study was conducted with 24 infants at the age of 6 months who were habituated to an action sequence in which a hand was lowered onto an object and then pushed the object toward the rear end of the stage. As expected, under these conditions, infants behaved in a similar manner as in the grasping study: They recovered attention after habituation more strongly when the target object was changed than when the motion path was changed. This is a first hint that action effects play an important role in infants' interpretation of actions as being goal-directed.

Project Area:

Learning About Contingencies Between Movements and Their Effects in Self- and Other-Performed Actions

From the earliest days of life, infants learn to act on their environments in order to bring about desired consequences. By exploring the contingencies between self-performed movements and environmental events, they learn to predict which consequences a certain movement will have. As the planning and control of goal-directed behavior relies on the anticipation of action effects, instrumental learning in infancy may provide the basis for voluntary action. However, instrumental learning in infancy is limited by physical constraints, because not all behaviors are possible. Nonetheless, because infants spend most of their first year of life inspecting the world around them, they have ample opportunity to watch others such as parents or siblings acting on the environment. Thus, infants could learn about actions and their consequences just by watching and imitating other agents.

Fig. 2

Figure 2: *Video and computer system for coding infant behavior (e.g., looking time, imitation behavior).*

Until now, little is known about social or observational learning in the first months of life. However, there is evidence that infants begin to understand the goal-directedness of other's actions from the age of around 6 months (Woodward, 1998, Cognition, 69, 1-34), and that infants as young as 3 months of age can acquire information in an operant conditioning paradigm on the basis of observation alone in the absence of prior practice (Greco, Hayne, & Rovee-Collier, 1990, JEP:LMC, 16, 617-633). Hence, this research project aims to investigate (1) whether infants learn about movement-effect contingencies in other persons' actions as they do in their own actions, and (2) whether infants transfer the effect expectations learned from observing other persons' actions to their own actions.

Project Area: The Roots of Action Perception

This project aims at developing a new methodology for studying the development of the understanding of both own actions and other persons' actions. The basic theoretical issue is the question whether infants come to understand other persons' actions *after and because* they understand their own – or whether exactly the reverse is true, and they understand themselves *after and because* they understand others. One of the major paradigms we are planning to develop is based on the logic of the habituation technique. In this task, infants observe pairs of actions that are always the same (presented simultaneously or sequentially at controlled intervals). Occasionally, however, the two actions differ in terms of means, or ends, or both. To the extent that infants »understand« what they observe, they should then be surprised (as assessed in terms of looking times, etc.). Further, to the extent that they »understand« means-ends hierarchies, they should be more surprised about deviant ends than means. Typically, in one condition, the infant watches two persons perform the same actions (say, in the sense that Person A mirrors Person B's actions after a short delay). However, from time to time, A's actions deviate from B's in means, ends, or both. This is the *Other Condition*. In the *Self Condition*, the infant is faced with the same situation, but this time A's and B's activities are completely unrelated. Instead, A now mirrors the infant's own activity (again with interspersed deviants), whereas B is doing something else. There are two questions here: First, at which age will infants detect deviants in means and ends at all? Second, does the development of deviant detection differ for the mirroring of self versus others?

Fig. 3

Figure 3: Infants' Perception of Goal-Directed Actions: Experimental set-up. *Upper row: Habituation event: The hand is lowered onto one object and displaces it. Lower row: Two test conditions: The positions of the objects are exchanged and the hand either moves to the old object via a new path (new path, right panel) or to the new object via the old path (new goal, left panel).*

2. Cognitive Psychophysiology of Action

The research unit »Cognitive Psychophysiology of Action« is investigating the processing of visual information for manual actions. The main aim of the unit is to identify conditions of efficient visuomotor information transfer, the mechanisms involved, and their boundary conditions. Both cognitive models of stimulus-response interactions as well as the physiology of the visuomotor system are taken into consideration. For this purpose, methods of cognitive psychophysiology are combined with behavioral measures in well-defined experimental situations.

Edmund Wascher (Head)
Monika Kiss
Katrin Wiegand
Maren Wolber

Background

Dorsal and Ventral Paths

The physiological structure of the visual system indicates that there are at least two paths for processing visual information: first, the dorsal path leading from primary visual cortex toward posterior parietal areas; second, the ventral path passing along temporal structures into the inferior-temporal cortex. These two structures are assumed not only to be physiologically separated but also to process different aspects of visual stimuli.

Based primarily on clinical studies, Goodale and Milner (1992, Trends in Neurosciences, 15, 20-25) proposed that the dorsal path processes visual input with respect to its relevance for behavior, whereas the ventral path generates object representations. Most important for this assumption was patient D.F. who suffered from visual agnosia after damage to structures in the ventral path. D.F. was not able to name objects, but had only minor problems in manipulating them. Recent investigations challenge this functional separation. Goodale and coworkers (1994, Neuropsychologia, 32, 1159-1178) pointed out that the remaining abilities of patients suffering from visual agnosia are temporally restricted. After a delay of 2 s, the ability to manipulate unknown objects becomes lost. On the basis of these findings, Rosetti and Pisella (in Prinz & Hommel, in press-a) proposed that dorsal and ventral processing differ with respect to their temporal characteristics rather than the contents processed. In line with this assumption, dorsal processing might in fact be better described as fast »visuomotor« transformation, whereas ventral processing is related to »cognitive« evaluation. Consequently, both forms of processing may be involved in the generation of action as well as in the processing of object properties.

Figure 1: *Time course of the Simon effect (left panel) plotted against the base response time (average from corresponding and noncorresponding trials) with regularly positioned (bold) and crossed hands. While the regular Simon effect decayed, the effect with crossed hands increased with slower responses. Additionally, motor activation as seen in the LRP (right panel) was reduced with crossed hands, whereas the asymmetric activity over posterior, visual areas did not change at all.*

Temporal Aspects of S-R Compatibility

Evidence toward a separation into visuomotor and cognitive processing of visual information comes from research on spatial stimulus-response compatibility (sSRC). In a recent study (Wascher, Schatz, Kuder, & Verleger, 2001), we identified two separate mechanisms subserving the Simon effect (an acceleration of manual responses whenever the location of a stimulus corresponds to the side of the response even when the location of the stimulus is not task-relevant) with and without crossed hands. Whereas the Simon effect was maximal for fast responses when participants performed in natural hand positions, the effect increased with increasing response times in the crossed-hands task. Additionally, the activation of motor areas as evidenced by the lateralized readiness potential (LRP) was reduced with crossed hands.

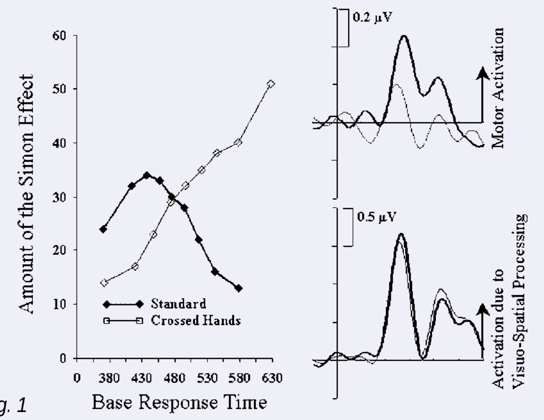

Fig. 1

Both the time course of the effect as well as its psychophysiological correlates indicate that the *fast* mechanism observed with regular hand positions might be due to an accelerating, activation-based mechanism. This finding is also in accordance with physiological findings on visuomotor connections. The *slow* mechanism observed with crossed hands might be due to a time-consuming cognitive evaluation of contradictory information.

Because both tasks used spatially presented stimuli that were task relevant, neither the distinction between »what versus where« (Ungerleider & Mishkin, 1982, Analysis of Visual Behavior, 549-586) nor that between »how versus where« (Goodale & Milner, 1992, Trends in Neurosciences, 15, 20-25) provide a satisfying explanation of the two mechanisms. They might, however, reflect the distinction between sensorimotor and cognitive mechanisms as outlined above.

Within three major project areas, we are trying to evaluate this distinction: We shall try to investigate (1) the boundary conditions of activation-based mechanisms in visuomotor interaction, (2) the temporal aspects of input processes, and (3) the importance of sensorimotor mechanisms in movement control.

Methods

Laboratory Equipment

The psychophysiological laboratory is equipped with two 32 channel DC amplifiers. Visual stimuli are presented on a 22-inch computer monitor driven by a VSG graphic accelerator. Participants are seated in a comfortable armchair (see Figure 3) that can be adjusted individually in height in order to equalize the vertical visual angle and body position across participants. All aspects of the experiment can be monitored from outside the cabin. The experimenter watches on-line displays from ongoing EEG, response statistics, and a video camera observing participants' gross movements (see Figure 2).

Event-Related EEG Activity

Brain-electrical activity can be measured at the human scalp with electroencephalography (EEG). The main portion of EEG activity is due to the spontaneous firing of cortical neurons. However, the processing of any event (e.g., stimulus evaluation or response preparation) changes this activity systematically. This event-related cortical activity can be made visible through averaging techniques. The resulting event-related activity is characterized by typical wave shapes consisting of peaks of positive and negative voltages. Temporal and quantitative aspects of cognitive processing can be evaluated by measuring the latencies and amplitudes of these peaks. Additionally, the scalp distribution of voltages at the moment of the peak indicates (admittedly with very low spatial accuracy) which cortical areas might be involved in an ongoing cognitive process.

First of all, we are interested in event-related potentials (ERPs).We are also investigating event-related lateralizations (ERLs) of the EEG that have been shown to be particularly informative for the investigation of visuomotor interactions. Based on the fact that many functions related to response and stimulus processing are organized contralaterally in the human brain (the left hemisphere controls right movements and processes right visual stimuli), one can measure functional asymmetries of the EEG. As the best known of these ERLs, the LRP has become established in cognitive psychology as a measure for tracking the time course of response preparation. Similarly, asymmetries over visual areas might become a helpful tool for investigating the time course of visual processing. Finally, the interaction of these two phenomena might function as an indicator for the visuomotor information transfer.

Fig. 2

Figure 2: *Experimenter controlling displays of ongoing EEG, response statistics, and a video camera.*

Fig. 3

Figure 3: *Participant seated in the sound-proof chamber.*

2. Cognitive Psychophysiology of Action

Project Area:

Dissociating Visuomotor Mechanisms by Processing Speed

Motor Priming in Simon-Like Tasks[1]

As pointed out in the introduction, sensorimotor and cognitive processing might subserve two distinct types of the Simon effect. Whereas the regular Simon effect seems to be caused by activation processes visible in cortical asymmetries, the crossed hands effect does not show these characteristics, even when both are quantitatively comparable in terms of mean response times. In a first follow-up study, we compared a vertical with a horizontal stimulus and response arrangement. As in the crossed hands study, these two types differed from each other in terms of the time course of the behavioral effects as well as in activation of the motor cortex. Vertical arrangements showed an increasing effect comparable to the results obtained with crossed hands.

According to the findings up to now, S-R compatibility in horizontal arrangements with natural hand positions seems to be caused by a fast activation process that does not depend on cognitive coding of stimuli and responses. To test this notion, we ran a second follow-up experiment introducing valid advance information about either the stimulus location or the response side. As previously reported in the literature, the Simon effect did not change with stimulus priming, but apparently increased with response priming. Both findings cannot be explained by cognitive (coding-based) models of S-R compatibility. Additionally, the lack of a decrease of the Simon effect in the response priming condition indicates that the accelerating effects of the irrelevant stimulus location influence processes after response selection. Furthermore, these data support the notion of a sensorimotor, code-independent mechanism as the origin of a regular visual Simon effect on the horizontal axis.

As a consequence of these experimental results, we are trying to integrate sensorimotor and cognitive S-R relation within a single task. Additionally, we are trying to investigate how far spatial parameters other than stimulus location (i.e., the direction of moving stimuli) have access to the same system.

Subliminal Motor Priming

In cooperation with Anthony Greenwald (University of Washington at Seattle, U.S.A.) and Jochen Müsseler.

Recent studies on unconscious motor priming propose a similar separation between fast (subliminal) visuomotor processes and slow (conscious) cognitive processes. These studies use masked primes that provide information either corresponding or noncorresponding to a subsequent response. Even when participants are not aware of these primes, their informational content has an efficient impact on response times (Neumann & Klotz, 1994, Attention & Performance 15, 123-150). Whereas previous studies focused on the impact of unconscious primes only on consciously selected responses, we shall try to investigate whether even the selection of a response can be performed on the basis of unconscious information.

[1] *Partly granted by the Deutsche Forschungsgemeinschaft (DFG Wa 987/7-1).*

Project Area: Temporal Parameters of Visual Attention

Psychophysiological Investigations of Visual Search[2]

Many theories of visual information processing propose two distinct mechanisms, namely, fast-parallel and slow-serial processes involved in visual search. However, the current literature reveals no clear consensus about what determines either parallel or serial processing (e.g., what kind of stimuli can be processed efficiently in a parallel mechanism).

By using event-related EEG activity, we are investigating the attentional mechanisms involved in searching for different target types in multistimulus arrays. In a first study (Wolber & Wascher, submitted), we found that it seems implausible to posit two distinct mechanisms for processing particular types of stimuli, although efficient and inefficient processing were distinguishable on basis of EEG latencies. The use of either fast or slow mechanisms depends rather on stimulus properties of target and distractors together, in other words, their relation to each other. Therefore, a further experiment is varying these relations systematically.

Priming in Visual Attention

The temporal characteristics of the Simon effect and the assumption of either fast »sensorimotor« or slow »cognitive« processes in stimulus-response transmission is not a phenomenon to be found exclusively in paradigms that are supposed to measure visuomotor processing. Two distinct mechanisms are also discussed within the context of the »covert orienting of visual attention task« (Posner, 1980, Quart J Exp Psychology, 32, 3-25). If a participant has to respond to a spatially validly cued visual stimulus, responses are accelerated when the stimulus-onset asynchrony (SOA) between cue and target is short (up to 150 ms) and decelerated when the SOA is long (more than 300 ms). We are trying to find out how far facilitation in such an attention experiment shares functional properties with motor facilitation as observed for subliminal priming or in the Simon effect.

[2] *Granted by the Deutsche Forschungsgemeinschaft (DFG Wa 987/6-1).*

Project Area: Movement Control

Plasticity of Human Visuomotor Coordination

To perform goal-directed hand movements, we need to integrate visual and proprioceptive information on the position of the desired target in relation to our limb. If the visual feedback is manipulated (e.g., by wearing prisms), these computations will be disturbed. This will result in aiming errors. Plasticity of the human visuomotor system is demonstrated by gradually decreasing errors until stable aiming accuracy is re-established and by the persistence of a negative after-effect when the prisms are removed. The aim of this project is to investigate EEG correlates of directing a movement and its plasticity.

In cooperation with Heinrich H. Bülthoff and Volker Franz (both Max Planck Institute for Biological Cybernetics, Tübingen).

EEG Correlates of Movement Control

The ongoing study on the plasticity of the motor system also intended to evaluate how far event-related EEG activity is measurable in tasks in which participants have to perform free-field movements. This is not a trivial question, because EEG measures are very sensitive to artifacts produced by muscle activity. Even minimal movement of the head might hinder the recording of an artifact-free ERP.

However, the measurement of EEG in tasks requiring free-field hand or arm movements might deliver important information on the functioning of the human visuomotor system. EEG measures might help in uncovering the time course and functional properties of the mechanisms involved.

A first series of experiments found EEG correlates of movement control (Berndt, Franz, Bülthoff, & Wascher, submitted) and of directing a movement (Wascher, Wolber & Schönstein, submitted). These findings were subsequently applied to free-field S-R compatibility tasks in order to investigate which stages in movement control might be affected by mechanisms like visuomotor priming.

3. Cognitive Robotics

The research unit »Cognitive Robotics« is investigating behavior-based approaches to visual perception which, in contrast to the classical »information-processing metaphor«, emphasize the bidirectional interaction between perception and the generation of behavior. Our work focuses on »common-coding« schemes in which perceptual and behavioral codes are integrated into a common representation. Such a common representation emerges through learning processes as part of a »forward model« – an internal model that can be used to predict »action effects«, the sensory consequences of self-generated actions. We shall specifically tackle the question whether forward models are a useful concept for the formation of a stable visual perception of three-dimensional space and shape and for understanding the basic physical laws that govern the interaction of an agent with its environment. A synthetic approach based on closed-loop computer simulations and robot experiments will be used to test how forward models can be learned in the interaction with the real world and applied for the generation of adapted spatial behavior.

Ralf Möller (Head)
Heiko Hoffmann
Bruno Lara
Wolfram Schenck

Theoretical Background

Problems of the Information-Processing Metaphor

Approaches that make a strict separation between the perception and generation of behavior suffer from a number of conceptual problems.

Our work generally aims at finding alternatives to the so-called »information-processing metaphor,« a concept that is still widely accepted in cognitive science and related disciplines. It embraces all approaches that consider cognition as a transformation process from the sensory input onto a purely sensory representation, which is afterwards »interpreted« by a separate subsystem to derive adapted behavior. From our perspective, this concept is afflicted with a number of conceptual problems (homunculus problem, lack of semantic grounding), and, when applied to visual object recognition, fails to provide satisfying solutions for invariance and constancy. Moreover, experimental evidence from neuroscience and cognitive psychology conflicts with the notion of purely sensory perception and indicates an influence of the behavioral state.

Forward Models as a Behavior-Based Approach to Visual Perception

The alternative approach is based on the concept of »forward models« that predict sensory changes from self-generated actions.

One concept of sensorimotor integration that is already being studied in motor control and somatosensory perception is a »forward model.« Forward models incorporate knowledge about the sensory changes produced by the self-generated actions of an agent. From the current system state and the currently executed motor commands, a forward model predicts the next system state. Forward models have been suggested as solutions to problems in motor control, e.g., to bypass the slow sensory feedback loop. In somatosensory perception, forward models are supposed to work as filters for self-generated sensory inflow. Experiments have demonstrated that human somatosensory perception changes when the temporal relationship between an action and the somatosensory feedback is modified.

Spatial perception may be based on the internal simulation of action effects in the current sensory situation.

Forward models could also provide a suitable theoretical concept for integrating perception and action that would overcome the above-mentioned problems with the information-processing metaphor. With a forward model at the core of the perceptual system, sensory representations would be replaced by sensorimotor representations, and the sensory transformation process would turn into an active, generative process that is controlled by motor units. Motor signals would not only be outputs of the system but would also be used in the form of an »efference copy« to predict the »reafferent« signals produced by actions. In our approach, spatial perception is thought to be based on the internal simulation of action effects in a given sensory situation. This simulation process is driven by a subliminal activation of motor units that is not turned into actions. A sensory situation is characterized (perceived) by a set of such sensorimotor sequences, but within the same neural process, goal-directed behavior can be generated by choosing actions according to some value criterion.

Methods

The unit »Cognitive Robotics« employs a synthetic methodology complementing the mainly analytical approach of cognitive psychology. In a first step, models of cognitive processes are studied in closed-loop computer simulations. Since computer simulations may be affected by unwarranted simplifications of the agent-environment interaction, in a second step, models will be tested under real-world conditions by implementing them on robots. The models will be based mainly on artificial neural networks which offer a wide repertoire of methods for the learning of forward models.

A synthetic approach based on closed-loop computer simulations and robot experiments will be employed.

Two experimental setups are currently under construction: a robot arm (six degrees of freedom) with a stereo-vision system and tactile sensors on the gripper, and a mobile robot with a stereo-vision system, sensitive bumpers, and tilt sensor. The goal for the arm setup is to show that, based on the anticipation approach, the system is able to interpret arrangements of objects on a table, as revealed by a successful manipulation of these objects. The system should thus be able to judge if and how objects can be grasped – it should, for example, grasp objects in the most appropriate gripper orientation. The mobile robot setup will explore whether forward models can provide the robot with the ability to navigate safely in a structured two- or three-dimensional environment while avoiding dangerous situations and reaching predefined goals.

Objects may be perceived not directly from their visual features but indirectly in terms of their behavioral meaning by anticipating action effects based on the visual features.

Such an approach bears some resemblance to Gibson's concept of »affordances.« Objects offer their behavioral meaning directly to the perceiver, because the recognition process characterizes them directly through a set of actions in which they play a role. Thus, a chair would not be represented by a model comprising a set of visual features that have to be matched with the current visual input; instead, it would be characterized by the sensory consequences of different actions that can be executed with it. Sitting down on a chair will, for example, produce typical tactile and proprioceptive impressions that can be predicted from the visual input and the action sequence. Knowledge on action effects will enable the agent to recognize a completely novel chair with hitherto unseen visual features in its function as a device that provides support. An approach based on forward models may thus also provide new solutions for invariance and constancy in visual perception.

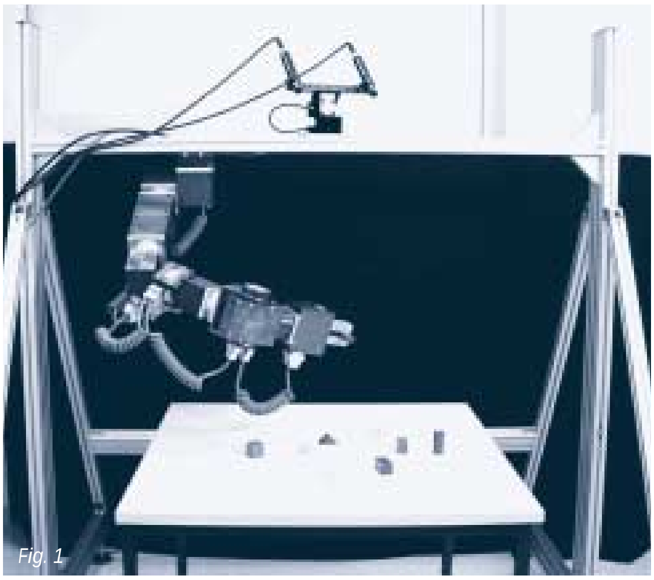

Figure 1: *Experimental setup with 6 degree-of-freedom arm and stereo-vision system.*

Project Area: Learning Methods for Forward Models

In this first phase, work is concentrating on the development of suitable methods for the learning of forward models. Forward models will be learned from data collected during the interaction of an agent with the environment. The sensory portion of these data will contain mainly visual, but also tactile and proprioceptive signals, whereas the motor portion will comprise the self-generated motor signals. We are currently following two different approaches for the learning of forward models based on either neural feed-forward or recurrent neural networks.

Feed-Forward Neural Networks

Feed-forward neural networks are one approach for the learning of forward models.

Feed-forward networks like multilayer perceptrons are function approximators that can learn functional relationships from examples. Given a set of input and output signals, the network is trained to reproduce the output signals from the input signals with minimal error. One straight-forward approach for the training of a forward model in a multilayer perceptron would be to present the current sensory situation together with the currently executed motor command at the input of the network and the sensory situation of the next time step as a training signal at the output. Once trained, a real or hypothetical sensory situation will be assigned to one part of the input and a simulated (subliminal) motor command to the other, and the predicted sensory situation for the next time step will appear at the output.

Forward models have to cope with unpredictability in parts of the data space.

The training of feed-forward networks is based on the assumption that forward relations are causal, and, therefore, when given a certain sensorimotor input, the subsequent sensory state will be fully determined. Although this may be the case in somatosensory systems, it will not be the case in the visual domain. Pulling aside an object, for example, will uncover background that is generally not predictable from the previous image and will appear as »noise« to the learning system. It is, on the one hand, desirable to prevent the learning system from wasting its complexity on these regions in the input space. On the other hand, information on the unpredictability of portions of the subsequent sensory situation may also be exploited to guide the prediction process or for hierarchical learning systems.

A coupled learning system provides an estimate of the predictability.

A simple coupled learning system was developed that fulfills these two requirements. The system, shown in Figure 2 (left), comprises two feed-forward networks, one that learns the functional relation (data network) and the other that learns the error of the first network (variance network). Whenever the data network is unable to produce a prediction with small error in a region of the input space, the variance network produces a high output signal. This signal controls the learning rate of the data network in such a way that it is unaffected by examples from unpredictable regions in the input space. The network has been tested on simple one-dimensional test functions. One such example is shown in Figure 2 (right): For a sine function with three unpredictable regions (training data), the network learns both the functional relation (network output) and the pre-

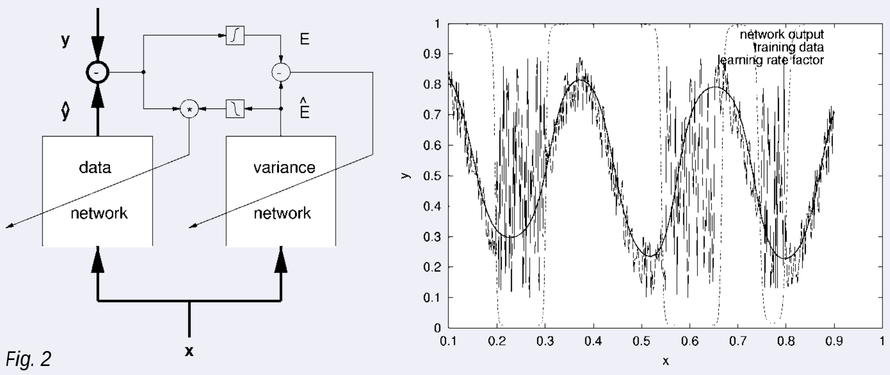

Fig. 2

Figure 2: *Coupled learning system (left) and results for a test function (right).*

dictability of the data (indicated by the learning rate factor). This method is currently being tested with data obtained from a computer simulation of a mobile agent moving through a cluttered environment.

Recurrent Neural Networks

In contrast to feed-forward networks, in recurrent networks, the role of a portion of the signals to be input or output signals is not already assigned during the training process, i.e., the current and the next sensory situation as well as the motor commands are treated as one »example«. The examples are imprinted in the network as attractor states. When the recurrent network is applied, a subset of the signals can be set to given values (inputs), while the remaining signals (output) converge towards the attractor states. Depending on the input-output assignment, the same network can be used as a forward model or an inverse model. Whereas forward relations are usually causal (many-to-one) relations, inverse models are generally one-to-many relations; a redundant arm, for example, can reach the same effector position with different joint angles. Such relations cannot be learned by feed-forward neural networks, because the networks would just average the apparently conflicting examples.

A recurrent neural network can be used as both forward model and as inverse model.

Figure 3 shows results of a first approach to the use of recurrent networks. Gray dots depict examples of a functional relationship between two variables. The system is a combination of the »neural gas« vector quantization system (Martinetz et al., 1993, IEEE Trans Neural Networks, 4, 558-569) and the potential field approach suggested by Bachmann et al. (1987, Proc Nat Acad Sci, 84, 7529-7531). The neural gas tries to approximate all examples with a fixed number of »code-book« vectors (black dots). The potential field is constructed by treating all code-book points as attractive charges. A particle put in this field will approach the closest charge. The system works reliably for the two-variable example and could be applied successfully to a simulated arm with three joints in which the task was to find the joint angles for a given end-effector position. We are currently extending the method to cope with more complex, higher-dimensional problems.

A recurrent network was developed that combines a vector quantization approach and a potential field method.

