Chapter 11
The Perception of Action and Movement

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1 INTRODUCTION

The perception of other people's behavior is a particularly important event for coexistence. Although the discussion of the perception of human action has some tradition in practical philosophy (Meggle, 1977), little empirical knowledge is available. Textbooks on perception occasionally mention some aspects under the headings of *biological motion perception*, *perception of causality* or *person perception* (Bruce and Green, 1990); however, a comprehensive presentation of the various aspects of the perception of human action and body movements is still missing. We hope to close this gap by presenting theoretical and methodical approaches, major findings, and by discussing some problems in this field.

Observers draw a great variety of information from the stream of behavior, for example:

(1) Simple and complex body movements or actions with or without objects such as: WALKING, DANCING, PICKING UP A CUP or TYING A TIE.
(2) Real or pretended internal states, that is, intentions, motives or emotions that are particularly reflected in expressive behavior such as: EFFORT, ANXIETY or HAPPINESS.
(3) Effects of movement or action such as: a fallen vase or a criminal who has been knocked out.
(4) Various verbal and paralinguistic utterances.
(5) Symbolic actions such as: GREETING or SIGNING A CONTRACT.
(6) Social actions such as: HELPING or COOPERATING.

This chapter focuses on the perception of visually presented instrumental behavior. Instrumental behavior can be subdivided – although with fuzzy borders – into *simple body movements (operations)*, *actions* and *activities* (Hacker, 1978; Leont'ev, 1972/1974). Highly automatized *simple body movements* such as WALKING or GRASPING are the basis of simple *intentional actions* such as LIGHTING A CIGARETTE. Perceiving an action requires a linkage of movements, intentions and effects (From, 1971). The perception of *symbolic actions* such as SIGNING A CONTRACT or more complex *activities* that include many actions, such as PREPARING A BIRTHDAY PARTY, requires a semantic integration of visual features of movement and actions, verbal

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communications and prior knowledge. Without denying the role of semantic integration, this chapter focuses on perceptual aspects. Therefore, complex activities, symbolic actions and verbal communications are excluded.

We will present and compare six approaches addressing the *perception* of visually presented behavior, its intentions and its effects. In view of the multiplicity of these approaches, any prior definition of perception seems rather inappropriate. However, the often implicit concepts of perception will be briefly compared in the discussion.

The first part of this chapter deals with the following six lines of research on different aspects of the perception of behavior:

(1) Johansson's (1973) *biological motion perception* focuses on simple, cyclic body movements such as WALKING. Studies on the perception of personal characteristics such as gender or identity through body motion – mostly through their gait – are also included.

(2) Unlike physical object movements, actions, by definition, have internal determinants that can be drawn from ongoing behavior. Heider and Simmel (1944) first studied the perception of *intention* with moving figural stimuli. More recently, Runeson and Frykholm (1981, 1983) studied this issue with the help of a method taken from biological motion perception. The relationship between feeling, emotional expression and impression is a central problem in research on emotions. Because of the particular importance of this field for the perception of internal determinants of behavior, we will also review some results on the perception of *real* and *pretended emotions*.

(3) Behavior often has intended effects. Therefore, observers must perceive when and whether there is a causal connection between a behavior and its consequences. To our knowledge, the *perception of causality* has not yet been studied with visually presented behavior. Therefore, we include some important results on the perception of causality in object movements that follow the tradition of Michotte (1946/1963).

(4) Any behavioral event extends over time. Therefore, earlier parts of an event have to be linked to later ones. To account for this linkage, Johansson (1973) postulated an integrative short-term memory. Empirical studies on this integration and on the form of memory are part of the *dynamic events models* proposed by Freyd (1983) and Jenkins, Wald and Pittenger (1978). Their major findings will be presented.

(5) Simple concrete actions such as OPENING THE DOOR and more complex ones such as LAYING THE TABLE consist of many body movements. Thus, observers have to perceive not only single body movements, but also have to segment the complex stream of behavior and organize it conceptually. This is a central aspect in Newtson's (1976a) theory of behavior perception, which, in our opinion, is linked to cognitive approaches.

(6) The perception of behavior frequently has action-guiding functions. Thus, behavior is often observed to reproduce it in a similar way, to judge it, or to give behavioral feedback to the performer. Among these functions, *imitation*, that is, observation with immediate reproduction, is an interesting field for research on perception of behavior. Under certain restraints imitation may be regarded as a nonverbal method of reconstructing perceptual experiences, and it is also an interesting link between perception and action.

In Part II we will examine these six fields together. Implicit concepts of perception and methodical approaches are compared and some general issues are discussed with a particular emphasis on the relationship of cognition and perception.

Several related fields are excluded: we do not present research based on mere behavioral *descriptions*. Despite some aspects in common, this particularly concerns studies on *action identification* (see, for example, Miller and Aloise, 1989; Vallacher and Wegner, 1987) and *impression formation*. Although these accomplishments often involve visual perception under natural conditions, this research focuses on semantic rather than perceptual processes. We will also not deal systematically with the *perception of faces* and *facial expression*, as research on facial recognition (Bruce, 1988; Young and Ellis, 1989) and the perception of facial expressions (Buck, 1984; Walbott, 1990) require comprehensive presentations in their own right. Research on *eyewitness accounts* is also excluded, as it deals more with memory than with perceptual issues (Loftus and Ketcham, 1983). Finally, no consideration is given to research on the visual perception of physical motion and events in general (see, for example, Cutting, 1986) or in video and cinematic displays (Hochberg, 1986), as each of these topics would also require a separate chapter.

I LINES OF RESEARCH

2 PERCEPTION AND IDENTIFICATION OF ACTING PERSONS

2.1 Perception of Biological Motion

We do not perceive human movements as mere changes in the location of parts of the body but, for example, as WALKING, TALKING, PLAYING CARDS or EATING. This classification seems to be effortless, but we have to ask which rules are used to organize such complex and temporally extended sensory information and assign it to specific categories. With regard to body movements, this question was first tackled by the Swedish psychologist Gunnar Johansson (1973). In some demonstrations, he introduced simple patterns of body movement such as WALKING or CYCLING as an object of perception. He coined the term *biological motion* for these patterns.

In his model of perception, which is influenced by Gestalt psychology, Johansson (1973, 1976) differentiates between a mandatory stimulus analysis performed by a basically autonomous perceptual system and central learning-dependent influences. The visual system is assumed to function according to the *principles of vector analysis*. Moving elements of the stimulus field are continuously interrelated, whereby simultaneous movements in the same direction are combined to form a perceptual unit. A hierarchical extraction of the vectors of these simultaneous movements leads to various hierarchically nested perceptual units. For example, when a girl rides a bicycle, the rotation of her feet, the movement of the spokes and the movement of the bicycle can be perceived independently from each other within various reference systems.

Johansson describes human body movements as *hierarchically organized pendulum motions*. If we look at a pedestrian from the side, the upper arm, for example,

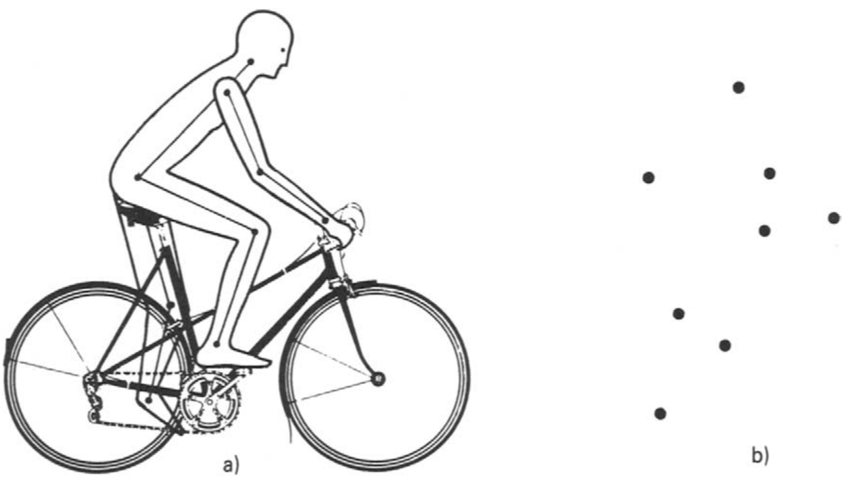

Figure 11.1. *Static illustration of the point-light technique: (a) sketch of the presented scene; (b) point-light presentation.*

describes a pendulum motion relative to the shoulder, the lower arm relative to the upper arm, and the hand relative to the lower arm. Another perceptual unit results from the opposing motions of shoulder and hip. According to Johansson, the vector analysis of such motions is followed by an *integration* of the extracted information in a *short-term memory*. Up to this point, processing is automatic and independent of foreknowledge. In contrast, the vividness of the perceptual impression and the assignment of extracted information to a movement category could be learning-dependent.

In order to exclude influences of knowledge on perception as far as possible and thus study the functioning of the visual system in isolation, Johansson adopted the *point-light technique*, originally introduced by the French physiologist Marey in his early depictions of animal and human movement patterns by photo sequences (Marey, 1894/1994; see also Muybridge, 1897/1979). In this technique, which had already been applied by Taylor (1911) to optimize work sequences, small lamps or light-reflecting patches are attached to the main joints of stimulus persons. By using special lighting and high contrast, the visibility of body movements is reduced until only moving points of light are seen in cinematic or video displays (Figure 11.1).

Johansson particulary varied the type of activity performed by his stimulus persons (1973; Maas *et al.*, 1970, 1971). Subjects either reported generally on what they saw or they judged the identity, gender or activity of the stimulus person. Filmed movement patterns of walking, cycling, climbing and dancing point-light stimulus persons were quickly and easily recognized as human movements – even in movements into spatial depth.

Static figural features of the point-light stimulus provided little help in identification, completely in contrast to information that is generated by the movement. While walking persons are recognized within 200 ms and discriminated from moving dolls within a maximum of 400 ms, observers did not recognize stationary persons as being human (Johansson, 1976). However, as soon as the stimulus person moved, even 3-month-old infants could discriminate between normal and inverted displays (Bertenthal, Proffitt and Cutting, 1984).

Johansson (1973) found some support for his assumption of a hierarchically ordered representation of complex human movement. For example, he was able to show that the subtraction of a common component from the elements of motions did not impair identification. In this case, the stimulus display was a point-light person who appeared to be walking on the spot. Even the addition of an extra vector by continuously rotating the entire stimulus event had hardly any effect on identifications. Thus, judgments did not depend on the absolute movement relative to the observer but on local aspects of movement, that is, on the internal dynamics of the figure (Cutting and Proffitt, 1981).

2.2 Perception of Gait and Gender Identification

While Johansson analyzed various types of movement, Cutting and his team (Cutting and Proffitt, 1981) focused on the perception of human GAIT, in particular, the identification of biological gender from gait. With their grammar for perceptual events, Cutting and Proffitt (1981) presented a broad theoretical framework for these studies. According to the hierarchically ordered *grammar for event perception*, a visual scene is segmented initially into the event and its ground. The event itself contains the acting figure and the action. Information on the internal dynamics, the component structure and the *center of moment* (see below) is obtained from the figure.

Kozlowski and Cutting (1977) first demonstrated that observers were able to specify beyond chance the biological gender of point-light stimulus persons from their gait, as long as they moved in a natural way. It seems that this identification depends on the detection of an invariant feature in the movement sequence: while the presentation of one-step cycle, for example, was insufficient to permit a valid judgment on gender, two-step cycles were sufficient (Barclay, Cutting and Kozlowski, 1978)

In a search for valid visual movement indicators of gender, Cutting and collaborators studied in vain the contribution of individual features such as arm-swing or walking speed. Barclay, Cutting and Kozlowski (1978) finally measured the width of the shoulders and hips of their male and female stimulus persons and found – as anatomy would lead us to expect – that the quotient of shoulder width/hip width was relatively consistently above 1 in men and below 1 in women. Accordingly, gender identification could be based on the perceptual evaluation of these features. However, this failed to explain why identification was also successful when gait could be viewed only from the side.

Cutting, Proffit and Kozlowski (1978) finally proposed the *center of moment* (C_m) an index that specifies the geometrical point on which the movement of shoulders and hips is drawn. In a frontal perspective, it lies at the intersection of the diagonal lines from shoulder and hip. In a sagittal perspective, the points of maximum extension of shoulder and hip have to be linked diagonally. Thus, the hypothetical point lies within the body, approximately between the navel and the breast bone. This point is lower when shoulders are broader and hips are narrower. An arithmetical description of this relationship is obtained from equation (1):

$$C_m = \text{shoulder width}/(\text{shoulder width} + \text{hip width}) \quad (1)$$

The index increases numerically as a function of broader shoulders and narrower hips. This relationship can also be drawn from a sagittal perspective and partial information on arm or leg movements if the level of extension of shoulders and hips is taken into account. Therefore, observers may be guided by the relation described with C_m when identifying gender from gait.

2.3 Identifying Oneself and Others Through Movement Perception

The relationship between body movement and biological gender is relatively simple, not least because of gender-specific body proportions. However, point-light movements seem to contain much more specific features that even permit the identification of an individual person.

As Wolff (1932, 1943) has already shown, persons who have not been given information on figural body features recognize themselves much more easily than acquaintances from samples of their filmed gait. This is remarkable, as generally one perceives the movements of other persons much more frequently and more completely than one's own body movements. Cutting and Kozlowski (1977) first compared self- and other identification in the point-light paradigm and found no differences in the precision of judgment. However, this may well have been because they asked for more self- than other identifications and, as a result, different levels of error probability were involved. In any case, Beardsworth and Buckner (1981) confirmed Wolff's findings with controlled error probabilities.

Following Cutting and Kozlowski's study, Frykholm (1983a) found that identification of others was more precise when several activities by each stimulus person were displayed with the point-light technique. On each trial, subjects viewed three film sequences: the first sequence showed the target person performing various actions; the two other sequences showed the same or another person in a random sequence. Subjects had to judge whether the target person appeared in the second or in the third sequence. Using this design, both unknown and known target persons were identified with more than random precision. Even 11-year-olds' identifications of their classmates were better than random. When the children viewed the films again after a 30-month interval, judgments were even more precise.

Frykholm (1983b) also studied the effect of feedback on the identification of point-light stimulus persons. The precision of identifications of friends or strangers decreased over time when subjects received incorrect feedback on their judgments. Nonetheless, the correctness of their judgments remained above random. In addition, some subjects seemed to be immune to incorrect feedback, while others 'gave in' very quickly. Finally, Frykholm showed that the ability to identify strangers correctly not only increased as a function of correct feedback but also generalized to judgments of new actions by the same stimulus persons.

2.4 Discussion

The first studies on the perception of biological motion were designed to test Johansson's (1973) assumption that the visual system functions according to the principle of vector analysis. Experimental procedures were thus based on a clear theoretical ground. Such a comparable base can scarcely be found in more recent studies.

Why, for example, has identifying gender from gait been studied so intensively? Is it really plausible to use kinematic parameters so frequently to determine gender under ecological conditions, although figural, vocal and culturally determined features such as dress and hairstyle should provide valid information more quickly?

Subjects' judgments oppose this: although the average hit rate of 70% compared to an error probability of 50% is certainly significant, this hardly supports the idea that a biologically adapted, direct perceptual process in the sense of Johansson is being studied. Instead, it seems to be a kind of data-induced hypothesis-testing as Cutting and Kozlowski (1977) originally suspected. Perhaps the information made available in the point-light design is, on the one hand, too sparse to permit a direct perception of gender but, on the other hand, sufficient enough to allow a high frequency of correct guesses.

More recent studies on the perception of biological motion are increasingly less concerned with detecting invariant working principles of perceptual systems and more involved in analyzing the assignment of specific perceptual information to specific categories. While both issues are important, they are not identical. Although the categorical decision requires valid perceptual information and, thus, precisely functioning perceptual systems, the decision could still be incorrect despite the availability of valid information because, for example, the analysis of perceptual information has to be learned. Perhaps this issue could be clarified by analyzing the relationships between stimulus information, judgment and feedback on learning trials, as initiated in the work of Frykholm (1983b).

3 PERCEPTION OF THE INTERNAL STATES OF OTHER PERSONS

Everyday interactions do not only require the recognition of specific patterns of movement. Observers frequently also have to identify whether the behavior of other persons was intentional or unintentional if they want to respond to it appropriately. The *perception of intention* was first addressed by Fritz Heider and later by students of Johansson.

3.1 Attribution of Intention

The first studies on the perception of action intentions can be traced back to the Austrian psychologist Fritz Heider who was strongly influenced by Gestalt psychology. According to Heider, the task of the perceptual system is to reconstruct the properties of the distal stimulus from the given sensory information and to form them into a perceptual impression, that is, the *percept*. Thus, a valid perception of events requires that the visual system possesses implicit information on the relationship between sensory information and the object of perception. In the perception of simple objects, Heider (1926/1959, 1930/1959) considered that it was plausible to assume regular relationships between information and object. In contrast, he considered the ability to perceive intentions directly through the perceptions of actions to be less plausible.

Indeed, relationships are very complicated in this case: as a mental cause that cannot be viewed directly, an intention leads to an observable (body) movement that is conveyed by the structure of the information available to the senses. Thus, the perceptual system must reconstruct not only the body movement from the available sensory information but also the intention from the body movement.

According to Heider, especially this second step cannot be performed by an autonomous perceptual system but must be a product of attribution. In his later work, Heider (1944, 1958, 1967) discriminated only rarely and imprecisely between perceptual and cognitive contributions to the percept, because he suspected that perception and cognition both were influenced by the same Gestalt laws. It follows that Gestalt laws of perception can also be used to predict *attributions*, that is, perceptions of intentions.

Heider and Simmel (1944) worked – like many subsequent researchers – with an animated cartoon. In the 150-second film, a large triangle, a small triangle and a circle move around a rectangle at different speeds. The 12 different scenes can be interpreted, for example, as a triangle that moves toward a house, opens a door, enters and closes the door behind it; or as if the two triangles are fighting each other.

One group of subjects should simply report what happens in the film. A second group should interpret the movements of the figures explicitly as human movements and then characterize the figures as persons. In all, only one subject described the contents of the film exclusively in geometrical terms. With the exception of two further subjects (who interpreted the movements as actions by birds), all the remainder interpreted the film as human activity, regardless of whether they were instructed to describe the contents only or to interpret them as human actions. Even a third group, who viewed the film in reverse, exclusively used descriptors of human actions. Comparable findings for displays with no specific prior information are reported by Heider (1967) and Oatley and Yuill (1985).

Heider (1944) attributed this personification to the *law of Prägnanz* from Gestalt psychology. He assumed that persons in contrast to objects are perceived as causes because they organize the stimulus field in the maximally salient ('prägnant' way. According to Heider, an event leads to a situation requiring an explanation that can be 'resolved' by attributing the event to a personal cause. In an ambiguous stimulus situation ('imperfectly structured environment'), this tendency also leads to the personification of objects to which specific intentions are assigned. Thus, each event elicits a need for attribution, and if more plausible causes are not available, material 'agents' are drawn upon to satisfy this need.

The tendency to perceive other persons as absolute causes is revealed not only in animated cartoons but also in more realistic displays such as audiotape (Alexander and Epstein, 1969) or videotape recordings (Storms, 1973) of a conversation between two persons. Depending on the observer's perspective, the contribution of situational factors to the explanation of behavior is underestimated more or less systematically. However, most studies of this *fundamental attribution error* (Ross, 1977) have addressed issues in motivational psychology and used verbal material (Kelley and Michela, 1980; Nisbett and Ross, 1980).