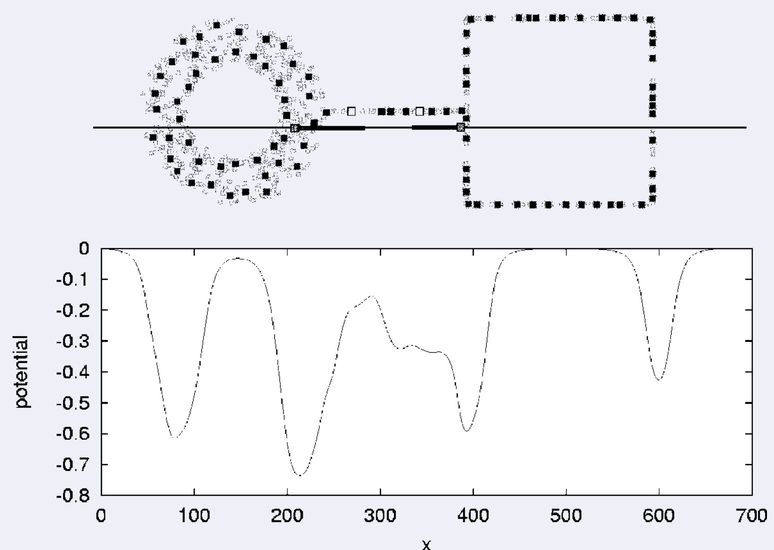

Fig. 3

Figure 3: *Combination of vector quantization (neural gas) and potential fields used as recurrent network. The lower diagram shows the potential on the constraint line. Two constrained relaxation trajectories are shown in the upper diagram, with the final points marked with gray squares.*

4. Moral Development

General Introduction

Gertrud Nunner-Winkler (Head)

Marion Nikele

Cognitive and motivational moral understanding are being studied from an ontogenetic and a sociohistorical perspective. The cognitive aspect includes knowledge of the content of moral rules and principles as well as understanding of the moral ought; the motivational dimension covers the intensity and type of moral concerns. The ontogenetic questions (i.e., how do children acquire moral knowledge and develop moral motivation?) are being explored within the context of LOGIC; the sociohistorical issues (i.e., are there changes in cognitive and motivational understanding?) are being studied in an intergenerational comparison with the GOLD sample representing the oldest cohort. The data analysis of both studies is almost complete, and several aspects of the findings have been reported (e. g., Nunner-Winkler, 1999b, Nunner-Winkler, 2000g, 2000h).

Some new data have also been collected: Understanding of identity was investigated in the GOLD replication study and in a pilot study involving college students; possible cognitive prerequisites for the development of second-order desires were explored in a preschool study (conducted in collaboration with Beate Sodian, University of Munich).

In the following months, these data will be analyzed, and the issue of differences and similarities in moral understanding between mono- and dizygotic twins will be examined in more depth. Furthermore, new instruments for the next LOGIC replication study will be developed and subjected to pretests.

Project Report:

Gender Differences in Moral Understanding: An Intergenerational Comparison

The following hypotheses can be derived from the debate on moral differences between genders:

1. Women adhere to an ethics of »care and responsibility« (Gilligan, 1982, In a Different Voice: Psychological Theory and Women's Development); men, in contrast, focus on rights and duties.
2. Women are motivated by empathy and compassion; men, by a sense of duty.
3. Men rigidly ascribe strict validity to moral rules; women flexibly allow for exceptions, taking context conditions and future consequences into account.

The stronger care orientation in women is explained within two (otherwise quite divergent) paradigms: *Sociobiology* views human characteristics as being determined by the survival advantage of selfish genes. This has implications for gender differences: Given their higher investment in reproduction and their limited bearing capacity, taking care of their offspring pays off for females. Only those who apply themselves to their children successfully will pass on their genes. Thus, by nature, females are more caring. According to *psychoanalytic thinking*, both male and female children will identify from birth on with their first caregiver, usually the mother. As they grow older, girls can uphold this identification with a caring and giving mother figure: They develop a relational self. Boys, in contrast, must distance themselves from this early encompassing relationship: They develop an autonomous self. Thus, caring for others becomes a core concern for women; maintaining autonomy, for men. By focusing on the welfare of concrete persons and maintaining relationships, women adjust their moral demands to the exigencies of situations while taking possible consequences into account. Men, in contrast, tend to rigidly insist on strict adherence to rules and abstract principles.

The hypotheses on moral gender differences are being studied in an intergenerational comparison. This makes it possible to contrast the influence of varying socio-cultural conditions on moral understanding with universalistic – biological or psychoanalytic – explanations.

Study

Sample: There were 300 participants, 100 in each of three age groups (20-30, 40-50, 65-75 years). The two younger cohorts are a random sample drawn and interviewed by a commercial research institute; the oldest group was drawn randomly from the GOLD sample (matching the educational status of this generation and – as far as possible – taking only one member from each twin pair).

Procedure: First, each participant's moral understanding was explored (»What does morality mean to you? Give me some examples of immoral behavior.«). Then 24 vignettes were presented in which a protagonist faces a conflict involving (culture-specific) family and gender norms, religious and political duties; (universal) negative duties; duties toward the self; supererogatory duties; and ecological duties. Participants were asked to pass a judgement on each situation and justify it. For some items, they also had to imagine conditions under which they might judge differently, and estimate how their own and other generations would judge the situation.

Interviews were audiotaped, and coding categories were obtained inductively from the transcripts. Because the same material arguments were used quite often to justify opposite stances (e.g., the protagonist joining the NSDAP (Nazi Party) for careerist reasons might be condemned for being opportunistic or excused for not having acted from conviction), a (highly reliable) two-level coding procedure could be developed: First, a global position was assigned (i.e., strict condemnation, qualified condemnation, ambivalence, qualified acceptance, full acceptance); then, individual arguments were coded by content.

The following will start by discussing the hypotheses in an exemplary manner based only on the responses to individual items by the oldest and the youngest cohort. The second step will present results in an aggregate manner.

Exemplary Results

Hypothesis 1: Care and Responsibility

The item »working mother« (»A mother of two small children works fulltime. Her husband makes enough money for the family to live comfortably.«) is used to test the claim that women have a stronger care orientation. At the content level, expecting a mother to provide for her children formulates a care norm. This norm can, however, be justified by either deontic considerations (e.g., caring for her children is a mother's duty) or by care concerns (e.g., a working mother's children will suffer). The data show that older participants more often condemn maternal employment, but across generations and sexes, those who do so refer considerably more often to a neglect of duty rather than to negative consequences for the children.

In declaring *responsibility* a female virtue, Gilligan refers to women's presumably greater willingness to provide for others. In everyday language, however, responsibility is often used as a synonym for accountability. A text-analysis program was used to mark all contexts in the interviews in which the radical irresponsibility appeared. Irrespective of sex, only about one-fourth of the participants used responsibility-related terms, and those who did hardly ever used these terms in the sense of »caring for.«

Hypothesis 2: Compassion

Although women's propensity for child care was shown to result not from their natural disposition but from their understanding of a mother's duties, it could still be the case that women act more often from compassion. This might be seen more easily in less clearly codified situations. Two items involving supererogatory acts are pertinent: Not giving alms to a beggar and committing one's debilitated father to a nursing home. No sex differences in global position were found: Only very few participants condemned the refusal to give alms; most (especially older female) participants not only accepted, but even justified the hard attitude by questioning the beggar's need or worthiness. Although quite a few (particularly older) participants condemned putting one's father in a home, most justified this in terms of filial duties rather than the father's welfare.

Hypothesis 3: Flexibility

The examples for immoral behavior given in response to the introductory question differed widely. Some participants simply listed rule transgressions (e.g., stealing; deceiving one's wife); whereas others embedded the incriminating action in context conditions that would nullify any possible justifications (e.g., stealing from someone who is needy himself; having an affair while vowing to be faithful to one's wife), thereby indicating that they ascribe a prima facie validity only to norms. There were small sex differences, but large cohort differences in the tendency to contextualize examples: Women in the oldest cohort did this the least frequently (just above 20%) and women in the youngest cohort the most frequently (just below 60%).

Once the basic idea has been accepted that exceptions to the norm may be justifiable, different factors prove relevant for explaining flexibility with respect to specific norms. For example:

Personal involvement. Participants who are afflicted more directly by possible consequences of norm conformity are more willing to allow exceptions. For example, in the oldest cohort, women show higher flexibility over the issue of abortion; men, over the issue of resistance to the draft (compulsory military service).

Understanding of the meaning of a norm. Older (particularly female) participants prove more rigid in their condemnation of people who do not recycle their garbage. They see the function of the recycling norm as upholding order, and therefore judge any transgressions as unacceptable. In contrast, younger (particularly female) participants understand the norm as a means for improving living conditions for future generations. If this goal cannot be reached (e.g., because different sorts of garbage are processed together afterwards), following the norm becomes meaningless and transgressions are acceptable.

Moral versus personal realm. With modernization, the concept of duties toward the self has eroded. As a result, many actions that older participants consider immoral (e.g., taking drugs) are classified as personal issues by younger participants.

In summary, the analysis of individual items refutes the assumption that women are more care-oriented, compassionate, and flexible than men. This conclusion is confirmed by an aggregate analysis of the data.

Aggregate Results

Figure 1 depicts the percentage of men and women in the oldest and youngest cohort who (with or without allowing for exceptions) condemn the behavior in question. Several features are remarkable: There are large and significant differences between the two cohorts; within each cohort, women are more similar to their male peers than to women in the other cohort; with respect to most items – and particularly to those in which large cohort differences appear – women tend to hold the more extreme positions. In other words, old women are (slightly) more conservative, and young women are (slightly) more liberal than their male counterparts.

Similar results emerge with respect to rigidity, that is, the tendency to deny exceptions (from condemnation or acceptance). Again, between-cohort differences are much greater than sex differences within each cohort. All in all, older women in particular are by no means more flexible than their male peers.

Process of Change

A final analysis aimed at a more detailed reconstruction of the process of change by comparing the global positions of women in all three cohorts. Results showed that the most radical change was effected by the middle generation. This implies that the drastic move toward progressive liberalism shown over the generations cannot be attributed to an age effect, that is, to a presumably higher rebelliousness among young people. Instead, it has to be understood within the context of the emancipatory debates of the late 1960s in which the women of the middle generation were engaged during their adolescent years.

Conclusion

The findings reported here reject universalistic interpretations of (moral) sex differences and support a historically contextualized approach based on socialization theory: Moral attitudes are acquired in a specific biographical phase under specific sociocultural conditions and then retained for life. Thus, care springs neither from a natural female disposition nor from differences in self-structure resulting from early childhood experiences, but from an ungendered sense of duty to fulfill the obligations that are expected of women under the condition of a socially institutionalized division of labor. Differences between the generations reflect cultural changes in moral understanding between the Nazi years and the post-1960s – the times during which the oldest and the youngest participants spent their late adolescence and early adulthood. These changes were largely implemented by the middle cohort with women in the vanguard. In Germany this period also marked a change from – in Max Weber's terms – »*Gesinnungsethik*« (ethics of intentions) to »*Verantwortungsethik*« (ethics of responsibility), that is, the traditional, strictly deontological moral understanding was softened through the integration of some utilitarian concerns. The rise of the women's movement happened to coincide with this increasing concern for the moral relevance of consequences. This was misinterpreted as indicating a specific female affinity to flexibility. In conclusion, moral understanding is a question of cultural context not of gender.

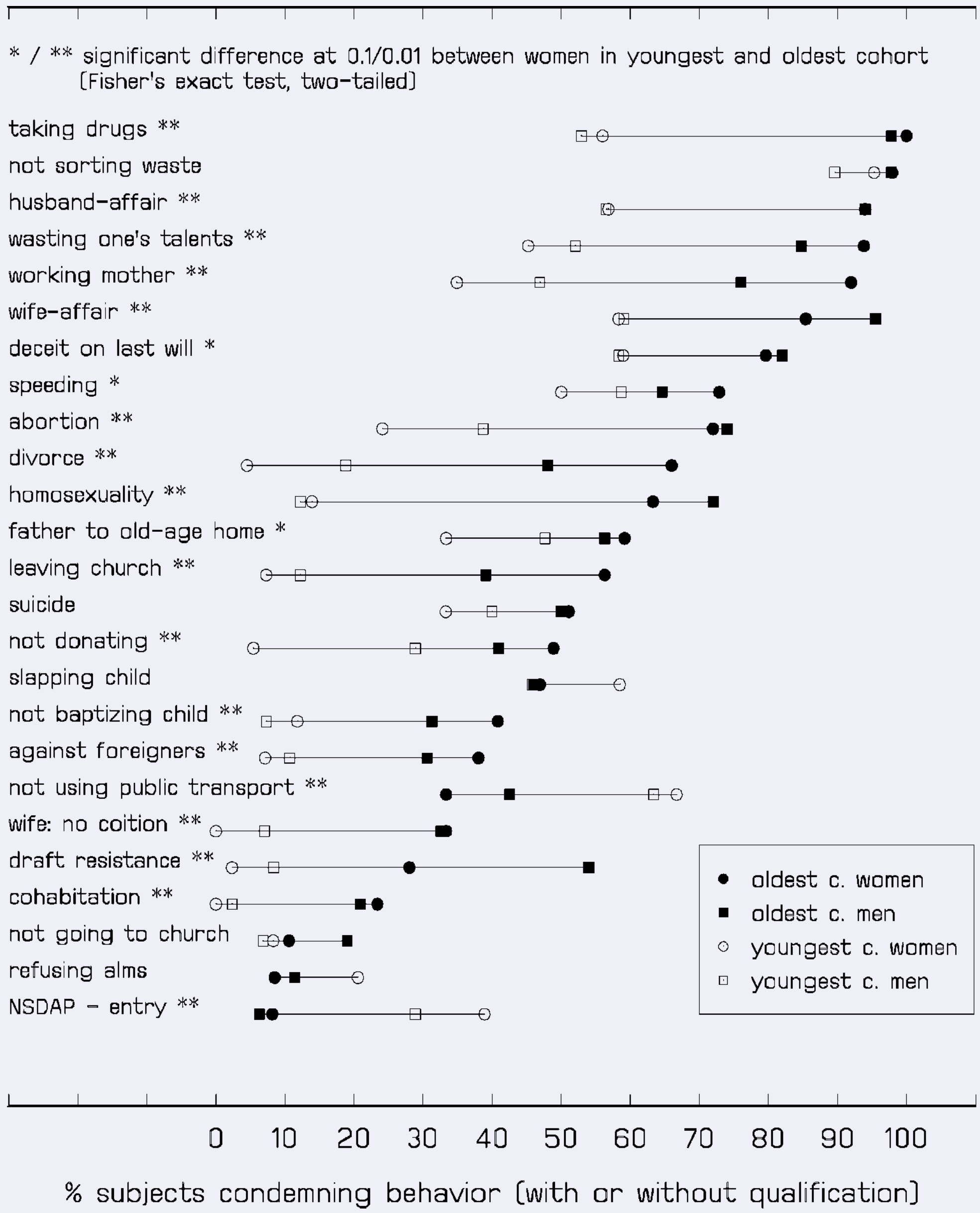

Fig. 1

Figure 1: *This figure shows the percentage of men and women in the oldest and youngest age group who condemn the behavior in question.*

5. Differential Behavior Genetics

The appointment of Franz E. Weinert to an emeritus in the fall of 1998 marked the end of the Research Unit »Behavioral and Cognitive Development.« A unit entitled »Differential Behavior Genetics« (Ulrich Geppert, Ernst A. Hany) was set up in October 1998 to continue the twin study GOLD (**G**enetically **O**riented **L**ifespan Study of **D**ifferential Development) started in 1995. In spring 1999, GOLD was completed with 191 pairs of twins (»Wave 5«: see Table 1). In fall 1999, a first follow-up (GOLD II) with 39 siblings of pairs of twins was organized. This was continued by starting a second follow-up in 2000 (GOLD III): Once again, the 191 pairs of twins were invited to a retest session (»Wave 6«) in Munich after a time period of about 4-5 years. At the present time (July 2001), 78 pairs of twins have already been retested (about 150 of these 191 pairs are expected to have attended our laboratory by summer 2003). The mean age in the retest group has increased from 70;3 to 74;9 years.

Ulrich Geppert
(Coordinator)
Ernst A. Hany
Gertrud Nunner-Winkler

Former Collaborators of the GOLD-Project (1995-1998):
Franz E. Weinert (Head) †
Ulrich Geppert
Ernst A. Hany (now at Erfurt)
Franz J. Neyer (now at Berlin)
Gertrud Nunner-Winkler
Michael R. Waldmann (now at Göttingen)
Frank Halisch (Consultant)

Theoretically, the GOLD study was inspired by two longitudinal studies (LOGIC, SCHOLASTIC) carried out by the research unit over the last 20 years. These studies revealed very large individual differences in childhood development that proved to be very stable across time. Thus, interest grew in two research issues: (1) Do these individual differences remain stable beyond childhood? (2) To what extent are inherited and early environmental conditions responsible for the observed stability in individual differences? The pursuit of these research goals was facilitated by the fact that Kurt Gottschaldt willed the data from his longitudinal twin study to the Max Planck Institute for Psychological Research in 1991. Gottschaldt had been able to continue his study from 1937 up until the 1970s. At the Max Planck Institute, a further (fourth) wave was carried out in 1992-1993 with 34 of the original 90 pairs of monozygotic (MZ) and dizygotic (DZ) twins from 1937 (Table 1). To meet the theoretical and methodological standards of modern behavioral genetics, this small sample of twins had to be enlarged with pairs of twins of same age. The new GOLD study (Wave 5) running since 1995 managed to recruit 171 new pairs of twins aged 63-85 years to join 20 of Gottschaldt's original pairs.

Table 1: *Change in the Gottschaldt sample between 1937 and 2001 and in the follow-up sample between 1995 and 2001, selected by twin type and gender (Wave 5: 1995-99: 90 original pairs reduced to 20 and 171 »Munich«-follow-up pairs; Wave 6: 2000-2003, in progress, at the moment of July 2001, with 78 retested pairs [13 original and 65 »Munich«-pairs]).*

Period of testing	Pairs of twins							
	MZ-Pairs			DZ-Pairs				Σ
	N	m	f	N	m	f	m/f	N
Original longitudinal sample (Gottschaldt)								
wave 1: 1937	47	14	33	43	21	21	1	90
wave 2: 1950/51	36	7	29	32	15	17	-	68
wave 3: 1965-68	32	6	26	21	10	11	-	53
wave 4: 1992/93	23	4	19	10	3	7	-	33
wave 5: 1995-99	15	3	12	5	1	4	-	20
wave 6: 2000-03	12	3	9	1	0	1	-	13
Follow up longitudinal sample (Munich)								
wave 5: 1995-99	116	40	76	55	20	35	-	171
wave 6: 2000-03	43	13	30	22	6	16	-	65
Both samples								
Σwave 5: 1995-99	131	43	88	60	21	39	-	191
Σwave 6: 2000-03	55	16	39	23	6	17	-	78

m = male, f = female

Table 1

The different research questions (age comparisons, longitudinal analyses, heritability estimations) require a large arsenal of tasks, tests, questionnaires, and interviews covering different developmental domains: Basic Cognitive Processes and Intellectual Abilities (Ernst A. Hany), Learning and Memory (Michael R. Waldmann), Motivation and Emotion, Personality (Ulrich Geppert), Moral Understanding (Gertrud Nunner-Winkler), and Social Relations (Franz J. Neyer). A small sample of results from the different domains of the GOLD study will be reported here.

Elementary Cognitive Processes and Psychometric Intelligence

One of the issues pursued in the field of intelligence is the continuity and flexibility of cognitive abilities through the second half of life. A recent investigation of our extensive data pool looked at verbal creativity and its dependence on fluid and crystallized intelligence. Verbal abilities are shaped more by the environment than by genetics, but the reverse is said to be true for fluid intelligence. Verbal creativity should depend on both types of abilities: When prompted to produce unusual uses for common objects, the structure of verbal knowledge is processed through fluid abilities.

Latent structure modeling was applied to the correlations between fluid intelligence, crystallized intelligence (both measured through German WISC subtests), and verbal creativity. The twin design of our data allowed us to estimate the common and individual factors of genetics—the shared and nonshared environment. A total of 131 pairs of identical and 60 pairs of same-sex fraternal twins with a mean age of 71 years provided the data for this analysis.

Results (Figure 1) show that verbal creativity has a substantial genetic basis that, for the most part, is shared by fluid and crystallized intelligence. Thus, a common genetic factor is the basis for the phenotypic correlations between the three constructs. Verbal creativity and crystallized intelligence are, furthermore, correlated through a common shared-environment factor that is independent of another shared-environment factor on which fluid and crystallized intelligence load. Nonetheless, nearly half of the variance of verbal creativity is due to nonshared environmental influences, that is, individual factors.

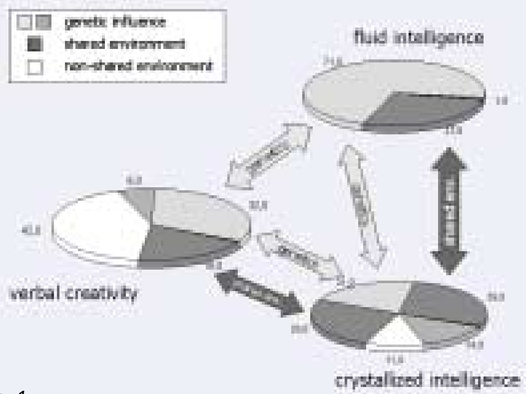

Fig. 1

Figure 1: *Graphical illustration of the common and separate genetic, and the shared and non-shared environment factors contributing to the phenotypic correlation of fluid intelligence, crystallized intelligence, and verbal creativity.*

Thus, individual differences in verbal creativity cannot be explained by its dependence on fluid and crystallized intelligence alone, or by the genetic and environmental factors forming the basis of their correlations. Although verbal creativity has a small genetic basis of its own, it depends mostly on individual experiences (e.g., knowledge and attitudes, presumably) as well as on individual ways of coping with the task. Therefore, any attempt to develop verbal creativity in old age can take different paths: over the shared-environment connection to crystallized intelligence (through long-term development of educatedness), over the genetic factor to both types of intelligence (through middle-term differential training), and over the individual-environment factor (through short-term individual training).

Heritability of Personality Characteristics

The remarkably high genetic determination of individual differences in basic personality traits (»Big Five«) such as extraversion and neuroticism is a well-known finding from genetic studies of personality. When genetic and environmental influences are examined more closely, extraversion reveals a strong portion of nonadditive genetic determination paired with a high individual (nonshared) environmental influence, whereas neuroticism is dominated by additive genetic influence and a common (shared) environment. Our results with the elderly generally confirm these findings (Table 2). Additive genetic influence dominates in neuroticism (42% of the variance); nonadditive influence dominates in extraversion (49%). But, according to our data, the other traits (openness [38%], conscientiousness [36%], and especially agreeability[18%]) are less influenced by genetic factors than expected. Across all the traits, the nonshared environmental influence surpasses the shared environmental influence on individual differences.

Alongside traits, we tested a number of other, more specific, personality characteristics, such as motives, coping strategies or competence- and control-related beliefs, in order to learn about their gene-environment determination of individual differences. Compared with the more fundamental traits, these more specific personality measures are generally expected to be less determined

Variable	r_{MZ}		r_{DZ}	a^2	d^2	c^2	e^2
Neuroticism	.43		.22	42	-	1	56
Extraversion	.49	*	.07	-	49	-	51
Openness	.49		.30	38	-	11	50
Agreeability	.45		.36	18	-	27	55
Conscientiousness	.58		.40	36	-	22	42
Achievement Motive	.30		.20	20	-	10	71
Affiliation Motive	.41	*	-.07	-	40	-	61
Power Motive	.27		.03	-	27	-	72
Flexibility	50	*	.05	-	49	-	50
Persistence	.41	*	.15	19	22	-	59
Competence Beliefs	.56	*	.18	13	40	-	44
Internality	.43		.29	28	-	15	56
Social Externality	.48		.27	42	-	6	52
Fatalistic Externality	.51		.49	4	-	48	49

** The difference between the intrapair correlations is significant.*

Table 2

Table 2: *Personality Characteristics (Traits, Motives, Coping, Control) – Age- and gender-corrected intrapair-correlations r_{MZ} / r_{DZ} (monozygotic vs. dizygotic pairs of twins) and variance components of additive (a) and nonadditive genetic (d) vs. shared (c) and nonshared (e) environmental determination (N_{MZ}=131; N_{DZ}=60).*

by genetic factors. Due to their ascribed role as learned dispositions, they should be influenced primarily by environment (learning and socialization). Taken together, the specific characteristics such as motives and beliefs are, in fact, less influenced by genetic factors (Table 2). Nonetheless, there are some unexpected exceptions, such as affiliation motive, coping strategies (persistence, flexibility), and competence beliefs that reveal a high genetic determination that even surpasses that of the fundamental traits.

Variable	corrected by	r_{MZ}		r_{DZ}	a^2+d^2	c^2	e^2
Achievement	—	.38		.22	33	6	62
Motive	A, G	.30		.20	20	10	71
	A, G, BF + IQ	.22		.15	14	8	77
Affiliation	—	.42	*	-.06	41	-	59
Motive	A, G	.41	*	-.07	40	-	61
	A, G, BF + IQ	.28	*	-.05	27	-	74
Power	—	.38	*	.14	38	-	62
Motive	A, G	.27		.03	27	-	72
	A, G, BF + IQ	.11		.07	8	3	88
Competence	—	.62	*	.20	62	-	38
Beliefs	A, G	.56	*	.18	56	-	44
	A, G, BF + IQ	.43	*	-.06	42	-	58

** The difference between the intrapair correlations is significant. A = age, G = gender, BF = „big five" personality traits, IQ = German WAIS.*

Table 3

Table 3: *Reducing genetic determination by stepwise regression – First order (1), age-/gender-corrected (2), and age-/gender-/traits-/intelligence-corrected intrapair correlations and the change of genetic vs. environmental determination.*

There are good reasons for not overestimating the genetic impact on all these personality characteristics. For instance, we have to test whether the ostensible genetic impact on the specific measures is due to the influence of the basic traits or intelligence, which are genetically determined to a substantial degree. We tested this hypothesis with regression analyses of the critical personality measures, controlling for not only age and gender—as in the basic analyses (cf. Table 2)—but also for the Big-Five traits and general intelligence (WAIS). These analyses reduced the genetic variance in favor of the environmental variance in different degrees (Table 3). For one group of measures, illustrated in our example by the power motive, the genetic influences obviously resulted from shared variance with the traits and intelligence, because the heredity index decreased substantially when the basic measures were controlled. However, for a second set of variables, illustrated by competence beliefs, the index of genetic determination is not reduced as considerably as in the first set. It seems justified to conclude a direct genetic determination for this second set of variables.

Moral Judgement

Alongside several other dimensions, we studied the content of moral convictions. Participants were presented with 24 moral conflict situations (e.g., a mother of young children who works fulltime although she does not need the money; a person who is considering whether to put his decrepit father in a nursing home; the proposal to award German citizenship to resident foreigners) and asked to pass a judgement on them and justify it. Behavioral genetic studies of social attitudes report higher similarities for monozygotic (MZ) than for dizygotic (DZ) pairs. Preliminary analyses show that, overall, MZs actually are slightly more similar in their attitudes compared with DZs (particularly in their rejection of citizenship for foreigners). However, this finding was qualified by regression analyses using gender and frequency of contact within pairs in addition to twin status. Depending on the content of attitudes, considerably higher agreement can be found among DZ pairs (e.g., working mother) or pairs with frequent contact (e.g., father in nursing home) than among MZ pairs. Nonetheless, the differences between either DZ or MZ twins seem small when compared to some of the rather large differences found between generations (cf. Unit Moral Development). In other words, the influence of genes on social attitudes seems to be outweighed by far by the influence of sociocultural context conditions.

Twin Relationships in Adulthood

Twins were interviewed separately over the relationship with their co-twin at different stages in life that are typical for many people though not normative,. Because it was assumed that people remember their biography in terms of meaningful life stages rather than their biological age, these life stages were defined in terms of the family life cycle. Participants were asked to remember how old they were at the beginning and the end of each stage. The family life cycle consisted of 6 stages: (1) leaving the family of origin, (2) building a new nest, (3) living in a family with children, (4) living in a family with adolescents, (5) living in an empty nest, and (6) up to the present. After this, the twins were instructed to try and remember each of these stages and the related age periods as precisely and thoroughly as possible. For each of the 6 stages, they were asked to rate (1) the frequency of contact; (2) the active social support provided to the co-twin; (3) the passive social support received by the co-twin; (4) their spatial closeness, operationalized in terms of how much time the twins had to invest in order to meet each other; and (5) their emotional closeness.

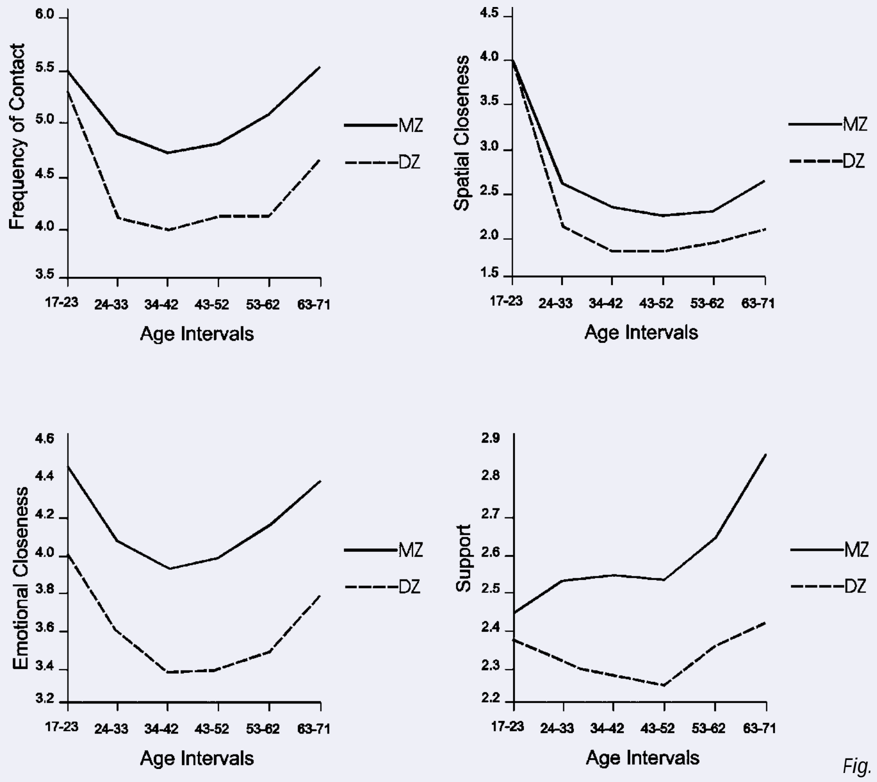

Fig. 2

Figure 2: *Development of MZ and DZ twin relationships from adolescence to old age. Frequency of contact, Spatial closeness, Emotional closeness, and Support.*

The retrospective evaluations of the twin relationship yielded a significant developmental course for each relationship domain in both MZ and DZ twin pairs (Figure 2). As confirmed by quadratic contrasts, the development of contact frequency across adulthood was U-shaped for both MZ and DZ twin pairs. The development of emotional closeness was also U-shaped in both types of twin pairs. After leaving their family of origin in late adolescence, spatial closeness decreased linearly. Further development of spatial closeness across adulthood showed a slight increase when approaching the empty nest phase, as reflected by quadratic contrasts. However, both linear and quadratic trends reveal overall effects, showing that the decrease in spatial closeness was stronger than its increase across adulthood. A different developmental pattern was observed for MZ and DZ twin pairs in the social support domain: Because actual support between DZ siblings decreased in young adulthood and increased again when the twins got older, its development appeared as a U-shaped curve. The development of support in MZ twins, however, was characterized by both linear and quadratic effects. Actual support seemed to increase in early adulthood and then remain constant until the participants were in their 40s. After this age, the support MZ twins actually provided each other increased dramatically.

The results show that MZ and DZ twin relationships in old age are unique types of sibling relationships, as indicated by substantial differences in all relationship domains and dynamics. Over the adult life course, the overall developmental patterns in both twin groups were similar to those that seem to apply for sibling relationships in general. However, MZ twin pairs not only contacted each other more frequently but also lived spatially closer to one another over the entire adult life course. Moreover, they provided more support and felt emotionally closer to one another. These differences can be interpreted in terms of gene-environment effects: Due to their higher genetic similarity, MZ twins are more inclined to seek each other as close relationship partners. The results also highlight the power of genetic kinship in close relationships.

Appendix

Publications

A

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Aschersleben, G., & Prinz, W. (2000, June). *Wahrnehmung und Handlungssteuerung. [Perception and Action Control].* Colloquium for doctoral students, Tutzing.

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Maasen, S. (1999, May). *Sociology of knowledge: Theoretical and practical issues.* Doctoral seminar, IUC Dubrovnik, Yugoslavia.

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Munich Encounters in Cognition and Action (MECA)

The cognition-action interplay has long been neglected in the behavioral and brain sciences. In psychology and physiology, perception and cognition and, to a lesser degree, movement and action have always been broadly studied topics, but the interactions between these domains were not systematically explored. In recent years, however, new approaches and paradigms have been developed and allow for novel insights. Once or twice a year, our Munich Encounters focus on particular themes from the field of the interactions between cognition and action, bringing together a number of leading researchers who have made significant contributions to the field.

Contributions to Congresses and Invited Lectures

A

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Aschersleben, G. (2001, May). *Early development of the cognitive control of action planning: Some theoretical considerations.* Workshop on Issues in Early Development of Perception and Action, München.

Aschersleben, G., Knuf, L., & Müsseler, J. (1999, March). *Aufgabenabhängige Datierung von Reizen beim Kappa-Effekt. [Task-dependent timing of stimuli in the Kappa Effect].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Aschersleben, G., Müller, K., & Prinz, W. (2000, February). *Einfluss der Länge der motorischen Sequenz auf ihre Datierung. [The influence of the length of a motor sequence on its timing].* Workshop on Synchronization, München.

Aschersleben, G., Müsseler, J., & Prinz, W. (2000, July). *Temporal dissociations in perception and action control.* 27th International Congress of Psychology, Stockholm.

B

Bach, P., Knoblich, G., & Prinz, W. (2000, April). *Erkennung von Bedeutungs- und Reihenfolgefehlern in Handlungssequenzen. [Recognition of semantic violations and violations of order in action sequences].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Bach, P., Knoblich, G., & Prinz, W. (2000, July). *Semantische und syntaktische Fehler in Handlungssequenzen. [Semantic and syntactic violations in action sequences].* Institute of Phonetics, Ludwig-Maximilians-Universität München.

Bach, P., Knoblich, G., & Prinz, W. (2001, April). *Prozesse des Handlungsverstehens. [Processes in action comprehension].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

Bekkering, H. (1999, February). *Das Imitationsproblem: Von der Bewegungs-Wahrnehmung zur Bewegungsausführung. [The imitation problem: From perceiving to performing movements].* Ludwig-Maximilians-Universität, München.

Bekkering, H. (1999, February). Die Antwort lautet: Gemeinsame Repräsentation von Wahrnehmung und Handlung. Wie war die Frage? [The answer is: Common representation of perception and action. So what was the question?]. Forschungsplanung Max-Planck-Institut für Psychologische Forschung, Ebersberg.

Bekkering, H. (1999, February). *Imitatie: Hoe kunnen we uitvoeren wat we zien, I. ? [Imitation: How can we perform what we see?].* University of Utrecht.

Bekkering, H. (1999, February). *Imitatie: Hoe kunnen we uitvoeren wat we zien, I.? [Imitation: How can we perform what we see?].* Informatie en Coordinatie bij complexe taakverrichting, Lunteren, The Netherlands.

Bekkering, H. (1999, February). *Task-dependent perception.* Forschergruppe Wahrnehmungsplastizität, Berg.

Bekkering, H. (1999, February). *Vorbereitung und Ausführung sakkadischer Augenbewegungen und zielgerichteter Handbewegungen in Parkinson-Patienten. [Preparation and execution of saccadic eye movements and goal-directed hand movements in patients with Parkinson's disease].* Basal Ganglia Workshop, Alf.

Bekkering, H. (1999, March). *Imitation: The perfect anticipation of a desired action.* The Imitative Mind: Development, Evolution, and Brain Bases, Kloster Seeon.

Bekkering, H. (1999, March). *Saccades are inhibited during goal-directed hand movements.* Annual Meeting of the German Neuroscience Society, Göttingen.

Bekkering, H. (1999, September). *Is attention object-based for nonspatial responses, but spatial-based for aiming movements?* Annual Meeting of the European Society of Cognitive Psychology, Gent, Belgium.

Bekkering, H. (1999, October). *Saccadic inhibition during arm movements.* 10th European Conference on Eye Movements, Utrecht, The Netherlands.

Bekkering, H. (1999, November). *The grasping eye.* 40th Annual Meeting of the Psychonomic Society, Los Angeles, USA.

Bekkering, H. (2000, July). *Tutorial: Action perception and imitation.* Attention and Performance XIX, Kloster Irsee.

Bekkering, H. (2001, June). *Imitation: Normal and pathological control of action.* Annual Meeting of Theoretical & Experimental Neuropsychology (TENNET), Montreal, Canada.

Berndt, I., Wascher, E., Franz, V., & Bülthoff, H. H. (2000, October). *A psychophysical and psychophysiological investigation of processing effort in manual pointing movements.* Neural Control of Movement Synergy, Ohlstadt.

Berndt, I., Wascher, E., Franz, V., Götz, K., & Bülthoff, H. (2001, February). *Lateralisierungen der hirnelektrischen Aktivität während Zeigebewegungen mit gespiegeltem Blickfeld. [Lateralisations of cortical electrophysiological activity during pointing movements with mirrored visual gaze].* 4. Tübinger Wahrnehmungskonferenz, Tübingen.

Braß, M. (1999, July). *Response competition in a simple response task.* Tutorials in Behavioral and Brain Sciences (TuBBS): Summerschool Neurocognitive Foundations of Perception and Action, Ohlstadt.

Braß, M., & Bekkering, H. (1999, April). *Imitation vs. symbolische Instruktion. [Imitation vs. symbolic instruction].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Braß, M., & Bekkering, H. (1999, September). *Response competition in a simple response task.* XIth Congress of the European Society of Cognitive Psychology, Gent, Belgium.

Contributions to Congresses and Invited Lectures

C

Caspi, A., & Wohlschläger, A. (2000, August). *The role of attention in sensorimotor synchronization.* 8th Workshop on Rhythm Perception and Production, Losehill Hall, Castleton, UK.

D

De Maeght, S., Hommel, B., & Schneider, W. X. (1999, March). *Entdeckung einfacher visueller Reizmerkmale: Präattentiv oder nicht? [Detecting simple visual stimulus characteristics: Preattentive or not?].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

De Maeght, S., Knuf, L., & Prinz, W. (1999, May). *The causes of ideomotor action: Attempt to unravel the myth.* Conference of the Belgian Psychological Society, Gent, Belgium.

De Maeght, S., Knuf, L., & Prinz, W. (1999, July). *Ideomotor action: What, why, when and how much?* Tutorials in Behavioral and Brain Sciences (TuBBS): Summerschool Neurocognitive Foundations of Perception and Action, Ohlstadt.

De Maeght, S., Knuf, L., & Prinz, W. (1999, September). *Ideomotor action: A new chapter.* 11th Conference of the European Society of Cognitive Psychology, Gent, Belgium.

De Maeght, S., Knuf, L., & Prinz, W. (1999, November). *Ideomotor phenomena: How intention and perception induce voluntary action.* 40th Annual Meeting of the Psychonomic Society, Los Angeles, USA.

De Maeght, S., Knuf, L., & Prinz, W. (1999, December). *What you see is what you act?* 7th Wintercongres NVP (Dutch Society of Psychonomics), Egmond aan Zee, The Netherlands.

De Maeght, S., Knuf, L., & Prinz, W. (2000, February). *Attempting to unravel the myth of ideomotor action.* Psychsoc, Student Society of the School of Psychology, St. Andrews, UK.

De Maeght, S., Knuf, L., & Prinz, W. (2000, June). *The influence of goal-directed movements on ideomotor action.* 4th Annual Meeting of the Association for the Scientific Study of Consciousness, Brussels, Belgium.

De Maeght, S., Knuf, L., & Prinz, W. (2000, July). *The human factor in ideomotor action.* Summerschool Tutorials in Behavioral and Brain Sciences (TuBBS), Wörlitz.

De Maeght, S., Knuf, L., & Prinz, W. (2000, September). *The acting observer: Ideomotor movements induced by intention?* The Acting Brain: An Interdisciplinary Workshop, Trieste, Italy.

De Maeght, S., Knuf, L., & Prinz, W. (2000, October). *On how involuntary movements reveal our thoughts.* EEBIC seminar of the School of Computer Science, University of Birmingham, UK.

De Maeght, S., Knuf, L., & Prinz, W. (2001, March). *The necessity of biological motion in ideomotor movements.* The neural control of space coding and action production, Lyon, France.

De Maeght, S., Knuf, L., & Prinz, W. (2001, May). *The observation of steering movements modulates ideomotor action.* Meeting of the Belgian Psychological Society, Louvain-La-Neuve, Belgium.

Drewing, K. (2001, April). *Bimanuelle Kopplung und taktile Reafferenzen. [Bimanual coupling and tactile reafference].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

Drewing, K., & Aschersleben, G. (2000, November). *Are enhanced sensory reafferences responsible for the bimanual advantage in tapping?* 41st Meeting of the Psychonomic Society, New Orleans, USA.

Drewing, K., Aschersleben, G., & Miedreich, F. (1999, September). *The influence of acoustic feedback on bimanual tapping.* XIth Conference of the European Society for Cognitive Psychology, Gent, Belgium.

Drewing, K., Hennings, M., & Aschersleben, G. (2000, August). *Reduced timing variability by bimanual coupling: The contribution of sensory information.* Rhythm Perception and Production Workshop (RPP), Castleton, UK.

Drewing, K., Miedreich, F., & Aschersleben, G. (1999, March). *Bimanuelle Kopplung unter der Wirkung auditiver Rückmeldung. [Bimanual coupling and the influence of auditory feedback].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Drewing, K., Miedreich, F., & Aschersleben, G. (1999, May). *Einfluss zusätzlichen Feedbacks auf uni- und bimanuelles Tappen im Continuation-Paradigm. [The influence of additional feedback on uni- and bimanual tapping in the continuation paradigm].* Tagung für interdisziplinäre Bewegungsforschung, Saarbrücken.

Drewing, K., Miedreich, F., & Aschersleben, G. (1999, July). *Is the reduction of timing variability during bimanual movements caused by augmentation of sensory consequences?* Tutorials in Behavioral and Brain Sciences (TuBBS): Summerschool Neurocognitive Foundations of Perception and Action, Ohlstadt.

Drewing, K., Miedreich, F., & Aschersleben, G. (2000, September). *Bewegungsfaszilitierung durch bimanuelle Kopplung: Ein Beitrag sensorischen Feedbacks. [Facilitation of movements by bimanual coupling: A contribution of sensory feedback].* 42. Kongress der Deutschen Gesellschaft für Psychologie, Jena.

Drost, U. C., Knoblich, G., & Goschke, T. (2001, April). *Koordination konfligierender Handlungen. [Coordination of conflicting actions].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

E

Elsner, B. (2000, June). *Reaktionsaktivierung durch erlernte Handlungseffekte. [Response activation by learned action effects].* Forschungskolloquium »Theoretische und experimentelle Kognitionspsychologie«, München.

Elsner, B. (2001, May). *The role of temporal contiguity and conditional probability in adults' learning about action outcomes.* Workshop »Issues in early development of perception and action«, München.

Elsner, B. (2001, June). *Der Erwerb kognitiver Handlungsrepräsentationen. [Acquiring cognitive representations of actions].* Dissertationswettbewerb der Fachgruppe Allgemeine Psychologie der Deutschen Gesellschaft für Psychologie, München.

Elsner, B., & Hommel, B. (1999, March). *Das Zwei-Stufen-Modell der Handlungssteuerung: Ein assoziativer Ansatz zum Erwerb von Handlungs-Effekt-Wissen. [The two-stage model of action control].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Elsner, B., & Hommel, B. (1999, July). *Action priming by conditioned action outcomes.* Tutorials in Behavioral and Brain Sciences (TuBBS): Summerschool Neurocognitive Foundations of Perception and Action, Ohlstadt.

Elsner, B., & Hommel, B. (1999, September). *Action priming by learned action effects under variations of contingency and contiguity.* XIth Congress of the European Society for Cognitive Psychology, Gent, Belgium.

Elsner, B., & Hommel, B. (2000, April). *Je näher und je häufiger, desto besser... Der Einfluss der Kontiguität und der Kontingenz auf das Erlernen von Reaktions-Effekt-Beziehungen. [The closer and the more frequent, the better... The impact of contiguity and contingency on the acquisition of response-effect associations].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Elsner, B., & Hommel, B. (2000, June). *Incidental action-outcome learning influences intentional response selection.* 4th Annual Meeting of the Association for the Scientific Study of Consciousness, Brussels, Belgium.

Elsner, B., Hommel, B., & Siebner, H. R. (2000, September). *Action-outcome learning and voluntary action control.* Summerschool »The acquisition of behavioural competence«, Würzburg.

Elsner, B., Hommel, B., & Siebner, H. R. (2000, November). *SMA-Aktivierung durch die Wahrnehmung sensorischer Bewegungskonsequenzen. [SMA activation through the perception of sensory consequences of movements].* Neurologische Poliklinik des Klinikums Rechts der Isar, München.

Elsner, B., Hommel, B., & Siebner, H. R. (2001, February). *Neuronale Aktivierung durch die Wahrnehmung erlernter Handlungskonsequenzen. [Neural activation through the perception of learnt action consequences].* Workshop »Neurologie, MEG Düsseldorf – MPI für Psychologische Forschung München«, Düsseldorf.

Elsner, B., Hommel, B., & Siebner, H. R. (2001, March). *The perception of learned action consequences activates motor representations: A PET study.* Symposium »Principles of Human Learning and Memory«, Delmenhorst.

Elsner, B., Siebner, H. R., & Hommel, B. (2001, April). *Neuronale Aktivierung durch die Wahrnehmung eines erlernten Handlungseffekts. [Neural activation by the perception of a learnt action effect].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

Elsner, B., Hommel, B., & Siebner, H. R. (2001, June). *Retrieving associations of actions and their sensory consequences: A PET study.* 7th Annual Meeting of the Organization for Human Brain Mapping, Brighton, UK.

F

Flach, R. (2001, April). *Die Rolle impliziter motorischer Kompetenzen in der zeitlichen Antizipation. [The role of implicit motor competencies in temporal anticipation].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

Flach, R., Knoblich, G., & Prinz, W. (2000, March). *Synchronisation mit eigenen und fremden Handlungseffekten. [Synchronization with self- and other-generated action effects].* Interdisziplinäres Kolleg IK2000, Günne / Möhnesee.

Flach, R., Knoblich, G., & Prinz, W. (2000, April). *Synchronisation mit eigenen und fremden Handlungseffekten. [Synchronization with self- and other-generated action effects].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Flach, R., Knoblich, G., & Prinz, W. (2000, August). *Synchronizing with self- and other-generated action effects.* Summerschool Tutorials in Behavioral and Brain Sciences (TuBBS), Wörlitz.

G

Geppert, U. (1999, September). *Microgenesis of self-evaluative emotional expression and rank order behavior in a competition task.* 8th European Conference 'Facial Measurement and Meaning', Saarbrücken.

Geppert, U. (1999, September). *Reaktion auf Erfolg und Misserfolg in Abhängigkeit von der kommunikativen Situation: Stolz, Beschämung, Verlegenheit und Submission im Kindergartenalter. [Reaction to success and failure as a function of the communicative situation: Pride, shame, embarrasssment, and submission in preschool age].* 14th Meeting on Developmental Psychology, Fribourg, Switzerland.

Geppert, U. (2000, December). *Was können Gene? Fakten aus der Zwillingsforschung. [What can genes do? Results from twin research].* Die Evolution verbessern? - Utopien der Erbgutentschlüsselung, Mülheim/Ruhr: Kath. Akademie des Bistums Essen.

Geppert, U., & Halisch, F. (2000, September). *Gen-Umwelt-Determination der Persönlichkeit: Eigenschaften versus Motive. [Genetic and environmental determinants of personality: Traits vs. motives].* 20. Motivationspsychologisches Kolloquium, Dortmund.

Geppert, U., & Lacher, V. (2000, May). *Reaction to success and failure in old age.* 7th Workshop on Achievement and Task Motivation / EARLI-SIG: Motivation and Emotion, Leuven, Belgium.

Goschke, T. (1999, June). *Implizites und explizites Gedächtnis für unerledigte Absichten. [Implicit and explicit memory for uncompleted intentions].* Technische Universität Dresden.

Goschke, T. (1999, June). *Wo, Was und Wie beim Sequenzlernen: Zur Modularität des impliziten Lernens. [Where, what, and how in sequence learning: On the modularity of implicit learning].* Universität Münster.

Goschke, T. (1999, July). *Unabhängiges Lernen von Orts-, Objekt- und Reaktionssequenzen: Zur Modularität impliziten Wissens. [Independent learning of location, object, and response sequences: On the modularity of implicit knowledge].* Universität Leipzig.

Goschke, T. (1999, October). *Exekutive Kontrolle. [Executive control].* Tagung der Assoziation für Experimentelle Kognitionsforschung, Ohlstadt.

Goschke, T. (1999, December). *Implizites Lernen und Gedächtnis: Von Dissoziationen zu Funktionsprinzipien. [Implicit learning and memory: From dissociations to functional principles].* Universität Mainz.

Goschke, T. (1999, December). *Independent learning of spatial, object, and response sequences: Evidence for the modularity of implicit knowledge. Symposium Cognition and Action, Max-Planck-Institut für Psychologische Forschung, München.*

Goschke, T. (2000, March). *Voluntary action and cognitive control: Toward a functional decomposition of the Central Executive.* Workshop »Voluntary Action«, Hanse Wissenschaftskolleg, Delmenhorst.

Goschke, T. (2000, March). *Warum gibt es explizite und implizite Gedächtnissysteme? Funktionale Dilemmata und adaptive Spezialisierungen in lernenden Systemen. [Why are there explicit and implicit memory systems? Functional dilemmas and adaptive specialications in learning systems].* BMFT-Tagung »Autonomie und Adaptivität«, Kloster Seeon.

Goschke, T. (2000, April). *Implizites Lernen sequentieller Strukturen: Von Dissoziationen zu Funktionsprinzipien. [Implicit learning of sequential structures: From dissociations to functional principles].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Goschke, T. (2000, April). *Inhibitorische Prozesse beim Aufgabenwechsel. [Inhibitory processes in task switching].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Goschke, T. (2000, May). *Kognitive Grundlagen der intentionalen Handlungssteuerung: Zur Dekomposition exekutiver Funktionen. [Cognitive foundations of intentional action control: Decomposition of executive functions].* Technische Universität Dresden.

Goschke, T. (2000, July). *Implizites Lernen als Plastizität in domänenspezifischen Repräsentationssystemen. [Implicit learning as plasticity in domain-specific representation systems].* Universität Konstanz.

Goschke, T. (2000, July). *Independent learning of spatio-motor and object sequences: Evidence for the modularity of implicit learning.* 27th International Congress of Psychology, Stockholm, Sweden.

Goschke, T. (2000, October). *Das Plastizitäts-Stabilitäts-Dilemma als Problem der adaptiven Verhaltenssteuerung. [The plasticity-stability dilemma in adaptive action control].* Universität Osnabrück.

Goschke, T. (2001, January). *Kognitive Grundlagen der Handlungssteuerung: Zur experimentellen Dekomposition exekutiver Funktionen. [Cognitive foundations of action control: Experimental decomposition of executive functions].* Universität Münster.

Goschke, T. (2001, March). *Implicit learning in domain-specific representation systems: Independent acquisition of spatiomotor and nonspatial sequences.* 8th Annual Meeting of the Cognitive Neuroscience Society, New York, USA.

Goschke, T. (2001, April). *Implizites Lernen: Von Dissoziationen zu Funktionsprinzipien. [Implicit learning: From dissociations to functional principles].* Universität Greifswald.

Goschke, T. (2001, May). *Voluntary action and cognitive control: Antagonistic constraints and complementary control functions.* Control of Cognitive Processes, Netherlands Royal Academy of Science, University of Amsterdam, The Netherlands.

Contributions to Congresses and Invited Lectures

H

Halisch, F., & Geppert, U. (2000, September). *Motivationale Determinanten des Wohlbefindens im Alter: Ergebnisse aus der Münchner GOLD-Studie. [Motivational determinants of well-being in old age: Results from the Munich Twin Study GOLD].* 20. Motivationspsychologisches Kolloquium, Dortmund.

Hany, E. A. (1999, October). *Stabilität kognitiver Fähigkeiten über einen Zeitraum von 60 Jahren. [The stability of cognitive skills in the course of 60 years].* Tagung der Fachgruppe Differentielle Psychologie und Psychologische Diagnostik, Wuppertal.

Hany, E. A. (2000, September). *Zur Dimensionalität kognitiver Geschwindigkeits-Veränderungen im Alter. [On the dimensionality of cognitive speed changes in old age].* 42. Kongress der Deutschen Gesellschaft für Psychologie, Jena.

Hommel, B. (1999, January). *Acquisition and control of intentional action.* University of Almería, Spain.

Hommel, B. (1999, March). *Acquisition and control of intentional action.* University of Leiden, The Netherlands.

Hommel, B. (1999, March). *Action concepts: Coding and integration in perception and action.* Behavioral and Neuroscience Approaches to Cognitive Aging, Dölln.

Hommel, B. (1999, March). *Automatische Reaktionsaktivierung und Reiz-Reaktions-Integration. [Automatic response activation and S-R integration].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Hommel, B. (1999, May). *Theorie der Ereigniskodierung in Wahrnehmung und Handlung. [The theory of event coding in perception and action].* Forschungskolloquium, Ludwig-Maximilians-Universität, München.

Hommel, B. (1999, June). *Kontrolle und Automatizität bei der Reiz-Reaktions-Übersetzung. [Control and automaticity in S-R translation].* Universität Konstanz.

Hommel, B. (1999, August). *Action as stimulus control.* 8th Oldenburg Symposium on Psychological Acoustics, Bad Zwischenahn.

Hommel, B. (1999, August). *Menschliches Handeln: Erwerb, Repräsentation und Kontrolle. [Human action: Acquisition, representation, and control].* Max-Planck-Institut zur Erforschung von Wissenschaftssystemen, Jena.

Hommel, B. (1999, September). *Permanent and transient links in the control of S-R translation.* 11th Conference of the European Society for Cognitive Psychology, Gent, Belgium.

Hommel, B. (1999, November). *How we perform two tasks at a time.* University of Gent, Belgium.

Hommel, B. (1999, November). *Routes from stimuli to responses under dual-task conditions.* 40th Meeting of the Psychonomic Society, Los Angeles, USA.

Hommel, B. (1999, December). *The impact of action planning on perception.* 7. Wintercongres van de Nederlandse Vereniging voor Psychonomie, Egmond an Zee, The Netherlands.

Hommel, B. (2000, February). *Erwerb und Kontrolle intentionalen Handelns. [Acquisition and control of intentional behavior].* Adaptivity and Autonomy of Human Action, Kloster Seeon.