Alongside the law of Prägnanz, Heider and Simmel (1944) found indications of the effectiveness of other Gestalt laws. The *law of similarity* agrees with the finding that subjects tended to perceive the movements of objects that were labeled 'aggressive' as being AGGRESSIVE and the movements of 'passive' objects more as TIMID or COWARDLY. As no prior information was given on the properties of the objects, the 'personality' judgment on the objects must have been conveyed by the judgment on their 'actions'.

The *law of proximity* corresponds to the increased use of interaction-related terms when movements of objects were coordinated in space and time. Simultaneous movements of two objects without contact led, for example, to interpretations such as LEADING or CHASING, depending on whether the 'stronger' or 'more powerful' object was in front or behind. Successive movements of two objects with momentary contact, in contrast, were interpreted as HITTING. Here, Heider and Simmel postulated the additional effect of the *law of good continuation.*

Heider did not trace back the organization of the stimulus field to the activity of a broadly autonomous perceptual apparatus but to a *conceptual, knowledge-controlled,* or – to use a more modern term – *schema-driven integration* of perceptually available data (Heider, 1958, ch. 2). This assumption is supported by findings from studies that varied prior information on the topic of the film or the 'personality' of the 'actors'. For example, Shor (1957) found an increase in the frequency of unfavorable judgments on an object when it had been labeled 'aggressive' before the study. When prior information was given on the 'fair-minded' disposition of the same object, the judgments were markedly more favorable. At the same time, the object's 'interaction partner' received a more negative judgment, and judgments increased in negativity when interaction was more extensive. Naming the topic of the film ('The jealous lover', Oatley and Yuill, 1985) and prior information on the actors' intentions in a realistic film (Zadny and Gerard, 1974) also had a major influence on subjects' judgments.

3.2 Perception of Intention

Runeson and Frykholm (1983) used experiments based on Johansson's research technique to investigate the direct perceptibility of psychological determinants of behavior. These authors interpret psychological determinants of behavior, such as intentions or motives, as dynamic factors in the sense of physical kinetics. In kinetics, dynamic factors determine the kinematic sequence of movements, for example, displacements of mass, speed and acceleration.

If internal states such as intentions unequivocally specify the kinematic properties of actions as dynamic factors, then the opposite inference from kinematic patterns to dynamic determinants is also feasible and testable. Thus, insofar as the psychological determinants of behavior are unequivocally and specifically linked to patterns of body movement, intentions, emotions or motives should be recognizable from the movement pattern on a purely perceptual basis. In addition, a perfect deception of (mental) states would be impossible, as this would violate the principle of the *kinematic specification of dynamics* (KSD) (Runeson, 1977/1983)

Initial empirical findings are very encouraging: Runeson and Frykholm (1981) and Bingham (1987) showed their subjects point-light stimulus persons who were LIFTING and CARRYING a box that was also marked with point-lights. The weight of the box was varied. With such meager stimulus information, observers were able to estimate weights with extreme precision even when the box remained invisible (Runeson and Frykholm, 1983). Estimations on the length of a throw with an invisible sandbag were also very precise. Runeson and Frykholm (1983) instructed their point-light stimulus persons to deceive observers about either the heaviness of the weight they were lifting or their gender. In line with the prediction of the KSD principle, observers gave very precise estimations on both actual and pretended weight. Gender was also determined very precisely as long as subjects were informed about the possibility of deception. However, as soon as this information was not available, there was a clear drop in the hit rate on deception trials.

3.3 Perception of Emotion

Recognizing emotions from facial expressions is a central topic in research on emotion (Buck, 1984; Wallbott, 1990). As a systematic presentation of the perception of facial expressions would go far beyond the bounds of this chapter, we will restrict ourselves to aspects that are related to the KSD principle.

According to this principle, every intensive emotion, such as true happiness, should, as a physiological and emotional state, control different expressive movements. However, as facial expression has a nonverbal communication function as well as an expressive function, the visible sequence will be determined not only by emotion but also by acquired communication rules, that is, *display rules*. According to the KSD principle, it should be impossible to completely hide the expression of an intensive emotion. Rather, a leakage of the hidden emotion is to be anticipated. In research on emotions, this position is represented by Ekman and Friesen (see Ekman, 1982).

In a series of intercultural studies (Ekman, 1972), they first showed that pictures of static prototypes of facial expressions were linked cross-culturally to specific emotions. For example, the state of HAPPINESS was recognized in a face in which both the outer corners of the mouth and the lower eyelids were raised simultaneously. Similar relationships applied to ANGER, DISGUST and SADNESS, while FEAR and SURPRISE were more frequently confused. Thus, the systematic relationship between judged emotional state and facial expression could be confirmed for at least some basic emotions.

Under communication conditions, we always have to expect that expression will be influenced by display rules. The synchronization of expressive movements might be important for the recognition of 'felt' and 'false' emotional states. Thus, the sequence of smiling in the expression of TRUE HAPPINESS differs from other forms of smiling through the face muscles involved (Ekman and Friesen, 1982) and probably also through shifts in time parameters. As spontaneous and intentional facial expressions are based on the same muscular patterns but not on the same neurophysiological foundations (see Buck, 1984, p. 93), happy and polite smiling should differ in their patterns of innervation. Ekman and Friesen (1969) have shown that deception is more difficult to recognize from facial expression alone than from less controlled channels of expression such as foot movements or vocal features (for further findings, see Zuckerman, DePaulo and Rosenthal, 1981). However, the expertness of the observer also plays an important role in the perception of deception, as laypersons are easier to deceive than, for example, CIA experts (Ekman, 1990). Thus, further support for the KSD principle is also to be seen here.

The recognition of emotions is relevant to research on perception from another perspective: early empirical studies were based on ecologically less valid, schematized line drawings (Brunswik and Reiter, 1937) or photographs of faces (Goodenough and Tinker, 1931). It took a long time before the potentials of film and video-recordings for the presentation of expressive movements were used (Isenhour, 1975; Wallbott, 1990). Indeed, the reduction of sequences of facial expression to static images must be partially responsible for the widespread opinion that the perception of emotions essentially depends on situational context information (Frijda, 1958). However, under natural conditions, static expression is a (pathological) exception, and it is possible that context information is only particularly necessary for recognizing such exceptions. Although it is claimed that the perception of emotions in nonstatic expression also depends on context cues (Isenhour, 1975; Russel and Fehr, 1987), this seems to be more characteristic for neutral rather than typical emotional facial expression (Ekman and O'Sullivan, 1988). The role of movement information in the perception of emotional expression has been confirmed by Bassili (1978, 1979), using the point-light technique.

Bassili (1978, 1979) studied whether observers were able to recognize emotions from expressive movements presented by point-light stimulus persons. These models used facial expressions to present various emotions. Their faces were covered with black make-up and up to 100 white spots, and they were presented either under normal lighting conditions, or as displays of moving spots, or as photographs.

Moving point-light displays of the expression of naive (Bassili, 1978) and trained (Bassili, 1979) stimulus persons were identified validly. However, emotions were recognized much more precisely under normal lighting conditions. In this case, even static facial expression was sufficient for identification (Ekman, 1972). However, this did not apply to all expressive movements: while normal lighting facilitated the identification of ANGER, SADNESS, DISGUST and FEAR, SURPRISE and HAPPINESS were just as easily recognized in the point-light display.

3.4 Discussion

Studies on the perception of internal states are based on a wide variety of different theoretical orientations. Studies using Heider's approach have a clear *cognitive orientation*. This is related to their widespread neglect of the concrete properties of the stimulus display and the amount of information that it may contain. Heider and his followers wanted to demonstrate that a specific local event is interpreted as a function of the global event structure and is in no way experienced as a mere relocation of objects. Although available findings are completely in line with this, Heider's (from 1944 onward) assumption that stimulus patterns are necessarily inherently ambiguous, so that perception always requires interpretative elements, remained untested. There are three possible criticisms here:

(1) Possible correspondences between stimulus parameters and judgment were never tested. For example, Heider and Simmel (1944, Scene 10) presented two objects that circled a third object at two successively equal distances. Did the second object FOLLOW the first one, or did it CHASE it? Heider assumed that the spatiotemporal relationships permitted no clear statement on this. Therefore, the subject had to know, for example, that the first object was 'more powerful' than the second one in order to perceive FOLLOWING. However, it is questionable whether this greater

power is not directly perceivable in the event without any need for inference. Indeed, the decision on CHASING or FOLLOWING could also depend on local stimulus parameters. Michotte (1946/1963), for example, found clear correspondences between specific stimulus parameters and judgments on PROPULSION or LAUNCHING by another object, the TRANSPORT of one object by another one, and the ENTRAINING of a following object by a preceding one. If these cases can be discriminated with available sensory data, why should judgments on CHASING or FOLLOWING not be based on specific local stimulus parameters as well?

(2) It is questionable whether findings obtained with ambiguous stimulus displays can also be generalized to unequivocal scenes. Heider and Simmel's (1944) animated cartoon did not provide the same information as a real hunt or a film of a real hunt. Therefore, it may well have been the experimentally introduced ambiguity of the stimulus materials that forced Heider and Simmel's subjects to make inferences.

(3) Heider and Simmel's stimulus display did not permit any test of the correctness of judgments. In contrast, judgments on the intentions of real persons are frequently controllable. Perhaps Heider and Simmel only really found indications that persons attempt a meaningful understanding of meaningless geometrical displacements.

These criticisms could be tested by manipulating the meaningfulness or the spatial and temporal relationships of the activities of two objects as independent variables. The extent of temporal contingency between the movements of the two 'agents' seems to be decisive for perceiving an interaction. In contrast, the spatial relationship influences the perceived nature of the interaction (Bassili, 1976). The more unequivocal the spatiotemporal relationships between the activities of the objects, the more observers tend to describe only the content of a film. With increasing ambiguity, there is an increase in the percentage of explanations added spontaneously to pure descriptions (Knowles, 1983).

In contrast to the Heider tradition, research by Johansson's followers is based on a *perception-related theory* in which the information content of stimulus events plays an essential role. Of particular theoretical and heuristic interest is the assumption of an unequivocal specification of internal states in the stimulus event (KSD). However, the KSD postulate is only convincing if unequivocal relationships can be confirmed between the causes of dynamic movement and the kinematic sequence of movement as well as correspondences between kinematic information and judgments. It is even more surprising that studies on the perception of internal states have neglected the analysis of stimulus conditions. As long as both relationships are not tested systematically, these studies will raise more questions than answers.

A promising approach – though it requires much further work – seems to be Runeson and Frykholm's attempt to substantiate the KSD principle with findings and hypotheses on action planning and action control. The specific parameters that determine the execution of an action probably also play a central role in its identification. It is therefore possible that parameters that determine the typical female gait or its faking play an equally important role in both production and perception.

Studies on the identification of internal states represent an interesting and stimulating extension of research on the perception of biological motion. This extension should also be encouraged for ecological and theoretical reasons. Studies on the perception of expression are very promising – also for testing the KSD principle. An advantage of this field lies in the fact that muscular foundations of facial expression movements are known and demarcated. This allows facial expressions to be described precisely with, for example, Ekman and Friesen's (1978) facial action coding system (FACS).

4 PERCEPTION OF CAUSALITY

Actions are performed to attain specific goals, that is, to elicit specific effects in the environment. Alongside the action sequence, these effects often provide essential information on the behavioral intentions of the observed person. For example, the aggressive intention underlying a movement frequently only becomes apparent when it leads to specific negative consequences. However, how do we recognize the relationship between an action and its effects? How can we know which effect belongs to which action?

4.1 Theoretical Basis

Up to now, there has been very little direct research on these issues in human behavior. However, Albert Michotte's research program on the perception of causality is closely linked to this field. Michotte investigated the more general issue of whether the causal relationship between two events (e.g. between two ball movements in a game of billiards) is inferred or can be perceived directly. He assumed that the perception of causality, that is, *phenomenal causality,* depends solely on parameters of the stimulus event and on autonomous organizational factors of perception. Accordingly, the causal relationship is directly perceived, that is, it is not added to the percept as a function of experience.

The perception of mechanical causality, as in the example of billiard balls, results from the solution of a *conflict between contradictory organizational tendencies* (Michotte, 1946/1963). On the one hand, the figural features of the billiard balls continue to exist before and after making contact with each other and permit the organization of the stimulus information into two independent objects in the phenomenal world. On the other hand, according to the Gestalt *law of good continuation,* there is a tendency for the movements of the two objects to be integrated into a unified percept of continuous movement.

The conflict between these two organizational tendencies leads to *phenomenal duplication,* that is, object identity and object movement are simultaneously but independently perceived. The movement of an object is accordingly not a constituent element of its identity. The experience of causality results from the integration of the information available from the phenomenal duplication into a unified percept. The integration follows the organizational *principle of ampliation,* a:

> '... process which consists in the dominant movement, that of the active object, appearing to extend itself on to the passive object, while remaining distinct from the change in position which the latter undergoes in its own right.' (Michotte, 1946/1963, p. 217)

This concept serves to predict and explain the experience of mechanical causality.

4.2 Findings on the Perception of Causality

Michotte and collaborators distinguished between two stimulus categories: in LAUNCHING, object *A* moves toward object *B*, stops, and then *B* moves forward in the same direction. In ENTRAINING, both objects move on in the same direction after their contact. After a single presentation of the stimulus pattern, up to 95% spontaneous causal judgments are made in LAUNCHING and up to 65% in ENTRAINING (Crabbé, cited in Michotte, 1966). Until now, size, movement distance, speed, form and color of *A* and *B* have been among the parameters varied. The subjects had to report their perceptual impression that was then tested for causal statements according to some (mostly incompletely specified) criteria. The dependent variable was the percentage of causal judgments, that is, a verbal indicator of the causation experience.

Michotte's approach is based on the assumption of a perceptual conflict in causal events. Accordingly, each manipulation of the prerequisites of this conflict, that is, the phenomenal constancy of the objects that perform the movements and the continuity of movement, should influence the probability of causal judgments. On the other hand, judgments should be resistant to manipulations of stimulus parameters that have no effect on this conflict.

In fact, the frequency of judgments depends not only on the existence of two, discriminable objects (Michotte, 1946/1963, Exp. 3 and 5) but also on the spatiotemporal continuity of the total sequence of movement (Exp. 4, pp. 33–37, ch. 15–16). Thereby the *temporal connection* of the 'effect' to the 'cause' is more important for continuity of movement and causal perception than *spatial proximity* (Yéla, 1952). In general the causal impression is the more compelling, the higher the velocity of *A* compared with *B* (Michotte, 1946/1963; Yéla, 1952). However, as soon as the object that has been launched moves off faster than the object launching it, the observers report an autonomous movement of B that is only contingent on contact with but not caused by *A* (Michotte, 1946/1963, pp. 108–109; Michotte, Knops and Coen-Gelders, 1957).

Michotte also studied stimulus events with more than two objects. Combining two contact events elicits the *tool effect*. In the basic experiment, three objects, *A, I* and *B*, are presented. Object *A* moves toward *I* and stops after having made contact. Then *I* moves toward *B* and also stops, while *B* moves on. According to Michotte (1951), subjects agree that, in this case, *I* adopts the role of a passive tool of *A*, with whose help *B* is manipulated. The effect depends above all on the speed of *I* and the distance between *I* and *B*. The effect is no longer found when the interval is large and the speed is low. *I* then goes beyond its (plausible) 'action radius' (Boyle, 1961; Yéla, 1954) and, to some extent, goes 'too far'.

4.3 Discussion

Michotte's (1946/1963) completely inadequate reports on the implementation of his studies, number of subjects, instructions, data collection and evaluation, as well as the forms of sample selection (see Boyle, 1972; Joynson, 1971) do not meet today's methodological requirements. Imprecise reports on the subjects' tasks and how the causal content of their judgments is determined make an assessment of the findings particularly problematic.

According to Michotte (1946/1963, p. 305), the *instructions* are summarized as, 'Say simply what is going on in the apparatus' or some equivalent wording such as 'Say what you see in the apparatus'. Thus, they provide little information on what information should be used to make a judgment (Joynson, 1971). The first version, in particular, is more to be understood as a request for intellectual interpretations of the occurrence than for reports on spontaneous perceptual impressions. Gockeln's findings (1978; cited in Heller and Lohr, 1982, p. 23) have demonstrated the importance of the concrete formulation of the instructions. Gockeln found that unpracticed subjects gave almost exclusively causal answers when they were asked, 'Describe what happens'. Given the instructions, 'Describe what you see', there were very few causal judgments.

For Michotte's theoretical approach, findings that indicate how perceptual impressions depend on the individual are problematic. If the experience of causality actually depends on autonomous organizational processes without any contributions based on knowledge, individual experiences should not be reflected in judgments. This is contradicted by the dependence of judgments on *intelligence level* (Beasley, 1968), *developmental level* (Olum, 1956) and special *strategies* (Gemelli and Cappellini, 1958). Short-term dependencies are also difficult to explain. For example, sometimes the causal impression only occurs after several presentations (Michotte, 1946/1963), and the frequency of causal judgments is influenced by special *training* (Lesser, 1977; Montpellier and Nuttin, 1973) or the type of preceding display (Gruber, Fink and Damm, 1957; Powesland, 1959).

The type of changes determined by practice remains unclear. Major aspects could be the fixation point and the pattern of eye movements. For example, Michotte (1946/1963, Exp. 7) found no causal judgments when the stimulus event was presented peripherally. Hindmarch (1973) reported increased causal judgments when the point of contact was fixated but not the starting point or goal of the total movement. Jansson (1964), nonetheless, also showed that the eye movements of persons who preferred causal judgments did not differ from those of other persons on the first trial. However, on subsequent trials, patterns of eye movement changed. Subjects who did not make causal judgments consistently fixated on object *A*, whereas subjects with causal judgments changed fixations more frequently. Thus, the type of eye movement or the choice of fixation point appears to be the consequence and not the cause of the judgment.

The causal impression does not seem to be completely independent from the skills and perceptual activity of the observer. This questions Michotte's conception, although it in no way excludes the assumption of a direct perception of causality. Perhaps causal experience is perceptually founded but requires experience in the active extraction of relevant stimulus information.

5 DYNAMIC EVENT MODELS

Unlike static images, behavior develops across time and makes different information available to the observer at various points in time. Thus, the perception of a dynamic event requires a medium in which information can be entered from and at different points in time. Simultaneously, a relationship (coherence) has to be constructed between pieces of information from different points in time. Johansson (1973, 1976) has postulated a short-term memory for this function in which information extended over time is integrated. More recent ideas and studies on the short-term representation of events have come from American research teams led by James Jenkins (Jenkins, Wald and Pittenger, 1978) and Jennifer Freyd (1987).

5.1 Theoretical Basis

When we see a walking person again, after he or she had been obscured by a tree trunk for a short while, we are certain that the person had also continued to exist during the interim period. This also applies to a ball whose line of movement is briefly hidden. Thus, we perceive a *phenomenally permanent* environment (Michotte, 1950) or objects with *apparent permanence* (Piaget, 1936/1952), although this perception is not supported continuously by sensory data. What is the basis of the certainty with which we assume the continued existence of objects that are temporally not confirmed by the senses?

On the one hand, this could be due to inference processes. Accordingly, the continued existence of an event that is temporally not represented in the senses is not perceived but is inferred with a certain probability. On the other hand, the way in which, for example, an object disappears from the field of vision and reappears could provide direct information about its continued existence (Gibson *et al.*, 1969; Michotte, 1950). Thus, the sensory effects of a bursting soap bubble are different from those of a soap bubble that is briefly hidden and then reappears. Such information could also be used to construct a mental model of the event.