Hommel, B. (2000, March). *The emergence of voluntary action.* Workshop »Voluntary Action«, Hanse Wissenschaftskolleg, Delmenhorst.

Hommel, B. (2000, March). *Welche Handlungen machen uns blind wofür? Wie Handlungsplanung unsere Wahrnehmung beeinflusst. [Which actions make us blind for which things? How action planning influences our perception].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Hommel, B. (2000, June). *Feature integration in perception and action.* Free University of Amsterdam, Amsterdam, The Netherlands.

Hommel, B. (2000, October). *The cognitive representation of action.* Summerschool European Diploma in Cognitive and Brain Sciences, Hanse Wissenschaftskolleg, Delmenhorst.

Hommel, B. (2000, October). *Control and automaticity in S-R translation.* Summerschool European Diploma in Cognitive and Brain Sciences, Hanse Wissenschaftskolleg, Delmenhorst.

Hommel, B. (2000, October). *Dual-task control.* Summerschool European Diploma in Cognitive and Brain Sciences, Hanse Wissenschaftskolleg, Delmenhorst.

Hommel, B. (2000, November). *Feature integration in perception and action.* Universität Saarbrücken.

Hommel, B. (2000, November). *Where is the bottleneck in human information processing?* Studium Universale, CREA, Amsterdam, The Netherlands.

Hommel, B. (2000, December). *Cognitive representation of voluntary action.* The Role of Internal Representation in Complex Animal Behavior, Bielefeld.

Hommel, B. (2001, January). *In the beginning was the act: A plea for an action-oriented approach to cognitive psychology.* Oration, University of Leiden, The Netherlands.

Hommel, B. (2001, May). *Stimulus-response translation and action planning in dual-task performance.* The Control of Cognitive Processes, Amsterdam, The Netherlands.

J

Jordan, J. S., Stork, S., Knuf, L., Kerzel, D., & Müsseler, J. (2000, July). *Action planning affects spatial localization.* Attention and Performance XIX: Common mechanisms in perception and action, Kloster Irsee.

Jordan, J. S., Stork, S., Knuf, L., & Müsseler, J. (2000, November). *Intentional binding in spatial perception.* 41st Annual Meeting of the Psychonomic Society, New Orleans, USA.

Jovanovic, B. (2000, March). *Entwicklung von Selbst und intentionalem Handeln. [Development of the self and intentional action].* Workshop »Voluntary Action«, Hanse-Wissenschaftskolleg, Delmenhorst.

Jovanovic, B. (2000, July). *Self and other: Concepts of agents in early childhood.* Summerschool Tutorials in Behavioral and Brain Sciences (TuBBS), Wörlitz.

Jovanovic, B. (2000, September). *Agent-concepts and the self throughout intentional development.* 9th Annual Meeting of the European Society for Philosophy and Psychology, Salzburg, Austria.

K

Kerzel, D. (1999, September). *The role of eye movements in judged displacement of a moving target.* XIth Conference of the European Society for Cognitive Psychology, Gent, Belgium.

Kerzel, D. (2000, February). *Augenbewegungen und die Fehllokalisation der letzten Position eines bewegten Reizes. [Eye movements and the mislocalization of the final position of a moving target].* 3. Tübinger Wahrnehmungskonferenz, Tübingen.

Kerzel, D. (2000, April). *Das visuelle Kurzzeitgedächtnis wird durch Körperbewegungen beeinflusst. [Visual short-term memory is influenced by body movements].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Kerzel, D. (2000, August). *The time course of perceptual momentum.* 23rd European Conference on Visual Perception, Groningen, The Netherlands.

Kerzel, D. (2000, September). *The mislocalization of the final position of a moving target: An error in memory and/or perception?* 1st International Workshop on Representational Momentum, Max-Planck-Institut für Biologische Kybernetik, Tübingen.

Kerzel, D. (2000, November). *Visual short-term memory is influenced by haptic perception.* 41st Annual Meeting of the Psychonomic Society, New Orleans, USA.

Kerzel, D. (2001, April). *Repräsentationales Momentum ist ein perzeptuelles Phänomen, keine Gedächtnisverzerrung. [Representational Momentum is a perceptual phenomenon, not a memory distortion].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

Kerzel, D. (2001, May). *Der Einfluss von Beobachteraktivität auf das visuelle Kurzzeitgedächtnis. [The influence of observer activity on visual short-term memory].* Universität Würzburg.

Kerzel, D., & Bekkering, H. (1999, March). *Eine motorische Interpretation des McGurk-Effekts: Evidenz aus einem Reaktionszeitparadigma. [A motor interpretation of the McGurk-effect: Evidence from a reaction-time paradigm].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Kerzel, D., & Bekkering, H. (1999, July). *Motor activation from visible speech: Evidence from stimulus-response compatibility.* Tutorials in Behavioral and Brain Sciences (TuBBS): Summerschool Neurocognitive Foundations of Perception and Action, Ohlstadt.

Kerzel, D., Jordan, J. S., & Müsseler, J. (1999, November). *Testing a perceptual-oculomotor account of effects deemed due to representational momentum.* 40th Annual Meeting of the Psychonomic Society, Los Angeles, USA.

Kerzel, D., Müsseler, J., Stork, S., & Neggers, B. (2000, September). *The mislocalization of the final position of a moving target: An error in memory and/or perception?* 1st International Workshop on Representational Momentum, Max-Planck-Institut für Biologische Kybernetik, Tübingen.

Knoblich, G. (1999, March). *Erkennung eigener Handlungen an Hand der Kinematik von Zeichenbewegungen. [Recognizing one's own action through the kinematics of drawing movements].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Knoblich, G. (1999, June). *Recognition of self-generated action.* 3rd Annual Meeting of the Association for the Scientific Study of Consciousness, London, Canada.

Knoblich, G. (1999, July). *Constraint relaxation and chunk decomposition in insight problem solving.* 1st Dissertationswettbewerb der Deutschen Gesellschaft für Psychologie, Regensburg.

Knoblich, G. (1999, August). *Resolving impasses in problem solving: An eye movement study.* 21st Annual Conference of the Cognitive Society, Vancouver, Canada.

Knoblich, G. (1999, September). *Allokation von Aufmerksamkeit und Metakognition beim Problemlösen mit Einsicht. [Allocation of attention and metacognition in insight problem-solving].* 4. Tagung der Gesellschaft für Kognitionswissenschaft, Bielefeld.

Knoblich, G. (1999, September). *Anticipation of forthcoming strokes is more accurate for self-generated trajectories.* 11th Conference of the European Society for Cognitive Psychology, Gent, Belgium.

Knoblich, G. (1999, November). *Insight problem solving.* St. Xavier University, Chicago, USA.

Knoblich, G. (1999, November). *Predicting the outcomes of self- and other-generated throwing actions.* 40th Annual Meeting of the Psychonomic Society, Los Angeles, USA.

Knoblich, G. (2000, January). *Veränderungen der Problemrepräsentation als Grundlage von Einsicht. [Representational change and insight].* Universität Jena.

Knoblich, G. (2000, September). *Offline perception of one's own actions,* Max-Planck-Institut für Biologische Kybernetik, Tübingen.

Knoblich, G. (2000, November). *Detecting changes in the mapping between movements and their effects.* 41st Annual Meeting of the Psychonomic Society, New Orleans, USA.

Knoblich, G. (2000, November). *Wahrnehmung und Koordination eigener und fremder Handlungen. [Perception and coordination of self- and other-generated actions].* Universität Köln.

Knoblich, G. (2000, December). *Kognitive Modelle der Einsicht. [Cognitive models of insight].* Universität Göttingen.

Knoblich, G. (2001, January). *Wahrnehmung eigener und fremder Handlungseffekte. [Perception of self- and other-generated action effects].* Universität Konstanz.

Knoblich, G. (2001, April). *Monitoring von Handlungseffekten. [Monitoring of action effects].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

Knoblich, G., Bach, P., Gunter, T., Friederici, A. D., & Prinz, W. (2000, November). *Processing the syntax and semantics of action sequences.* Cognitive Brownbag, University of Illinois at Chicago, USA.

Knoblich, G., Bach, P., & Prinz, W. (2000, July). *Erkennung von Reihenfolge- und Bedeutungsfehlern in Handlungssequenzen. [Detecting violations of order and meaning in action sequences].* Workshop des Max-Planck-Instituts für Neuropsychologische Forschung und des Max-Planck-Instituts für Psychologische Forschung, Leipzig.

Knoblich, G., & Flach, R. (2000, April). *Vorhersage von Effekten eigener und fremder Handlungen. [Predicting self- and other-generated action effects].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Knoblich, G., & Flach, R. (2000, October). *Perceiving self- and other-generated actions.* Lyon-München Workshop, Institutes des Sciences Cognitives, CNRS, Lyon.

Knoblich, G., Gunter, T., Bach, P., Friederici, A. D., & Prinz, W. (2001, June). *Action comprehension.* Annual Meeting of Theoretical and Experimental Neuropsychology, University of Québec at Montréal, Canada.

Knoblich, G., & Jordan, S. (2000, July). *Individual and joint coordination of conflicting actions.* The mirror system and the evolution of brain and language, Hanse Wissenschaftskolleg, Delmenhorst.

Knoblich, G., & Jordan, S. (2000, August). *Constraints of embodiment on action coordination.* 22nd Annual Meeting of the Cognitive Science Society, University of Pennsylvania, USA.

Knuf, L., Gehrke, J., & Hommel, B. (1999, February). *Die Rolle handlungsbezogener Information bei der Entstehung räumlicher Repräsentationen. [The role of action-related information in the genesis of spatial representations].* 2. Tübinger Wahrnehmungskonferenz, Tübingen.

Knuf, L., Gehrke, J., & Hommel, B. (1999, March). *Raumkognition: Evidenz für die Integration handlungsrelevanter Information. [Spatial cognition: Evidence for the integration of action-relevant information].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Knuf, L., Gehrke, J., & Hommel, B. (1999, May). *Conditions for spatial coding in perception and memory.* 5. Plenarkolloquium des DFG-Schwerpunktprogramms Raumkognition, Tutzing.

Knuf, L., Gehrke, J., & Hommel, B. (1999, May). *Handlungsbezogene Determinanten räumlicher Strukturierungen im Gedächtnis. [Action-related determinants of spatial structurings in memory].* 5. Plenarkolloquium des DFG-Schwerpunktprogramms Raumkognition, Tutzing.

Knuf, L., Gehrke, J., & Hommel, B. (1999, November). *Action-related determinants of spatial coding in perception and memory.* 40th Annual Meeting of the Psychonomic Society, Los Angeles, USA.

Knuf, L., & Hommel, B. (1999, September). *Spatial cognition: Functional determinants of spatial coding in perception and memory.* 11th Conference of the European Society for Cognitive Psychology, Gent, Belgium.

Knuf, L., Klippel, A., Freksa, C., Hommel, B., & Gehrke, J. (1999, May). *Konfiguration versus Karte: Zur Frage nach der Kodierung piktorieller Darstellungen. [Configurations vs. maps: On the coding of pictorial representations].* 5. Plenarkolloquium des DFG-Schwerpunktprogramms Raumkognition, Tutzing.

Knuf, L., Klippel, A., Hommel, B., & Freksa, C. (2000, May). *Einflüsse perzeptiver und kontextspezifischer Faktoren auf die räumliche Repräsentation (karto-)graphischer Darstellungen. [Impact of perceptual and context-specific factors on the spatial representation of graphic images].* 6. Plenarkolloquium des DFG Schwerpunktprogramm Raumkognition, Tutzing.

Knuf, L., Klippel, A., Hommel, B., & Freksa, C. (2000, April). *Konfiguration versus Karte: Untersuchungen zur räumlichen Kodierung piktorieller Darstellungen. [Configurations vs. maps: On the spatial coding of pictorial representations].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Koch, I. (1999, March). *Effekte der Reiz-Reaktions-Zuordnung auf Sequenzlernen. [Effects of S-R allocation on sequence learning].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Contributions to Congresses and Invited Lectures

Koch, I. (1999, September). *Response preparation in sequence learning: Effects of stimulus-response compatibility.* 11th Conference of the European Society for Cognitive Psychology, Gent, Belgium.

Koch, I. (2000, January). *Kompatibilitätseffekte bei zeitlich überlappenden Wahrnehmungs- und Handlungsaufgaben. [Compatibility effect with temporally overlapping perception and action tasks].* Universität Heidelberg.

Koch, I. (2000, July). *Automatische und intentionale Aktivierung von »Task-sets«. [Automatic and intentional activation of task sets].* Universität Würzburg.

Koch, I. (2000, July). *Dissoziierbare Interferenzkomponenten bei zeitlich überlappenden Wahrnehmungs- und Reaktionsaufgaben. [Dissociable components of interference with temporally overlapping perception and action tasks],* Max-Planck-Institut für Neuropsychologische Forschung, Leipzig.

Koch, I. (2000, September). *Der Einfluss inzidentell erworbener Aufgabenantizipationen auf die Kosten beim Aufgabenwechsel. [The influence of incidentally acquired task anticipations on the costs of switching tasks].* 42. Kongress der Deutschen Gesellschaft für Psychologie, Jena.

Koch, I. (2000, November). *Bedeutung exogener Hinweisreize für endogen gesteuerte kognitive Rekonfigurationsprozesse. [The importance of exogenous cues for endogenous control of cognitive reconfiguration].* Universität Konstanz.

Koch, I. (2000, November). *Experimental approaches to intentional control of cognition and action.* University of Chicago, USA.

Koch, I. (2000, November). *Incidental learning of task shifts.* 41st Meeting of the Psychonomic Society, New Orleans, USA.

Koch, I. (2001, April). *Das Zusammenspiel exogener und endogener »Cues« beim Aufgabenwechsel. [The interplay of exogenous and endogenous cues in task switching].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

Koch, I. (2001, May). *Automatic activation and decay of task sets: Evidence from incidental task-sequence learning.* KNAW Academy Colloquium: The control of cognitive processes, Amsterdam, The Netherlands.

Koch, I., & Prinz, W. (2000, April). *Kompatibilitätseffekte bei zeitlich überlappenden Reaktions- und Wahrnehmungsaufgaben. [Compatibility effects with temporally overlapping action and perception tasks].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Kutschmann, W., & Mechsner, F. (2000, May). *Zeichen, Formeln, Systeme. [Tokens, formula, systems].* Lernwege. Bildungstag 2000 der Gewerkschaft Erziehung und Wissenschaft, Weimer.

L

Lohmann, P., Müsseler, J., & Esser, K.-H. (2001, June). *Vocal effects of delayed auditory feedback in the lesser spear-nosed bat Phyllostomus discolor.* 6th International Congress of Neuroethology, Bonn.

M

Maasen, S. (1999, October). *Science and public discourses: Communicating in spite of and through the differences.* Science and the media I and II. '4S' - Conference of the Society for Social Studies of Science, University of San Diego, CA, USA.

Maasen, S. (1999, December). *Was ist überhaupt und wie funktioniert Diskursanalyse? [What is discourse analysis at all and how does it work?].* Graduiertenkolleg Wissenschafts- und Technikgeschichte, Universität Bielefeld.

Maasen, S. (2000, March). *Consciousness: The emergence of a heterogeneous concept. A metaphor analysis.* Workshop »Voluntary Action«, Hanse Wissenschaftskolleg, Delmenhorst.

Maasen, S. (2000, March). *Genealogie der Unmoral: Ein theoretisch-methodisches PS zu einer historischen Diskursanalyse. [The genealogy of immorality: A theoretical and methodological P.S. on a historical discourse analysis].* Workshop »Diskursanalyse«, Augsburg.

Maasen, S. (2000, March). *Was ist überhaupt und wie funktioniert Diskursanalyse? [What actually is discourse analysis and how does it work?].* Arbeitsgruppe Diskursanalyse, Graduiertenkolleg Wissenschafts- und Technikgeschichte, Universität Bielefeld.

Maasen, S. (2000, June). *»Klinische Soziologie«: Soziologie (in) der Wissensgesellschaft. Intervention als Problem einer reflexiven Wissenschaftspraxis. [»Clinical sociology«: The sociology of (in) the knowledge society. Intervention as an issue of a reflexive science practice].* University of Basel, Switzerland.

Maasen, S. (2000, June). *Sexual therapeutic constructions of selves.* 30th Annual Meeting of the Jean-Piaget Society: Alternative Constructions of Self and Mind, Montreal, Canada.

Maasen, S. (2000, July). *Chaotics: Ein Fall von Wissens(un)ordnung in der Wissensgesellschaft. [Chaotics: A case of knowledge (dis-)order in the knowledge society].* Workshop Wissensgesellschaft: Transformationen im Verhältnis von Wissenschaft und Alltag, Universität Bielefeld.

Maddox, M. D., Wulf, G., & Wright, D. L. (1999, June). *The effect of an internal vs. external focus of attention on the learning of a tennis stroke.* North American Society for the Psychology of Sport and Physical Activity, Clearwater Beach, FL, USA.

McNevin, N. H., & Wulf, G. (1999, June). *Increasing the distance of an external focus enhances learning.* North American Society for the Psychology of Sport and Physical Activity, Clearwater Beach, FL, USA.

McNevin, N. H., & Wulf, G. (1999, July). Attention and motor learning: *Benefits of a »distant« external focus.* 4th Annual Meeting of the European College of Sport Science, Rome, Italy.

Mechsner, F. (1999, March). *Raum erleben, Raum verstehen. [Experiencing and understanding space].* Zentrum für Allgemeine Wissenschaftliche Weiterbildung, Universität Ulm.

Mechsner, F. (1999, September). *Bewegte Hände. [Moving hands].* Zentrum für Allgemeine Wissenschaftliche Weiterbildung, Universität Ulm.

Mechsner, F. (1999, November). *Kognitive Steuerung von bimanuellen Bewegungen. [Cognitive control of bimanual movements].* Freie Universität Berlin.

Mechsner, F. (1999, November). *Mathematische Aspekte einer Theorie des Kleinhirns. [Mathematical aspects of a cerebellar modeling].* Institut für Kognitive Mathematik, Universität Osnabrück.

Mechsner, F. (2000, September). *Gestaltpsychologie und ihre Geschichte im 20. Jahrhundert. [Gestalt Psychology and its 20th century history].* Universität Ulm.

Mechsner, F. (2000, October). *Perceptual coding in limb and tool movements.* Joint Meeting of the Institute for Cognitive Sciences, Lyon and the Max Planck Institute for Psychological Research, München, Lyon.

Mechsner, F. (2000, October). *Perceptual coupling in bimanual circling.* Self-Organization of Cognition and Applications in Psychology, Ascona, Switzerland.

Mechsner, F. (2000, October). *Spontane Kopplung bei bimanuellen Bewegungen. [Spontaneous coupling in bimanual movements].* Institut für Medizinische Psychologie, München.

Mechsner, F. (2000, December). *Hände, Werkzeuge und Objekte. [Hands, tools, and objects].* 1. Herbsttagung Experimentelle Kognitionspsychologie, Münster.

Mechsner, F. (2001, January). *Bimanuelle Koordination. [Bimanual coordination].* Abteilung für Psychiatrie, Universität Bern, Switzerland.

Mechsner, F. (2001, January). *Bimanuelle Koordination. [Bimanual coordination].* Ludwig-Maximilians-Universität München.

Mechsner, F. (2001, January). *Tausendfüßlers Dilemma: Über die unterschiedliche funktionale Rolle von bewussten und unbewussten Prozessen bei der Koordination von Bewegungen. [Millepede's dilemma: On the differing functional role of conscious and subconscious processes in movement coordination].* Sportmotorik 2001 - Bewusstsein, Bewegung, Lernen, Gießen.

Mechsner, F. (2001, February). *Fast and frugal strategies in voluntary movements.* Max-Planck-Institut für Bildungsforschung, Berlin.

Mechsner, F. (2001, February). *Hände und Werkzeuge. [Hands and tools].* Universität Braunschweig.

Mechsner, F. (2001, May). *Aufmerksamkeit und Bewegungskoordination. [Attention and movement coordination].* 33. Fachtagung Sportpsychologie, Magglingen, Switzerland.

Mechsner, F. (2001, May). *Eine Theorie des Kleinhirns. [A theory of the cerebellum].* Deutsches Zentrum für Luft- und Raumfahrt, Oberpfaffenhofen.

Mechsner, F., Kerzel, D., & Prinz, W. (2001, March). *Coupling of perception and action in bimanual coordination.* 4. Tübinger Wahrnehmungskonferenz, Tübingen.

Miedreich, F. (1999, February). *Zeitliche Steuerung von Handlungen: Empirische Untersuchungen zum Wing-Kristofferson-Modell. [Temporal control of actions: Empirical studies on the W-K model].* Max-Planck-Institut für Psychologische Forschung, München.

Miedreich, F., & Aschersleben, G. (1999, November). *Temporal control of repetitive movements in the tapping task.* Conference of the Psychonomic Society, Los Angeles, USA.

Möller, R. (2000, June). *Visual homing without image matching.* Neurotechnology for Biomimetic Robots, Marine Science Center, Northeastern University, Nahant, MA, USA.

Möller, R. (2000, July). *Biorobotik-Studien zur Landmarken-Navigation bei Insekten. [Biorobotic studies on landmark navigation in insects].* Universität Bielefeld.

Möller, R. (2000, November). *Analog implementation of an insect visual-homing strategy on a mobile robot.* SPIE Sensor Fusion and Decentralized Control in Robotics Systems, Boston, MA, USA.

Müller, K. (1999, March). *Magnet-Enzephalographie und Sprachforschung. [Magnetencephalography and language research].* Arbeitskreis Klinische Psychologen in Phoniatrischer Diagnostik und Therapie, Duisburg.

Müller, K. (1999, April). *Methoden zur Messung kortikaler Aktivität im Zusammenhang mit Rhythmusverarbeitung am Beispiel von MEG-Analysen. [Methods for measuring cortical activity related to rhythm processing].* Kognitive Aspekte der Wahrnehmung und Produktion von Rhythmus, Ohlstadt.

Müller, K., Aschersleben, G., Esser, K. H., & Müsseler, J. (1999, April). *Effekte verzögerter auditiver Rückmeldung: Nur ein Rhythmusproblem? [Effects of delayed auditory feedback: Only a rhythm problem?].* DFG-Schwerpunkttagung »Sensomotorische Integration«, Ulm.

Müller, K., Aschersleben, G., Schmitz, F., Schnitzler, A., Freund, H.-J., & Prinz, W. (1999, September). *The influence of acoustic feedback on bimanual tapping.* Congress of the European Society for Cognitive Psychology, Gent, Belgium.

Müller, K., Pollok, B., Aschersleben, G., Schmitz, F., Schnitzler, A., Freund, H.-J., & Prinz, W. (2000, November). *Central control of precision in sensorimotor synchronization during regular and irregular modality changes.* 41st Annual Meeting of the Psychonomic Society, New Orleans, USA.

Müller, K., Schmitz, F., Aschersleben, G., Schnitzler, A., Freund, H. J., & Prinz, W. (1999, March). *Neuromagnetische Untersuchungen zum Einfluss der Modalität in sensomotorischen Synchronisationsaufgaben. [Neuromagnetic studies on the influence of modalities on sensorimotor synchronization tasks].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Müller, K., Schmitz, F., Aschersleben, G., Schnitzler, A., Freund, H. J., & Prinz, W. (1999, June). *Modality-dependent cortical activation during a sensorimotor synchronization task.* Human Brain Mapping Meeting 1999, Düsseldorf.

Müller, K., Schmitz, F., Aschersleben, G., Schnitzler, A., Freund, H. J., & Prinz, W. (1999, September). *A neuromagnetic view on the role of modality in sensorimotor synchronization.* 11th Conference of the European Society for Cognitive Psychology, Gent, Belgium.

Müller, K., Schmitz, F., Aschersleben, G., Schnitzler, A., Freund, H. J., & Prinz, W. (1999, November). *Are modality-specific central control units responsible for preciseness in sensorimotor synchronization?* 40th Annual Meeting of the Psychonomic Society, Los Angeles, USA.

Müsseler, J. (1999, January). *Der Wille und sein antizipierter Effekt: Zur effektorientierten Steuerung von Handlungen. [Volition and its anticipated effect: The effect-oriented control of actions].* Wille und Tat, Tutzing.

Müsseler, J. (1999, January). *Wahrnehmungs- und Handlungsfehler bei der Lokalisation von Reizen. [Perception and action errors in the localization of stimuli].* Universität Düsseldorf.

Müsseler, J. (1999, April). *Variationen zum Thema Wahrnehmung und Handlungssteuerung. [Variations on the topic of perception and action control].* Universität Marburg.

Müsseler, J. (1999, June). *Visuelle Lokalisation im Raum. [Visual localization in space].* Tagung DFG-Schwerpunktprogramm »Sensomotorische Integration«, Bochum.

Müsseler, J. (1999, July). *Wahrnehmung und Handlung. Empirische Befunde und anwendungsorientierte Aspekte. [Perception and action: Empirical findings and practical aspects].* Universität Erlangen/Nürnberg.

Müsseler, J. (1999, September). *Space perception and attentional shifts.* Symposium on »Functional aspects of visual attention«, XIth Conference of the European Society for Cognitive Psychology, Gent, Belgium.

Müsseler, J. (2000, January). *Wahrnehmung und Handlungssteuerung. [Perception and action control].* Universität Wuppertal.

Müsseler, J. (2000, May). *Handeln während wir wahrnehmen: Können wir uns auf unser perzeptives System verlassen?[Acting while perceiving: Can we trust our perceptual system?].* Humboldt-Universität Berlin.

Müsseler, J. (2001, April). *Visuelle Lokalisation bei Reizbewegung. [Visual localization with moving stimuli].* Symposium der Fachgruppe Allgemeine Psychologie: Modellierung und Psychophysik kognitiver Prozesse, Regensburg.

Müsseler, J., & Stork, S. (1999, March). *Lokalisationsfehler von Reizen bei Bewegung. [Localization errors for moving stimuli].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Müsseler, J., Stork, S., & Kerzel, D. (2000, September). *Mislocalization of the initial position of the moving stimulus.* 1st International Workshop on Representational Momentum, Max-Planck-Institut für Biologische Kybernetik, Tübingen.

Müsseler, J., Stork, S., & Kerzel, D. (2001, April). *Wahrgenommene Fehllokalisationen in Bewegungsrichtung. [Perceived mislocalization in the direction of motion].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

Müsseler, J., Stork, S., Kerzel, D., & Jordan, J. S. (2000, February). *Localization errors with linear and circular movements.* 3. Tübinger Wahrnehmungskonferenz, Tübingen.

Müsseler, J., Stork, S., Kerzel, D., & Jordan, S. (2000, November). *Mislocalization of the initial and final position of a moving stimulus.* 41th Annual Meeting of the Psychonomic Society, New Orleans, USA.

Müsseler, J., & van der Heijden, A. H. C. (1999, February). *Fehllokalisation bei kurzzeitiger Präsentation von Reizen. [Mislocalization of briefly presented stimuli].* 2. Tübinger Wahrnehmungskonferenz, Tübingen.

Müsseler, J., & van der Heijden, A. H. C. (1999, November). *Relative mislocalization of briefly presented stimuli.* 40th Annual Meeting of the Psychonomic Society, Los Angeles, USA.

Müsseler, J., & Wühr, P. (2000, February). *Spezifische Interferenzen zwischen Handlungssteuerungs- und Wahrnehmungsprozessen. [Specific interferences between processes of action control and perception].* Tagung DFG Schwerpunkttprgramm »Sensomotorische Integration«, Bonn - Bad Godesberg.

Müsseler, J., & Wühr, P. (2000, July). *Motorisch bedingte Interferenzen beim visuellen Enkodieren. [Motor caused interferences in visual encoding].* Max-Planck-Institut für Neuropsychologische Forschung, Leipzig.

Müsseler, J., & Wühr, P. (2000, July). *Response-evoked interference in visual encoding.* Attention and Performance XIX: Common mechanisms in perception and action, Kloster Irsee.

Müsseler, J., & Wühr, P. (2001, March). *Motorisch hervorgerufene Modulationen visueller Encodierungsprozesse. [Motor-triggered modulations of visual encoding processes].* Symposium über Sensumotorik, 4. Tübinger Wahrnehmungskonferenz, Tübingen.

N

Neggers, S. F. W., & Bekkering, H. (1999, July). *Target selection is different for a saccade-and-pointing movement sequence as compared to a single saccade.* Tutorials in Behavioral and Brain Sciences (TuBBS): Summerschool Neurocognitive Foundations of Perception and Action, Ohlstadt.

Nißlein, M., & Müsseler, J. (2000, April). *Der Missing Letter Effekt bei Wortstamm- und Präfixverben. [The Missing-Letter effect in word stem- and prefix verbs].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Nißlein, M., & Müsseler, J. (2000, September). *Variationen der Wortform: Ein Beitrag zur Erklärung des Missing Letter Effekts. [Variations of word shape: A contribution to the explanation of the Missing Letter Effect].* 42. Kongress der Deutschen Gesellschaft für Psychologie, Jena.

Nißlein, M., Müsseler, J., & Koriat, A. (1999, March). *Inkongruente Groß- und Kleinschreibung und der Missing-Letter Effekt. [Incongruent capitalization and the Missing-Letter effect].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Nißlein, M., Müsseler, J., & Koriat, A. (1999, September). *Orthographic word shape in German and the Missing-Letter Effect.* 11th Conference of the European Society for Cognitive Psychology, Gent, Belgium.

Nißlein, M., Müsseler, J., & Koriat, A. (2000, July). *Orthographic variations of word shape and letter detection: Some evidence from German.* 27th International Congress of Psychology, Stockholm.

Nunner-Winkler, G. (1999, May). *Moralische Entwicklung und Motivation von Kindern. [Moral development and motivation in children].* Tagung zur Werteerziehung und zum Fach Humanistische Lebenskunde: »Dem Leben selbst Wert geben«, Humanistische Akademie, Berlin.

Nunner-Winkler, G. (1999, June). *Die soziale Reproduktion von Moral. [The social reproduction of morality].* Tagung der Sektion »Politische Theorien und Ideengeschichte« der »Deutschen Vereinigung für Politische Wissenschaft« (DVPW): »Interesse und Moral als Orientierungen politischen Handelns«, Ev. Akademie, Loccum.

Nunner-Winkler, G. (1999, July). *Moralische Bildung. [Moral education].* Interdisziplinäres Symposium zum 70. Geburtstag von Jürgen Habermas: Die Öffentlichkeit der Vernunft und die Vernunft der Öffentlichkeit, Universität Frankfurt.

Nunner-Winkler, G. (1999, August). *Sympathy, shame and guilt - the relevance of emotions to moral development.* Ethics and Emotion, Padua, Italy.

Nunner-Winkler, G. (1999, September). *Familie in der Krise? [Family in crisis?].* Wie jugendhilfefähig ist Politik - wie politikfähig ist Jugend?, Nürnberg.

Nunner-Winkler, G. (1999, November). *Brauchen Kinder mehr Erziehung? [Do children need more educating?].* Institut für soziale Arbeit, Potsdam.

Nunner-Winkler, G. (1999, November). *Wertewandel und moralische Identität. [Change in values and moral identity].* Strukturwandel in der Arbeitswelt und individuelle Bewältigung, Universität Dortmund.

Nunner-Winkler, G. (2000, February). *Die Entstehung des moralischen Bewußtseins. [The growth of moral understanding].* Was wäre, wenn sich alle an die Regeln hielten? Gesetze hüten im Wandel der Werte, Hofgeismar.

Nunner-Winkler, G. (2000, February). *Die Zusammenarbeit zwischen normativen und empirischen Disziplinen in der Moralforschung. [Cooperation between normative and empirical approaches to morality].* Normative und empirische Gerechtigkeitsforschung im Dialog, Universität Potsdam.

Nunner-Winkler, G. (2000, April). *Moralvorstellungen im Wandel. [Changes in moral understanding],* Universität Köln.

Nunner-Winkler, G. (2000, May). *Gewaltbegriffe und Gewalttheorien. [Violence - concepts and theoretical paradigms].* Paradigmen und Analyseprobleme der Gewaltforschung, Institut für interdisziplinäre Konflikt- und Gewaltforschung, Universität Bielefeld.

Nunner-Winkler, G. (2000, May). *Kommentar zu Nassehi: Religion und Moral. [Comments on Nassehi: Religion and morality].* Religion und Moral, Wiesbaden.

Nunner-Winkler, G. (2000, May). *Warum hilft Bildung den Frauen nicht zum Durchbruch? [Equality of education and still no break-through for women].* Die Bedeutung des Berufs für die Jugendberufshilfe und die Benachteiligtenförderung, Bad Boll.

Nunner-Winkler, G. (2000, July). *The development of moral motivation. Presentation of the Munich LOGIC study.* 27th International Congress of Psychology, Stockholm.

Nunner-Winkler, G. (2000, July). *Moralentwicklung bei Kindern. [Children's moral development].* Veranstaltung des Gesamtelternbeirates der Ulmer Schulen, Ulm.

Nunner-Winkler, G. (2000, September). *Die Entwicklung moralischer Motivation. Präsentation der Münchner LOGIK-Studie. [Development of moral motivation. Presentation of the Munich LOGIC study].* 42. Kongress der Deutschen Gesellschaft für Psychologie, Jena.

Nunner-Winkler, G. (2000, September). *Von Selbstzwängen zur Selbstbindung. [From self-constraint to voluntary commitment].* Gute Gesellschaft? Zur Konstruktion sozialer Ordnungen, Köln.

Nunner-Winkler, G. (2000, October). *Relativism and cynicism - the cooling-out process in adolescence.* Adolescents into citizens: Integrating young people into political life, Schloss Marbach am Bodensee.

Nunner-Winkler, G. (2001, March). *Moral und Beziehungsverständnis. [Morality and the understanding of social relations].* Soziale Bindung und Differenz: Innere Widersprüche des Zusammenlebens, Essen.

Nunner-Winkler, G. (2001, May). *Familie und Erziehung - Anforderungen und Erschwernisse. [Family and education: Demands and impediments].* Mut zur Erziehung - Zumutung Erziehung, Weimar.

Nunner-Winkler, G. (2001, May). *Moralbildung (Erwerb von moralischen Kompetenzen). [Moral development (Acquisition of moral competences)].* Das Gesetz bin ich - keine Regel ohne Ausnahme, Propstei Wislikofen.

Nunner-Winkler, G. (2001, June). *Gut und Böse in der Sozialisation von Kindern und Jugendlichen. [Good and evil in the socialisation of children and adolescents].* 17. Bayreuther Historisches Kolloquium, Bayreuth.

O

Oellinger, M., Knoblich, G., & Koch, I. (2001, April). *Sequenzlernen bei Papier, Schere, Stein. [Sequence learning in Paper, Scissors, Rock].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

P

Pollok, B., Müller, K., & Aschersleben, G. (2001, August). *Neuromagnetic correlates of bimanual synchronization.* Summerschool Tutorials in Behavioral and Brain Sciences (TuBBS), Nijmegen, NL.

Pollok, B., Müller, K., Aschersleben, G., & Prinz, W. (2000, July). *Informational feedback in synchronization tasks: Do MEG data provide information about the basic mechanisms of KR?* Summerschool Tutorials in Behavioral and Brain Sciences (TuBBS), Wörlitz.

Pösse, B., & Hommel, B. (1999, March). *Priming von task sets.* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Pösse, B., & Hommel, B. (1999, July). *The role of task-relevant and irrelevant dimensions in task switching.* Tutorials in Behavioral and Brain Sciences (TuBBS): Summerschool Neurocognitive Foundations of Perception and Action, Ohlstadt.

Pösse, B., & Hommel, B. (1999, September). *The role of task-relevant and irrelevant dimensions in task switching.* 11th Conference of the European Society for Cognitive Psychology, Gent, Belgium.

Pösse, B., & Hommel, B. (2000, March). *Vorbereitungsprozesse beim Aufgabenwechseln. [Preparation processes in task switching].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Pösse, B., & Hommel, B. (2000, June). *Binding of stimulus and response features after a task switch.* 4th Annual Meeting of the Association for the Scientific Study of Consciousness, Brussels, Belgium.

Pösse, B., & Hommel, B. (2000, July). *Binding of stimulus and response features after a task switch.* Summerschool Tutorials in Behavioral and Brain Sciences (TuBBS), Wörlitz.

Pösse, B., & Hommel, B. (2000, September). *Bindung von Reiz- und Reaktionsmerkmalen unter Aufgabenwechsel-Bedingungen. [Binding of stimulus and response features after a task switch].* 42. Kongress der Deutschen Gesellschaft für Psychologie, Jena.

Pösse, B., & Hommel, B. (2001, April). *Interaktionen zwischen Reiz- und Reaktionsbindung und Aufgabenwechsel. [Interactions between stimulus and response binding and task switch].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

Prinz, W. (1999, February). *Zwischen 'top' und 'bottom'. [Between 'top' and 'bottom'].* Forschungsplanung des Max-Planck-Instituts für Psychologische Forschung, Ebersberg.

Prinz, W. (1999, March). *Experimental approaches to imitation.* The imitative mind: Development, evolution, and brain bases, Kloster Seeon.

Prinz, W. (1999, April). *Perceiving while acting.* Symposium Wahrnehmungsplastizität, Berg.

Prinz, W. (1999, May). *Kognitive Grundlagen der Handlungssteuerung. [The cognitive basis of action control].* 2. Tagung für interdisziplinäre Bewegungsforschung, Universität Saarbrücken.

Prinz, W. (1999, July). *Cognition and action: Experimental approaches to imitation.* Tutorials in Behavioral and Brain Sciences (TuBBS), Ohlstadt.

Prinz, W. (1999, July). *Experimental approaches to imitation.* Summer School of the German American Academic Council Foundation, Zentrum für interdisziplinäre Forschung, Bielefeld.

Prinz, W. (1999, July). *Nachahmung: Experimentelle Analysen. [Imitation: Experimental analyses].* Interdisziplinäre Grundlagen der Mensch-Maschine-Kommunikation, Technische Universität München.

Prinz, W. (1999, September). *Experimental approaches to imitation.* Summer school Sensorimotor Integration, Hanse Wissenschaftskolleg, Delmenhorst.

Prinz, W. (2000, February). *Bewusstsein: Was ist das eigentlich und wie kann man es erklären? [The mind: What is it and how can it be explained?].* Evangelische Studentengemeinde der Ludwig-Maximilians-Universität München.

Prinz, W. (2000, April). *Funktion und Mechanismen der Nachahmung. [Function and mechanisms of imitation].* Urania, Berlin.

Prinz, W. (2000, May). *Nachahmungslernen. [Imitation learning].* Technische Universität, München.

Prinz, W. (2000, July). *Was soll bloß werden? [Where are things heading at?].* Doctoral seminar, Tutzing.

Prinz, W. (2000, September). *Nachahmung: Theoretisches und Experimentelles. [Imitation: Theoretical and experimental issues].* Universität Dortmund.

Prinz, W. (2000, November). *What gets coordinated in bimanual coordination?* PennState University, Pennsylvania, USA.

Prinz, W. (2000, December). *Imitation and ideomotor action.* Universität Bielefeld.

Prinz, W. (2000, December). *Imitation and its role in action selection.* Zentrum für interdisziplinäre Forschung, Bielefeld.

Prinz, W. (2000, December). *Neue Beobachtungen über bimanuale Kopplung. [New observations on bimanual coupling].* Humboldt Universität Berlin.

Prinz, W. (2001, January). *Das unmittelbare und das mittelbare Selbst. [The direct and the indirect self].* Ludwig-Maximilians-Universität München.

Prinz, W. (2001, January). *Nachahmung: Experimentelle Untersuchungen. [Imitation: Experimental studies].* Universität Jena.

Prinz, W. (2001, January). *Nachahmung: Experimentelle Untersuchungen. [Imitation: Experimental studies].* Freie Universität Berlin.

Prinz, W. (2001, February). *Neue Beobachtungen über bimanuale Kopplung. [New observations on bimanual coupling].* Universität Kiel.

Prinz, W., Stenneken, P., Aschersleben, G., & Cole, J. (2000, November). *Tapping without proprioception: A case study in sensorimotor synchronization.* 41st Annual Meeting of the Psychonomic Society, New Orleans, USA.

R

Rieger, M., & Gauggel, S. (2000, October). *Die Beteiligung frontostriataler Schleifen an der Hemmung bereits initiierter Reaktionen. [The role of frontostriatal circuits in the inhibition of ongoing responses].* 15. Jahrestagung der Gesellschaft für Neuropsychologie, Leipzig.

Rosendahl, I., Baumann, M., & Wascher, E. (1999, March). *Psychophysiologische Korrelate aufmerksamkeitsbasierter Suchprozesse. [Psychophysiological correlates of attention based visual search].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Rosendahl, I., Baumann, M., & Wascher, E. (1999, October). *Psychophysiological correlates of attentive and preattentive target detection.* 39th Annual Meeting of the Society for Psychophysiological Research, Granada, Spain.

S

Saathoff, J., Melzer, A., Wagener, M., Mecklenbräuker, S., Wippich, W., Knuf, L., Gehrke, J., & Hommel, B. (1999, May). *Action-related determinants of route and survey knowledge.* 5. Plenarkolloquium des DFG-Schwerpunktprogramms Raumkognition, Tutzing.

Schubö, A. (1999, January). *Interferenz zwischen Wahrnehmung und Handlungssteuerung. [Interference between perception and action control].* Kolloquium der DFG-Forschergruppe Arbeitsgedächtnis und des Promotionskollegs Kognitionswissenschaften, Universität Leipzig.

Shalev, L., Caspi, A., & Mevorach, C. (1999, October). *Integrating an experimental laboratory on visual attention in a distance-learning environment.* Tele '99 Conference, Tel-Aviv, Israel.

Stenneken, P., Aschersleben, G., Cole, J., & Prinz, W. (2000, August). Somatosensory feedback and the timing of movements: A tapping study with a patient revealing sensory deficits. Rhythm Perception and Production, Castleton, UK.

Contributions to Congresses and Invited Lectures

Stenneken, P., Aschersleben, G., Cole, J., & Prinz, W. (2001, January). *How can I model in my head the repeat movement?* Doctoral seminar, Ohlstadt.

Stenneken, P., Aschersleben, G., Cole, J., & Prinz, W. (2001, March). *Temporal control of movements by their intended outcome: A comparative study with a deafferented patient.* Neural Coding of Space and Action Control - Espace et Action, Lyon, France.

Stenneken, P., Aschersleben, G., Cole, J., & Prinz, W. (2001, April). *Zeitliche Steuerung von Bewegungen: Eine Fallstudie mit einem deafferentierten Patienten. [Temporal control of movements: A case study with a deafferented patient].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

Stork, S. (1999, July). *Task-dependent localization errors with circular movements.* Tutorials in Behavioral and Brain Sciences (TuBBS): Summerschool Neurocognitive Foundations of Perception and Action, Ohlstadt.

Stork, S., Müsseler, J., & Jordan, J. S. (1999, August). *Localizations at the beginning of linear and circular movements.* 22nd European Conference on Visual Perception, Trieste, Italy.

Stork, S., Müsseler, J., Knuf, L., & Jordan, J. S. (2000, September). *Aufgabenabhängige Lokalisation am Bewegungsende. [Task-dependent localization errors at the end of a movement].* 42. Kongress der Deutschen Gesellschaft für Psychologie, Jena.

Stork, S., Müsseler, J., Knuf, L., Neggers, B., & Jordan, J. S. (2000, October). *Task-dependent mislocalization at the vanishing point of a moving stimulus].* Neural Control of Movement Synergy, Ohlstadt.

Stork, S., Müsseler, J., & Neggers, B. (2001, March). *Der Einfluss von Blickbewegungen auf Lokalisationsfehler am Bewegungsende. [The influence of eye movements on localization errors at the end of a movement].* 4. Tübinger Wahrnehmungskonferenz, Tübingen.

Stork, S., Müsseler, J., & Neggers, B. (2001, April). *The influence of eye movements on the perceived vanishing point of a moving stimulus.* European Conference on Cerebellar and Cortical Control of Eye Movements, Granada, Spain.

V

Vierkant, T. (2000, February). *Das reale und das fiktionale Selbst. [The real and the fictional self].* Action Workshop, Hanse Wissenschaftskolleg, Delmenhorst.

Vierkant, T., Jovanovic, B., Maasen, S., & Prinz, W. (2000, July). *The ontogeny of narrative self and the unity of consciousness.* 4th Annual Meeting of the Association for the Scientific Study of Consciousness, Brussels, Belgium.

Vierkant, T., Maasen, S., & Prinz, W. (2000, April). *Philosophical tradition and the folk-psychological belief in the Cartesian self.* Annual Meeting of the Jean Piaget Society, Montreal, Canada.

Vierkant, T., Maasen, S., & Prinz, W. (2000, September). *Are the real self and the fictional self really opposing concepts?* Annual Meeting of the European Society for Philosophy and Psychology, Salzburg, Austria.

W

Wascher, E. (1999, June). *EEG correlates of directed arm movements.* 25. Arbeitstagung Psychophysiologische Methodik, Trier.

Wascher, E. (1999, June). *Interaction of perceptual and motor processes revealed by event-related lateralizations.* 7th International Conference on Cognitive Neuroscience, Budapest, Hungary.

Wascher, E. (1999, October). *EEG correlates of directed arm movements.* 39th Annual Meeting of the Society for Psychophysiological Research, Granada, Spain.

Wascher, E. (2000, May). *Interaction of perceptual and motor processes revealed by event-related lateralizations.* 4th European Conference of the Federation of European Psychophysiology Societies, Amsterdam, The Netherlands.

Wascher, E. (2000, May). *Psychophysiologische Korrelate räumlicher Parameter in der Bewegungsplanung. [Psychophysiological correlates of spatial parameters in the planing of a movement].* Institut für Arbeitsphysiologie, Dortmund.

Wascher, E. (2000, June). *EEG correlates of automatic response activation evoked by moving-dot pattern.* Arbeitstagung Psychophysiologische Methodik, Düsseldorf.

Wascher, E. (2000, November). *Hirnelektrische Korrelate räumlicher Parameter. [Brain-electrical correlates of spatial parameters].* Medizinische Universität Lübeck.

Wascher, E. (2001, February). *Automatische Reaktionsaktivierung ausgelöst durch bewegte Punktemuster. [Automatic response activation released by moving-dot patterns].* 4. Tübinger Wahrnehmungskonferenz, Tübingen.

Wascher, E. (2001, March). *Automatic response activation evoked by directional information.* 8th Annual Meeting of the Cognitive Neuroscience Society, New York, USA.

Wascher, E. (2001, April). *Spatial parameters in perception and action. A psychophysiological approach.* University of Casimirus the Great, Bydgoszcz, Poland.

Wascher, E. (2001, April). *Wahrnehmungsbeschleunigung durch Reaktionsvorbereitung. [Facilitation of perception by response preparation].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

Wascher, E. (2001, May). *Räumliche Kodes in Wahrnehmung und Handlung: Psychophysische Evidenz für unterscheidbare Mechanismen in der Informationsübertragung. [Spatial codes in perception and action].* Forschungskolloquium »Theoretische und Experimentelle Kognitions-Psychologie«, Ludwig-Maximilians-Universität München.

Wascher, E. (2001, May). *Wo, Was, Wie, Wann? Neues von zwei Pfaden. [Where, what, how, when? News about two pathways].* Metacontrast, Sensorimotor Integration, and Attentional Selection, Bielefeld.

Wascher, E., Kozcy, P., & Kuder, T. (2000, April). *Kosten und Nutzen irrelevanter visueller Information. [Costs and benefits due to irrelevant visual information].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Wascher, E., Rosendahl, I., & Wolber, M. (1999, March). *Die Rolle motorischer Aktivierung im Simon-Effekt. [The role of motor activation in the Simon effect].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Wascher, E., Schönstein, S., & Kuder, T. (2000, February). *EEG-Korrelate visuomotorischer Prozesse. [EEG-correlates of visuo-motor processes].* 3. Tübinger Wahrnehmungskonferenz, Tübingen.

Wascher, E., Wolber, M., & Schönstein, S. (2000, October). *Tracking the visuo-motor system by measuring event-related asymmetries of the EEG.* Neural Control of Movement Synergy, Ohlstadt.

Waszak, F., & Hommel, B. (1999, March). *Proaktive Inhibition kompetitiver »task sets«. [Proactive inhibition of competitive task sets].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Waszak, F., & Hommel, B. (1999, July). *Proactive inhibition of competitive task sets.* Tutorials in Behavioral and Brain Sciences (TuBBS): Summerschool Neurocognitive Foundations of Perception and Action, Ohlstadt.

Waszak, F., & Hommel, B. (1999, September). *Task switching: Proactive inhibition of competitive task sets.* 11th Conference of the European Society for Cognitive Psychology, Gent, Belgium.

Waszak, F., Hommel, B., & Allport, A. (2000, March). *Task-switching: Item-spezifischer Transfer episodischer S-R Ereignisse. [Task switching: Item-specific transfer of episodic S-R events].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Waszak, F., Hommel, B., & Allport, A. (2000, September). *Item-specific and semantic priming in task-switching.* 42. Kongress der Deutschen Gesellschaft für Psychologie, Jena.

Waszak, F., Hommel, B., & Allport, A. (2000, November). *Task-shift costs due to transfer of stimulus-response episodes.* 41st Annual Meeting of the Psychonomic Society, New Orleans, USA.

Weinert, F. E. (1999, January). *Ergebnisse empirischer Forschung zum guten Unterricht. [Results of empirical research on good teaching].* Pädagogisches Institut der Erzdiözese Wien, Hof, Austria.

Weinert, F. E. (1999, April). *Grußwort zur Eröffnung des Instituts für Klinische Neuroimmunologie. [Inauguration speech on the opening of the Institute for Clinical Neuroimmunology].* Klinikum Großhadern, Ludwig-Maximilians-Universität München.

Weinert, F. E. (1999, May). *Lebenslanges Lernen: Visionen, Illusionen und Realisationen. [Life-long learning: Visions, illusion, realizations].* Dies academicus, Ilmenau.

Weinert, F. E. (1999, June). *Begabung und Lernen: Zur Entwicklung geistiger Leistungsunterschiede. [Giftedness and learning: The development of mental differences in achievement].* Jahreshauptversammlung der Max-Planck-Gesellschaft, Dortmund.

Weinert, F. E. (1999, June). *Lernen im Erwachsenenalter: Psychologische Grundlagen und didaktische Gestaltungsmöglichkeiten. [Learning at adult age: Foundations and didactical options].* Psychologie der Erwachsenenbildung, Katholische Akademie in Bayern, München.

Weinert, F. E. (1999, June). *Was soll Schule leisten? [What should schools achieve?].* Zukunft der Schule, Konrad-Adenauer-Stiftung, Berlin.

Weinert, F. E. (1999, July). *Fördert das System der Leistungsbewertung die Leistungsbereitschaft der Schülerinnen und Schüler? [Does the system of achievement rating boost pupils' achievement motivation?].* Parlament Baden-Württemberg, Fraktion »Bündnis 90/Die Grünen«, Stuttgart.

Weinert, F. E. (1999, July). *Sind Schulen evolutionäre Agenturen? [Are schools evolutionary agencies?].* Colloquium in honor of the retirement of Prof. Ahrens, Universität Heidelberg.

Weinert, F. E. (1999, September). *Disparate Unterrichtsziele: Empirische Befunde und theoretische Probleme multikriterialer Zielerreichung. [Disparate teaching goals: Empirical findings and theoretical problems of multi-criterion goal attainment].* 58. Tagung der Arbeitsgruppe für Empirische Pädagogische Forschung, Nürnberg.

Weinert, F. E. (1999, October). *Concepts of competence.* OECD Project Definitions and Selection of Competences: Theoretical and Conceptual Foundations (DeSeCo), Bern, Switzerland.

Weinert, F. E. (1999, October). *What is meant by 'competences', 'key competences', and 'metacompetences'? - Clarifying the concepts and the terminology.* OECD-Symposium Definition and selection of competencies: Theoretical and conceptual foundations, Neuchâtel, Switzerland.

Weinert, F. E. (1999, November). *Kann man Intelligenz und Kreativität erlernen? [Can intelligence and creativity be learned?].* Schloss Puchberg, Wels, Austria.

Weinert, F. E. (1999, November). *Kreativität: Fakten und Mythen. [Creativity: Facts and myths].* Pädagogische Akademie der Diözese Linz, Austria.

Weinert, F. E. (1999, November). *Schüler und Schulen als Bedingungen erfolgreichen Lernens. [Students and schools as conditions for successful learning].* Seminar leader workshop, Pappenheim.

Weinert, F. E. (1999, December). *Entwicklung als Veränderung persönlicher Merkmale und als Stabilisierung von Merkmalsunterschieden - Kommentar). [Development as modification of personal characteristics and as stabilization of differences in characteristics - a commentary].* Symposium on occasion of the honorary doctorate award to F.E. Weinert, Freie Universität Berlin.

Weinert, F. E. (1999, December). *Individuelle Kreativität und kollektives Ergebnis. [Individual creativity and collective outcome].* 4. Gespräch des Bundes Deutscher Architekten, Berlin.

Weinert, F. E. (1999, December). *Intelligenzentwicklung und Wissenserwerb: Autobiografische Anmerkungen zu einem Forschungsprogramm. [The development of intelligence and knowledge acquisition: Autobiographical comments on a research program].* Address on occasion of the honorary doctorate award to F.E. Weinert, Freie Universität Berlin.

Weinert, F. E. (2000, January). *Aktuelle bildungspolitische Probleme im Lichte moderner psychologischer Forschung. [Current problems of educational policy in the light of modern psychological research.* Institut der Erzdiözese Wien, Hof, Austria.

Weinert, F. E. (2000, January). *Die Entwicklung des autobiographischen Gedächtnisses. Wie zuverlässig sind Erinnerungen an persönliche Erlebnisse? Psychologische Forschungen und strafrechtliche Folgerungen. [The development of autobiographical memory. How reliable are memories of personal events? Psychological research and conclusions for penal law].* Kolloquium aus Anlass des 65. Geburtstags von Prof. Dr. Albin Eser, Max-Planck-Institut für ausländisches und internationales Strafrecht, Freiburg.

Weinert, F. E. (2000, March). *Ansprüche an das Lernen in der heutigen Zeit. [Demands on learning in modern times].* Kreissparkasse Idar-Oberstein.

Weinert, F. E. (2000, March). *Lehren und Lernen für die Zukunft: Ansprüche an das Lernen in der Schule. [Teaching and learning for the future: Demands on learning at school].* Pädagogisches Zentrum Rheinland-Pfalz, Bad Kreuznach.

Weinert, F. E. (2000, March). *Lehren und Lernen für die Zukunft: Ansprüche an das Lernen in der Schule. [Teaching and learning for the future: Demands on learning at school].* Sparkasse Rhein-Nahe, Bad Kreuznach.