An *inference approach* assumes a continuous flow of information from the observed event in the environment, across features of the event that are given and represented in the senses, to a percept. According to this approach, missing sensory information has to be replaced by inferences as soon as an object disappears for a short while. According to a *perceptual approach,* event perception does not primarily provide a continuous representation of sensory impressions in a percept but uses perceptual samples to construct an event model that is continuously updated. Although the event model is based on sensory data, it contains only an orientation- or action-relevant excerpt of information about the event in the environment. Thus, the short-term loss of sensory data does not lead to any impairment of perception and requires no inference processes. It is only essential that the model corresponds to the relevant part of reality and provides an orientation for further activity.

The assumption that the environment is *modeled* instead of *represented* requires the model to possess a degree of autonomy from sensory representation. This also applies to the inference approach, as inferences should replace the missing information. In the inference approach, autonomy only arises from a lack of information, and a lack of sensory information may lead to outcomes that deviate from reality. In the perceptual approach, autonomy provides improved orientation, that is, a more precise correspondence between model and modeled event.

If the relationship between the event itself and the event model is closer than the relationship between the sensory representation of the event and its model, the following predictions ensue:

(1) The construction of the model should not depend on the continuity of the flow of sensory information. It should also be possible to construct an event model from visual samples, for example, on the basis of a sequence of static images.

(2) The primacy of the event model over the information represented in the senses should lead to new individual images from the modeled event (e.g. photographs) not being recognized as new but being integrated into the event structure.

(3) The model should exhibit intrinsic dynamic properties, that is, it should reflect the continuity of the event sequence without corresponding to a continuous flow of sensory information. If, for example, a sequence of pictures only represents an event up to a certain point in time, the model should continue this sequence beyond this point.

5.2 Event Models and the Integration of New Information

In studies on the recognition of previously presented and new pictures, Jenkins (1980), Jenkins, Wald and Pittenger (1978) and Pittenger and Jenkins (1979) have found indications of a representation of the total event sequence that extends beyond the individual pictures presented.

In these studies several sequences of behavior were presented as series of slides that had been photographed with a stationary camera. For example, one sequence of 26 pictures showed a woman MAKING A CUP OF TEA. In the subsequent recognition test, eight previously shown pictures, eight new pictures from the same sequence and eight pictures from a similar sequence were presented. The subjects had to indicate which pictures they had already seen. This made it possible to test whether new pictures taken from the event would be recognized as new or would be integrated into the event model because of their similarity of content. Variations of this experimental design presented unrelated sequences of pictures and pictures in which the original spatial relationships were switched (Kraft and Jenkins, 1977) or perspectives were changed (Jenkins, Wald and Pittenger, 1978).

In these studies, the previously shown pictures were identified reliably. In addition, pictures that belonged to the same event but had not been presented before were frequently recognized (incorrectly). This finding is surprising when we recall that Standing (1973) and Standing, Conezio and Haber (1970) found highly accurate recognition of up to 10 000 thematically unorganized pictures. Finally, according to Jenkins' team, new pictures that did not belong to the same event were correctly identified as new. This excluded the possibility that the subjects were generally working imprecisely.

The readiness to recognize pictures that fit the event although they have not been presented before depends on various conditions. In thematically unrelated sequences, it was rarely ever present. Subjects then seemed to recall each picture by itself. In thematically homogeneous sequences, new pictures were recognized as new if they changed the perspective (Jenkins, Wald and Pittenger, 1978) or switched spatial relationships (Kraft and Jenkins, 1977). Finally, as in studies on phenomenal causality (Gemelli and Cappellini, 1958), using an analytical attitude made it possible to counteract the incorrect integration of suitable pictures with mnemonic strategies (Jenkins, 1980).

The studies of Jenkins' team support the idea that new visual samples of an event are integrated into an internal event model. However, an event model that permits the integration of information samples only seems to be created when the visual samples come from the same event in the environment. Subsequently available sensory information is used to update the model if it fills in gaps in the sensory flow of information.

5.3 Dynamic Representation

Freyd (1983) also assumed that presented subsets of an event are not stored discretely but stimulate an internal dynamic representation of the given event. In her experiments, she presented two or more individual pictures of an event in their natural temporal sequence. The last picture in each sequence – the standard – was followed by a comparison picture that was either identical to the standard or showed another stage in the event. If, for example, the standard portrayed a man halfway through JUMPING OFF A WALL, the nonidentical comparison picture showed him either just before landing on the ground or just after he had jumped.

If event models exist and possess a temporal direction, it should be easier to judge the difference of comparison pictures that show an unrealistic temporal continuation of the standard. For example, if an event is presented as a picture stage 1, the internal model should develop autonomously (in anticipation) toward a temporally subsequent stage 2. Therefore, it should be more difficult for a subject to discriminate the representation of the following stage 2 from stage 1 than a prior stage 0 from stage 1.

This assumption is supported by Freyd's studies using pictures of object movements. Subjects required a particularly long time for a 'different' judgment when the comparison picture showed a good temporal and spatial continuation of the previously presented event (Freyd and Finke, 1984, 1985).

The similarity between the standard and the comparison picture was determined, as in Jenkins *et al.*, according to the coherence of the total event. When the standard provided a poor continuation of the prior picture, the effect was not found: 'good' and 'poor' continuations of the standard were then discriminated equally rapidly (Freyd and Finke, 1984). The length of the retention interval was fairly unimportant (Finke and Freyd, 1985). Like the findings of Jenkins, Wald and Pittenger (1978), this raises doubts about whether the effect has a sensory basis. The number of incorrect judgments even increased with longer retention intervals. In contrast, spatial and temporal coherence was decisive: when the three previously presented pictures implied a certain velocity, the judgment effect depended on how well the comparison picture continued the temporal sequence (Finke, Freyd and Shyi, 1986).

In pictures of natural events, also, Freyd (1983) found that nonidentical comparison pictures (stage 0 or 2) were less well discriminated from the standard (stage 1) if they represented a good spatiotemporal continuation of the stage of the event. The good continuation of JUMPING OFF A WALL was discriminated more slowly from the standard than a preceding stage 0. In a similar experiment, Freyd, Pantzer and Cheng (1988) showed a sequence of three slides of flower pots. On the first slide, the flower pot stood on a stand. The second slide was identical to the first except that the stand was missing. The third slide was the same as the second one except that the pot was either above, below or in the same position. Subjects had to memorize the exact position of the pot on the second slide and report whether this was the same as the position on the third slide. An error analysis of 'same' judgments given on trials with objective differences in position showed that flower pots were more often incorrectly linked to the position that they would have occupied if they had fallen off the stand.

The results of studies on the modeling of object movements in which several pictures were shown are compatible with the assumption that the judgment effect has a perceptual basis. The internal modeling of the event had access to larger samples of the prior sequence of events, thus permitting the extrapolation of future development. However, in studies using natural events, a maximum of one or two pictures were presented as the standard from which it was hardly possible to obtain perceptual information about further development. The reported effects are therefore only understandable under the assumption that knowledge about physical laws is used in addition to a temporally oriented event model. Accordingly, the internal model formation does not depend exclusively upon the momentarily available perceptual information but also draws on knowledge about relationships in the environment.

5.4 Discussion

Illusions or distortions of perception are traditionally evaluated as evidence that inferences play a major role in perception. Thus, the demonstration of knowledge-dependent judgment effects in studies on dynamic modeling also initially seems to support an inference approach rather than a perceptual one. Freyd, Pantzer and Cheng (1988) counter this inconsistency by discriminating between knowledge use and inference. They assume that it was not conceptual but perceptual knowledge that was involved in their study. Perceptual knowledge is either innate or is acquired at an early stage of perceptual learning. It determines the way in which the perceptual system works directly without any dependence on intentions or attitudes and thus stipulates a specific structure for event models.

To some extent, this position is the same as Johansson's (1973). In a given situation, both assume a mandatory activity of autonomic perceptual systems. However, in contrast to the influence of Gestalt psychology in Johansson's approach, Freyd *et al.* suspect that the way this system works can be changed by perceptual learning. This makes it very difficult to maintain Johansson's very clear differentiation of the influences of perceptual and conceptual knowledge and increasingly blurs the border between perception and memory. Thus, it is still unclear whether findings on internal modeling can go beyond their significance for memory theory and provide answers to questions on the direct representation of observed behavior.

On the other hand, 'dynamic' approaches force us to reconsider the traditional assumption that perception is a more or less discrete act. This assumption is not implausible for object perception, but the temporal extension of behavior and other events questions the meaningfulness of a strict differentiation between perception and memory, between perceptual and conceptual knowledge (Gibson, 1979; Johansson, 1979; Neisser, 1976). If perception is understood less as a representation of events in the environment and more as an extraction of information about events and their course, then internal modeling approaches can also contribute to an understanding of the perception of behavior.

6 STRUCTURING THE STREAM OF BEHAVIOR

With the exception of Heider and Simmel's (1944) animated cartoon, previous samples of behavior could only be assigned to a single behavior category. However, when perceiving a more complex action, events have to be isolated from the flow of behavior and be related to each other. Roger Barker has discussed the problems of structuring the stream of behavior, while, more recently, Darren Newtson has studied them empirically.

6.1 Theoretical Conceptions

Barker's (1963, 1978) naturalistic observation method refers to Lewin and Heider by assuming that the stream of behavior contains 'gestalt-like' units that 'naive' observers can assess reliably after a short practice. Although Barker admitted that his method presupposed a theory of behavior perception, his research team restricted itself to demonstrating 'natural' units in the stream of behavior. For example, after viewing an 8-minute film, Dickman's (1963) subjects grouped temporally ordered scene descriptions of a movie into an arbitrary number of units. Alongside a large variation in the number of segments, there was a more than random frequency of segmentations at specific locations.

Wright (1967, pp. 68–76) has used numerous observation protocols of behavior in natural situations to work out the following criteria for structuring them into *episodes*, that is, goal-directed actions in concrete situations: (1) change in the sphere of behavior (e.g. verbal, physical); (2) change in the parts of the body predominantly involved; (3) change in the direction of behavior or its tempo; and (4) change in behavior setting and in objects manipulated. The defining criterion of an episode, which Barker viewed as a natural unit of action, is the adherence to the same goal direction. Using an analytical attitude, episodes can be separated into parts (*phases*). By techniques such as time-loop recordings, they can be broken down even further into *actones*. These authors did not speculate about the psychological basis of this unit formation. They also did not test their assumption that the verbally formed units correspond to those found on a visual basis.

An American research team led by Darren Newtson has been analyzing the structuring of the visually presented stream of behavior since 1973 (Newtson, 1976a, 1977; Newtson *et al.*, 1987). According to Newtson (1976b), any action, such as HANGING UP A PICTURE, is defined by a major change in features between at least two points in time. Their empirical work has addressed only postural changes and not object (location) changes, which, however, leads to problems even in HANGING UP A PICTURE. As there are many simultaneous changes in ongoing behavior, observers have to select features whose change they monitor. Behavior perception would accordingly be a *feature monitoring process*.

Drawing on Neisser's (1976) *perceptual cycle model*, Engquist, Newtson and LaCross (1979, unpubl.) introduced *schemata* as the basis of feature selection. Activated schemata are confirmed or rejected by the information available or changed by surprising events (Newtson, 1973; Wilder, 1978a, b). Differences in prior information lead to the perception of different actions if, in each case, other features are specified for monitoring (Cohen and Ebbesen, 1979; Neisser and Becklen, 1975; Newtson, Engquist and Bois, 1977; Newtson and Rindner, 1979).

In agreement with Heider (1958), Newtson (1980) has adopted an interactionist perspective on the relationship between cognitive and perceptual processes. Perceptual organization can be influenced cognitively at any time. Thus, the structuring of ongoing behavior is – unlike in Barker – an outcome of available stimulus features as well as perceptual and cognitive influences.

6.2 Findings on Structuring the Stream of Behavior

6.2.1 General Methods

Newtson's team has mostly used ongoing one-person actions lasting between 30 s and 3 min as stimulus material. These are displayed as film or videotape recordings without any additional structuring aids such as cuts or changes in focus (cf. Hochberg, 1986). Naive observers have to structure the scene 'meaningfully' by pressing a button when they consider that one action has ended and another has begun. Sometimes, the *level of analysis* has been varied through the instructions and demonstrated on the example of OPENING A DOOR. In *natural segmentation*, observers are free to choose the size of units. In *fine* or *large segmentation*, subjects have to mark the finest or largest units. Each button press is temporally precisely assigned to the scene. The individual number of *button presses* is viewed as a measure of the amount of information processed (Newtson, 1973; Newtson, Engquist and Bois, 1977; Newtson and Rindner, 1979). Within an experimental group, all button presses are plotted over constant time intervals of either 0.5, 1.0 or 2.0 s. The resulting irregular *frequency distribution* of the button presses is used to determine the intervals with a particularly large or small frequency. Intervals with a frequency higher than one or two standard deviations above the mean are called *breakpoints* (BP), and intervals one or two standard deviations below the mean are *nonbreakpoints* (NBP).

The method provides stable interindividual differences in the number of segments with a mean retest reliability of 0.72 after 5 weeks, and individual segmentation patterns are also repeated more than randomly (Newtson, Engquist and Bois, 1976).

Alternative methods for determining the segment structure using cluster analysis (Massad, Hubbard, and Newtson, 1979; Newtson *et al.*, 1987, p. 207) or psycholinguistic methods (Carroll, 1980; Corcoran, 1981) have not become popular.

6.2.2 Segments as Coherent Perceptual Units?

Drawing on the click displacement experiments in sentence recognition (Fodor and Bever, 1965), Newtson and Engquist (1976) have studied the organization of units through the detection of deletions of frames from ongoing film at BPs or NBPs. If segments between BPs form a *coherent perceptual unit*, it should be easier to recognize deletions at the borders that define the action rather than within the unit. Newtson and Engquist (1976) have demonstrated for several actions that breaks of 4, 8 and 12 (= 0.5 s) individual frames at three successive BPs are more easily recognized than at matched NBPs. In addition, detection of deletions depended on the length of the deletion for BPs but not for NBPs. Likewise, Carroll (1980) and

Corcoran (1981) confirmed that visual interference was more easily recognized at linguistically defined action borders than within a single unit.

Newtson and Engquist (1976) further suspected that the action-defining BPs are emphasized in ongoing behavior and therefore easier to detect. In the *recognition paradigm,* subjects watch a film display of an action. Ten minutes later, they are presented with slides of BPs and NBPs as well as similar actions by the same stimulus person that were not shown previously. They have to judge whether they have seen them before or not (cf. Jenkins, Wald and Pittenger, 1978). Regardless of whether they segmented the display by button pressing or not, the subjects recognized BPs significantly better than NBPs (Newtson and Engquist, 1976).

Similar to studies on sentence processing in which units are based on the recognition of presented and semantically similar nonpresented words from various parts of sentences, linguistically segmented actions also show that individual pictures from the beginning of the second unit are better recognized than those from the end of the first unit (Carroll, 1980; Corcoran, 1981; Lasher, 1978, 1981). Independently from Newtson, these authors suspect that the perceptual processing of a 'grammatical' action unit proceeds to the subsequent one. The preceding unit is recoded abstractly and holistically, thus impeding precise recognition.

Whether the segmentation procedure provides proof of *coherent perceptual units* remains unclear. On the one hand, feature differences between BPs and NBPs are confirmed (see below). On the other hand, Newtson, Engquist and Bois (1976) report for eight actions a mean unit length of approximately 12 s under natural segmentation, 7 s under fine segmentation, and approximately 26 s under large segmentation. A primarily perceptual organization of units of this length is improbable if a time limit of approximately 3 s is assumed for perceptual organization (Pöppel, 1985).

The psychological foundations of unit formation must therefore be defined more precisely. Is segmentation based – as Newtson suspects – on the comparison of two, temporally separated states, between which a monitored posture feature changed critically, or is it, instead, based on the perception of a holistic 'event Gestalt' (Verlaufsgestalt) (see Johansson, 1973)? It is also necessary to clarify whether action units are perceived directly or are subject to cognitive mediation.

6.2.3 Foundations of Segmentation

According to Newtson's (1976b) *feature monitoring hypothesis*, the perception of an action requires at least one critical posture change between two points in time. To test this hypothesis, posture changes between successive BPs and temporally matched NBPs were coded with the *Eshkol–Wachman movement notation system* (Eshkol, 1973; Rosenfeld, 1982). This goniometric procedure records 15 changes in the angle between the major limbs and their pivot joints. If, for example, the right arm is raised and extended without bending the forearm, a change in the position of the upper arm but not of the forearm is registered. In addition, the frontal orientation and the weight distribution of the body are taken into account. Each comparison of body positions between two points in time thus results in a 17-point vector. Factor and Fourier analyses can be calculated for larger numbers of vectors.

Newtson, Engquist and Bois (1977) tested posture changes between successive BP–BP, NBP–BP, BP–NBP and NBP–NBP pairs in correct and random sequence under all three levels of analysis. As anticipated, the extent of change between correct BP sequences was the highest. For each action, separate factor analyses produced several specific, interpretable factors. For example, in WAITING FOR A PHONE CALL, movements of the right hand and the right forearm formed one factor that, according to Newtson *et al.*, is related to answering the phone. Movements of the head and neck, lower leg and the left upper arm loaded on a second factor. These movements were interpreted as reactions to the ringing of the phone bell.

In an extension of the feature monitoring hypothesis, Newtson *et al.* (1987) looked for periodic changes in ongoing behavior. Posture changes in seven actions were coded with the Eshkol–Wachman system in 1-second intervals. A Fourier analysis of the wave-like course of the posture changes resulted in significant periods for all actions. For CONSTRUCTING STICK FIGURES, for example, these lay at 4 and 16 s. At these intervals there was a repeated increase in posture changes. Other actions showed other significant periods that revealed a nonrandom relationship to the large segments. As the authors did not interpret the content of these periods, we suspect that for CONSTRUCTING STICK FIGURES, one part is added about every 4 s and a whole figure is completed and put aside every 16 s.

In addition to stimulus effects there are also person-dependent effects. For example, instructing subjects to segment finely, naturally or largely leads to the anticipated changes in the number of segments (Hanson and Hirst, 1989; Jensen and Schroeder, 1982; Kogelheide and Strothe, 1980; Koopman and Newtson, 1981; Lassiter, 1988; Newtson, 1973). Thus, the level of analysis is chosen intentionally.

Attitude effects have also been demonstrated. According to Neisser (1976) as well as Engquist, Newtson and LaCross (1979), variations in prior information or observational tasks specify different schemata that should lead to different segmentation patterns (and retention performances). For example, differences in segmentation patterns could be demonstrated following the information that subjects would subsequently have to recall the scene or to judge the person (Atkinson and Allen, 1983; Cohen and Ebbesen, 1979; Engquist, Newtson and LaCross, 1979; Graziano, Moore and Collins, 1988; Markus, Smith, and Moreland, 1985; Massad, Hubbard and Newtson, 1979; with the same tendency, but not significant: Schorneck and Berger, 1980).

Newtson (1973) and Wilder (1978a, b) have also demonstrated that segmentation becomes finer after inserting a *surprising event*. The authors believe that surprised observers try to overcome the uncertainty about the action by a more acute monitoring of the event. Conversely, a known scene should be segmented in larger units, which, as yet, remain unconfirmed. For example, Droste and Holtmann (1980) found no effect of a preceding summary of the scene. Segmentation also did no change significantly during repeated displays (Kogelheide and Strothe, 1980; Nyce and Becklen, 1978). The relationship between segmentation and predictability thus remain's open.