Weinert, F. E. (2000, May). *Lernkompetenz, Lernmotivation und Lernleistung: Einfache Prinzipien, aber komplizierte Zusammenhänge. [Learning competence, learning motivation, and learning achievement: Simple principles but complicated relationships]. Büro Bildungstag 2000* der Gewerkschaft Erziehung und Wissenschaft, Weimar.

Weinert, F. E. (2000, May). *Lernqualität und Schulleistung. [Learning quality and academic achievement].* Universität Jena.

Weinert, F. E. (2000, June). *Entwicklung und Förderung intellektueller Kompetenzen. [Development and promotion of intellectual competencies].* Die Welt im Kopf: Intelligenz, Heinz Nixdorf Museums Forum, Paderborn.

Weinert, F. E. (2000, July). *Lernen des Lernens. [Learning how to learn].* 1. Kongress des Forums Bildung: »Wissen schafft Zukunft«, Berlin.

Weinert, F. E. (2000, July). *Lernen für die Zukunft: Neue Anforderungen, aktuelle Defizite, realistische Perspektiven. [Learning for the future: New demands, current deficits, and realistic perspectives].* Universität Würzburg.

Weinert, F. E. (2000, August). *Ziel-Perspektiven für eine nachhaltige Verbesserung des Lehrens, Lernens und Leistens in deutschen Schulen. [Goal perspectives for a lasting improvement in teaching, learning, and achieving at German schools].* Forum Bildung: Wissen schafft Zukunft, München.

Weinert, F. E. (2000, September). *Vorstellungen von gutem Unterricht. [Ideas on good teaching].* Tagung des Oberschulamts Stuttgart »Vorstellungen von gutem Unterricht«, Stuttgart.

Weinert, F. E. (2000, October). *Begabung und ihre Förderung. [Giftedness and its promotion]. »Begabungen fördern, Lernen differenzieren«,* Bundesvereinigung der Deutschen Arbeitgeberverbände, Berlin.

Weinert, F. E. (2000, October). *Lebenslanges Lernen. [Life-long learning].* »Wir gestalten Zukunft«, Wirtschaftsjunioren Kelheim, Abensberg.

Weinert, F. E. (2000, October). *Lernen als Brücke zwischen hoher Begabung und exzellenter Leistung. [Learning as a bridge between high giftedness and excellent achievement].* 2. Internationale Konferenz zu Begabungsfragen und Begabtenförderung, Salzburg, Austria.

Contributions to Congresses and Invited Lectures

Weinert, F. E. (2000, October). *Lernen für die Zukunft: Neue Anforderungen an Schüler und Schulen. [Learning for the future: New challenges for students and schools].* Forum Realschulseminar - Begegnungen und Gespräche mit Persönlichkeiten, Schwäbisch-Gmünd.

Weinert, F. E. (2000, October). *Psychologische Regelhaftigkeiten des kumulativen Lernens. [Psychological regularities of cumulative learning].* St. Galler Lerntage: Gehirnforschung: Im Spannungsfeld von moderner Gehirnforschung und praktischem Schulalltag, St. Gallen, Switzerland.

Weinert, F. E. (2000, October). *Was heißt Instruktion für die Schule? [What does instruction mean for schools]?* Seminar zum berufsbegleitenden Nachdiplomstudium für Lehrpersonen der Volksschule und des Kindergartens, Zürich, Switzerland.

Weinert, F. E. (2000, October). *Was ist guter Unterricht in und zwischen den Fächern? [What is good teaching within and between thematical subjects?].* 20. Geburtstag Didaktik & Mathematik der Chemie - Interdisziplinarität an der Universität und in der Schule', Historisches Institut, Universität München.

Weinert, F. E. (2000, November). *Inwieweit sind Schulleistungen Leistungen der Schule oder der Schüler? [How far are academic achievements achievements of the school or the students?].* »Schultag 2000« der Superiorenkonferenz der männlichen Ordensgemeinschaften Österreichs zum Thema »Katholische Schulen mit Zukunft - Pädagogische und wirtschaftliche Herausforderungen«, Vienna, Austria.

Weinert, F. E. (2000, November). Lernen und Leisten als Ergebnisse guten Gymnasial-unterrichts. [Learning and achieving as outcomes of good grammar-school teaching]. Friedrich-Koenig-Gymnasium, Würzburg.

Weinert, F. E. (2000, November). *Schulleistungen: Leistungen der Schüler oder der Schule? [Academic achievements: Achievements of the students or the school?].* »Pädagogischer Dialog«, Staatliches Seminar für Schulpädagogik, Freiburg.

Weinert, F. E. (2000, December). *Der Einfluss der Schule auf die kognitive und motivationale Entwicklung im Kindesalter. [The impact of the school on cognitive and motivational development in childhood].* Universität Zürich, Switzerland.

Weinert, F. E. (2001, January). *Die evaluierte Universität. [The evaluated university].* Heidelberger Universitätsvorlesungen, Universität Heidelberg.

Weinert, F. E. (2001, January). *Für und Wider die neuen pädagogisch-psychologischen Lerntheorien. [For and against the new learning theories in educational psychology].* Symposium New Media, Complex Methods, Economic University, Vienna, Austria.

Whitacre, C., Shea, C. H., & Wulf, G. (1999, June). *Surfing the implicit wave.* Congress of the North American Society for the Psychology of Sport and Physical Activity, Clearwater Beach, FL.

Wohlschläger, A. (1999, February). *Das Handlungseffektprinzip: Ein potentieller Therapie-Ansatz bei Apraxien. [The principle of action effects: A potential approach to the treatment of apraxia.].* Fachklinik, Bad Heilbrunn.

Wohlschläger, A. (1999, June). *Der Synchronisationsfehler: Ein Fehler der Zeitwahrnehmung. [The synchronization error: An error in time perception].* Forschungskolloquium Theoretische und Experimentelle Kognitionspsychologie, Ludwig-Maximilians-Universität München.

Wohlschläger, A. (1999, March). *GOAD-I: A theory of goal-directed imitation.* The Imitative Mind: Development, Evolution, and Brain Bases, Kloster Seeon.

Wohlschläger, A. (1999, March). *Handlungsabhängige Speicherung von Objektattributen im Arbeitsgedächtnis. [Action-dependent storage of object attributes in working memory].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Wohlschläger, A. (1999, April). *Imitation als zielgerichtete Handlung. [Imitation as goal-directed action].* Forschungskolloquium Psychologie, Universität Konstanz.

Wohlschläger, A. (1999, June). *Wahrnehmen und Handeln: Neue Erkenntnisse aus Psychologie und Hirnforschung. [Perception and action: New insights from psychology and brain research].* Münchner Volkshochschule am Harras, München.

Wohlschläger, A. (1999, October). *Imitation in young children: Mapping means or mapping ends?* 1st Annual Meeting of the Human Frontier Science Program Organization, Heraklion, Greece.

Wohlschläger, A. (1999, October). *Imitation und die Entwicklung der Intelligenz. [Imitation and the development of intelligence].* Münchner Volkshochschule (Adult Education Center), München.

Wohlschläger, A. (1999, October). *Wahrnehmen und Handeln: Neue Erkenntnisse aus Psychologie und Hirnforschung. [Perception and action: New insights from psychology and brain research].* Münchner Volkshochschule Gasteig, München.

Wohlschläger, A. (1999, October). *Wahrnehmung und Handeln - Neue Erkenntnisse aus Psychologie und Hirnforschung. [Perception and action: New findings from psychology and brain research].* Münchner Volkshochschule Zentrum, München.

Wohlschläger, A. (1999, November). *Action perception and action planning in imitation: Towards a goal-directed theory of imitation.* University of California at Berkeley, USA.

Wohlschläger, A. (1999, November). *Imitation und die Entwicklung der Intelligenz. [Imitation and the evolution of intelligence].* Münchner Volkshochschule am Harras, München.

Wohlschläger, A. (1999, November). *Synchronization error: An error in time perception.* 40th Annual Meeting of the Psychonomic Society, Los Angeles, USA.

Wohlschläger, A. (1999, November). *The synchronization error: An error in time perception.* University of California at Berkeley, USA.

Wohlschläger, A. (2000, March). *Imitation und Handlungswahrnehmung bei Erwachsenen. [Imitation and action perception in adults].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Wohlschläger, A. (2000, March). *The role of objects in imitation.* Mirror Neurons and the Evolution of Brain and Language, Hanse Wissenschaftskolleg, Delmenhorst.

Wohlschläger, A. (2000, July). *Human perception during performance.* Attention and Performance XIX: Common mechanisms in perception and action, Kloster Irsee.

Wohlschläger, A. (2000, August). *Imitation im Vorschulalter. [Imitation in preschoolers].* Symposium »Talent im Sport«, Potsdam.

Wohlschläger, A. (2000, August). *Synchronization error and performance in continuation: Two sides of the same coin?* Rhythm Perception and Production Workshop, Castleton, UK.

Wohlschläger, A. (2000, September). *Imitation im Vorschulalter. [Imitation in preschoolers].* Universität Potsdam.

Wohlschläger, A. (2000, October). *Antizipation in Evolution und Kognition. [Anticipation in evolution and cognition].* Institute for Cybernetic Anthropology, Starnberg.

Wohlschläger, A. (2000, November). *Human perception during performance.* 41st Annual Meeting of the Psychonomic Society, New Orleans, USA.

Wohlschläger, A. (2001, January). *Gehirn und Handlung. [Brain and action].* Münchner Volkshochschule Zentrum, München.

Wohlschläger, A. (2001, February). *Handlungsabhängige Wahrnehmung oder die Intentionalität in Handlung und Wahrnehmung. [Action-dependent perception or intentionality in action and perception].* Universität Passau.

Wohlschläger, A. (2001, June). *Vorstellung, Wahrnehmung, Handlung und die mentale Rotation Gehirn. [Imagery, perception, action, and mental rotation].* Universität Eichstätt.

Wohlschläger, A. (2001, June). *Wahrnehmung und Gehirn. [Perception and brain].* Münchner Volkshochschule am Hart, München.

Wohlschläger, A. (2001, July). *Imagery and action goals.* 8th European Workshop on Imagery and Cognition, Saint Malo, France.

Wohlschläger, A., & Bekkering, H. (1999, April). *Action-dependent perception.* Forschergruppe Wahrnehmungsplastizität, Berg.

Wohlschläger, A., Bekkering, H., & Gattis, M. (1999, September). *Imitation in young children: Mapping means or mapping ends?* 11th Conference of the European Society for Cognitive Psychology, Gent, Belgium.

Wolber, M., Angele, S., & Wascher, E. (2000, April). *EEG-Korrelate raum- und objektbasierter Aufmerksamkeitszuwendung. [EEG-correlates of space- and object-based attention).* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Wolber, M., Neeb, B., & Wascher, E. (2001, February). *Ereigniskorrelierte Lateralisierungen als Indikatoren paralleler und serieller Prozesse in einer visuellen Suche. [Event-related lateralisations as an index of parallel and serial processes in a visual search task].* 4. Tübinger Wahrnehmungskonferenz, Tübingen.

Wolber, M., Neeb, B., & Wascher, E. (2001, March). *Event-related lateralisations as an index of parallel and serial processing in visual search.* 8th Annual Meeting of the Cognitive Neuroscience Society, New York, USA.

Wolber, M., Neeb, B., & Wascher, E. (2001, April). *EEG-Lateralisierungen als Indikatoren für parallele und serielle Prozesse. [EEG lateralisations as an index of parallel and serial processes].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

Wühr, P. (1999, July). *Does response selection interfere with stimulus identification in the PRP paradigm?* Tutorials in Behavioral and Brain Sciences (TuBBS): Summerschool Neurocognitive Foundations of Perception and Action, Ohlstadt.

Wühr, P., Knoblich, G., & Müsseler, J. (2000, April). *Schlecht für das Auge und gut für die Hand? Der Einfluss von Distraktoren auf Identifikation und Reaktionsgeschwindigkeit. [Bad for the eye and good for the hand? The influence of distractors on identification and reaction speed].* 42. Tagung experimentell arbeitender Psychologen, Braunschweig.

Wühr, P., Knoblich, G., & Müsseler, J. (2000, July). *When do speed and accuracy agree or disagree? A binding explanation.* 4th Annual Meeting of the Association for the Scientific Study of Consciousness, Brussels, Belgium.

Wühr, P., & Müsseler, J. (1999, March). *Gibt es Wahrnehmungsbeeinträchtigungen durch die Handlungsselektion im PRP-Paradigma? [Is there perceptual impairment by action selection in the PRP paradigm?].* 41. Tagung experimentell arbeitender Psychologen, Leipzig.

Wühr, P., & Müsseler, J. (1999, April). *Erwartete und unerwartete Wechselwirkungen zwischen dem Hören von Tönen, dem Drücken von Tasten und dem Sehen von Pfeilen. [Expected and unexpected interactions between the hearing of signals, pressing of keys, and seeing arrows].* Tagung DFG-Schwerpunktprogramm »Sensomotorische Integration«, Bielefeld.

Wühr, P., & Müsseler, J. (1999, May). *Eine Bewegungsabsicht beeinträchtigt die Wahrnehmung von Reizmerkmalen, die Reiz und Bewegung gemeinsam haben. [A movement intention impairs the perception of stimulus features shared by stimulus and movement].* 2. Tagung für interdisziplinäre Bewegungsforschung, Universität Saarbrücken.

Wühr, P., & Müsseler, J. (2001, February). *Assoziierte Reaktionen erleichtern die Identifikation visueller Reize. [Associated reactions facilitate the identification of visual stimuli].* 4. Tübinger Wahrnehmungskonferenz, Tübingen.

Wühr, P., & Müsseler, J. (2001, April). *Einfluss von Wahlreaktionen auf die gleichzeitige Identifikation reaktions-assoziierter Buchstaben. [The impact of choice reactions on the simultaneous identification of reaction-associated letters].* 43. Tagung experimentell arbeitender Psychologen, Regensburg.

Wulf, G. (1999, January). *Zur Wirksamkeit von Instruktionen beim Bewegungslernen. [On the effectiveness of instructions in movement learning].* Universität Osnabrück.

Wulf, G. (1999, April). *Attentional focus and motor skill learning.* 20th Annual Conference in Movement Sciences »Acquisition of movement skill«, Teachers' College, Columbia, NY, USA.

Wulf, G. (1999, June). *Attention in motor skill acquisition,* University of Reading, UK.

Wulf, G., Clauss, A., Shea, C. H., & Whitacre, C. (1999, June). *Self-control enhances learning in dyad practice.* Congress of the North American Society for the Psychology of Sport and Physical Activity, Clearwater Beach, FL, USA.

Wulf, G., Shea, C. H., Whitacre, C., & Park, J.-H. (1999, November). *Implicit vs. explicit learning of complex motor skills.* 40th Annual Meeting of the Psychonomic Society, Los Angeles, USA.

Appointments and Awards

Harold Bekkering accepted a chair as an Associate Professor of Cognitive Psychology at the University of Groningen, The Netherlands (as of January 2001).

Marcel Braß was awarded the Poster Prize of the XIth Congress of the European Society for Cognitive Psychology, Gent, Belgium (September 1999).

Ernst Hany accepted a chair for Pedagogical-Psychological Diagnostics and Differential Psychology at the University of Erfurt (as of July 1999).

Bernhard Hommel accepted a chair for General Psychology at the University of Leiden, The Netherlands (as of September 1999).

Dirk Kerzel was awarded the Poster Prize of the 41. Tagung experimentell arbeitender Psychologen [41st German Meeting of Experimental Psychology] in Leipzig (March 1999).

Sabine Maasen accepted a chair for Sociology of Science/Science Studies at the University of Basel, Switzerland (as of September 2001).

Gertrud Nunner-Winkler was awarded the title of an unscheduled professor at the Ludwig-Maximilians-University, Munich (as of June 2001).

Gijsbert Stoet was awarded the Otto-Hahn-Medal for Junior Scientists in the Max Planck Society for his dissertation 'The role of feature integration in action planning' (June 1999).

Franz Emanuel Weinert was awarded
- an honorary doctorate from the Free University of Berlin, Faculty of Education Sciences and Psychology (1999)
- Verdienstkreuz Erster Klasse des Verdienstordens der Bundesrepublik Deutschland (2000). [The Distinguished Service Cross, First Category, of the German Federal Order of Merit].

Gabriele Wulf accepted a chair as a lecturer at the University of Reading, UK (as of January 2000).

Memberships in Scientific Institutions, Committees, and Editorial Boards

Bekkering, Harold

- Associate Editor, *Human Movement Science*

Goschke, Thomas

- Member of the Advisory Board, Department of Psychology, University of Osnabrück (1999-2000)
- Member of the Teaching Committee, International Cognitive Science Program, University of Osnabrück

Halisch, Frank

- Co-editor, series *Motivationsforschung [Motivation research]*

Hommel, Bernhard

- Associate Editor, *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*
- Associate Editor, *Current Psychology Letters: Behaviour, Brain & Cognition*
- Co-Editor, *Journal of Experimental Psychology: Human Perception and Performance*
- Editorial Advisory Board, *Psychological Research/Psychologische Forschung*

Knoblich, Günther

- Member, Advisory Board *Gesellschaft für Kognitionswissenschaft*

Maasen, Sabine

- Editorial Board, Yearbook *Sociology of the Sciences*

Nunner-Winkler, Gertrud

- *Deutsche Gesellschaft für Soziologie:* Member of the ethics committee
- *Journal für Konflikt- und Gewaltforschung:* Member of the scientific board
- *Kriminologisches Forschungsinstitut Niedersachsen:* Member of the scientific board
- *Kulturwissenschaftliches Institut, Essen:* Member of the scientific board
- *Leviathan:* Member of the editorial board
- *Max Planck Society:* Member of the working group of the Scientific Council for the promotion of female scientists; member of the committee for the promotion of young scientists (until December 2000)
- *Thyssen-Preis:* Member of the jury forwarding the award for the three best articles in German-speaking sociological journals
- *Zeitschrift für Soziologie:* Member of the scientific board
- *Zeitschrift EuS – Ethik und Sozialwissenschaften:* Member of the board
- *ZUMA / GESIS:* Member of the scientific board (until April 2000)

Prinz, Wolfgang

- Chair, Humanities Section of the Max Planck Society (June 1997 – June 2000); Vice Chair since June 2000
- Member, *Academia Europaea*
- Executive Committee Member, *International Association for the Study of Attention and Performance*
- Chair of the Advisory Board, *Minerva Max-Wertheimer-Center for Cognitive Processes and Human Performance,* Haifa, Israel
- Extended Faculty Member, *SISSA (Scuola Internationale Superiore Di Studi Avanzate),* Trieste, Italy
- Member, Maier-Leibnitz Nominating Committee of the Deutsche Forschungsgemeinschaft (1996-2000)
- Scientific Advisory Board, Hanse-Wissenschaftskolleg (HWK), Delmenhorst
- Scientific Advisory Board, Zentrum für interdisziplinäre Forschung (ZiF), Bielefeld
- Editorial Board, *Enzyklopädie der Psychologie*
- Editor, *Psychologische Rundschau*
- Consulting Editor *Psychologische Beiträge*
- Associate Editor, *European Journal of Cognitive Psychology*
- Advisory Board, *'Sprache und Kognition', 'Kognitionswissenschaft'*
- Editorial Board *Neurology, Psychiatry and Brain Research*
- Consulting Editor *Psychological Review*

Weinert, Franz Emanuel

- Member, *Bayerische Akademie der Wissenschaften* (philosophical-historical class); *Academia Europaea; Royal Norwegian Society of Sciences and Letters; International Academy of Education; National Academy of Education (USA)*
- *Vice President of the Max Planck Society for the Advancement of Science* (until June 1999)
- Member of the Executive Committee, *International Society for the Study of Behavioral Development*
- Member of the Board, *German Center for Research in Old Age*

Wulf, Gabriele

- Consulting Editor, *Journal of Motor Behavior*
- Member of the Editorial Board, *Women in Sport and Physical Activity Journal* and *Human Movement Science*

Professorial Habilitations, Doctoral Dissertations, Diploma and Magister These

Professoral Habilitations

Aschersleben, G. (1999). *Aufgabenabhängige Datierung von Ereignissen. [Task-dependent timing of events].* Ludwig-Maximilians-Universität München.

Wascher, E. (1999). *Kognitive Prozesse zwischen Reiz und Reaktion: Psychophysiologische Untersuchungen reaktionsvorbereitender Prozesse. [Cognitive processes preceding a response].* Universität Tübingen.

Doctoral Dissertations

Braß, M. (1999). *Imitation und ideomotorische Kompatibilität: Untersuchungen zur Theorie der ideomotorischen Handlung. [Imitation and ideomotor compatibility: Studies on the theory of ideomotor actions].* Ludwig-Maximilians-Universität München.

Drewing, K. (2001). *Die Rolle sensorischer Reafferenzen bei der zeitlichen Steuerung von Handlungen. [A role for sensory reafferences in the timing of actions].* Ludwig-Maximilians-Universität München.

Elsner, B. (2000). *Der Erwerb kognitiver Handlungsrepräsentationen. [Acquiring cognitive representations of actions].* Ludwig-Maximilians-Universität München.

Kerzel, D. (1999). *Launching the effect: Representations of causal movements are influenced by what they lead to.* Ludwig-Maximilians-Universität München.

Miedreich, F. (1999). *Zeitliche Steuerung von Handlungen: Empirischer Test des Wing-Kristofferson-Modells. [The temporal control of actions: An empirical test of the WK-model].* Ludwig-Maximilians-Universität München.

Neggers, S. (2000). *Oculomotor behavior during pointing.* Ludwig-Maximilians-Universität München.

Nikele, M. (1999). *Ein Modell mit latenten Variablen für stetige und ordinale Response-Variablen: Bayesianische und frequentistische Schätzstrategien mit einem Anwendungsbeispiel aus der Soziologie. [A latent variable model for continuous and ordinal response variables: Bayesian and frequentist estimation-strategies including a sociological application].* Ludwig-Maximilians-Universität München.

Nißlein, M. (2001). *Über das Entdecken von Buchstaben und das Verstehen von Sätzen: Experimentelle Untersuchungen zu kognitiven Verarbeitungsmechanismen beim Lesen von Texten. [Letter detection and sentence processing: Experimental studies on cognitive processing in reading texts].* Ludwig-Maximilians-Universität München.

Pösse, B. (2000). *Eine Aufgabe umfasst mehr als eine Menge Regeln: Zur Bindung von Reiz- und Reaktionsmerkmalen unter Aufgabenwechsel-Bedingungen. [A task consists of more than a set of rules: On the binding of stimulus- and response features under task switching conditions].* Ludwig-Maximilians-Universität, München

Steininger, S. (1999). *Handeln und Wahrnehmen: Eine experimentelle Analyse einer Wahrnehmungsbeeinträchtigung bei simultan ausgeführten Handlungen. [Acting and perceiving: An experimental analysis of impaired perception in simultaneously performed actions].* Ludwig-Maximilians-Universität München.

Stumpf, L. (1999). *Mentale Repräsentation von Vertrauen: Eine entwicklungspsychologische Studie bei Kindern. [The mental representation of trust in children].* Ludwig-Maximilians-Universität München.

Waszak, F. (2001). *Task switching and long-term priming: Role of episodic S-R bindings in task-shift costs.* Ludwig-Maximilians-Universität München.

Wühr, P. (2000). *Sieht man immer was man tut? Wie sich Handlungen auf visuelle Wahrnehmungen auswirken. [Do we always see what we do? How actions influence visual perception].* Ludwig-Maximilians-Universität München.

Diploma Theses

Gruber, S. (2000). *Computerdiagnostik und Rehabilitation der Fähigkeit zur mentalen Rotation bei Apraktikern. [Computer diagnostics and rehabilitation of the mental-rotation ability in apractic patients].* Ludwig-Maximilians-Universität, München. (Wohlschläger)

Häberle, A. (2000). *Visual search and action intention.* Universität Konstanz. (Bekkering)

Lacher, V. (1999). *Emotionale Reaktion auf Erfolg und Misserfolg im Alter: Entwicklung eines Beobachtungssystems. [Emotional reaction to success and failure in old age: Development of an observational coding system].* Ludwig-Maximilians-Universität, München. (Geppert)

Schuch, S. (2000). *Inhibition as a component process in executive control: On the effect of no-go trials in a task-shifting paradigm.* Universität Heidelberg. (Koch)

Seigerschmidt, E. (1999). *Anticipation of forthcoming letters and strokes from self- and other-generated kinematic displays.* Ludwig-Maximilians-Universität, München. (Knoblich, Prinz)

Stork, S. (1999). *Visuelle Lokalisationsfehler bei Reizbewegung. [Visual localization errors with moving stimuli].* Ludwig-Maximilians-Universität, München. (Müsseler)

Woschina, S. (2000). *Imitation in apraxia.* Katholische Universität Eichstätt. (Bekkering)

Master's Thesis

Zirngibl, C. (2001). *Implicit learning: Empirical and pedagogical issues.* Ludwig-Maximilians-Universität, München. (Koch)

Postgraduate Training and the Promotion of Young Scientists

Apart from providing individual supervision of dissertation projects by senior researchers, the Institute runs a variety of regular courses for postgraduate students:

Literature seminars. Once every 2 weeks during the university semester, a senior researcher offers a lecture seminar on topics from cognitive science or neuroscience. The idea behind these seminars is to provide a critical forum for discussing current theoretical trends.

Postgraduate student colloquium. Twice a year, a 2- to 3-day postgraduate student colloquium is held outside the Institute at which all PhD students present their dissertation projects and invite discussion. This seminar is run by Wolfgang Prinz and Günther Knoblich.

Tutorials in behavior and brain sciences (TUBBS). TUBBS is an interdisciplinary summer school for PhD students attending the Max Planck Institutes for Cognitive Neuroscience (Leipzig), Evolutionary Anthropology (Leipzig), Psycholinguistics (Nijmegen), and Psychological Research (Munich). Leading scientists offer courses and workshops on topics going beyond the special field of interest at each individual institution. The PhD students at the Max Planck Institutes present their research in poster sessions.

Lunch sessions. Once a week, senior and junior researchers have lunch together followed by a discussion of current research work in an informal atmosphere.

Research colloquium on »Theoretical and Experimental Psychology«. This is a series of meetings organized jointly by the Max Planck Institute for Psychological Research and the Department of Experimental Psychology of Munich University. Once a week, national and international experts present papers on current themes in cognitive psychology. This colloquium can also be used to present and discuss dissertations before a broader public.

Courses Given by Institute Members

A

Aschersleben, G., Knoblich, G., & Prinz, W. *Wahrnehmung und Handlungssteuerung. [Perception and action control]* (Ludwig-Maximilians-Universität München, summer term 1999).

Aschersleben, G., & Prinz, W. *Wahrnehmung und Handlungssteuerung. [Perception and action control]* (Ludwig-Maximilians-Universität München, summer term 2000).

Aschersleben, G., & Stenneken, P. *Wahrnehmung und Produktion von Rhythmus. [Rhythm perception and production]* (Ludwig-Maximilians-Universität München, winter term 2000/2001).

Aschersleben, G., & Elsner, B. *Entwicklung der Handlungssteuerung bei Kleinkindern. [Development of action control in infancy]* (Ludwig-Maximilians-Universität München, summer term 2001).

B

Bekkering, H. *Neurokognitive Grundlagen von Wahrnehmung und Handlung. [The neurocognitive basis of perception and action]* (Ludwig-Maximilians-Universität München, summer term 1999).

Bekkering, H. *Introduction to Psychology, I: History and systematics* (Ludwig-Maximilians-Universität München, winter term 1999/2000).

Bekkering, H. *Learning in social context: Imitation and theory* (Ludwig-Maximilians-Universität München, summer term 2000).

Bekkering, H. *Thinking and problem solving* (Ludwig-Maximilians-Universität München, summer term 2000).

Braß, M., & Kerzel, D. *Neurokognitive Grundlagen von Wahrnehmung und Handlung. [Neurocognitive basis of perception and action]* (Ludwig-Maximilians-Universität München, summer term 1999).

E

Elsner, B., & De Maeght, S. *Bewusste und unbewusste Prozesse der Handlungssteuerung. [Conscious and unconscious processes in action control]* (Ludwig-Maximilians-Universität München, summer term 2000).

G

Goschke, T. *Emotion and cognition* (Universität Osnabrück, summer term 1999).

Goschke, T. *Implicit memory* (Universität Osnabrück, summer term 1999).

Goschke, T. *Introduction to Cognitive Psychology: Perception, attention, memory, language, thinking* (Universität Osnabrück, summer term 1999).

Goschke, T. *Cognition and action* (Universität Osnabrück, winter term 1999/2000).

Goschke, T. *Cognitive neuropsychology* (Universität Osnabrück, winter term 1999/2000).

Goschke, T. *Introduction to psychology* (Universität Osnabrück, winter term 1999/2000).

H

Hany, E. A. *Der diagnostische Prozess. [The diagnostic process]* (Pädagogische Hochschule Erfurt, summer term 1999).

Hany, E. A. *Hochbegabung. [High-giftedness]* (Pädagogische Hochschule Erfurt, summer term 1999).

Hany, E. A. *Kreativität. [Creativity]* (Pädagogische Hochschule Erfurt, summer term 1999).

Hany, E. A. *Verhaltensdiagnostik. [Behavioral diagnostics]* (Pädagogische Hochschule Erfurt, summer term 1999).

Hommel, B. *Einführung in die Experimentelle Psychologie. [Introduction to experimental psychology]* (Ludwig-Maximilians-Universität München, summer term 1999).

Hommel, B. *Tier und Bewusstsein: Vergleichende Kognitionsforschung. [Animals and consciousness: Comparative cognitive research]* (Ludwig-Maximilians-Universität München, summer term 1999).

K

Kerzel, D., Bekkering, H., & Braß, M. *Neurokognitive Grundlagen von Wahrnehmung und Handlung. [Neurocognitive basis of perception and action]* (Ludwig-Maximilians-Universität München, summer term 1999).

Kerzel, D. *Begleitseminar zur Vorlesung »Einführung in die Experimentelle Psychologie«. [Course accompanying the lecture »Introduction to experimental psychology«]* (Ludwig-Maximilians-Universität München, summer term 2000).

Kerzel, D., & Koch, I. *Doktorandenseminar: Modellbildung in der kognitiven Psychologie. [Course for PhD-students: Models in cognitive psychology]* (Ludwig-Maximilians-Universität München, summer term 2000).

Kerzel, D., & Wohlschläger, A. *Einführung in die Statistik für Nebenfächler. [Introductory statistics for students minoring in psychology]* (Ludwig-Maximilians-Universität München, summer term 2000).

Kerzel, D., & Flach, R. *Einführung in die Statistik für Nebenfächler. [Introductory statistics for students minoring in psychology]* (Ludwig-Maximilians-Universität München, winter term 2000/2001).

Kerzel, D., & Müsseler, J. *Einführung in die Statistik für Nebenfächler. [Introductory statistics for students minoring in psychology]* (Ludwig-Maximilians-Universität München, winter term 2000/2001).

Kerzel, D. *Lernen und Motivation. [Learning and motivation]* (Technische Universität München, summer term 2001).

Kerzel, D., & Bosbach, S. *Begleitseminar zur Vorlesung »Einführung in die Experimentelle Psychologie«. [Course accompanying the lecture »Introduction to experimental psychology«]* (Ludwig-Maximilians-Universität München, summer term 2001).

Kerzel, D., & Müsseler, J. *Einführung in die statistischen Methoden für Nebenfächler. [Introductory statistics for students minoring in psychology]* (Ludwig-Maximilians-Universität München, summer term 2001).

Knoblich, G., & Fischer, M. *Kopfrechnen II. [Mental arithmetics II]* (Ludwig-Maximilians-Universität München, summer term 1999).

Knoblich, G. *Soziale Einbettung von Kognition. [Social embedding of cognition]* (Ludwig-Maximilians-Universität München, summer term 2000).

Knoblich, G., & Bekkering, H. *Denken und Problemlösen. [Thinking and problem solving]* (Ludwig-Maximilians-Universität München, summer term 2000).

Knoblich, G., & Koch. I. *Symbolismus, Konnektionismus und Embodied Cognition: Perspektiven zur Erklärung von Kognition. [Symbolism, connectionism, embodied cognition: Perspectives on the explanation of cognition]* (Ludwig-Maximilians-Universität München, summer term 2000).

Knoblich, G. *Sozialpsychologie. [Social Psychology]* (Technische Universität München, winter term 2000/2001).

Knoblich, G., & Bekkering, H. *Handeln und Lernen im sozialen Kontext. [Acting and learning within a social context]* (Ludwig-Maximilians-Universität München, winter term 2000/2001).

Koch, I. *Begleitseminar zur Einführung in die Experimentelle Psychologie. [Introduction to experimental psychology]* (Ludwig-Maximilians-Universität München, summer term 2000).

Koch, I. *Einführung in Lern- und Gedächtnistheorien. [Introduction to learning and memory theories]* (Ludwig-Maximilians-Universität München, summer term 1999).

Koch, I. *Grundkurs Allgemeine Psychologie: Lernen und Motivieren. [Basics of General Psychology: Learning and motivation]* (Technische Universität München, summer term 2001).

Koch, I. *Theoretische Sportpsychologie II. [Theoretical sport psychology II]* (Technische Universität München, summer term 2001).

Koch, I. *Literaturseminar für Doktoranden. [Seminar on literature for doctoral students]* (Ludwig-Maximilians-Universität München, winter term 2000/2001).

Koch, I. *Experimentalpsychologisches Praktikum. [Practical course in experimental psychology]* (Ludwig-Maximilians-Universität München, winter term 2000/2001).

M

Maasen, S. *Klinische Soziologie: Zur Soziologie (in) der Wissensgesellschaft.[Clinical sociology in/of the knowledge society]* (Universität Bielefeld, winter term 1999/2000).

Maasen, S. *Diskursanalysen und Diskurstheorien in der Soziologie: Bestandsaufnahmen eines (?) Diskurses. [Discourse analyses and discourse theories in sociology: The state-of-the art of a/one? discourse]* (Universität Bielefeld, winter term 2000/2001).

Maasen, S. *Diskursanalysen und Diskurstheorien in der Soziologie: Bestandsaufnahmen eines (?) Diskurses. [Discourse analyses and discourse theories in sociology: The state-of-the art of a/one? discourse]* (Universität Bielefeld, winter term 2000/2001).

Mechsner, F. *Raum erleben, Raum verstehen. [Experiencing and understanding space]* (Ludwig-Maximilians-Universität München, winter term 1999/2000).

Mechsner, F. *Wahrnehmung, Bewegung und Bewusstsein. [Perception, Motion, and Consciousness]* (Ludwig-Maximilians-Universität München, winter term 2000/2001).

Miedreich, F., & Aschersleben, G. *Wahrnehmung und Repräsentation von Zeit. [Perception and representation of time]* (Ludwig-Maximilians-Universität München, summer term 2000).

Möller, R. *Biomimetische Robotik. [Biorobotics]* (Universität Zürich, winter term 2000/2001).

Müsseler, J., & Wühr, P. *Selektionsmechanismen bei Wahrnehmung und Handlung. [Selective mechanisms in perception and action]* (Ludwig-Maximilians-Universität München, summer term 1999).

Müsseler, J. *Einführende Kapitel zu Wahrnehmungs-Handlungs-Interaktionen. [Introductory chapters to perception-action interactions]* (Ludwig-Maximilians-Universität München, summer term 2000).

Müsseler, J., & Stork, S. *Einführende Kapitel zur Wahrnehmung von Raum und Zeit. [Introduction to the perception of space and time]* (Ludwig-Maximilians-Universität München, winter term 2000/2001).

Müsseler, J., & Kerzel, D. *Begleitseminar zu »Einführung in die statistischen Methoden für Nebenfächler« [Seminar accompanying the lecture »Introductory statistics for students minoring in psychology«]* (Ludwig-Maxmilians-Universität München, summer term 2001).

N

Nunner-Winkler, G. *Soziale Integration. [Social integration].* München: Ludwig-Maximilians-Universität München, winter term 1999/2000.

P

Prinz, W., Stoffer, T. H., & Fischer, M. *Forschungskolloquium. [Research colloquium]* (Ludwig-Maximilians-Universität München, summer term 1999).

Prinz, W., Deubel, H., & Schneider, W. X. *Forschungskolloquium. [Research colloquium]* (Ludwig-Maximilians-Universität München, winter term 2000/2001).

R

Rieger, M. *Strategien in der neuropsychologischen Rehabilitation [Strategies in neuropsychological rehabilitation]* (Philipps-Universität Marburg, winter term 2000/2001).

W

Wascher, E. *Grundlagen psychophysiologischer Methoden. [Foundations of psychophysiological methods]* (Universität Tübingen, winter term 1999/2000).

Wascher, E. *Neue Ansätze in der Untersuchung von Verhalten. [New approaches in research on behavior]* (Universität Tübingen, winter term 1999/2000).

Wascher, E. *Neue Ergebnisse der kognitiven Neurowissenschaft. [New findings in cognitive neuroscience]* (Universität Tübingen, winter term 1999/2000).

Wascher, E., & Wolber, M. *Psychophysiologisches Praktikum. [Practical course in psychophysiology]* (Universität Tübingen, summer term 2000).

Wascher, E., & Sokolow, A. *Grundlagen psychophysiologischer Methoden. [Foundations of psychophysiological methods]* (Universität Tübingen, winter term 2000/2001).

Wascher, E., & Wolber, M. *Neue Ergebnisse der kognitiven Neurowissenschaft. [New findings in cognitive neuroscience]* (Universität Tübingen, winter term 2000/2001).

Weinert, F. E. *Der gute Lehrer im Spiegel der Wissenschaft. [The good teacher as seen by science]* (Universität Zürich, summer term 2000).

Wohlschläger, A. *Begleitseminar zur Vorlesung »Einführung in die experimentelle Psychologie«. [Course accompanying the lecture »Introduction to experimental psychology«]* (Ludwig-Maximilians-Universität München, summer term 1999).

Wohlschläger, A. *Einführung in die statistischen Methoden für Nebenfächler. [Introductory statistics for students minoring in psychology]* (Ludwig-Maximilians-Universität München, summer term 1999).

Wohlschläger, A. *Gedächtnis. [Memory]* (Ludwig-Maximilians-Universität München, winter term 1999/2000).

Wohlschläger, A., *& Kerzel, D. Einführung in die Statistik für Nebenfächler. [Introductory statistics for students minoring in psychology]* (Ludwig-Maximilians-Universität München, winter term 1999/2000).

Wohlschläger, A. *Methoden der kognitiven Neurowissenschaften. [Methods of the Cognitive Neurosciences]* (Katholische Universität Eichstätt, summer term 2001).

Wulf, G. *Skill acquisition* (Texas A&M University, spring term 1999).

Invited Lectures at the Institute

A

Allport, A., St.Anne's College, Oxford, UK. (2001, July). *What Concept of Task Set? A few Subversive Observations.*

Ansorge, U., Universität Bielefeld. (2001, July). *Direkte Parameterspezifikation. [Direct parameter specification].*

Azuma, R., University of Cambridge, UK. (1999, June). *S-R Compatibility and the Costs of Switching Tasks.*

B

Bertelson, P., Free University of Brussels, Belgium. (2001, May). *Audio-Visual Crossmodal Interaction: Some Recent Developments.*

Biederman, I., University of California at L.A., USA. (2000, February). *Neural Basis of Face Versus Object Recognition.*

Bieri, P., Freie Universität Berlin. (2001, February). *Schadet die Regie des Gehirns der Freiheit des Willens? [Does the Brain Dominance Affect the Freedom of the Will?].*

Billard, A., University of Southern California, L.A., USA. (2000, December). *Learning Motor-Skill Imitation: A Computational Model.*

Blakemore, S., Parliamentary Office of Science and Technology, London, UK. (2000, July). *How Do We Predict the Sensory Consequences of Action? The Role of Self-Monitoring in Schizophrenia.*

Bremmer, F., Ruhr-Universität Bochum. (2000, December). *Polymodale Raumrepräsentation im Parietalcortex von Primaten. [Polymodal Spatial Representation in the Parietal Cortex of Primates].*

Bridgeman, B., University of California at Santa Cruz, USA. (1999, October). *Symbolic and Iconic Visual Systems.*

Bülthoff, H., Max-Planck-Institut für Biologische Kybernetik, Tübingen. (2000, November). *Image-Based Object Recognition.*

Burr, D., Institute of Neurophysiology, Pisa, Italy. (2000, November). *Compression of Visual Space During Saccades.*

C

Cave, K., University of Verona, Italy. (2001, June). *Making the Most of Spatial Attention.*

Chelazzi, L., University of Verona, Italy. (2000, June). *Visual Search: Exploring the Underlying Mechanisms with Behavioral and Physiological Methods.*

Christel, M., Freie Universität Berlin. (2000, March). *Reich- und Greifbewegungen bei Affen und Menschen. Ein Artenvergleich. [Reaching and Grasping Movements in Apes and Humans: Comparing the Species].*

Cohen, A., University of Jerusalem, Israel. (2001, July). *Dimensions, Objects, Attention and Action.*

Coward, A., Nortel Networks, Elmendorf, TX, USA. (1999, June). *Software Architecture, Functional Complexity, and the Need to Deal with Ambiguous Information: A Basis for Cognition.*

Craighero, L., University of Parma, Italy. (2000, January). *Influence of Action Programming on the Perception of Objects and Actions.*

Cruse, H., Universität Bielefeld. (2000, February). *Untersuchungen zum Körpermodell: Messungen von Reaktionszeiten nach taktiler Reizung. [Studies on the Body Model: Measuring RTs after Tactile Stimulation].*

D

Daprati, E., Scuola Internazionale Superiore di Studi Avanzati (SISSA), Trieste, Italy. (2000, May). *Perception of Self-Generated Movement after Brain Lesions.*

Daum, I., Ruhr-Universität Bochum. (1999, July). *Neuropsychologische Grundlagen falscher Erinnerungen. [Neuropsychological Principles of False Memories].*

De Haan, E., Utrecht University, The Netherlands. (1999, November). *Selective Processing of Physiognomic Information: Old Controversies and New Evidence.*

DeGraf, P., University of Leuven, Belgium. (2001, January). *Transsaccadic Processing of Scene Semantics.*

Di Pellegrino, G., University of Bologna, Italy. (1999, February). *Mechanisms of Selective Spatial Attention in Neuropsychological Patients.*

Dichgans, J., Neurologische Klinik Tübingen. (1999, May). *Das Erlernen von Greifbewegungen: Wann, wie, wo? [Learning to Grasp: When, How, Where?].*

Dohle, C., Heinrich-Heine Universität Düsseldorf. (2001, June). *Bewegungsstörungen realer und virtueller Arme. [Impaired Movements in Real and Virtual Limbs].*

Duhamel, J.-R., Centre national recherche scientifique (CNRS), Bron, France. (2000, June). *Spatial Reference Frames in the Parietal Cortex: Single Cells, Models, and Psychophysics.*

Duncan, J., MRC, Cambridge, U.K. (2000, July). *A Neural Basis for General Intelligence.*

F

Fadiga, L., University of Parma, Italy. (2000, January). *Motor Representation and »Motor Perception«.*

G

Gallese, V., University of Parma, Italy. (1999, December). *Cognitive Functions of the Premotor Cortex.*

Gergely, G., Hungary Academy of Sciences, Budapest, Hungary. (2000, March). *Contingency Detection and Early Socio-Emotional Development: Implications for Developmental Psychopathology.*

Greenwald, A. G., University of Washington, USA. (2001, May). *The Resting Parrot, the Dessert Stomach, and Other Perfectly Defensible Theories.*

Greve, W., Kriminologisches Institut, Hannover. (2000, July). *Ist Willensfreiheit ein Problem für die Psychologie? [Is the Freedom of the Will a Problem for Psychology?].*

Grosjean, M., Pennsylvania State University, USA. (2001, May). *Temporal S-R Compatibility: Going Beyond Traditional Measures of Performance.*

Grunewald, A., California Institute of Technology, Pasadena, USA. (2000, July). *The Brain in Motion.*

H

Hübner, R., Universität Konstanz. (1999, May). *Über die Kosten mentaler Aufgabenwechsel und ihre Ursachen. [The Costs of Mental Task Switching and their Causes].*

I

Iverson, J., University of Indiana, USA. (1999, May). *There's More to the Hand than Meets the Eye: Links Between Gesture, Speech, and Cognition.*

J

Jordan, J. S., University of Chicago, USA. (2000, July). *Intentionality in Experimental Psychology.*

K

Karnath, H.-O., Neurologische Klinik, Tübingen. (2001, May). *Zur Wahrnehmung der Orientierung von Objekten und des eigenen Körpers. [On the Perception of the Orientation of Objects and the Own Body].*

Kelemen, D., Boston University, USA. (2001, May). *Reasoning about Design and Object Function: The Development of Teleological Thought.*

Kliegl, R., Universität Potsdam. (1999, July). *Syntax und Arbeitsgedächtnis. [Syntax and Working Memory].*

Kohlrausch, A., Philips Research Laboratories Eindhoven, The Netherlands. (2000, November). *Der Einfluss von Asynchronie auf die Wahrnehmung einfacher und komplexer audio-visueller Stimuli. [The Impact of Asynchrony on the Perception of Simple and Complex Audiovisual Stimuli].*

Kourtzi, Z., Max-Planck-Institut für Biologische Kybernetik, Tübingen. (2001, June). *Shape Processing in the Human Brain.*

Kunde, W., Universität Würzburg. (1999, December). *Bahnende Wirkungen antizipierter Aktionseffekte. [Priming Effects of Anticipated Actions].*

Kusch, M., University of Cambridge, UK. (2000, February). *Folk Psychology and Social Institutions.*

L

Logothetis, N., Max-Planck-Institut für Biologische Kybernetik, Tübingen. (2000, July). *Neural Correlates of Bistable Perception.*

Lösel, F., Universität Erlangen-Nürnberg. (1999, November). *Psychologie & Recht unter einem Dach. [Psychology and Law Under One Roof].*

M

Marzi, C., University of Verona, Italy. (1999, December). *Differential Representation of Visual Space in Hemineglect and Hemianopic Patients.*

Mühlenen von, A., Universität Leipzig. (2000, May). *Objektbasiertes »Inhibition of Return« in der Visuellen Suche. [Object-Based 'Inhibition of Return' in Visual Search].*

Müller, H., Ludwig-Maximilians-Universität, München. (2000, November). *Dimensionsbasierte Aufmerksamkeit. [Dimension-Based Attention].*

Müller, H., Universität Leipzig. (1999, January). *40-Hz-Synchronicity Priming of Kanizsa-Figure Detection.*

P

Pratt, J., University of Toronto, Canada. (2000, November). *Facilitating and Inhibiting Eye Movements and Attention Movements.*

R

Rafal, B., University of Wales, Bangor, UK. (2000, January). *Cortical Control of the Visual Grasp Reflex.*

Rensink, R., Nissan CBR, Boston, USA. (1999, July). *The Role of Attention in the Perception of Scenes.*

Rosenbaum, D., Pennsylvania State University, USA. (2000, March). *Studies of Motor Planning and Timing.*

Rosenbaum, D., Pennsylvania State University, USA. (2001, June). *Hand-Mind Coordination.*

Rossetti, Y., Institut National de la Santé et de la Recherche Médicale (INSERM) Lyon, France. (1999, May). *Dissociation and Interaction Between Implicit and Explicit Space Representations.*

Roth, G., Hanse Wissenschaftskolleg Delmenhorst. (2001, May). *Emotion und Kognition aus der Sicht der Hirnforschung. [Emotion and Cognition in Brain Research].*

Rumiati, R., Scuola Internazionale Superiore di Studi Avanzati (SISSA), Trieste, Italy. (1999, July). *A Cognitive Model for Actions: Evidence from Normal Observers and Neuropsychological Patients.*

Rumiati, R., Scuola Internazionale Superiore di Studi Avanzati (SISSA), Trieste, Italy. (2000, November). *Working Memory for Meaningful and Meaningless Actions.*

S

Schneider, W. X., Hanse-Wissenschafts-Kolleg Bremen. (1999, January). *Visuell-räumliches Arbeitsgedächtnis: Eine neurokognitive Perspektive. [Visuospatial working memory: A neurocognitive perspective].*

Schwank, I., Universität Osnabrück. (2000, February). *Das Gehirn ins Zeug legen: Kognitive Mathematik. [Testing the Brain: Cognitive Mathematics].*

Shapiro, K., University of Wales, Bangor, UK. (1999, February). *The Attentional Blink as a Tool for Understanding Human Information Processing.*

Sodian, B., Universität Würzburg. (2001, May). *Verständnis intentionalen Handelns in der frühen Kindheit. [Understanding Intentional Action in Early Childhood].*

Stins, J., University of Portsmouth, UK. (1999, January). *Constraints on Hand Selection.*

Stoet, G., Washington University, St. Louis, USA. (1999, July). *Intention and Attention.*

Striano, T., Max-Planck-Institut für Evolutionäre Anthropologie, Leipzig. (2000, October). *Ermerging Dyadic and Triadic Social Competencies and Understanding Intentions in Others.*

T

Tetens, H., Freie Universität Berlin. (2001, February). *Willensfreiheit und empirische Forschungsmethodik. [The Free Will and Empirical Research Methodology].*

Theeuwes, J., Free University Amsterdam, The Netherlands. (2000, January). *Our Eyes do not Always Go Where we Want them to Go: Capture of Eyes by Abrupt Onsets.*

Theeuwes, J., Free University Amsterdam, The Netherlands. (2001, July). *Top-Down and Bottom-Up Control of Visual Selection.*

Thornton, I. A., Max-Planck-Institut für Biologische Kybernetik, Tübingen. (2000, June). *Exploring the Onset Repulsion Effect: Why do Initial Mislocalization Errors sometimes fall behind rather than ahead of the True Starting Point of a Moving Object?*

Tipper, S., University of Wales, Bangor, UK. (2000, February). *Frames of Reference in Attention.*

Tipper, S., University of Wales, Bangor, UK. (2001, August). *Object- and Location-Based Inhibition-of-Return: Implications for memory and attention.*

Trujillo, J. C. M., Neurologische Klinik, Tübingen. (2000, May). *Space and Feature-Based Attentional Modulation.*

U

Umiltà, C., University of Padua, Italy. (2001, July). *Nonspatial Attentional Shifts Between Modalities.*

V

Van Leeuwen, K., University of Amsterdam, The Netherlands. (1999, April). *Information Processing with Coupled Map Lattices.*

Verwey, R., Universität Dortmund. (1999, June). *Learning Sequences of Keypresses.*

Vetter, T., Max-Planck-Institut für Biologische Kybernetik, Tübingen. (1999, May). *Maschinelle Bildanalyse und Bildsynthese von Gesichtern. [Mechanical Picture Analysis and Picture Synthesis of Faces].*

Vossenkuhl, W., Ludwig-Maximilians-Universität München. (2001, July). *Der eigene Wille. [One's Own Will].*

W

Ward, R., University of Wales, Bangor, UK. (2001, January). *Contributions of the Pulvinar to Selective Attention and Response Control.*

Watson, J., University of California at Berkeley, USA. (2001, May). *»Intention Contagion« in Cognitive Development: A Speculation from Research on Infants, Rett Syndrome, and Artificial Life.*

Z

Zetzsche, C., Ludwig-Maximilians-Universität München. (1999, February). *Visuelle Informationsverarbeitung und die Statistik der natürlichen Umwelt. [Visual Information Processing and the Statistics of Natural Environment].*

Zimmer, F., Universität Saarbrücken. (2000, December). *Visuelles Arbeitsgedächtnis: Funktionen, Modelle, Dissoziationen. [Visual Working Memory: Functions, Models, Dissociations].*

Projects Supported by Third-Party Funds[1]

Artificial Mouse *(AMOUSE)*

(Ralf Möller; Andreas Engel, Forschungszentrum Jülich; Rolf Pfeifer, University of Zürich; Peter König, ETH Zürich; Matthew Diamond, SISSA, Trieste, Italy). Funded by the European Community, Project No. IST-2000-28127 (4 years as of October 2001).

Using a parallel investigation of an artificial and a natural system, we will study sensory processing in the somatosensory (vibrissal) and visual pathway of rodents, cross-modal interaction between the two pathways, and sensorimotor integration. The cognitive-robotics group (Möller) will focus on the concept of forward models and their application in the modulation of sensory signals by the behavioral state of an animal, on strategies of active perception in the sensorimotor loop, and on cross-modal associative learning. A major technological achievement will be the construction of a robot equipped with an artificial whisker system.

Aufgabenabhängige Datierung von Wahrnehmungsereignissen. *[Task-Dependent Timing of Perceptual Events]*

(Gisa Aschersleben, Jochen Müsseler, Wolfgang Prinz)

DFG project Pr 118/19-1 within the »Forschergruppe Wahrnehmungsplastizität« [Research Group »Perceptual Plasticity«]. (1.10.1997–31.9.2000).

Task-Dependent Timing of Perceptual Events. (Gisa Aschersleben, Jochen Müsseler, Sonja Stork). DFG project As 79/3-1 (1.10.2000–31.9.2002). (See Section 1.1 and 1.4).

Comparative Cognitive Robotics: Towards an Integrative Model of Learning and Adaptation in Autonomous Agents

(Thomas Goschke; Paul F. Verschure, Institute for Neuroinformatics, ETH Zürich; Claus R. Rollinger, Cognitive Science Programme, University of Osnabrück).

Funded by the Volkswagen-Stiftung (2000-2003). We will study learning of sensory and behavioral patterns in humans and robots in an attempt to develop an integrative model of basic forms of learning and adaptation in autonomous agents. Specifically, results from experimental studies of implicit learning of event and action sequences in humans (Goschke) will be used to constrain and validate neural network models of sequence learning developed within the »Distributed Adaptive Control« (DAC) framework developed by Dr. Paul Verschure and his group.

Conditions for Spatial Coding in Perception and Memory

(Bernhard Hommel, Lothar Knuf).

DFG project Ho 1430/6-2 within the Priority Program »Spatial Cognition: Representation and Processing of Spatial Knowledge« (2nd phase: 1.8.1998 - 31.7.2000). The project investigates the cognitive processes involved in cognitively processing and representing visual maps. In particular it focuses on interactions between, and the integration of, spatial and nonspatial perceptual and functional, action-related information.

Die Integration von sensorischem Feedback und motorischen Kontrollstrukturen. *[The Integration of Sensory Feedback and Motor Control Structures]*

(Birgit Elsner, Gisa Aschersleben, Bernhard Hommel, Wolfgang Prinz)

DFG project C2 within the Special Research Unit 462 »Sensomotorik: Analyse biologischer Systeme, Modellierung und medizinisch-technische Nutzung« [Sensorimotor Functions: Analysis, Modeling and Medical-Technical Application of Biological Systems]. (1st phase: 1.7.1996-30.6.1999, 2nd phase: 1.7.1999-31.12.2002). (See Section 5.1).