6.2.4 Relationships Between Units

Newtson and Engquist (1976) suspected that BPs summarize the action like *comic strips*. Thus, they tested the intelligibility of BP and NBP sequences. Observers saw pairs or triads of BPs or NBPs in natural or randomized sequence. They had to rate the intelligibility of the slides, summarize them into one sentence and judge the correctness of their order. BP sequences scored better than NBP sequences in intelligibility, descriptiveness and in order judgments (Newtson and Engquist, 1976). Variations of the sequence influenced the intelligibility of BPs only and not of NBPs. Scrambled sequences were better recognized in BPs than in NBPs.

Newtson (1977, Exp. 8 and 9) also presented the pictures used in the triads pairwise and found weaker effects. The intelligibility judgments were better for triad displays than those calculated from pairwise presentation of the pictures. Comprehension seems to depend not only on changes from picture to picture: the temporal picture context seems to have an overall effect on comprehension (see Jenkins' concept of coherence).

Further studies investigated whether segmentation varied over a *hierarchical structure*. A 'hierarchical' dependence would be present if a higher than random number of BPs agreed across various segmentation instructions. This has been confirmed repeatedly for fine or large segmentation (see, for example, Hanson and Hirst, 1989; Newtson, 1973; Rindner, 1982, cited in Newtson *et al.*, 1987). Hierarchical dependencies were also found when varying predictability (Wilder, 1978a, b), arousal (Newtson, 1977, Exp. 2), and film projection speed (Newtson and Rindner, 1979).

The type of hierarchical dependence remains undetermined. Hierarchical dependence in the sense of a differentiation of larger segments when performing fine segmentation or summarizing fine units to large ones has not yet been confirmed unequivocally. Although there is a more than random agreement on the number of BPs under large and fine segmentation, the agreement between large breakpoints and fine ones is consistently less than 50% (Hanson and Hirst, 1989: 34%; Kogelheide and Strothe, 1980: 41%; Newtson, 1973: 36%). However, as nearly all previous research has studied mean segmentations in independent groups, a hierarchical organization on the individual level may well remain undetected.

Thus, little is known about the relationships between the units. Findings from Newtson (1977) and Newtson, Gowan and Patterson (1980), like similar findings from Jenkins, Wald and Pittenger (1978), suggest that the relationship between units is determined semantically.

6.3 Discussion: A Cognitive Interpretation of Segmentation

According to Newtson, observers segment when they notice a meaningful change in the postural features monitored. Segmentation assesses a perceptual process that can be influenced cognitively. Although our perspective is compatible with Newtson's findings, we interpret segmentation as a conceptual classification on the basis of activated knowledge structures, and thus as a cognitive process. This elaborates the unpublished schema theory by Engquist, Newtson and LaCross (1979).

Like Barker and Newtson, we assume that ongoing behavior contains anatomical and physical features that are used to identify actions (see the spike structure of posture changes in Newtson *et al.*, 1987; episode criteria in Wright, 1967).

However, which features are attended to and integrated perceptually depends not only on activated knowledge structures and the behavioral intentions of the perceiver but also on the situational context (Cohen, 1981; Engquist, Newtson and LaCross, 1979; Neisser, 1976). As long as the context under natural conditions is not blanked out with the point-light technique or by pantomime (see Becklin, 1983, cited in Newtson *et al.*, 1987; Hilse, 1985; Sakowski, 1985), features of the present situation and experiences with similar action contexts should also activate knowledge structures about probable actions (see *schema* or *script* in Rumelhart, 1980; Rumelhart and Ortony, 1977; Schank and Abelson, 1977). Schank and Abelson (1977) introduced the term *vignette* for the visual properties of actions represented in knowledge structures. We believe that these vignettes, which are embedded in knowledge structure, facilitate the identification of action. In experiments, observers are forced to interpret for themselves the size of a *meaningful action unit*. The example of OPENING A DOOR that is given with the instruction might suggest a finer size of meaningful units than a more complex example like TYPING A LETTER would do (Cohen, 1981; Ebbesen, 1980). Observers might infer further cues from the duration of the event. Thus, A TELEPHONE CALL in a longer office scene might well be segmented into larger units than when it is presented in isolation.

Against this background, our interpretation of segmentation moves away from Newtson's concept: although we do not deny a perceptual basis in the identification of actions, we believe that the button press is cognitively based. Without recourse to knowledge structures, it remains unclear according to which criteria observers discriminate meaningful from meaningless changes. Given the assumption that the visual display activates a domain-specific knowledge structure with visual features, 'meaningful' changes are those that have a correspondence in the knowledge structure. Changes without this correspondence are 'meaningless' and perhaps overlooked. 'Surprising events', which Newtson does not define, do not fit the active script. A hierarchical knowledge structure also permits various, possibly hierarchically nested levels of analysis. The above-mentioned 3-second time limit for the perceptual organization of events and further cues support this cognitive reinterpretation of segmentation as a conceptual classification of visual changes.

Natural conceptual classifications have *fuzzy borders* (Zadeh, 1972). This is also seen in the segmentation of ongoing behavior. According to Stränger, Schorneck and Droste (1983, p. 27), about 30% of BPs conveyed on a 2-second basis are surrounded by intervals of intermediate segmentation frequency (IBP; pattern: IBP–BP–IBP). The BP–BP–IBP and IBP–BP–BP pattern each represent about 13% of the patterns. The pattern NBP–BP–NBP, that should be most prominent if Newtson is right, occurred in less than 4% of the patterns. Accordingly, segmentation seems to be more allotted to time zones than to time points. This is very plausible when we consider that, for example, CLOSING A WINDOW can be segmented somewhere on the way to or from the window. The time of segmentation might depend on what the observer knows about the context of the activity of the actor. If the observer, for example, knows that the actor is irritated by a sudden traffic noise from outside, he may realize the intention of the actor earlier than without that knowledge.

If units are formed on the basis of natural knowledge structures, segments should be *easy to name*. Thus, Schorneck and Berger (1980) showed that observers who had to describe aloud while segmenting mostly gave behavior-synchronous or summarizing descriptions. A detailed analysis of the behavior-synchronous utterances revealed that 63% of the segmentations followed their naming. Accordingly, the conceptual classification seems to be primary; naming or segmenting is secondary.

If conceptual classification is primary, similar segmentation patterns should result on both a verbal and a visual basis. Baggett (1979) has reported a high level of agreement on the segmentation of a 34-minute film using either 367 verbal phrases or 571 single stills. Nonetheless, subjects were presented with a broader, text-linguistic episode concept. If the segmentation pattern of a visually and verbally presented event would also be similar under the instructions given by Newtson, this would be a further confirmation for a cognitive–semantic interpretation of the segmentation.

One of the most notable features of the studies on segmentation is the *high (and reliable) differences in the number of segments*. Stränger, Schorneck and Droste (1983) reported 7 to 80 units for the segmentation of a 10-minute office scene. Similarly high variations can be found in other studies. In free classification tasks, major individual differences in the number of concepts applied are well known (Gardner, 1953/1954; Glixman, 1965). The cognitive style of *category width* was derived from this observation (Pettigrew, 1958). Unfortunately, category width has not yet been correlated with the number of segments in any study on the segmentation of ongoing behavior.

In a theoretical interpretation of observational learning, Stränger has assumed that segments influence memory performance as *chunks* in the sense of Miller (1956). Initial attempts to test this hypothesis on memory for actions with cued recall tests have been unsuccessful (Cohen and Ebbesen, 1979; Droste and Holtmann, 1980; Kogelheide and Strothe, 1980; Schorneck and Berger, 1980; Stränger, 1977), whereas other authors have reported weak relationships (Koopman and Newtson, 1981; Lassiter, Stone and Rogers, 1988). According to Hanson and Hirst (1989), the type of test is a major variable. In free recall, observers recalled more after fine segmentation than after large segmentation. In a cued recall test, these differences could not be found. Thus, segmentation and the representation of an event in memory are probably closely related (Neisser, 1976; Stränger, 1977, 1979). Free recall seems to reflect the memory representation of actions better than tests with prompts. Nonetheless, this discussion is certainly not yet complete (Hanson and Hirst, 1991; Lassiter and Slaw, 1991).

Considering these secondary findings together with some of the findings by Newtson, we assume that visual events in ongoing behavior are primarily classified conceptually. Secondarily, the units are named or marked by the button presses, depending on the instructions (cf. Ebbesen, 1980).

7 BEHAVIOR PERCEPTION AND MOTOR REPRODUCTION

Among the processes that are based on the perception of behavior, direct reproduction, that is, *imitation*, is of particular interest to research on perception. Given certain preconditions, imitation can be regarded as a method of reproducing the perceptual experience. Although each motor imitation requires the perception and storage of observed behavior as well as its transformation into the motor system, these processes are only occasionally addressed in empirical research on imitation. They are mostly neglected in favor of the motivational conditions of imitation (Bandura, 1971, 1986; Scully and Newell, 1985; Stränger, 1977, 1979; Whiting, 1988)

7.1 Imitation Phenomena that are Relevant to Research on Perception

From a functional perspective, *imitation* is not a unified phenomenon (see Stränger, 1977; for a historical review see Scheerer, 1985).

Sensory Modalities

With reference to the sensory modalities involved, *acoustically, verbally and visually* conveyed forms of *imitation* are often distinguished (see, for example, Guilliaume, 1926/1971; Piaget, 1945/1962). We will only consider the latter.

Relationship Between Perception and the Motor System

Regarding the kind of relationship between perception and the motor system, *automatic, reflex-like* forms of imitation can be discriminated from *conscious, intentional* forms (see, for example, Koffka, 1921/1952; McDougall, 1908; Morgan, 1896; Piaget, 1945/1962). The automatic forms are of particular interest to research on perception as they suggest a connection between perception and the motor system that is originally not mediated by cognition. These automatic forms include:

(1) *Self-imitation,* that is, the repetition of one's own body movement on the basis of its perception (Baldwin, 1895; Guilliaume, 1926/1971; Piaget, 1945/1962).
(2) *Ideomotor,* that is, nonintentional movements or *motor mimicry* that accompany the observation of movements seen in others (James, 1890; McDougall, 1908)
(3) *Movement imitation by infants* (McDougall, 1908) that have received much attention since the studies by Meltzoff and Moore (1977, 1983a, b; see also: Vinter, 1985a, b, 1986; Whiting, 1988)
(4) *Response facilitation,* that is, the elicitation of a behavior in the observer that corresponds roughly to the model (Aronfreed, 1969; Bandura, 1986; Koffka, 1921/1951; McDougall, 1908)

These imitation phenomena particularly occur in early childhood. The similarity between observed and executed behavior is mostly slight.

Type of Agreement

A further important differentiation concerns the type of agreement between model and observer behavior. Process-like *movement imitation* requires the perception and reproduction of spatial and temporal features of a (body) movement. Outcome-oriented *action imitation,* in contrast, emphasizes the reproduction of similar (environmental) effects, while agreement on the course of body movement may be only slight (Aronfreed, 1969; Miller and Dollard, 1941; Morgan, 1896). Different reference systems and forms of representation are linked to this conceptual distinction: if a movement of another person is imitated as a body movement, it should be related to one or more reference points of the actor's body, as for example the center of moment in the imitation of gait (see Johansson and Cutting). These body movements may also be represented dynamically (see Freyd). As a *motor task,* the reproduction of new body movements is not expected to be very successful on the first trials, because the execution also depends on kinesthetic feedback. If a movement of another person is imitated as an object-directed action, it relates, in contrast, to the spatial context outside the actor's body, especially to the displacement and change of the manipulated objects. For an effective representation of these *cognitive tasks,* it is important to discriminate which environmental effects are critical. A rough representation of the changes of objects or their position is sufficient to reproduce similar effects on the first trials with body movements, which may widely diverge from the movements seen in the model.

Observational Learning

In *learning by imitation* or *observational learning*, the observation of a model's behavior plays an important role in the acquisition of a plan for a new body movement or an object-directed action. *Observational learning effects* include the transfer of an available movement or action pattern to a new situation and the recombination of existing movement or action patterns into a new configuration (Bandura, 1971, 1986; Koffka, 1924). In reinforcement theories, these effects are interpreted by generalization (Gewirtz and Stingle, 1968), otherwise by diverse cognitive processes (Aronfreed, 1969; Bandura, 1971, 1986; Stränger, 1977).

7.2 Theoretical Conceptions

Koffka (1924) already emphasized that a central problem in imitation is how perception can issue in a movement similar to the model's behavior. He solved this old *ideomotor problem* by assuming a direct relationship between a perceptual and a movement structure to which Gestalt laws could be applied. In the ontogenetically earlier *compulsory imitation*, the observation of a movement provides an event-Gestalt-like perceptual structure that, according to the *law of configurative supplementation* and the *law of repetition of figures*, directly and necessarily elicits an ideomotor movement. Automatic imitation phenomena could be interpreted in this way (for further theoretical approaches, see Prinz, 1987). In the ontogenetically higher and later *ability to imitate*, that is, *voluntary imitation*, the relationship between perception and movement is mediated by cognitive processes. The central issue here is how the observation leads to a correct perceptual structure. Koffka already pointed to the possibilities of emphasizing the point of attack for the solution, of drawing attention to things not previously connected with the situation, or of pointing out essential features of an action by means of language. The impulse for imitation in these cases mostly comes from sources other than perception. This motivational issue is not a particular problem of imitation but a problem within a general theory of motivated action. However, it has been this motivational aspect that has received the most attention in empirical research on imitation (Bandura, 1986; Halisch, 1990)

According to Piaget (1945/1962), the development of imitation is based on innate reflexes in which perception and movement are closely linked. Through practice, reflexes are integrated into more flexible sensorimotor schemata, which, like grasping, contain invariant perceptual and motor features. These schemata can be applied with increasing flexibility and purpose to different objects. Through repeated application, the child adjusts his or her sensorimotor schemata to reality (*accomodation*) and simultaneously, but to a lesser extent, adopts new features into his or her schemata (*assimilation*). By repeatedly combining originally isolated sensorimotor schemata, more comprehensive sensorimotor units are formed. This makes the child's behavior increasingly more differentiated and flexible. The perception of another person's or the child's own body movements activates known schemata, which the child first attempts to make persist through similar movements. Originally, this imitation can only be elicited by the perception of own movements (*self-imitation*); later, movements seen in others can also be continued in this way (*imitation of others*). After the sixth stage of sensorimotor development, that is, after approximately 18 months, this procedure is internalized. According to Piaget, the first representations, which also permit *delayed imitation*, are based on this internalization. Because these representations are later linked to language and thought, imitation becomes cognitively mediated, more conscious, and selective.

Koffka and Piaget solved the ideomotor problem by assuming an innate relationship between perception and movement that is later mediated cognitively by language and thought. In this way, they had already provided solutions to a theoretical problem in the early formulation of Bandura' s social learning theory (Stränger, 1977).

Bandura (1962) originally interpreted the mediating representations in observational learning by *stimulus contiguity* (Sheffield, 1961). According to this idea, sensations that are repeatedly elicited by events in close spatiotemporal proximity become associated with each other; this association results in an integrated perception. This conception fails to solve the ideomotor problem unless one assumes a connection between the integrated perception and the motor systems. It also remains unclear why observers are not able to imitate every repeatedly observed behavior at any time. Later, Bandura (1971, 1986) advanced an *information processing interpretation* of observational learning effects. Active observers abstract common features and rules from the model's behavior, transform stimuli into easily remembered schemata, classify and organize actions, and construct ideas about how they should be performed. While originally only visual and verbal representations were taken into account, Bandura (1986) – like Aronfreed (1969) earlier – now also mentions amodal schemata as well as conceptual and propositional representations.

Stränger (1977, 1979) specified Bandura's interpretation in a heuristic model of the processing of visually presented behavior. Taking into account Piaget's *schema concept* and E. J. Gibson's (1969) concept of *perceptual learning*, he proposed a multistorage model with closely interrelated patterns (schemata) of visual and kinesthetic invariances of body movements (and manipulated objects). The schemata have a conceptual character in older children and adults and can frequently be named (e.g. GRASPING, CATCHING A BALL). They permit a conceptual classification and the naming of the observed actions. Fitting in with this conception, Hoenkamp (1978) and Todd (1983) have shown that computer-simulated matchstick-like 'leg or arm movements', whose angle and speed were varied systematically, are also given different names. Accordingly, observers 'know' different visual features of WALKING or RUNNING. Eye movement patterns are considered to be a part of the schema that is constructed through the repeated visual analyses of behavior. These patterns may later control analyses of similar behavior (Neisser, 1976). The selection of analyzing schemata should depend on observational intentions, early stimulus characteristics in the display, and domain-specific perceptual and performance-related experiences. The information available in ongoing behavior either confirms or rejects the schemata underlying the analysis. Visually displayed behavior is thought to be represented in the form of confirmed schemata that are mostly nameable. Up until reproduction, the activated schemata may be maintained through imaging or verbal repetition, and – as long as they are structured hierarchically – may also be organized in higher categories. Kinesthetic components of the active schemata control the motor performance on a strategic level (Miller, Galanter and Pribram, 1960). Depending on the intention of the child or adult observer, behavior is either imitated as an action with similar effects (in the environment) or as a body movement with a similar spatiotemporal structure. In the case of learning, motor reproduction requires kinesthetic and visual feedback as well as adaptations to object properties. This feedback is especially important for movement imitation. Thus, the ideomotor problem is theoretically solved with a schema conception. The differentiation of the schemata may result from mere perceptual learning (see E. J. Gibson, 1969). By emphasizing domain-specific experiences in perception and performance and the need for kinesthetic feedback, the obvious limitations of observational learning are taken into account.

The assumptions of this and similar conceptions can only be tested piecemeal by referring to hypotheses from current research on perception, memory and motor behavior. The available findings are sparse and heterogeneous.

7.3 Findings on Movement and Action Imitation that Relate to Perception

7.3.1 Methods

For a functional analysis of movement and action imitation, known or new behavior is presented with a duration of between 3 s and 4 min. Typically, the sequences last about 20 s in order to avoid intraserial interference (Margolius and Sheffield, 1961).

New body movements with low verbal codability and without objects are appropriate to study the learning of body movements by imitation: for example, the manual language of the deaf (Gerst, 1971), simplified tai chi (Teubner, 1985), or ballet sequences (Gray *et al.*, 1991) and sport exercises (Whiting, 1988) – as well as meaningless hand or arm movements (Prinz and Müsseler, 1988; Vogt, 1988). Action imitation is often studied with namable actions that are related to objects (e.g. tying knots: Roshal, 1961; dismantling and reassembling objects: Margolius and Sheffield, 1961; Jeffery, 1976; Stränger, 1977). As no theoretically based taxonomy of behavior is available, selection depends on practical considerations and individual preferences. For studying visual perception and visual recognition in imitation, patterns with low verbal codability should be preferred.

Older children, adolescents and adults are explicitly told in advance that they must perform the behavior subsequently. Reproduction immediately follows the display, or, when memory is being tested, after a filled time interval of several minutes. In action imitation, the objects are available for the reproduction. Thus, the task is similar to a cued recall test. In contrast, movement imitation is closer to free recall.

If imitation research focuses on differences between acquisition and performance, a *verbal reproduction* may be required as an index of acquisition. In this case, it would be more advantageous to test the *recognition* of presented as compared to similar nonpresented behavior units, as behavior varies in verbal codability and observers have to decide what they consider to be worth reporting. However, this procedure has rarely been applied (see, for example, Hilse, 1985; Weißenfeld, 1984).

In analyses of action imitation, it is mostly tested only how many units or how often previously seen effects roughly agree with the model's demonstration. In contrast, studies on movement imitation also take into account event features such as similarity of posture changes and movement speed (Gray *et al.*, 1991; Teubner, 1985). The dependent variable in observational learning is either the number of trials up to a fixed performance criterion or the quality of reproduction after a set number of demonstrations.

7.3.2 Exemplary Findings

Action Versus Movement Imitation

Infants up to two months of age seem to imitate facial movements more readily than similar object movements (Legerstee, 1991). However, at the end of the first year, infants spontaneously imitate more object-related actions than pure body movements (Abravanel, Levan-Goldschmidt and Stevenson, 1976; Rodgon and Kurdek, 1977). At about the age of four years, children imitate more actions with appropriate objects than equivalent movements without objects (Killen and Uzgiris, 1981; Uzgiris and Silver, 1976, cited in Uzgiris, 1984).

Contrary to Piaget's conception, imitation seems to exist already in the neonate (cf. Field *et al.*, 1982; Meltzoff and Moore, 1977, 1983a; Vinter 1985a, b), and it seems to be based on an inborn intermodal relationship between the perceptual and motor system (cf. Meltzoff and Moore, 1983b). The imitations in neonates may serve communicative functions. In older children, the meaning of an action seems to be essential for imitation.

Extending two experiments from Bandura (Bandura and Jeffery, 1973; Bandura, Jeffery and Bachicha, 1974), Stränger (1977) demonstrated that the reproduction of filmed patterns of 'arm movements' performed in front of a regular background increased as a function of the discriminability of the background. As in Bandura *et al.*, the traceless 'movement' seen had to be reproduced as a trace on paper. With a dotted background, 12-year-olds drew the trace but did not try to reproduce the movement precisely, and some even presented the body movement in the opposite direction. Thus, observers did not copy an arm movement but the linkage between the points. The arm movements could probably have been replaced just as effectively by a moving point-light or a sequence of lamps flashing.

These findings show that older children and adults prefer to reproduce understandable actions rather than meaningless movements (Koffka, 1921/1952). Therefore, studies on movement imitation must explicitly call for the reproduction of the spatial and temporal course of the observed event.

Perceptual aspects

Constant displays of behavior are mostly provided with film or videotape recordings. The *reduction of spatial depth* does not impair reproduction compared to real-life presentation (Martens, Burwitz and Zuckerman, 1976; Stränger, 1977, Exp. 2). However, this might depend on the task and on the developmental level of the observer (Gibson, 1969). Real-life presentations are preferable for the study of movement imitation.

Stränger (1977, Exp. 3) has demonstrated the importance of the *visual display* for action imitation. It was far more difficult to solve a mechanical puzzle on the basis of an effective solution description presented on audiotape than to solve it on the basis of a filmed demonstration.

A prerequisite of any visually conveyed imitation is the *visibility* of the relevant behavior. As kinesthetic sensations are not visible, it is hardly surprising that, for example, in the pursuit-rotor task, observational learning effects on the contact time are not found, although some features of posture are adopted (McGuire, 1961;

Burwitz, 1975, cited in Scully and Newell, 1985). Thus, only the external structure of a behavior is conveyed by observation. Although this structure can clearly be assessed in a more differentiated manner if it is presented repeatedly, successful reproductions of a motor task require own performances.

Body movements and goal-directed actions are imitated better after *dynamic display* than after a sequence of selected stills from the same event (Gray *et al.*, 1991; Roshal, 1961; Stränger, 1977; Thompson, 1940, cited in Miller and Dollard, 1941). If these results can be replicated with selected stills (cf. breakpoints in the sense of Newtson) and controlled presentation times, they suggest that, mediated by perception, the reproduction also profits by dynamic displays.

Williams (1985, cited in Whiting, 1988) displayed target and throwing movements either under normal conditions or with the *point-light technique*. During imitation, he recorded electromyographic and goniometric data. The lack of any significant differences in reproduction suggests that even moving point-lights provide a sufficiently unequivocal specification of the movement.

It thus seems as though dynamic visual presentations facilitate the construction of a coherent and possibly even dynamic representation (Freyd, 1987) that is used to control one's own imitation.

Relationship Between Perception and Motor Performance

When adults learn the manual alphabet for the deaf, they tend to copy the movements already during presentation (Berger, 1966). This particularly applies when other ways of coding are hardly available (Berger *et al.*, 1979). Such accompanying movements also occur covertly: Berger also demonstrated by electromyography that observers show specific innervations in their corresponding muscles during the observaton of different body movements by a model (Berger and Hadley, 1975; Berger, Irwin, and Frommer, 1970; see Jacobson, 1932, on imagined movements). These findings, like imitations of facial movements in human neonates (Field, *et al.*, 1982; Meltzoff and Moore, 1977, 1983a; Vinter, 1985a, b), suggest a direct, not cognitively mediated link between the visual and the motor system even in adults.

Aspects of Motor Reproduction

Initial movement imitations of new skills mostly agree only roughly with the observed behavior (Gray *et al.*, 1991; Teubner, 1985). The construction of new sensorimotor schemata clearly requires *kinesthetic feedback*.

The role of *visual feedback* is documented by studies in which the visual angle between display and reproduction is manipulated. In action imitation, the best results are generally achieved when model and observer stand side by side or the camera follows the corresponding 'subjective' perspective. If, in contrast, the visual angle or the spatial reference system changes between display and reproduction, imitative performance usually deterioriates (Greenwald and Albert, 1968; Poljakova, 1958; Roshal, 1961; Stränger, 1977, Exp. 1). Comparable findings are also available on movement imitation (Jordan, 1977, cited in Whiting, 1988). These designs clearly require *mental transformations* of the visual representation (Shepard and Cooper, 1982) that are time-consuming and subject to interference (Stränger, 1977, Exp. 1)

Such findings also suggest that a primary visual representation of the observed behavior is involved in the control of imitation. It should marginally be noted that action imitation is facilitated by the additional presentation or self-generation of verbal descriptions. The presentation of relevant evidence is beyond the scope of this chapter (see Bandura, 1986; Stränger, 1977).

7.4 Discussion

Systematic functional analysis of imitation performance is impeded by the following deficits. First, there has long been a lack of procedures for systematically describing actions and body movements (see Section 8.2). In addition, there is no theoretically based taxonomy for selecting behaviors. Our differentiation between (body) movement imitation and action imitation is only a first step in this direction. There is also a lack of experimental paradigms for studying theoretically derived issues. From the perspective of research on perception, the following aspects particularly require more attention.

Before far-reaching speculations are made about the cognitive–semantic processing of observed behavior, analyses of eye movements should be used to determine what is actually being observed (Scully and Newell, 1985; Stränger, 1977).

Expert–novice differences in eye movements during the analysis of an event would be particularly interesting here. Everyday experience already suggests such differences: while novices, for example, can scarely differentiate ice-skating figures or types of stroke in tennis, experts easily perceive specific patterns of movement on the basis of visual features. Usually, they can also name these patterns. For the perception and coding of static displays, expert–novice differences have frequently been confirmed empirically (Chase and Simon, 1973; De Groot, 1965; Gibson, 1969); for dynamic displays such studies are at least available on automobile drivers (Shinar, 1978).

Under natural conditions, experts and novices mostly differ in their perceptual experience *and* their motor skills in the domain in question. One becomes expert at a skill through repeated close observation, by extracting invariant patterns, learning labels for these patterns and performing the skill with different forms of feedback. If observational learning is considered to be independent of motor reproduction processes (see Bandura), then *pure perceptual learning* without any motor performance should be sufficient to acquire a behavior. This seems to be true for observational learning of actions. For example, Stränger (1977, Exp. 3) found no group differences in the frequency of solutions of a rather difficult mechanical puzzle after repeated observation of a filmed solution or after a performance trial following each of the five presentations. This might be due to the verbal codability of the task. We were unable to find similar investigations on movement imitation, but would expect obvious differences in the quality of performance in this case.

Another indication of expert–novice differences has been a reported by Scully (1986). Experienced raters differed little in their judgment of a normal gymnastic exercise and the exercise presented with the point-light technique. The ratings of unexperienced subjects were more heterogeneous. Nonetheless, Scully did not test whether the experienced raters themselves had mastered the exercises. Another test of theories that consider observational learning as being independent of motor reproduction, requires a comparison of the visual discrimination of human movement patterns by motorically (but blindly) pretrained 'experts' and by novices without this motor training. As the motor reproduction would handicap the novices, the registration of eye movements during the presentation and/or the recognition of the same and slightly different dynamic displays would provide a more appropriate test of the visual discrimination.

II DISCUSSION: COMPARING THE LINES OF RESEARCH

8 CONCEPTS OF PERCEPTION, METHODS AND THEORETICAL PROBLEMS

8.1 Differences in the Concepts of Perception

The explicit or implicit concepts of perception in the lines of research discussed above can be described and classified in the following manner:

8.1.1 Concepts of Autonomous Perceptual Organization

Groups that approach the perception of behavior from classic perceptual research, such as motion perception, conceive behavior as a complex dynamic event that can be described anatomically and physically in the form of mass displacements with specific acceleration and speed. Behavior is ecologically valid as an object of perception, and its perception may have biological survival value. However, the symbolic meaning of behavior is never mentioned.

Sensory information from the behavioral event is organized by an autonomous perceptual system. Attitudes, inferences, comparisons with stored knowledge and other cognitive influences do not play any major role in the construction of the perceptual experience. Thus, the perceptual system is conceived as being cognitively impenetrable (Fodor and Pylyshyn, 1981). At best, the perception is modifiable through perceptual learning (see Runeson). In the research designs, stimulus parameters of a specific type of behavior are varied systematically and simple perceptual judgments are assessed. Individual influences on perceptual experience are rarely studied at all. A major research goal is to determine invariants of the event, for example, the center of moment in gait.

Variants of this concept of perception are proposed by Johansson, Cutting and Michotte. Their conceptions of autonomous perceptual processes and the focuses of their empirical research programs nonetheless diverge.

In terms of the popular but oversubscribed dichotomy of direct and indirect theories of perception (Bruce and Green, 1990), these concepts seem to be closer to the direct pole.

8.1.2 Concepts of Cognitively Penetrable Perceptual Organization

A second group of authors base their work on a broader concept of perception. Perception does not refer exclusively to autonomous perceptual processes responsible for the detection of visual invariants in stimulus events that can be described completely in anatomical and physical terms. Instead, perceptual processes can be cognitively penetrated. Perceptual experience is based on event features and a species-specific, universal and automatic perceptual processing that is nonetheless influenced by attitudes, prior information, knowledge structures (see our interpretation of Newtson's results) and inferences (see Heider on intention 'perception'). The perception of meaning, which results partially from event features and partially from the knowledge base, is also considered.

The empirical approach is more molar: minute-long scenes are presented that would require an enormous effort to describe systematically. Stimulus displays are rarely varied systematically and related to perceptual judgments. Instead, statements on perception are derived from verbal reports (Heider) or button presses and recognition performance at various points in the stream of events (Newtson). More attention is given to individual influences on perception.

These concepts correspond to indirect theories of perception. If a strict distinction is made between perception and cognition, these concepts would be classified as being closer to cognition. They are also more appropriate for symbolic actions, which are excluded from this chapter. With reference to Fodor and Pylyshyn (1981), who have criticized the unacceptable extension of Gibson's concept of invariance formation with their example of discriminating between a real and a fake picture from Leonardo da Vinci, we suspect that, even for the perception of a relatively simple sequence such as GREETING, the extraction of visual invariants alone is scarcely sufficient to permit a culturally appropriate reaction without referring to symbolic meaning in memory.

8.1.3 Perception in the Service of Other Functions

A third area of research is not particularly concerned with either the perceptual organization of behavior or the cognitive influences on perception. Instead, perception serves the formation of orienting (Freyd, Jenkins) or action-guiding representations (theories on imitation). Ideas on perception are not worked out in detail and precise descriptions of the stimulus event are not given. The inclusion of these approaches in a chapter on behavior perception is above all justified because these fields deal with relationships between perception, memory and the motor system, which require a more detailed empirical analysis.

A premature restriction to a specific concept of perception would hardly be appropriate to the study of perception of action and movement. Nonetheless, the first concept is central to psychophysically oriented research on perception.

8.2 Research Methods

Statements on perception are mostly derived from the relationship between systematically varied properties of the available information and various indicators of perception. Therefore, we will compare some possibilities for describing and varying behavior and discuss the most important indicators of its perception.

8.2.1 Stimulus Description Procedures

In the approaches presented here, the behavioral event is described in different ways. If – as in Heider and in action imitation – no clear borders are drawn between perception and cognition, researchers mostly dispense with a precise description of the stimulus event. However, if it is assumed that cognition influences perception, the available (and used) information should be described in as much detail as possible. Methods are to be found in other approaches.

The comparably simple structure of events that form the basis of the perception of causality and the recognition of biological movements permits a detailed description of the spatial and temporal features of the stimulus event. For example, Cutting (1978a, b) was able to specify the cyclic movement of gait so precisely in *physical–anatomical terms* that differences in the course of point-light movement in the gait of men and women could be simulated on a computer. This form of description would require too much effort to be applied to anything other than simple, cyclic body movements.

The course of more complex, irregular patterns of behavior can be assessed with systems for the *notation of body movements* (see the Eshkol–Wachman system in Newtson *et al.*, 1977, 1987). Further movement notation systems have been described by Rosenfeld (1982) and Wallbott (1982). Ekman and Friesen's (1978) facial action coding system (FACS) is widely used in research on facial expression. Choice depends on the area of behavior and the research issue in question. However, until analysis can be performed automatically (see, on the development of automatic systems, Grieve *et al.*, 1975; Woltring, 1984), these analysis-intensive systems are only meaningful when research focuses on the perception and reproduction of spatial and temporal parameters of the course of movement.

For classifying ongoing behavior into categories, which is typical for research on segmentation and action imitation, an event description with a (hierarchical) *proposition structure* is sufficient (Kintsch and van Dijk, 1978). Suggestions on how to construct a proposition structure can be found in articles on action memory that use film and text displays (Baggett, 1979; Lichtenstein and Brewer, 1980) as well as in work on action identification (Vallacher and Wegner, 1987). Such procedures are appropriate when research focuses on the cognitive organization of observed behavior.

8.2.2 Experimental Variations in Presented Behavior

Body Movement, Point-light Movement, Removal of Manipulated Objects

As yet, the point-light technique has mostly been used to separate figural body features and movement. It has been demonstrated repeatedly that recognition is superior under natural display conditions as compared to the presentation of point-lights. Therefore, it has to be explained which features are responsible for the better recognition of natural displays.

The point-light technique, like pantomime, disassociates body movements from their spatial context. The influence of spatial context and objects on the perception and reproduction of actions can be tested by systematic comparison between mere body movements without appropriate objects and real-life actions incorporating the appropriate objects. For example, Sakowski (1985) confirmed clear retention advantages for real as compared to pantomimic displays of REFUELLING in free recall. When the title REFUELLING was presented, performances under mimed and real conditions became more similar. However, there were no differences in recognition performance (Hilse, 1985). Therefore, context influences have a stronger effect on verbal retention and less on visual recognition.

The role of body movements in learning object-related actions can be studied by means of animation films. For example, Roshal (1961) showed that learning to tie knots with the help of an animated film demonstration was even superior to a film version with observable hands.

Context Influences

The montage techniques of film directors such as Kuleshov, Eisenstein and Hitchcock assume that individual camera frames are influenced by the surrounding frames. In an analogous manner, the perception of a neutral emotional expression may depend on the contexts that directly surround it (Isenhour, 1975; Russell and Fehr, 1987; Wallbott, 1990). For prototypical sequences of expression, this effect is less probable (Section 3.3). Perhaps the embedding of ambiguous actions in preceding, subsequent and accompanying behavior (in other channels of expression) might influence their identification. As a renewed controversy in the recognition of facial expressions between Russell and Ekman shows (Ekman, O'Sullivan and Matsumoto, 1991; Russell, 1991a, b), it is essential to distinguish multiple kinds of context. An important distinction is made between the context of expression, that is, the time and spatial context of the behavior displayed (in different channels), and the context of judgment, that is, the circumstances of the observer's judgment. Given the intention to find out whether effects in the context of expression are based on judgment (i.e. anchor effects and adaptation level), on memory, or on perception, the use of different test procedures seems to be appropriate.

As in the work of Hilse and Sakowski, different test procedures are needed here to test whether these are judgment and memory effects or perceptual effects.

Static and Dynamic Display with Variations in Speed

Both biological motion perception and imitation research have confirmed repeatedly that dynamic compared with static display facilitates recognition and imitation. However, dynamic and static displays are only two points on a continuum of possible variations in speed. Professional film and video techniques permit displays of single stills with varying sequential speed and dynamic displays ranging from extreme slow-motion to time-lapse recordings.

As Barker already suspected, various aspects of behavior are emphasized at different display speeds. In the analysis of facial expression under natural speed, we see, for example, SMILING. If the constituent muscle movements of this smiling are analyzed with the FACS (Ekman and Friesen, 1978) on successive stills at a speed of 25 pictures per second, changes can be seen that are scarcely detectable at natural speed. On the other hand, in extreme time-lapse recordings of, for example, a therapy session, (synchronized) changes in body posture are much more apparent than when they are displayed at their natural speed (Scheflen, 1964). Barker's team has proposed that the 'normal behavior perspective' specifies natural behavior units with basic evolutionary significance (see Wright, 1967, p. 78).

Variable display speeds open up interesting possibilities for studying the perception of behavior. For example, subjects can be asked to scan behavioral events at self-selected, variable speeds, and the observation times for single sections can be related to performance variables. Stränger (1977, Exp. 2), for example, has shown that children who learn a difficult mechanical puzzle look at slides of the single solution stages for different lengths of time given a free choice of display times. If they are permitted to attempt a solution after each observational trial, the peak of display times shifts successively toward later solution stages. This was observed less frequently during multiple observations without performances. The children seemed to scan the event as a function of their reproduction progress. Further, children performed slightly better under self-controlled display times compared with constant display. Under self-controlled display times, subjects with higher variability in times also attained the learning criterion more rapidly. Advanced film and video techniques also permit such studies on dynamic events.

Further Variations

Masking (Cutting, Moore and Morrison, 1988; Johansson, 1976) or *selective point-light marking* of specific parts of the body (Johansson, 1975), can be used to determine the stimulus features on which behavior identification depends. Identifying breaks at specific points in ongoing behavior (Newtson and Engquist, 1976) permits statements on differences in the information content of an event. Superimposing two behaviors can provide information on the selective perception and processing of simultaneously presented behavior (Neisser and Becklen, 1975).

8.2.3 Registering Indicators of Perception

Eye-movement Analyses

Studies of eye movements, like those used to study the perception of causality, are also desirable in other fields. Modern systems of eye-movement analysis make it possible to present a video scene to observers and to play back their fixation point in the observed scene on a second video screen. This permits a precise identification of which features observers monitor in a complex scene. This method is useful for studies on perceptual learning and to determine differences between experts and novices in the perception of behavior.

Phenomenal Report, Describing and Naming

Michotte based the causality statements on his subjects' reports on what they had experienced. The criteria for reporting, however, remain unclear. Heider derived perceptions of intention from intentional descriptions. In biological motion perception, display patterns are either named freely (Johansson) or assigned to one of several verbal categories (Cutting)

However, linking verbal utterances to properties of the percept is problematic for two reasons: unlike visual perception, statements on perception are always categorical. For example, when subjects state after perceiving gait that the stimulus person is a woman, we do not know whether they had also recognized features of the individual gait that they did not report. A second problem is that although, in natural speech, subjects prefer to describe specific stimulus configurations causally or intentionally, perception is described differently, depending on the instructions (see Section 4.3).