[1] *In the following: DFG = Deutsche Forschungsgemeinschaft (German Science Foundation).*

Dynamic Interactions Between Complementary Components of Executive Control: Combination of Behavioral Experiments and Functional Neuroimaging

(Thomas Goschke; Oliver Gruber, Max Planck Institute for Cognitive Neuroscience, Leipzig).

DFG project within the Priority Program SPP 1107 »Executive Functions«, Go 720/3-1 (2001-2003). (See Sections 4.1 and 4.3).

EEG-Correlates of Visual Search: Investigation of Discriminative Subprocesses in Visual Perception

(Edmund Wascher)

DFG project Wa 987/6-1 (1999-2002). (See Unit »Cognitive Psychophysiology of Action«).

Investigation of the Functional Distinctiveness of Event-Related Lateralizations of the EEG as a Tool to Explore Visuomotor Interactions

(Edmund Wascher)

DFG project Wa 987/7-1 within the Priority Program »Sensorimotor Integration« (1998-2002). (See Unit »Cognitive Psychophysiology of Action«).

Modularität und Integration beim impliziten Lernen sequentieller Strukturen. *[Modularity and Integration in Implicit Learning of Sequential Structures]*

(Thomas Goschke)

DFG project Go 720/1-2 (1999-2001). (See Section 5.2).

Optimierung sportmotorischer Lernprozesse. *[Optimization of Motor Learning Processes in Sports]*

(Gabriele Wulf, Wolfgang Prinz)

DFG project Pr 118/18-1/2 (1.5.1996-31.5.2000). (See Section 5.3).

Satzstrukturelle Verarbeitung und Buchstabenerkennung: Experimentelle Untersuchungen zur kognitiven Verarbeitung von Textoberflächen. *[Structural Sentence Processing and Letter Detection]*

(Jochen Müsseler, Monika Nißlein)

DFG project Mu 1298/3-1/2 (1.10.1997-30.9.2000). This project examines early structural processes during reading. A robust finding in this area is the so-called missing-letter effect, MLE. When asked to circle a target letter in connected text, participants are more likely to miss that letter in frequent function words (determiners etc.) than in less common content words (e.g., nouns, verbs). We exploit some of the unique properties of German to clarify this effect.

Specific Interferences Between Action Control and Perceptual Processes

(Jochen Müsseler, Peter Wühr)

DFG project Mu 1298/2. (See Sections 3.1 and 3.2).

Schulleistungen. *[Performance in Schools]*

(Franz Emanuel Weinert)

Funded by the 'Ständige Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland'.

Cooperations

Allport, D. Alan (St. Anne's College, Oxford University) with Iring Koch, Wolfgang Prinz. *Item-Priming Effects in Task-Switching.* (See Section 4.2).

Allport, D. Alan (St. Anne's College, Oxford University) with Florian Waszak. *Item-Specific Transfer in Task-Switching: Role of Episodic S-R Bindings in Switch Costs.* (See Section 4.2).

Bachmann, Talis (Tallin, Estonia / Portsmouth, UK) with Gisa Aschersleben. *Metacontrast and Synchronization.* Since 1997. (See Section 1.4).

Baltes, Paul; Li, Shu-Chen; Lindenberger, Ulman (all Max Planck Institute for Human Development, Berlin); Schneider, W.X. (University of Munich) with Gisa Aschersleben, Knut Drewing, Bernhard Hommel (now Leiden University), Frank Miedreich, Wolfgang Prinz. *Peripheral and Central Factors of Cognitive Aging.* Findings from Baltes and co-workers have revealed close relations between sensory and intellectual abilities, particularly in older persons. These could be due to age-related changes in the proportion of cognitive resources taken up by simple sensory and sensorimotor functions. To analyze the functional basis of these relationships, we ran a cross-sectional study with participants aged 6 to 89 years. It included a large number of measures of sensory and intellectual abilities and eight pairs of cognitive tasks differing systematically in terms of their demands on cognitive resources. Preliminary results agree with earlier studies indicating that the differences between tasks of varying complexity are much more marked in the young and the aged compared with the middle-aged.

Bertelson, Paul (Free University of Brussels, Belgium) with Gisa Aschersleben. *Intermodal Integration and Timing.* (See Section 1.5).

Bülthoff, Heinrich H.; Franz, Volker (Max Planck Institute for Biological Cybernetics, Tübingen) with Edmund Wascher. *Plasticity of the Human Motor System.* (See Unit »Cognitive Psychophysiology of Action«).

Cole, Jonathan (University of Southampton, UK) with Gisa Aschersleben, Prisca Stenneken, Wolfgang Prinz. *Sensory Feedback and the Timing of Actions: Studies with the Deafferented Patient I.W.* Since 1999. (See Section 2.1).

Dehler, Jessica; Greenwald, Anthony (University of Washington); Kahraman, Birsen (University of Hamburg); with Günther Knoblich, Peter Wühr. *Stereotyping.* This project aims at determining the content of stereotypes about Turks in Germany. Moreover, we are interested in the question under which conditions stereotype activation occurs automatically. A third question addressed is whether there are differences in valence in the attributes and traits assigned to the Turkish minority and the German majority.

Freund, Hans-Joachim (Institute for Neurology, University of Düsseldorf) with Gisa Aschersleben, Katharina Müller, Wolfgang Prinz, Bettina Pollok. *Action Control: Functional Analysis with Neuroimaging Techniques and Studies with Deafferented Patients.* (See Section 2.1).

Friederici, Angela D.; Gunter, Thom (Max Planck Institute for Cognitive Neuroscience, Leipzig) with Patric Bach, Günther Knoblich, Wolfgang Prinz. *Action Comprehension.* (See Section 1.8).

Greenwald, Anthony (University of Washington, Seattle) with Edmund Wascher, Jochen Müsseler. *Mechanisms Involved in Subliminal Priming.* (See Unit »Cognitive Psychophysiology of Action«).

Gergely, György; Király, Ildiksió (Hungarian Academy of Sciences, Budapest) with Harold Bekkering (now University of Groningen, NL). *Rational Imitation of Goal-Directed Actions in 14-month-olds.* The study sheds new light on the nature of imitative learning in infancy. It is demonstrated that while 14-month-olds can indeed re-enact a novel means modeled to them, they do so only if they consider the action to be the most rational alternative to the goal available within the constraints of the situation. The findings support the theory of rational imitation according to which re-enactment of intentional action is a selective interpretative process driven by the inferential principle of rational action rather than an automatic copying process triggered by identification with a human actor.

Gergely, György (Hungarian Academy of Sciences, Budapest) with Gisa Aschersleben, Bianca Jovanovic, Wolfgang Prinz. *Early Development of Action Control.* (See Section 2.4 and Unit »*Infant Cognition and Action*«).

Gruber, Oliver (Max Planck Institute for Cognitive Neuroscience, Leipzig) with Thomas Goschke. *Dynamic Interactions Between Complementary Components of Executive Control: Combination of Behavioral Experiments and Functional Neuroimaging.* (See Section 4.1).

Haggard, Patrick (University College London, UK) with Gisa Aschersleben, Wolfgang Prinz. *Timing of Perceptual Events and Actions.* Since 1998. (See Section 1.5).

Haggard, Patrick (University College London, UK) with Andreas Wohlschläger, Wolfgang Prinz. *Awareness of Self- and Other-Generated Actions.* (See Section 1.5).

Hecht, Heiko, PD Dr. (Man Vehicle Lab, MIT Cambridge), Dr. Nam-Gyoon Kim (University of Connecticut, Storrs) with Dirk Kerzel. *Time-to-Passage Judgments in Optical Flow Fields.* Current theories of arrival time have difficulties to explain performance in the common but neglected case of non-linear approach. Global tau, a variable supposed to guide time-to-passage (TTP) judgments of objects approaching on linear trajectories, does not apply to circular movement. We investigated TTP judgments in such cases and found them to be surprisingly reliable. We suggested that observers base their judgments on the relative optical velocity changes of the target.

Heijden, A.H.C. van der (Leiden University, NL) with Jochen Müsseler. *Localizing Briefly Presented Stimuli.* Since 1998. (See Section 1.1).

Iacoboni, Marco (University of California at Los Angeles); Harold Bekkering (now University of Groningen, NL) with Andreas Wohlschläger. *Brain Activity During Action Imitation.* Studies the imitation of goal-directed and non-goal-directed, simple finger movements in terms of brain activity (since 1999).

Iacoboni, Marco (University of California at Los Angeles); Rizzolatti, Giacomo (University of Parma, Italy); with Harold Bekkering (now University of Groningen, NL), Marcel Braß (now Max Planck Institute for Cognitive Neuroscience, Leipzig), Dirk Kerzel. *Neural Activity in Imitation.* Neural activity during the observation and execution of hand or mouth movements are measured by means of fMRI (functional magnetic resonance imaging).

Jordan, Jerome Scott (Illinois State University, USA) with Günther Knoblich, Wolfgang Prinz. *Joint Action.* (See Section 2.5).

Jordan, Jerome Scott (Illinois State University, USA) with Jochen Müsseler, Dirk Kerzel, Lothar Knuf, Sonja Stork. *Effects of Intention on Perception.* (See Section 1.2).

Koriat, Asher (University of Haifa, Israel) with Jochen Müsseler, Monika Nißlein. *Structural Sentence Processing and Letter Detection.* (See Appendix, Projects supported by Third Parties).

Kuhl, Julius (University of Osnabrück) with Thomas Goschke. *Priming of Control Structures in Memory: Costs and Benefits of Persisting Activation of Intentions.* (See Section 4.3).

Mates, Jirí (Prague, Czech Republic) with Gisa Aschersleben. *Influence of Auditory Feedback in the Timing of Simple Movements.* (See Section 2.1).

McNevin, Nancy (State University Detroit); Shea, Charles and Wright, David (Texas A&M University, College Station); Toole, Tonya (Florida State University, Tallahassee) with Gabriele Wulf, Wolfgang Prinz. *Optimization of Motor Learning Processes in Sports.* (See Appendix, Projects supported by Third Parties).

Meiran, Nachshon (University of Beer Sheva, Israel); von Cramon, Yves; Braß, Marcel (Max Planck Institute for Cognitive Neuroscience, Leipzig) with Iring Koch, Wolfgang Prinz. *Neurocognitive Analysis of Executive Functions in Task Switching.* GIF: German-Israeli Foundation for Scientific Research and Development, Grant No. 635-88.4/1999. (See Section 4.1).

Meyer, Thomas D. (University of Tübingen) with Edmund Wascher. *Psychophysiological Investigations on the Risk for Bipolar Affective Disorders.* We investigate the theory of a fundamental dysfunction in the behavior-activation system in persons hypothesized to be at risk for Bipolar Affective Disorders. To this end we measure ERP correlates of cognitive processing in tasks in which the control of movement activation is essential to perform properly. Participants are young adults at risk for affective disorders as measured by the Hypomanic Personality Scale.

Ohlsson, Stellan; Raney, Gary (University of Illinois at Chicago) with Günther Knoblich. *Insight Problem Solving.* Insight problem solving is characterized by impasses, states of mind, in which the thinker does not know what to do next. We study the question how such impasses arise and how they are resolved. The results of several experiments suggest that prior knowledge can bias the initial problem representation in a way that keeps the problem solver from finding the solution. This bias may be reversed by implicit processes that change the representation of the problem elements or the goal. The reversal suddenly allows the problem solver to see the solution, at least if it is simple.

Cooperations

Pfeifer, Rolf (Institute for Informatics, University of Zürich); Engel, Andreas (Forschungszentrum Jülich); König, Peter (Institute for Neuroinformatics, ETH Zürich); Diamond, Matthew (SISSA, Trieste, Italy) with Ralf Möller. *Artificial Mouse*. (See Appendix, Projects Supported by Third Parties).

Pratt, Jay (University of Toronto, Canada) with Harold Bekkering (now University of Groningen, NL). *Selection of Objects.* It is studied how a target object is selected among different distractors.

Rosenbaum, David A. (PennState University, USA) with Florian Waszak, Wolfgang Prinz, Edmund Wascher, Gisa Aschersleben, Iring Koch. *IntAct (Intentional Action).* The project addresses the question how self-generated and internally triggered intentional actions differ from externally triggered re-actions.

Rumiati, Raffaella (Scuola Superiore di Studi Avanzati, Trieste, Italy) with Iring Koch. *Action Priming in Dual Tasks.* It is studied whether perceiving objects affording daily-life actions affects response selection in a logically unrelated second task. Potential dual-task action priming effects are tested by variations of interstimulus intervals.

Rumiati, Raffaella (Scuola Superiore di Studi Avanzati, Trieste, Italy) with Iring Koch. *Sequence Learning in Frontal Patients.* The aim of this study is to test the idea that motor-sequence learning requires the formation of complex action plans (response chunks or motor programs), so that frontal patients should be impaired although they do not have specific motor deficits but only planning deficits.

Siebner, Hartwig, R.; Conrad, Bastian (Neurologische Klinik des Klinikums Rechts der Isar – MRI; Technische Universität München) with Birgit Elsner, Bernhard Hommel (now Leiden University), Wolfgang Prinz. *Die Verknüpfung von Handlungen und ihren Konsequenzen im menschlichen Gehirn. [Linking Actions and their Consequences in the Human Brain.]* Cooperation within the DFG-Priority Program SFB 462 »Sensorimotor Functions: Analysis, Modeling and Medical-Technical Application of Biological Systems«. (See Section 5.1).

Tipper, Steve (University of Bangor, Wales, UK) with Edmund Wascher. *EEG-Correlates of Object- and Space-Based Inhibition-of-Return (IOR).* The distinction between object- and space-based factors might be essential to understand mechanisms involved in IOR. Basically, this cooperation is a consequence of first experiments we ran on IOR (see also Unit »Cognitive Psychophysiology of Action«) where ERP-measures indicated distinct mechanisms involved in spatial priming and IOR.

Walker, Robin (Royal University of London) with Harold Bekkering (now University of Groningen, NL). *Eye-Hand Coordination in Parkinson Patients.* Involves studies that focus on the planning and execution of saccadic eye movements and goal-directed hand movements with Parkinson patients.

Library and Scientific Information

Library

Primarily, the library is a research service focusing on collecting literature on the specific research areas of the Institute. However, from the very beginning, its task has also been to include basic literature covering the entire field of scientific psychology. With a continuous growth in stock and a careful acquisition strategy (including the purchase of used books), the library has now evolved from a narrowly focused research resource into a respectable collection covering the broad field of academic psychology. The collection now consists of about 40,000 monographs and 15,000 bound journals. There are approximately 360 journal subscriptions. In addition, the library holds a compendium of psychological tests (Testothek) and the private library inherited from the late Prof. Dr. Kurt Gottschaldt.

The cataloguing and shelving systems are organized according to a somewhat modified version of the classification system of the American Psychological Association (APA). All titles are multiply classified according to this system. Most procedures in the library are automated. In July, 2001 the library software Bis-Lok, which proved its worth for 10 years, was replaced by the much more powerful, window-based system Aleph including a Web online catalog. The installation of Aleph on a central server at the GWDG in Göttingen is a joint project of several Max Planck Institutes who have access to the system via the Internet.

Documentation and Information

Wide-ranging electronic facilities are available for documentation and information. These include primarily information services that are provided by the Max Planck Society: (1) various literature databases on a central server of the GWDG in Göttingen, in particular PsycInfo and Current Contents; (2) access to the Web of Science, the most comprehensive literature database in the world, as well as the Journal Citation Report for ascertaining impact factors; and (3) access to many full-text electronic journals available through consortium agreements between the MPG and several publishers. In addition, the internal network also provides access to Psyndex-*plus* (the German equivalent of PsycInfo) with Psytkom (a compendium of reviews on psychological tests) on CD-ROM. Finally, we use, to a limited degree, our access to DIMDI *(Deutsches Institut für Medizinische Information und Dokumentation)*, which also provides several less frequently accessed databases.

Computer Department

At the beginning of October 2000, the institute started to re-conceptualize the computer department. It is now headed by a senior researcher. While still actively involved in experimental research, he is in charge of reorganizing the computer department that is now a common service unit for both the Max Planck Institute for Psychological Research and the Max Planck Institute for Foreign and International Social Law. The idea behind having a scientist with profound knowledge and experience in both the IT sector and in scientific research is to guarantee that the reorganization will meet the scientific needs of the institute. The computer department now also houses the electronics workshop, the mechanics workshop, and the video/audio facilities.

Technical Equipment

Computers and Network

The MPI has retained the data-processing structure introduced in 1990 with central file and compute servers (operating system DEC-UNIX) and networked PCs/MACs as workplace and laboratory computers. The local network is organized in a radial pattern (fast ethernet) with a gigabit optical fiber backbone. It currently connects about 220 computers. The optical fiber cable hooks up directly with the Munich University Net run by the Leibniz Computing Center. This university net continues to provide access to the computer center of the Max Planck Institute for Plasma Physics at Garching, responsible for routing into the science net. Database programs (Oracle and the library program BIS-LOK) and statistics packages (SAS, SPSS, BMDP) are available at the compute servers. High-performance PCs are increasingly taking over the tasks of the file and compute servers (SPSS, Matlab, Statistica, Mathematica). Hence, one of the future tasks is to slim down the server net while simultaneously replacing some of the old servers with new ones. The new servers' operating system will be LINUX. An internal Webserver has been introduced. It is designed to be a platform-independent information server for internal administrative services. The MPI net is now protected by a firewall, installed in January 2000.

Video/audio

Various facilities are available for making audiovisual recordings and analyzing the behavior of research participants. Complete S-VHS facilities consist of two to three flexibly mounted, remote-controlled color cameras with zoom and wide-angle lenses in the observation rooms and one to two recorders with timecode generation (VITC, LTC) and color mixers in the technical rooms. Additional cabling makes it possible to hook up recorders, monitors, and PCs in both the technical rooms and the observation rooms. VHS and S-VHS camcorders are available for use outside the Institute. There is an electronic editing station with three professional S-VHS-standard video-recorders for processing video-recordings. The editing station can be controlled with FAST over a editing control unit as well as a PC workstation with integrated video machine.

Electronics Workshop

The electronics workshop contains all the necessary equipment to carry out most electronic work internally. Its main duties are to adapt or design peripheral units, but also to service and repair research instruments, PCs, printers, and video systems.

Mechanics Workshop

The mechanics workshop is responsible for designing, developing, constructing, and producing all mechanical research equipment. It contains all the necessary technical equipment for milling, turning, drilling, woodwork, and so forth. The demands of the new junior research groups and the Baby Lab are keeping the mechanics workshop busier than ever, showing how essential it is for the institute.

Administration

The general administration is responsible for running both the Max Planck Institute for Psychological Research and the Max Planck Institute for Foreign and International Social Law.

Cognition and Action

The laboratory area of the Department for Cognition and Action is located on the second floor of the Institute. Some of the rooms are equipped with a total of 12 air-conditioned and soundproof test booths measuring between 2.6 and 4.8 m^2. The laboratory is equipped with a Purkinje Eyetracker and a video-based eye-measuring instrument (SMI), an electromagnetic Polhemus system and an infrared optical system (Optotrak) for registering movements in 3D, and various digitizing tablets. (OPTOTRAK). The SMI and OPTOTRAK systems are integrated into a compound system for measuring eye and limb movements simultaneously.

The laboratory of the unit **Infant Cognition and Action** consists of four rooms on the third floor. The waiting room for parents and their babies is equipped with cooking and nursing facilities. The two test rooms are air-conditioned and linked by one-way mirrors to the observation room. One test room is equipped with a stage and three digital video cameras. The other test room is being used currently for off-line analyses of videos, and is equipped with a monitor, a recorder, and a PC with a time code reader card. Off-line analyses are being conducted with the »Interact« software package. The observation room is also air-conditioned and equipped with a digital video system to record and analyze the videos. This video system consists of five monitors, two recorders, and one mixer.

Psychophysiological Laboratory

The psychophysiological laboratory on the third floor is equipped with two 32-channel »Synamps« (Neuroscan) DC EEG amplifiers. Visual stimuli are presented on a 22'' Multisynch monitor. Presentation is controlled by a VSG 2/5 (Cambridge Research Systems) video controller that enables visual presentation of stimuli of high resolution in space and color with complete temporal control. The VSG 2/5 additionally controls the triggering of EEG recording and the recording of responses. Varying response devices can be connected to this system, including digital and analogue (force sensitive) response keys.

Participants are seated in a soundproof chamber on a comfortable armchair, electrically adaptable in height to control their vertical position in relation to visual stimuli.

Cognitive Robotics

The Cognitive Robotics group (two lab rooms on the third floor) will use two experimental setups as a test bed for neural models of visual cognition and action selection. The first setup is based on a modular robot arm with six rotatory degrees of freedom and alinear two-finger gripper (amtec GmbH). The arm is mounted in a hanging positionon a metal frame and operates on a table underneath it. The table lies in the visual field of a pan-tilt unit (Directed Perception, Inc.) that carries two-color cameras (Sony XC-999). The pan-tilt unit will be used to emulate human eye or head movements, whereas the two cameras will provide a stereo image of the scene. Two framegrabbers (Hauppauge) digitize the camera images. All units are controlled by a Linux PC. A distributed software architecture is being developed that will allow a parallel simulation of the models on a cluster of Linux PCs. A set of tactile sensors on the gripper will be added later. The second setup will be a wheeled mobile robot with vision system based on a commercially available robot platform.

Differential Behavior Genetics

Two rooms located on the third floor of the institute are equipped for psychological assessment. The seating arrangements permit an individual administration of paper-and-pencil tests and tape-recorded qualitative interviews. Experimental tasks requiring the recording of reaction times are presented through personal computers equipped with ERTS software and other programs developed with PASCAL. Audiometric screening is performed with a Hortmann Selector 20K apparatus for determining hearing thresholds on sinus tones. Vision is measured through Landolt figures provided on small and large OCULUS displays and through a Pelli-Robson sensitivity chart.

Advisory Board, Scientific Members, Scientific Staff, Office and Technical Staff, Guest Scientists

Scientific Members

Prof. Dr. Wolfgang Prinz (Executive Director)
Prof. Dr. Franz Emanuel Weinert († 07.03.2001)

External Scientific Members

Prof. Dr. Dietrich Dörner
Prof. Dr. Jürgen Habermas

Advisory Board

Prof. Dr. Vicki Bruce (Stirling, UK)
Prof. Dr. Steven Hackley (Columbia, USA)
Prof. Dr. Reinhold Kliegl (Potsdam, Germany)
Prof. Dr. Asher Koriat (Haifa, Israel)
Prof. Dr. Rolf Pfeifer (Zürich, Switzerland)
Prof. Dr. David Rosenbaum (University Park, PA, USA)
Prof. Dr. Rolf Ulrich (Tübingen, Germany)
Prof. Dr. Carlo Umiltà (Padova, Italy)

Staff

Department for Cognition & Action

Prof. Dr. Wolfgang Prinz (Head)

Senior Researchers

Dr. Harold Bekkering (until December 2000), Dr. Knut Drewing (as of August 2001), PD Dr. Thomas Goschke, PD Dr. Bernhard Hommel (until August 1999), Dr. Dirk Kerzel, Dr. Günther Knoblich, Dr. Iring Koch, Dr. Sabine Maasen (until August 2001), Dr. Frank Miedreich (until August 2000), PD Dr. Jochen Müsseler, Dr. Monika Nißlein (as of April 2001), Dr. Martina Rieger (as of February 2001), Dr. Andrea Szymkowiak (until October 1999), Dr. Florian Waszak (as of August 2001), Dr. Andreas Wohlschläger

Postdoctoral Research Fellows

Dr. Rayna Azuma (until March 2001), Dr. Annette Bolte (DFG), Dr. Birgit Elsner (until December 2000, DFG), Dr. Lothar Knuf (until July 2000), Dr. Franz Mechsner (MPG), Dr. Katharina Müller-Schmitz (MPG), Dr. Bas Neggers (until 31.12.2000, DFG), Dr. Bettina Walde (Volkswagen-Foundation), Dr. Peter Wühr (DFG), PD Dr. Gabriele Wulf (until December 1999, DFG)

Predoctoral Research Fellows

Simone Bosbach, Avner Caspi (MINERVA-Foundation), Rüdiger Flach, Sara de Maeght, Bettina Pollok (MPG), Bianca Pösse (until January 2001, MPG), Stefanie Schuch, Natalie Sebanz, Prisca Stenneken, Sonja Stork (DFG), Tillmann Vierkant

Office and Technical Staff

Silvia Bauer, Marina von Bernhardi (until May 2001), Angelika Gilbers, Irmgard Hagen, Heide John, Nicola Korherr, Regina Schuberth, Ursula Weber

Research Units

1. Infant Cognition and Action

Senior Researchers: PD Dr. Gisa Aschersleben (Head), Dr. Birgit Elsner
Predoctoral Research Fellows: Bianca Jovanovic
Office and Technical Staff: Inga Gegner, Maria Zumbeel

2. Cognitive Psychophysiology of Action

Senior Researcher: PD Dr. Edmund Wascher (Head)
Predoctoral Research Fellows: Monika Kiss (DFG), Katrin Wiegand (DFG), Maren Wolber
Technical Staff: Renate Tschakert-Bittkowski

3. Cognitive Robotics

Senior Researchers: Dr. Ralf Möller (Head), Dr. Bruno Lara Guzman
Predoctoral Research Fellows: Heiko Hoffmann, Wolfram Schenck
Technical Staff: Henryk Milewski

4. Unit Moral Development

Senior Researcher: Prof. Dr. Gertrud Nunner-Winkler (Head), Dr. Marion Nikele
Office and Technical Staff: Katharina Raab, Veronika Stroh (until March 2001)

5. Unit Differential Behavior Genetics

Senior Researcher: Dr. Ulrich Geppert (Coordinator), Prof. Dr. Ernst-Albert Hany (until July 1999)
Office and Technical Staff: Adelheid Pretzlik, Heidi Schulze

6. Unit Sensorimotor Coordination

Senior Researcher: Dr. Rafael Laboissière (Head, as of September 2001)

Service Units

Library and Scientific Information

Dr. Frank Halisch (Head), Ellen Bein, Renate Boes, Ludwig Rickert, M.A.

Computer Department

Dr. Andreas Wohlschläger (Head), Fiorello Banci, Hans-Jürgen Dieckmann, Karlheinz Honsberg, Henryk Milewski, Andreas Schmidt, Max Schreder

Administration

Josef Kastner (Head), Jutta Czöppan, Brigitte Ederer, Elfriede Hurmer, Karl-Heinz Katzbach, Silvia Klemm, Hans Puchberger, Katharina Raab, Hermann Spiegl, Ingeborg Theimer

Guest Scientists

Bruce Bridgeman (1.10.-31.10.1999)
Marianne Christel (1.3.-31.3.2000)
Lorenza Colzato (15.3.-15.9.1999)
Wolfram Erlhagen (1.8.-30.9.1999)
Anthony Greenwald (1.5.-28.5.2001)
Alexander Grunewald (1.7.-26.8.2000)
Alexander H.C. van der Heijden (16.8.-12.9.1999)
David E.Irwin (18.6.-2.7.1999)
J. Scott Jordan (1.3.-17.8.1999 and 1.7.-31.7.2000)
Asher Koriat (1.6.-30.9. 1999 and 1.6.-30.9.2000)
Nancy McNevin (17.6.-31.8.1999)
Jay Pratt (1.6.-30.6.1999)
Ron Rensink (15.7.-15.8.1999)
Orit Rubin (19.6.-11.7.2001)
Raffaela Rumiati (1.11.-30.11.2000)
Charles Shea (1.8.-28.8.1999)
Jan Theeuwes (1.7.-31.7.2001)
Steven Tipper (1.8.-31.8.2001)
David Wright (1.8.-28.8.1999)