Perceptual experience and description are thus at best correlated but not identical. Reports on spatial and temporal relationships of observed behavior, in particular, are mostly poor when given verbally.

Recognition

Spatial and temporal properties of perceptual experience are easier to derive from the recognition of identical or similar visual displays (see Jenkins, Freyd, Newtson).

A major advantage of these methods is that both stimulus material and testing procedures are presented in the visual modality and are therefore directly comparable. However, previous studies have almost exclusively used static recognition material, despite the fact that film and video techniques also permit the construction of dynamic comparisons (Hilse, 1985; Sakowski, 1985). By using dynamic comparison stimuli with slightly changed spatial and temporal features, it should be possible to derive specific characteristics of the visual representation of the event. Although the criticism that this would involve memory effects is appropriate, it is secondary for two reasons: (1) when testing the perception of a behavior that extends over time, memory effects always have to be assumed (Johansson, 1973); and (2) other criteria, such as phenomenal report or motor reproduction, are also subject to these memory effects.

One main problem in recognition methods is the selection of the comparison stimuli. The more they are made similar to the display materials, the higher the error rate; the more the differences are emphasized, the higher the hit rate and the lower the error rate. One solution is to consider the procedures used in signal detection theory.

Segmentation

The cognitive organization of ongoing behavior could possibly be studied with a combination of Newtson's segmentation procedure and accompanying description. It would be particularly interesting to develop methods for the assessment of cognitive organizations on hierarchically nested levels of abstraction.

Imitation as Motor Reproduction

Imitation permits statements on perception as long as the behavior is easy to perform motorically, as is the case for simple arm movements (Prinz and Müsseler, 1988; Vogt, 1988). In difficult motor tasks, imitation does not merely include perceptual features but also features of the motor tranformation.

At least as far as older children and adults are concerned, the type of imitation is probably very dependent on the instructions: unless explicitly instructed, subjects have to find out whether the imitation requires a reproduction of a movement outcome, for example, an imaged movement trace or the reproduction of the spatial and temporal features.

8.2.4 Comparisons Between Stimulus Dislay and Indicators of Perception

It is easier to draw conclusions on perceptual processes if the stimulus display and the indicators of perception can be described in the same medium. If, for example, it is intended to study the perception of temporal and spatial features of an easily performed movement pattern, it is advantageous if the movement pattern and the reproduction are described with a differentiated movement notation system. By this procedure, it should be possible to clarify which features of the event are imitated. An elegant variant has been developed by Prinz and Müsseler (1988) and by Hösl (1988) to study movement imitation. They demonstrated a simple arm movement with a computer mouse. The subjects had to perform an exact movement imitation.

A computer program was developed that permitted a precise determination of spatial and temporal deviation in the imitation. However, this procedure is restricted to movements in two-dimensional space and, in addition, they could equally well be displayed as a moving point-light. Systems for notating body movements are not subject to this restriction. Nonetheless, they do not provide such a detailed assessment of the temporal course of movement.

If a study is only concerned with categorical recognition and not the representation of spatial and temporal features, then a proposition structure of the behavioral event is an appropriate standard with which the verbal indicators of perception can be compared. Properties of the primary visual representation can, as mentioned above, best be assessed with the recognition of dynamic displays.

8.3 Theoretical Problems

Most previous studies on the perception of behavior have been designed as demonstration experiments. Systematic research programs are rare or restricted to narrow aspects such as the perception of gait. Contacts between the various research traditions are still slight; related research is barely taken into account. This may be because behavior is a very complex object of perception, thus permitting the study of different aspects. In addition, the approaches have their origins in different theoretical traditions – above all, Gestalt theory – more recent information processing approaches and neo-Gibsonian concepts.

However, the perception of behavior could gain a greater theoretical importance as a particular type of event: behavior is an ecologically valid event, whose recognition probably has biological survival value. In contrast to traditional movement perception, multiple simultaneous reference systems and the possibility of mental determination should be taken into account. The perception of temporally extended behavior requires a reconceptualization of the rigid separation between perception and memory. Perhaps even the primary visual representation of behavior takes a dynamic form. Finally, certain kinds of imitation suggest a noncognitively mediated relationship between perception and the motor system. This is not the place to discuss all these points in detail. We consider the issue of the relationship between perceptual and cognitive determinants in the occurrence of perceptual events to be of basic and primary importance for this and other areas of perceptual psychology. As this aspect reappears continuously in the research traditions, we shall pay particular attention to it.

8.3.1 The Relationship Between Cognitive and Perceptual Processes

Behavior provides information that is perceptually organized, selected, interpreted and finally forms the basis for conscious perception. This perceptual experience, the percept, is the foundation for various actions that may serve as indicators of perception, as they permit inferences on the properties of the percept and the perceptual process. These perceptual indicators include description, recognition, segmentation or imitative reproduction.

Cognitive determinants such as expectations, attitudes or conceptual knowledge could enter into the perceptual process at four points. (1) It is conceivable, though hardly confirmed empirically, that they influence the organization and integration of sensory data (see Section 8.3.2). (2) They might interfere in the selection of stimulus features (see Section 8.3.3). (3) They could also influence the interpretation of organized information (see Section 8.3.4). (4) Finally, cognitions could also influence the indicators of perception, that is, they could influence the use of the percept for solving a specific task (see Section 8.3.5).

8.3.2 The Autonomy of Perceptual Organization and Integration

Unlike other processes, the organization and integration of the data available to the senses is probably largely independent of cognitive influences. Various types of autonomy have to be differentiated here:

(1) According to *genetic autonomy*, the perceptual system is practically unchangeable in ontogenesis. This autonomy could, for example, be responsible for the perceptual organization of an event into figure and ground or for the perception of causality. This autonomous perceptual organization prepares the information available to and registered by the senses and thus determines the percept. In the perception of behavior, this assumption of autonomy is most closely found in the modeling of the functions of the perceptual system (Cutting, 1981; Hochberg and Fallon, 1976; Hoffman and Flinchbaugh, 1982; Johansson, 1973; Vaina and Bennour, 1985).

(2) A weaker form of autonomy permits modifications of the autonomous perceptual system through perceptual experiences while simultaneously maintaining its independence from cognitive influences. This *functional autonomy* would be reconcilable with age- or practice-dependent differences and with experiences of highly 'compelling' perceptual impressions, as frequently reported in, for example, Michotte's paradigm. Changes in the perceptual system could be based on *perceptual learning* in the sense of Gibson (1969) and Wolff (1984), that is, on an adaptation of the functions of the perceptual system to relevant structures in the environment.

An empirical discrimination between genetic and functional autonomy calls for systematic developmental studies or perception training programs. If effects of development or training cannot be demonstrated in either eye-movement patterns or recognition performance, this would support genetic autonomy. Strong developmental or training effects in eye-movement patterns and/or recognition performance would, in contrast, support functional autonomy. Cognitive effects on the autonomously conceived organization of perception would be present if findings analogous to developmental and training effects could be demonstrated as a pure function of instructions.

Functional autonomy could also be tested with *induced perceptual conflicts*. For example, Michotte (e.g. 1946/1963, p. 71) systematically varied the relationships between stimulus parameters and cognitive information in order to determine which information was more dominant in the perceptual judgment. Systematic analyses of the effect of contradictions between perceptual and cognitive information still have to be performed in other areas. Particular attention should also be paid to the selection of the indicators of perception. Results based on judgments alone have little power, as they render it difficult to decide which features have guided the subjects. Perceptual conflicts can also be constructed with correct versus false feedback, as applied by Frykholm (1983a, b) in the identification of point-light stimulus persons. This would make it possible to test whether feedback that was either consistent with or contradicted the perceptual impression would lead to experienced and reported disassociations between subjects' spontaneous perceptual impressions and their beliefs.

8.3.3 Cognitive Influences on Selective Attention to Behavior

Possibly, conceptual knowledge, expectations and attitudes influence the selection of specific aspects of events. The situational context and other prior information could activate schemata that, in turn, specify features that are monitored for changes in ongoing behavior (Engquist, Newtson and LaCross, 1979; Neisser, 1976; Neisser and Becklen, 1975; Stränger, Schorneck and Droste 1983). The perceptual organization of features selected in this way could, in turn, be mandatory and autonomous.

Empirical confirmation could be provided by analyses of eye movements. If, given constant stimulus display, the eye movements vary systematically with the prior information or the observation tasks, this would support cognitive influences on feature selection.

8.3.4 Cognitive Influences on the Interpretation of Organized and Selected Information

The probable autonomy of the organization of perception does not exclude cognitive contributions to its outcomes. Nonetheless, it would be necessary to clarify: (1) under which conditions cognitive influences might occur; (2) what is their purpose; and (3) how far they are dependent on the task requirements.

(1) Regarding the *conditions*, some studies on the perception of causality (Knowles, 1983; Levelt, 1962) suggest that cognitive influences are more probable in ambiguous stimulus displays. Similar ideas are discussed for the perception of emotions (Ekman and O'Sullivan, 1988; Russell and Fehr, 1987). Experimental variations of the *ambiguity of the stimulus event* can be used to test across paradigms whether cognitive influences occur more frequently in ambiguous displays. Michotte (1946/1963) already differentiated in this sense between stimulus-dependent and experience-dependent causal judgments. A comparative study of the contributions of stimulus information and explicit knowledge requires a more detailed description of the stimulus display than that found in previous studies on the perception of intention, on segmentation and on imitation.

(2) As well as demonstrating conditions under which perceptual organization can be influenced cognitively, the function of such influences should also be analyzed. Perhaps, *concepts of causality* or *intention* do not serve just to supplement or replace incomplete perceptual information. Conceptual and situational knowledge could also ensure a more effective and directed extraction of environmental information. Thus, Jansson (1964), for example, demonstrated in a study of the perception of causality that the pattern of eye movements changes as a function of the preceding judgment. The acquisition of situation-specific knowledge about the causal relationship of two events is thus not only a consequence of preceding activity but also a basis for subsequent action. If this acquisition of knowledge is

equated with the formation of internal event models, this would simultaneously be an indication of the action-guiding function of such models. Thus, the dynamic properties of internal models postulated by Freyd (1987) perhaps permit not only a reliable prediction of the temporal development of an event but also probably the planning of one's own perceptual activity.

(3) The control of a precise movement imitation also requires the use of information on behavior, while the quality of reproduction simultaneously increases as a function of practice. Schema theoretical approaches trace this back to the development of a behavior-specific schema that possibly also permits a more effective use of the information given by the model. This relationship is similar to that between situational knowledge and eye movements according to Jansson (1964). This similarity may well not be arbitrary, as the schemata underlying imitation could also be event models in which the behavior-controlling function comes to the fore.

8.3.5 Cognitive Influences on the Use of Information

The dependent variables on the perception of behavior are always founded on the results of *intentional actions* that are based on a percept without representing it directly. If, for example, the same film of a woman playing billiards serves as stimulus material in studies on the perception of causality, intention, emotion, biological motion, segmentation and imitation, the perceptual indicators would clearly seem to depend on the specific task.

In Heider's paradigm, the subjects might report that a woman was playing billiards; their judgments would thus be gender- and action-related. Perhaps the observers would not fail to notice, however, that the woman intentionally aims the balls toward the pockets and is pleased when she is successful, or that the ball movements have a causal effect on each other. However, the observer would hardly report on this spontaneously. Following a nonspecific imitation instruction, the observer would probably play billiards without precisely reproducing the observed movements. After corresponding instructions and some practice, they could nonetheless achieve this. Thus, each individual indicator of perception gives only an incomplete report on what the observer *saw*.

Each action and thereby each indicator of perception requires *comprehending the instructions*, the *ability to extract appropriate stimulus information*, and the *adequate use of this information*. For example, subjects in studies on the perception of emotions must comprehend what is asked of them and report the emotions they perceive in a comprehensible way. This requires the inclusion of explicit *conceptual knowledge*. In contrast, lay persons should hardly be able to report which stimulus information was precisely taken into account in the judgment, as this *perceptual knowledge* is often implicit.

Perhaps it also applies to other areas of the perception of behavior that comprehending the instructions and appropriately using the percept require conceptual knowledge. Organizing and integrating the complex stimulus event into a percept, in contrast, requires a perceptual system that is probably autonomous. The working rules of this system need to be detected through studies in perceptual psychology.

If we follow this differentiation between conceptual knowledge in the use of the percept and implicit rules in its formation, observers should, for example, visibly perceive the emotions of others even when they possess no concept of emotions and are therefore unable to communicate their experience verbally.

The concept that only an indicator of perception and not the formation of the percept can be influenced cognitively would be supported by the following data pattern:

(1) Eye and head movements while observing an identical event are independent of instructions to perform different perceptual actions, that is, they are relatively constant. Thus, the perceptual actions do not influence the selection of information.

(2) Different indicators of perception vary in the strength with which they are influenced by systematically varied expectations and attitudes. Indicators of perception that are broadly independent of instruction and attitude effects best reflect the perceptual properties of the perceptual experience. In the discussion of methods, this is suspected for recognition.

Cognitive influences on indicators of perception and thus on the use of the percept are highly plausible but previously not proven unequivocally, as demonstrated cognitive effects could already be due to the selection of features.

8.3.6 Outlook: Perception and Action

Many of the aspects discussed lead up to the issue of the relationship between perception- and action-related event models, or – in Neisser's (1985) terminology – perception and action schemata. Perhaps perception does not lead just to action; the action competencies may also influence perception and thus the relationship between the two functional areas might be cyclic (Neisser, 1976; von Weizsäcker, 1940).

Reproductions of observed point-light movements (Scully and Newell, 1985; Williams, 1985, cited in Whiting, 1988) are an appropriate way to study the relationship between perception and own performance. To test the possible influence of domain-specific action competence on perceptual differentiation, the expert–novice dichotomy could be used to study, in particular, how far the identification of (point-light) movement patterns depends on the observer's level of mastering the actions (see Section 7.4).

Available studies on the perception of movement and action are not sufficient to provide satisfactory answers to the questions formulated here. At first glance, the approaches and methods seem to be too heterogeneous. On the other hand, this multiplicity provides the opportunity to analyze perceptual processes on different levels without losing sight of their complexity. In everyday perception and action, the criteria of perception also change continuously; intention, causality and sequences of movement are inseparably entangled in actions. At the same time, perception, cognition, memory and action are closely related. To analyze such relationships, we consider it to be meaningful and promising to engage in further experimental studies of the perception of behavior.

REFERENCES

Abravanel, E., Levan-Goldschmidt, E. and Stevenson, M. B. (1976). Action imitation: The early phase of infancy. *Child Development*, **47**, 1032–1044.
Alexander, C. N. and Epstein, J. (1969). Problems of dispositional inference in person perception research. *Sociometry*, **32**, 381–395.
Aronfreed, J. (1969). The problem of imitation. In L. P. Lipsit and H. W. Reese (Eds), *Advances in Child Development and Behavior*, vol. 4 (pp. 209–319). New York: Academic Press.
Atkinson, M. L. and Allen, V. L. (1983). Perceived structure of nonverbal behavior. *Journal of Personality and Social Psychology*, **45**, 458–463.
Baggett, P. (1979). Structurally equivalent stories in movie and text and the effect of the medium on recall. *Journal of Verbal Learning and Verbal Behavior*, **18**, 333–356.
Baldwin, J. M. (1895). *Mental Development in the Child and in the Race*. New York: Macmillan.
Bandura, A. (1962). Social learning through imitation. In M. R. Jones (Ed.), *Nebraska Symposium on Motivation*, vol. 10 (pp. 211–269). Lincoln, NE: University of Nebraska Press.
Bandura, A. (1971). Analysis of modeling processes. In A. Bandura (Ed.), *Psychological Modeling* (pp. 1–62). Chicago, IL: Aldine.
Bandura, A. (1986). *Social Foundations of Thought and Action. A Social Cognitive Theory*, ch. 2: Observational learning (pp. 47–105). Englewood Cliffs, NJ: Prentice-Hall.
Bandura, A., and Jeffery, R. W. (1973). Role of symbolic coding and rehearsal processes in observational learning. *Journal of Personality and Social Psychology*, **26**, 122–130.
Bandura, A., Jeffery, R. W. and Bachicha, D. L. (1974). Analysis of memory codes and cumulative rehearsal in observational learning. *Journal of Research in Personality*, **7**, 295–305.
Barclay, C. D., Cutting, J. E. and Kozlowski, L. T. (1978). Temporal and spatial factors in gait perception that influence gender recognition. *Perception and Psychophysics*, **23**, 145–152.
Barker, R. G. (1963). The stream of behavior as an empirical problem. In R. G. Barker (Ed.), *The Stream of Behavior* (pp. 1–22). New York: Appleton.
Barker, R. G. (1978). Stream of individual behavior. In R. G. Barker and associates (Eds), *Habitats, Environments and Human Behavior* (pp. 3–16). San Francisco, CA: Jossey-Bass.
Bassili, J. N. (1976). Temporal and spatial contingencies in the perception of social events. *Journal of Personality and Social Psychology*, **33**, 680–685.
Bassili, J. N. (1978). Facial motion in the perception of faces and of emotional expression. *Journal of Experimental Psychology: Human Perception and Performance*, **4**, 373–379.
Bassili, J. N. (1979). Emotion recognition: The role of facial movement and the relative importance of upper and lower areas of the face. *Journal of Personality and Social Psychology*, **37**, 2049–2058.
Beardsworth, T. and Buckner, T. (1981). The ability to recognize oneself from a video recording of one's movements without seeing one's body. *Bulletin of the Psychonomic Society*, **18**, 19–22.
Beasley, N. A. (1968). The extent of individual differences in the perception of causality. *Canadian Journal of Psychology*, **22**, 399–407.
Berger, S. M. (1966). Observer practices and learning during exposure to a model. *Journal of Personality and Social Psychology*, **3**, 696–701.
Berger, S. M., Carli, L. L., Hammersla, K. S., Karshmer, J. F. and Sanchez, M. E. (1979). Motoric and symbolic mediation in observational learning. *Journal of Personality and Social Psychology*, **37**, 735–746.
Berger, S. M. and Hadley, S. W. (1975). Some effects of a model's performance on an observer's electromyographic activity. *American Journal of Psychology*, **88**, 263–276.
Berger, S. M., Irwin, D. S. and Frommer, G. P. (1970). Electromyographic activity during observational learning. *American Journal of Psychology*, **83**, 86–94.

Bertenthal, B. I., Proffitt, D. R. and Cutting, J. E. (1984). Infant sensitivity to figural coherence in biomechanical motions. *Journal of Experimental Child Psychology*, **37**, 213–230.

Bingham, G. P. (1987). Kinematic form and scaling: Further investigations on the visual perception of lifted weight. *Journal of Experimental Psychology: Human Perception and Performance*, **13**, 155–177.

Boyle, D. G. (1961). The concept of the 'radius of action' in the causal impression. *British Journal of Psychology*, **52**, 219–226.

Boyle, D. G. (1972). Michotte's ideas. *Bulletin of the British Psychological Society*, **25**, 89–91.

Bruce, V. (1988). *Recognising Faces*. Hillsdale, NJ: Erlbaum.

Bruce, V. and Green, P. R. (1990). *Visual Perception. Physiology, Psychology and Ecology*, 2nd edn. Hillsdale, NJ: Erlbaum.

Brunswik, E. and Reiter, L. (1937). Eindruckscharaktere schematisierter Gesichter. [Impression formation by schematized faces.] *Zeitschrift für Psychologie*, **142**, 67–134.

Buck, R. (1984). *The Communication of Emotion*. New York: Guilford Press.

Carroll, J. M. (1980). *Toward a Structural Psychology of Cinema*. The Hague, Netherlands: Mouton.

Chase, W. G. and Simon, H. A. (1973). Perception in chess. *Cognitive Psychology*, **4**, 55–81.

Cohen, C. E. (1981). Goals and schemata in person perception: Making sense from the stream of behavior. In N. Cantor and J. F. Kihlstrom (Eds), *Personality, Cognition and Social Interaction* (pp. 45–68). Hillsdale, NJ: Erlbaum.

Cohen, C. E. and Ebbesen, E. B. (1979). Observational goals and schema activation: A theoretical framework for behavior perception. *Journal of Experimental Social Psychology*, **15**, 305–329.

Corcoran, F. (1981). Processing information from screen media: A psycholinguistic approach. *Educational Communication and Technology Journal*, **29**, 117–128.

Cutting, J. E. (1978a). Generation of synthetic male and female walkers through manipulation of a biomechanical invariant. *Perception*, **7**, 393–405.

Cutting, J. E. (1978b). A program to generate synthetic walkers as dynamic point-light displays. *Behavior Research Methods and Instrumentation*, **10**, 91–94.

Cutting, J. E. (1981). Coding theory adapted to gait perception. *Journal of Experimental Psychology: Human Perception and Performance*, **7**, 71–87.

Cutting, J. E. (1986). *Perception with an Eye for Motion*. Cambridge, MA: MIT Press.

Cutting, J. E. and Kozlowski, L. T. (1977). Recognizing friends by their walk: Gait perception without familiarity cues. *Bulletin of the Psychonomic Society*, **9**, 353–356.

Cutting, J. E., Moore, C. and Morrison, R. (1988). Masking the motions of human gait. *Perception and Psychophysics*, **44**, 339–347.

Cutting, J. E. and Proffitt, D. R. (1981). Gait perception as an example of how we may perceive events. In R. D. Walk and H. L. Pick (Eds), *Intersensory Perception and Sensory Integration* (pp. 249–273). New York: Plenum Press.

Cutting, J. E., Proffitt, D. R. and Kozlowski, L. T. (1978). A biomechanical invariant for gait perception. *Journal of Experimental Psychology: Human Perception and Performance*, **4**, 357–372.

De Groot, A. D. (1965). *Thought and Choice in Chess*. The Hague, Netherlands: Mouton.

Dickman, H. R. (1963). The perception of behavioral units. In R. G. Barker (Ed.), *The Stream of Behavior* (pp. 23–41). New York: Appleton.

Droste, I. and Holtmann, R. (1980). Kognitive Mechanismen in der Handlungswahrnehmung: Der Einfluß von Struktur und Modalität einer Vorinformation auf die Wahrnehmungsorganisation und die Erinnerungsleistung von Handlungen. [Cognitive processes in perception of action: The infuence of the structure and modality of preinformation on the perceptual organization and memory for actions.] Unpublished master's thesis, Dept. of Psychology, Ruhr-University Bochum, Germany.

Ebbesen, E. B. (1980). Cognitive processes in understanding ongoing behavior. In R. Hastie, T. M. Ostrom, E. B. Ebbesen, R. S. Wyer, D. L. Hamilton and D. E. Carlston (Eds), *Person Memory. The Cognitive Basis of Social Perception* (pp. 179–225). Hillsdale, NJ: Erlbaum.

Ekman, P. (1972). Universals and cultural differences in facial expressions of emotion. In J. Cole (Ed.), *Nebraska Symposium on Motivation, 1971*, vol. 19 (pp. 207–283). Lincoln, NA: University of Nebraska Press.
Ekman, P. (Ed.) (1982). *Emotion in the Human Face*, 2nd edn. Cambridge: Cambridge University Press.
Ekman, P. (1990). New findings and work in progress using FACS. Paper presented at the 4th European Conference on Facial Expression – Measurement and Meaning. Berlin, Germany.
Ekman, P. and Friesen, W. V. (1969). Nonverbal leakage and clues to deception. *Psychiatry*, **32**, 88–106.
Ekman, P. and Friesen, W. V. (1978). *Facial Action Coding System*. Palo Alto, CA: Consulting Psychologists Press.
Ekman, P. and Friesen, W. V. (1982). Felt, false, and miserable smiles. *Journal of Nonverbal Behavior*, **6**, 238–252.
Ekman, P. and O'Sullivan, M. (1988). The role of context in interpreting facial expression: Comment on Russell and Fehr (1987). *Journal of Experimental Psychology: General*, **117**, 86–88.
Ekman, P., O'Sullivan, M. and Matsumoto, D. (1991). Confusions about context in the judgment of facial expression: A reply to 'The contempt expression and the relativity thesis'. *Motivation and Emotion*, **15**, 169–176.
Engquist, G., Newtson, D. and LaCross, K. (1979). Prior expectations and the perceptual segmentation of ongoing behavior. Unpublished manuscript, Univerity of Virginia, Charlottesville, VA.
Eshkol, N. (1973). *Moving, Writing, Reading*. Tel Aviv, Israel: Movement Notation Society.
Field, T. M., Woodson, R., Greenberg, R. and Cohen, D. (1982). Discrimination and imitation of facial expressions by neonates. *Science*, **218**, 179–181.
Finke, R. A. and Freyd, J. J. (1985). Transformations of visual memory induced by implied motions of pattern elements. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **11**, 780–794.
Finke, R. A., Freyd, J. J. and Shyi, G. C.-W. (1986). Implied velocity and acceleration induce transformations of visual memory. *Journal of Experimental Psychology: General*, **115**, 175–188.
Fodor, J. A. and Bever, T. G. (1965). The psychological reality of linguistic segments. *Journal of Verbal Learning and Verbal Behavior*, **4**, 414–420.
Fodor, J. A. and Pylyshyn, Z. W. (1981). How direct is visual perception? Some reflections on Gibson's 'ecological approach'. *Cognition*, **9**, 139–196.
Freyd, J. J. (1983). The mental representation of movement when static stimuli are viewed. *Perception and Psychophysics*, **33**, 575–581.
Freyd, J. J. (1987). Dynamic mental representation. *Psychological Review*, **94**, 427–438.
Freyd, J. J. and Finke, R. A. (1984). Representational momentum. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **10**, 126–132.
Freyd, J. J. and Finke, R. A. (1985). A velocity effect for representational momentum. *Bulletin of the Psychonomic Society*, **23**, 443–446.
Freyd, J. J., Pantzer, T. M. and Cheng, J. L. (1988). Representing statics as forces in equilibrium. *Journal of Experimental Psychology: General*, **117**, 395–407.
Frijda, N. H. (1958). Facial expression and situational cues. *Journal of Abnormal and Social Psychology*, **57**, 149–154.
From, F. (1971). *The Perception of Other People*. New York: Columbia University Press. (Original work published in Danish, without year.)
Frykholm, G. (1983a). *Perceived Identity I: Recognition of Others by their Kinematic Patterns*. Uppsala, Sweden: Uppsala Psychological Reports, No. 351.
Frykholm, G. (1983b). *Perceived Identity II: Learning to Recognize Others by their Kinematic Patterns*. Uppsala, Sweden: Uppsala Psychological Reports, No. 352.

Gardner, R. W. (1953/1954). Cognitive styles in categorizing behavior. *Journal of Personality,* **22,** 214–233.

Gemelli, A. and Cappellini, A. (1958). The influence of the subjects attitude in perception. *Acta Psychologica,* **14,** 12–23.

Gerst, M. S. (1971). Symbolic coding processes in observational learning. *Journal of Personality and Social Psychology,* **19,** 7–17.

Gewirtz, J. L. and Stingle, K. G. (1968). Learning of generalized imitation as the basis for identification. *Psychological Review,* **75,** 374–397.

Gibson, E. J. (1969). *Principles of Perceptual Learning and Development.* New York: Appleton-Century-Crofts.

Gibson, J. J. (1979). *The Ecological Approach to Visual Perception.* Boston, MA: Houghton Mifflin.

Gibson, J. J., Kaplan, G. A., Reynolds, H. N. and Wheeler, K. (1969). The change from visible to invisible: A study of optical transitions. *Perception and Psychophysics,* **5,** 113–116.

Glixman, A. T. (1965). Categorization behavior as a function of the meaning domain. *Journal of Personality and Social Psychology,* **2,** 370–377.

Goodenough, F. L. and Tinker, M. A. (1931). The relative potency of facial expression and verbal description of stimulus in the judgment of emotion. *Comparative Psychology,* **12,** 365–370.

Gray, J. T., Neisser, U., Shapiro, B. A. and Kouns, S. (1991). Observational learning of ballet sequences: The role of kinematic information. *Ecological Psychology,* **3,** 121–134.

Graziano, W. G., Moore, J. S. and Collins, J. E. Jr (1988). Social cognition as segmentation of the stream of behavior. *Developmental Psychology,* **24,** 568–573.

Greenwald, A. G. and Albert, S. M. (1968). Observational learning: A technique for elucidating S–R mediation processes. *Journal of Experimental Psychology,* **76,** 267–272.

Grieve, D. W., Miller, D. I., Mitchelson, D., Paul, J. P. and Smith, A. J. (Eds) (1975). *Techniques for the Analysis of Human Movement.* London: Lepus Books.

Gruber, H. E., Fink, C. D. and Damm, V. (1957). Effects of experience on perception of causality. *Journal of Experimental Psychology,* **53,** 89–93.

Guilliaume, P. (1926/1971). *Imitation in Children.* Chicago, IL: University of Chicago Press, 1971. (Original work published 1926.)

Hacker, W. (1978). *Allgemeine Arbeits- und Ingenieurspsychologie.* [General work and engineering psychology, 2nd edn.] Bern, Switzerland: Huber.

Halisch, F. (1990). Beobachtungslernen und die Wirkung von Vorbildern. [Observational learning and the impact of models.] In H. Spada (Ed.), *Allgemeine Psychologie* (pp. 373–402). Bern, Switzerland: Huber.

Hanson, C. and Hirst, W. (1989). On the representation of events: A study of orientation, recall and recognition. *Journal of Experimental Psychology: General,* **118,** 136–147.

Hanson, C. and Hirst, W. (1991). Recognizing differences in recognition tasks: A reply to Lassister and Slaw. *Journal of Experimental Psychology: General,* **120,** 211–212.

Heider, F. (1926/1959). Thing and medium. *Psychological Issues,* 1959 Monograph 3 (pp. 1–34). (Original work published 1926.)

Heider, F. (1930/1959). The function of the perceptual system. *Psychological Issues,* 1959, Monograph 3 (pp. 35–52). (Original work published 1930.)

Heider, F. (1944). Social perception and phenomenal causality. *Psychological Review,* **51,** 358–374.

Heider, F. (1958). *The Psychology of Interpersonal Relations.* New York: John Wiley.

Heider, F. (1967). On social cognition. *American Psychologist,* **22,** 25–31.

Heider, F. and Simmel, M. (1944). An experimental study of apparent behavior. *American Journal of Psychology,* **57,** 243–259.

Heller, O. and Lohr, W. (1982). Das Werk Michottes und seiner Mitarbeiter: Eine Einführung in den Gegenstand. [The work of Michotte and his colleagues: An introuction to the topic.] In O. Heller and W. Lohr (Eds), *Albert Michotte, Gesammelte Werke,* vol. 1 (pp. 15–41). [Albert Michotte, Collected works]. Bern, Switzerland: Huber.

Heller, O. and Lohr, W. (Eds) (1982). *Albert Michotte, Gesammelte Werke,* Bd. 4. [Albert Michotte, Collected Works, vol. 4]. Bern, Switzerland: Huber.

Hilse, B. (1985). Beobachtungslernen: Wiedererkennen von Routinehandlungen nach Wissens-aktualisierung durch den Kontext. [Observational learning: Recognition of scripted actions after knowledge instigation by the context.] Unpublished master's thesis. Dept. of Psychology, Ruhr-University Bochum, Germany.

Hindmarch, I. (1973). Eye movements and the perception of phenomenal causality. *Psychologica Belgica,* **13,** 17–23.

Hochberg, J. (1986). Representation of motion and space in video and cinematic displays. In K. R. Boff, L. Kaufman, and J. P. Thomas (Eds), *Handbook of Perception and Human Performance)* vol. I: *Sensory Processes and Perception,* ch. 22 (pp. 1–64). New York: John Wiley.

Hochberg, J. and Fallon, P. (1976). Perceptual analysis of moving patterns. *Science,* **194,** 1081–1083.

Hoenkamp, E. (1978). Perceptual cues that determine the labeling of human gait. *Journal of Human Movement Studies,* **4,** 59–69.

Hoffman, D. D. and Flinchbaugh, B. E. (1982). The interpretation of biological motion. *Biological Cybernetics,* **42,** 195–204.

Hösl, K. (1988). Frequenzanalytische Untersuchungen zur Bewegungsnachahmung. [Frequency analyses of movement imitation.] Unpublished master's thesis. Dept. of Psychology and Physical Education, University of Bielefeld, Germany.

Isenhour, J. P. (1975). The effects of context and order in film editing. *AV Communication Review,* **23,** 69–80.

Jacobson, E. (1932). Electrophysiology of mental activities. *American Journal of Psychology,* **44,** 677–694.

James, W. (1890). *The Principles of Psychology.* New York: Holt.

Jansson, G. (1964). Measurement of eye movements during a Michotte launching event. *Scandinavian Journal of Psychology,* **5,** 153–160.

Jeffery, R. W. (1976). The influence of symbolic and motor rehearsal in observational learning. *Journal of Research in Personality,* **10,** 116–127.

Jenkins, J. J. (1980). Can we have a fruitful cognitive psychology? In H. E. Howe (Ed.), *Nebraska Symposium on Motivation, 1979,* vol. 27 (pp. 211–238). Lincoln, NE: University of Nebraska Press.

Jenkins, J. J., Wald, J. and Pittenger, J. B. (1978). Apprehending pictorial events: An instance of psychological cohesion. In C. W. Savage (Ed.), *Minnesota Studies in the Philosophy of Science,* vol. 9 (pp. 129–163). Minneapolis, MN: University of Minnesota Press.

Jensen, T. D. and Schroeder, D. A. (1982). Behavior segmentation in a dyadic situation. *Personality and Social Psychology Bulletin,* **8,** 264–272.

Johansson, G. (1973). Visual perception of biological motion and a model for its analysis. *Perception and Psychophysics,* **14,** 201–211.

Johansson, G. (1975). Visual motion perception. *Scientific American,* **232,** 76–88.

Johansson, G. (1976). Spatiotemporal differentiation and integration in visual motion perception. *Psychological Research,* **38,** 379–393.

Johansson, G. (1979). Memory functions in visual perception. In L.-G. Nilsson (Ed.), *Perspectives on Memory Research* (pp. 93-103). Hillsdale, NJ: Erlbaum.

Joynson, R. B. (1971). Michotte's experimental methods. *British Journal of Psychology,* **62,** 293–302.

Kelley, H. H. and Michela, J. L. (1980). Attribution theory and research. *Annual Review of Psychology,* **31,** 457–501.

Killen, M. and Uzgiris, I. C. (1981). Imitation of actions with objects: The role of social meaning. *Journal of Genetic Psychology,* **138,** 219–229.

Kintsch, W. and Van Dijk, T. (1978). Toward a model of text comprehension and production. *Psychological Review,* **85,** 363–394.

Knowles, P. L. (1983). Measuring human social perception directly. *Human Movement Studies*, **2**, 161–170.

Koffka, K. (1921/1924, 1928/1952). *The Growth of Mind. 'The problem of imitation'.* London: Routledge and Kegan Paul. (Original work published 1921; 2nd edn 1928.)

Kogelheide, P. and Strothe, Ch. (1980). Kognitive Mechanismen in der Handlungswahrnehmung: Der Einfluß von wiederholter Darbietung und Strukturierungsauftrag auf die Wahrnehmungsorganisation und Erinnerungsleistung von Handlungen. [Cognitive processes in action perception: The influence of repeated presentation and segmentation instructions on the perceptual organization and memory for actions.] Unpublished master's thesis. Dept. of Psychology, Ruhr-University, Bochum, Germany.

Koopman, C. and Newtson, D. (1981). Level of analysis in the perception of ongoing instruction: An exploratory study. *Journal of Educational Psychology*, **73**, 212–223.

Kozlowski, L. T. and Cutting, J. E. (1977). Recognizing the sex of a walker from a dynamic point-light display. *Perception and Psychophysics*, **21**, 575–580.

Kraft, R. N. and Jenkins, J. J. (1977). Memory for lateral orientation of slides in picture stories. *Memory and Cognition*, **5**, 379–403.

Lasher, M. D. (1978). The pause in the moving structure of dance. *Semiotica*, **22**, 107–126.

Lasher, M. D. (1981). The cognitive representation of an event involving human action. *Cognitive Psychology*, **13**, 391–406.

Lassiter, G. D. (1988). Behavior perception, affect, and memory. *Social Cognition*, **6**, 150–176.

Lassiter, G. D. and Slaw, R. D. (1991). The unitization and memory of events. *Journal of Experimental Psychology: General*, **120**, 80–82.

Lassiter, G. D., Stone, J. I. and Rogers, S. L. (1988). Memorial consequences of variation in behavior perception. *Journal of Experimental Social Psychology*, **24**, 222–239.

Legerstee, M. (1991). The role of person and object in eliciting early imitation. *Journal of Experimental Child Psychology*, **51**, 423–433.

Leont'ev, A. N. (1972/1974). The problem of activity in psychology. *Soviet Psychology*, 1974/75, **13**, 4–33. (Original work published 1972.)

Lesser, H. (1977). The growth of perceived causality in children. *Journal of Genetic Psychology*, **130**, 145–152.

Levelt, W. J. M. (1962). Motion braking and the perception of causality. In A. Michotte *et al.* (Eds), *Causalité, Permanence et Réalité Phénoménale* (pp. 244–258). Louvain, Belgium: Publications Universitaires.

Lichtenstein, E. H. and Brewer, W. F. (1980). Memory for goal-directed events. *Cognitive Psychology*, **12**, 412–445.

Loftus, E. F. and Ketcham, K. E. (1983). The malleability of eye witness accounts. In S. M. A. Lloyd-Bostock and B. R. Clifford (Eds), *Evaluating Witness Evidence* (pp. 159–171). New York: John Wiley.

Maas, J. B., Johansson, G. Jansson, G. and Runeson, S. (1970). *Motion Perception I.* [Film]. Boston, MA: Houghton Mifflin.

Maas, J. B., Johansson, G., Jansson, G. and Runeson, S. (1971). *Motion Perception II.* [Film]. Boston, MA: Houghton Mifflin.

Marey, E.-J. (1894/1994). Le mouvement. Nimes, France: J. Chambon. (Original work published 1894.)

Margolius, G. J. and Sheffield, F. D. (1961). Optimum methods of combining practice with filmed demonstration in teaching complex response sequences: Serial learning of a mechanical-assembly task. In A. A. Lumsdaine (Ed.), *Student Response in Programmed Instruction* (pp. 33–53). Washington, DC: National Academy of Sciences – National Research Council, Publ. No. 943.

Markus, H., Smith, J. and Moreland, R. L. (1985). Role of the self-concept in the perception of others. *Journal of Personality and Social Psychology*, **49**, 1494–1512.

Martens R., Burwitz, L. and Zuckerman, J. (1976). Modeling effects on motor performance. *Research Quarterly*, **47**, 277–291.

Massad, Ch. M., Hubbard, M. and Newtson, D. (1979). Selective perception of events. *Journal of Experimental Social Psychology*, **15**, 513–532.

McDougall, W. (1908). *An Introduction to Social Psychology*. London: Methuen.

McGuire, W. (1961). Some factors influencing the effectiveness of demonstrational films: Repetition of instructions, slow motion, distribution of showings, and explanatory narration. In A. A. Lumsdaine (Ed.), *Student Response in Programmed Instruction* (pp. 187–207). Washington, DC: National Academy of Sciences – National Research Council, Publ. No. 943.

Meggle, G. (Ed.) (1977). *Analytische Handlungstheorie*. [Analytic theory of action.] Frankfurt, Germany: Suhrkamp.

Meltzoff, A. N. and Moore, M. K. (1977). Imitation of facial and manual gestures by human neonates. *Science*, **198**, 75–78.

Meltzoff, A. N. and Moore, M. K. (1983a). Newborn infants imitate adult facial gestures. *Child Development*, **54**, 702–709.

Meltzoff, A. N. and Moore, M. K. (1983b). The origins of imitation in infancy: Paradigm, phenomena, and theories. In L. P. Lipsitt and C. Rovée-Collier (Eds), *Advances in Infancy Research* vol. 2 (pp. 265–301). Norwood, NJ: Ablex.

Michotte, A. (1946/1963). *The Perception of Causality*. London: Methuen. (Original work published 1946.)

Michotte, A. (1950). A propos de la permanence phénoménale, faits et théories. [On phenomenal permanence, facts and theories.] *Acta Psychologica*, **7**, 298–322.

Michotte, A. (1951). La perception de la fonction 'outil'. [The perception of the 'tool function'.] In G. Ekman *et al.* (Eds), *Essays in Psychology, Dedicated to David Katz* (pp. 193–213). Uppsala, Sweden: Almquist and Wicksells.

Michotte, A. (1966). Die Kausalitätswahrnehmung. [Perception of causality.] In W. Metzger and H. Erke (Eds), *Handbuch der Psychologie*, vol. 1/1 (pp. 954–977). Göttingen, Germany: Hogrefe.

Michotte, A., Knops, L. and Coen-Gelders, A. (1957). Etude comparative de divers situations expérimentales donnant lieu à des impressions d'entrainement. [A comparative study of various experimental conditions giving rise to the impressions of 'entraining'.] In *Rencontre – Encounter – Begegnung. Contributions à une Psychologie Humaine, Dédidées au Professeur F. J. J. Buytendijk* (pp. 284–294). Utrecht, Netherlands: Het Spectrum.

Miller, G. A. (1956). The magical number seven, plus minus two: Some limits on our capacity for processing information. *Psychological Review*, **63**, 81–97.

Miller, G. A., Galanter, E. and Pribram, K. H. (1960). *Plans and the Structure of Behavior*. New York: Holt.

Miller, N. E. and Dollard, J. (1941). *Social Learning and Imitation*. New Haven, CT: Yale University Press.

Miller, P. H. and Aloise, P. A. (1989). Young children's understanding of the psychological causes of behavior: A review. *Child Development*, **60**, 257–285.

Montpellier, G. de and Nuttin, J. R. (1973). A note on 'Michotte's experimental methods' and 'Michotte's ideas'. *British Journal of Psychology*, **64**, 287–289.

Morgan, C. L. (1896). *Habit and Instinct*. London: Arnold.

Muybridge, E. (1897/1979). *Muybridge's Complete Human and Animal Locomotion*. New York: Dover Publications.

Neisser, U. (1976). *Cognition and Reality*. San Francisco, CA: Freeman.

Neisser, U. (1985). The role of invariant structures in the control of movement. In M. Frese and J. Sabini (Eds), *Goal-directed Behavior: The Concept of Action in Psychology* (pp. 97–108). Hillsdale, NJ: Erlbaum.

Neisser, U. and Becklen, R. (1975). Selective looking: Attending to visually specified events. *Cognitive Psychology*, **7**, 480–494.

Newtson, D. (1973). Attribution and the unit of perception of ongoing behavior. *Journal of Personality and Social Psychology*, **28**, 28–38.

Newtson, D. (1976a). Foundations of attribution: The perception of ongoing behavior. In J. H. Harvey, W. J. Ickes, and R. F. Kidd (Eds), *New Directions in Attribution Research*, vol. 1 (pp. 223–247). Hillsdale, NJ: Erlbaum.

Newtson, D. (1976b). The process of behavior observation. *Journal of Human Movement Studies*, **2,** 114–122.

Newtson, D. (1977). *Task and Observer Skill Factors in Accuracy of Assessment of Performance*, Technical Report TR-77-A7. US Army Research Institute for the Behavioral and Social Sciences.

Newtson, D. (1980). An interactionist perspective on social knowing. *Personality and Social Psychology Bulletin*, **6,** 520–531.

Newtson, D. and Engquist, G. (1976). The perceptual organization of ongoing behavior. *Journal of Experimental Social Psychology*, **12,** 436–450.

Newtson, D., Engquist, G. and Bois, J. (1976). The reliability of a measure of behavior perception. *JSAS Catalog of Selected Documents in Psychology*, **6,** MS 1173, 1–30.

Newtson, D., Engquist, G. and Bois, J. (1977). The objective basis of behavior units. *Journal of Personality and Social Psychology*, **35,** 847–862.

Newtson, D., Gowan, D. and Patterson, C. (1980). The development of action discrimination (abstract). *Personality and Social Psychology Bulletin*, **6,** 192–193.

Newtson, D., Hairfield, J., Bloomingdale, J. and Cutino, S. (1987). The structure of action and interaction. *Social Cognition*, **5,** 191–237.

Newtson, D. and Rindner, R. J. (1979). Variation of behavior perception and ability attribution. *Journal of Personality and Social Psychology*, **37,** 1847–1858.

Nisbett, R. and Ross, L. (1980). *Human Inference: Strategies and Shortcomings of Social Judgment.* Englewood Cliffs, NJ: Prentice-Hall.

Nyce, D. and Becklen, R. (1978). Effects of familiarity on behavior segmentation. Unpublished manuscript, Dept. of Psychology, Cornell University, Ithaca.

Oatley, K. and Yuill, N. (1985). Perception of personal and interpersonal action in a cartoon film. *British Journal of Social Psychology*, **24,** 115–124.

Olum, V. (1956). Developmental differences in the perception of causality. *American Journal of Psychology*, **69,** 417–425.

Pettigrew, T. F. (1958). The measurement and correlates of category width as a cognitive variable. *Journal of Personality*, **26,** 532–544.

Piaget, J. (1936/1952). *The Origins of Intelligence in Children.* New York: International Universities Press, 1952. (Original work published 1936.)

Piaget, J. (1945/1962). *Play, Dreams, and Imitation in Childhood.* London: Heinemann, 1951; New York: Norton, 1962. (Original work published 1945.)

Pittenger, J. B. and Jenkins, J. J. (1979). Apprehension of pictorial events: The case of a moving observer in a static environment. *Bulletin of the Psychonomic Society*, **13,** 117–120.

Poljakova, A. G. (1958). Analiz processa usvoenija navyjov putem podrazanija u detej doskol'nogo vozrasta. [The analysis of skill acquisition by imitation in preschoolers.] *Voprosy Psichologii*, **5,** 88–97.

Pöppel, E. (1985). *Grenzen des Bewußtseins.* [The borders of consciousness.] Stuttgart, Germany: dva.

Powesland, P. F. (1959). The effect of practice upon the perception of causality. *Canadian Journal of Psychology*, **13,** 155–168.

Prinz, W. (1987). Ideo-motor action. In H. Heuer and A. F. Sanders (Eds), *Perspectives on Perception and Action* (pp. 47–76). Hillsdale NJ: Erlbaum.

Prinz, W. and Müsseler, J. (1988). Nachahmungen einfacher Köprerbewegungen [Imitations of simple body movement.] Unpublished DFG-Research report, Dept. of Psychology and Physical Education, University of Bielefeld, Germany.

Rodgon, M. M. and Kurdek, L. A. (1977). Vocal and gestural imitation in 8-, 14-, and 20-month-old children. *Journal of Genetic Psychology*, **131,** 115–123.

Rosenfeld, H. M. (1982). Measurement of body motion and orientation. In K. R. Scherer and P. Ekman (Eds), *Handbook of Methods in Nonverbal Behavior Research* (pp. 199–286). London: Cambridge University Press.

Roshal, S. M. (1961). Film-mediated learning with varying representation of the task: Viewing angle, portrayal of demonstration, motion, and student participation. In A. A. Lumsdaine (Ed.), *Student Response in Programmed Instruction* (pp. 155–175). Washington, DC: National Academy of Sciences–National Research Council, Publ. No. 943.
Ross, L. (1977). The intuitive psychologist and his shortcomings: Distortions in the attribution process. In L. Berkowitz (Ed.), *Advances in Experimental Social Psychology*, vol. 10 (pp. 173–220). New York: Academic Press.
Rumelhart, D. E. (1980). Schemata: The building blocks of cognition. In R. J. Spiro, B. C. Bruce, and W. F. Brewer (Eds), *Theoretical Issues in Reading Comprehension* (pp. 33–58). Hillsdale, NJ: Erlbaum.
Rumelhart, D. E. and Ortony, A. (1977). The representation of knowledge in memory. In R. C. Anderson, R. J. Spiro and W. E. Montague (Eds), *Schooling and the Acquisition of Knowledge* (pp. 99–136). Hillsdale, NJ: Erlbaum.
Runeson, S. (1977/1983). *On Visual Perception of Dynamic Events*. Acta Universitatis Upsaliensis, Sweden: Studia Psychologica Upsaliensia, Serial No. 9. (Original work published 1977.)
Runeson, S. and Frykholm, G. (1981). Visual perception of lifted weight. *Journal of Experimental Psychology: Human Perception and Performance*, **7**, 733–740.
Runeson, S. and Frykholm, G. (1983). Kinematic specification of dynamics as an informational basis for person-and-action perception: Expectation, gender recognition, and deceptive intention. *Journal of Experimental Psychology: General*, **112**, 585–615.
Russell, J. A. (1991a). The contempt expression and the relativity thesis. *Motivation and Emotion*, **15**, 149–168.
Russell, J. A. (1991b). Rejoinder to Ekman, O'Sullivan, and Matsumoto. *Motivation and Emotion*, **15**, 177–184.
Russell, J. A. and Fehr, B. (1987). Relativity in the perception of emotion in facial expressions. *Journal of Experimental Psychology: General*, **116**, 233–237
Sakowski, H. (1985). Beobachtungslernen: Freie Wiedergabe von Routinehandlungen nach Wissensaktualisierung durch den Kontext. [Observational learning: Free recall of scripted actions after knowledge instigation by the context.] Unpublished master's thesis, Dept. of Psychology, Ruhr-University Bochum, Germany.
Schank, R. C. and Abelson, R. P. (1977). *Scripts, Plans, Goals and Understanding. An Inquiry into Human Knowledge*. Hillsdale, NJ: Erlbaum.
Scheerer, E. (1985). Pre-evolutionary conceptions of imitation. In G. Eckhardt, W. G. Bringmann and L. Sprung (Eds), *Contributions to a History of Developmental Psychology: International William T. Preyer Symposium* (pp. 27–53). The Hague, Netherlands: Mouton.
Scheflen, A. E. (1964). The significance of posture in communication systems. *Psychiatry*, **27**, 316–331.
Schorneck, D. and Berger, G. (1980). Kognitive Mechanismen in der Handlungswahrnehmung: Der Einfluß von Lern- un Beschreibungsauftrag auf die Wahrnehmungsorganisation und die Erinnerung von Handlungen. [Cognitive processes in action perception: The influence of learning and description instructions on the perceptual organization and memory for actions.] Unpublished master's thesis, Dept. of Psychology, Ruhr-University Bochum, Germany.
Scully, D. M. (1986). Visual perception of technical execution and aesthetic quality in biological motion. *Human Movement Science*, **5**, 185–206.
Scully, D. M. and Newell, K. M. (1985). Observational learning and the acquisition of motor skills: Toward a visual perception perspective. *Journal of Human Movement Studies*, **11**, 169–186.
Sheffield, F. D. (1961). Theoretical considerations in the learning of complex sequential tasks from demonstration and practice. In A. A. Lumsdaine (Ed.), *Student Response in Programmed Instruction* (pp. 13–32). Washington, DC: National Academy of Sciences–National Resarch Council, Publ. No. 943.
Shepard, R. N. and Cooper, L. A. (1982). *Mental Images and their Transformations*. Cambridge, MA: MIT Press.

Shinar, D. (1978). *Psychology on the Road.* New York: John Wiley.

Shor, R. E. (1957). Effect of preinformation upon human characteristics attributed to animated geometrical figures. *Journal of Abnormal and Social Psychology,* **54,** 124–126.

Standing, L. (1973). Learning 10 000 pictures. *Quarterly Journal of Experimental Psychology,* **25,** 207–222.

Standing, L., Conezio, J. and Haber, R. N. (1970). Perception and memory for pictures: Single-trial learning of 2500 visual stimuli. *Psychonomic Science,* **19,** 73–74.

Storms, M. D. (1973). Videotape and the attribution process: Reversing actors' and observers' points of view. *Journal of Personality and Social Psychology,* **27,** 165–175.

Stränger, J. (1977). Beobachtungslernen: Kognitive Analyse des Erwerbs von Handlungsplänen durch intentionale: Modellbeobachtung bei elf- bis dreizehnjährigen Schülern. [Observational learning: Cognitive analysis of the acquisition of actions plans by intentional model observation in 11- to 13-year-old students.] Unpublished doctoral dissertation, Dept. of Psychology, Ruhr-University Bochum, Germany.

Stränger, J. (1979). Intentionales Beobachtungslernen bei Schülern: Die Entstehung von Handlungsplänen durch Modellbeobachtung. [Intentional observational learning: The acquisition of action plans by observation of a model.] In K. J. Klauer and H. J. Kornadt (Eds), *Jahrbuch für Empirische Erziehungswissenschaft* (pp. 143–182). Düsseldorf, Germany: Schwann.

Stränger, J., Schorneck, D. and Droste, I. (1983). Wahrnehmungsstrukturierung und Erinnerung konkreter Handlungen. [Perceptual organization and memory for concrete actions.] *Zeitschrift für Sozialpsychologie,* **14,** 2–33.

Taylor, F. W. (1911). *The Principles of Scientific Management.* New York: Harper.

Teubner, C. (1985). Beobachtungslernen: Kodierungshilfen in der Anfangsphase des Erwerbs von Tai-Chi-Komponenten. [Observational learning: Coding aids in the initial phase of the acquisition of tai-chi-components.] Unpublished master's thesis, Dept. of Psychology, Ruhr-University Bochum, Germany.

Todd, J. T. (1983). Perception of gait. *Journal of Experimental Psychology: Human Perception and Performance,* **9,** 31–42.

Uzgiris, I. C. (1984). Imitation in infancy: Its interpersonal aspects. In M. Perlmutter (Ed.), *Parent–Child Interaction and Parent–Child Relations in Child Development* (pp. 1–32). Hillsdale, NJ: Erlbaum.

Vaina, L. and Bennour, Y. (1985). A computational approach to visual recognition of arm movements. *Perceptual and Motor Skills,* **60,** 203–228.

Vallacher, R. R. and Wegner, D. M. (1987). What do people think they're doing? Action identification and human behavior. *Psychological Review,* **94,** 3–15.

Vinter, A. (1985a). *L'imitation chez le nouveau-né.* [Imitation in the neonate.] Paris: Delachaux et Niestlé.

Vinter, A. (1985b). La capacité d'imitation à la naissance: Elle existe, mais que signifie-t-elle? [The capacity of imitation at birth: It exists but what does it mean?] *Revue Canadienne de Psychologie,* **39,** 16–33.

Vinter, A. (1986). The role of movement in eliciting early imitations. *Child Development,* **57,** 66–71.

Vogt, S. (1988). *Einige gestaltpsychologische Aspekte der zeitlichen Organisation zyklischer Bewegungsabläufe.* [Some Gestalt-psychological aspects of the temporal organization of cyclic movements.] Bremen, Germany: Bremer Beiträge zur Psychologie, No. 77.

von Weizsäcker, V. (1940). *Der Gestaltkreis. Theorie der Einheit von Wahrnehmen und Bewegen.* [The Gestalt circle. Theory of the unit of perception and action.] Stuttgart, Germany: Thieme.

Wallbott, H. G. (1982). *Bewegungsstil und Bewegungsqualität. Untersuchungen zum Ausdruck und Eindruck gestischen Verhaltens.* [Movement style and movement quality. Research on the expression and impression of gesture.] Weinheim, Germany: Beltz Forschungsberichte.

Wallbott, H. G. (1990). *Mimik im Kontext.* [Facial expression in context.] Göttingen, Germany: Hogrefe.
Weißenfeld, G. (1984). Beobachtungsauftrag, Schemaaktivierung und die Wiedergabe beobachteter Handlungen mit Abrufhilfen. [Observational task, script instigation and the recognition of observed actions.] Unpublished master's thesis, Dept. of Psychology, Ruhr-University Bochum, Germany.
Whiting, H. T. A. (1988). Imitation and the learning of complex cyclical actions. In O. G. Meijer and K. Roth (Eds), *Complex Movement Behaviour: The Motor-action Controversy* (pp. 381–401). Amsterdam: North Holland.
Wilder, D. (1978a). Effect of predictability on the units of perception and attribution. *Personality and Social Psychology Bulletin,* **4,** 281–284.
Wilder, D. (1978b). Predictability of behaviors, goals, and unit of perception. *Personality and Social Psychology Bulletin,* **4,** 604–607.
Wolff, P. (1984). Saccadic eye movements and visual stability: Preliminary considerations towards a cognitive approach. In W. Prinz and A. F. Sanders (Eds), *Cognition and Motor Processes* (pp. 121–137). Berlin: Springer.
Wolff, W. (1932). Selbstbeurteilung und Fremdbeurteilung im wissentlichen und unwissentlichen Versuch. Physiognomische Untersuchungen an der Stimme, dem Profil, den Händen und der freien Nacherzählung. [Judgments about self and others in a witting and unwitting investigation. Physiognomic inquiries of voice, profile, hands, and free recall.] *Psychologische Forschung,* **16,** 251–328.
Wolff, W. (1943). *The Expression of Personality.* New York: Harper.
Woltring, H. J. (1984). On methodology in the study of human movement. In H. T. A. Whiting (Ed.), *Human Motor Actions – Bernstein Reassessed* (pp. 35–73). Amsterdam, Netherlands: Elsevier.
Wright, H. F. (1967). *Recording and Analyzing Child Behavior,* ch. 4 (pp. 56–98). New York: Harper.
Yéla, M. (1952). Phenomenal causation at a distance. *Quarterly Journal of Experimental Psychology,* **4,** 139–154.
Yéla, M. (1954). La nature du 'rayon d'action' dans l'impression de causalité mécanique. [The nature of the 'radius of action' in the impression of mechanical causality.] *Journal de Psychologie Normale et Pathologique,* **47,** 330–348.
Young, A. W. and Ellis, H. D. (Eds) (1989). *Handbook of Research on Face Processing.* Amsterdam: Elsevier.
Zadeh, L. A. (1972). A fuzzy-set-theoretic interpretation of linguistic hedges. *Journal of Cybernetics,* **2,** 4–34.
Zadny, J. and Gerard, H. B. (1974). Attributed intentions and informational selectivity. *Journal of Experimental Social Psychology,* **10,** 34–52.
Zuckerman, M., DePaulo, B. M. and Rosenthal, R. (1981). Verbal and nonverbal communication of deception. In L. Berkowitz (Ed.), *Advances in Experimental Social Psychology,* vol. 14 (pp. 1–59). New York: Academic Press.