Abelson 1977), and situation models (Zwaan & Radvansky 1998). All three postulate hierarchical part-subpart relationships governing the represented structure of activity. At the same time, researchers in planning have proposed hierarchical representations of action that reflect recursive goal-subgoal relationships (Newell & Simon 1972).

Recent perceptual studies have established that observers perceive event structure in terms of the same sort of hierarchical organization postulated for narrative understanding and memory (Zacks et al. 2001). It has been argued that this reflects the influence of shared representations guiding perception and action (Zacks & Tversky 2001). Such representations may be adaptive because information about actors' goals is correlated with distinctive physical features of activity, so a perceiver can better predict an actor's future activity by using a shared representation to mutually constrain perception of physical and intentional structure. In short, the common coding claim appears to have similar implications for larger scale events as for brief events, and those implications have begun to be explored.

Regarding the claim that perception/action representations refer to distal features of the environment, researchers studying larger-scale events appear to be ahead of the game. For speeded responses such as keypresses or simple reaching movements, and for simple stimulus patterns such as colored shapes or characters, the question looms large whether event representations are based on proximal features (muscle tensions, retinal stimulation) or distal features (movements of objects or changes of the state of a computer screen). However, I know of no theorists who have suggested that events on timescales longer than a few seconds are perceived or planned in terms of proximal features. Rather, the representations posited by researchers studying larger-scale events are uniformly described in terms of external objects, other people, and their relations – all distal properties. For example, in script theory (Schank & Abelson 1977) the primitive operators (Schank 1972) include physical transfers of objects, ingestion, and speaking, all of which are underdetermined relative to proximal features.

Hommel et al. present two arguments for the use of distal representations (sect. 5.2). First, action planning based on proximal features is inefficient. Second, prediction of future stimulus input is easier with distal features. They present a range of evidence in support of these arguments for small-scale events. This evidence is crucial because for these sorts of events the arguments for distal features, though reasonable, are not overpowering. However, for complex events the limits of proximal features become painfully clear: Although it may be plausible that the system plans a ballistic reaching motion in terms of the individual muscle contractions involved, planning a trip to the doctor's office is another story.

Thus, the implications of the TEC view for complex events have been more or less assumed in the literature. This is apparently because the arguments for distal features become overwhelming as they scale up.

The final claim of TEC is that the formation of an event code consists of two discrete stages: In the first stage features are activated and in the second stage they are integrated. The first stage facilitates processing of other events with overlapping features, whereas the second stage interferes with processing such events (sect. 3.2.2). Importantly, these stages have an intrinsic dynamic, which unfolds rapidly (sect. 4.1).

There is some evidence that representations of larger-scale events can prime each other. In one paradigm, participants studied a series of short stories that contained pairs of stories with overlapping features. They then answered questions about these stories. Under some study and test conditions, answering a question about a story was facilitated when it was preceded by a question about a different story that shared thematic (Seifert et al. 1986) or structural (McKoon et al. 1989) features. This demonstrates the possibility of feature activation facilitating processing of related events (the first stage in TEC) for complex events. Inhibition of related events (the second stage) has also been demonstrated for complex events. Radvansky (1999) had participants study a series of sentences about a number of events, which were distinguishable by their different locations. Participants then made speeded recognition judgments about the sentences. Responses to test sentences were slower when the previous sentence had referred to a different event that shared an object with the event of the test sentence.

These two sets of findings show that shared features can lead to both facilitation and interference for complex events as well as for simple ones. On the surface, this suggests that the activation/binding component of TEC may scale up. However, in these studies facilitation was observed more often, either with equivalent (McKoon et al. 1989; Seifert et al. 1986) or much longer (Seifert et al. 1986) delays, than inhibition was (Radvansky 1999). Moreover, perceiving and acting in larger-scale events unfolds over a much longer timescale than the one postulated for the two stages in TEC. This suggests that although the activation-plus-integration notion may apply to events on longer timescales, an important modification will be needed to scale up. On longer timescales, the intrinsic dynamics of automatic activation and integration are probably less important than constraints imposed by the task being performed and the semantics of the particular events.

In short, the first two of TEC's claims are consistent with theories of larger-scale events: Common coding is implicit in those theories and has begun to be explored directly, and distal features are assumed. However, the activation-plus-integration claim will likely need modification to scale up.

Authors' Response

Codes and their vicissitudes[1]

Bernhard Hommel,[a,b] Jochen Müsseler,[b]
Gisa Aschersleben,[b] and Wolfgang Prinz[b]

[a]*University of Leiden, Section of Experimental and Theoretical Psychology, 2300 RB Leiden, The Netherlands;* [b]*Max Planck Institute for Psychological Research, D-80799 Munich, Germany.*

{muesseler;aschersleben;prinz}@mpipf-muenchen.mpg.de
www.mpipf-muenchen.mpg.de/~prinz hommel@fsw.leideniniv.nl

Abstract: First, we discuss issues raised with respect to the Theory of Event Coding (TEC)'s scope, that is, its limitations and possible extensions. Then, we address the issue of specificity, that is, the widespread concern that TEC is too unspecified and, therefore, too vague in a number of important respects. Finally, we elaborate on our views about TEC's relations to other important frameworks and approaches in the field like stages models, ecological approaches, and the two-visual-pathways model.

R0. Introduction

As we stress in the target article, the Theory of Event Coding (TEC) is meant to be a broad framework for understanding relationships between perception, cognition, and action planning, not a specific model or theory. Accordingly, and not surprisingly, a number of commentaries address basic theoretical and methodological issues regarding the nature and appropriateness of that framework *in toto,* as well as its relation to other frameworks and approaches. Others raise more specific issues and offer detailed suggestions for extensions, modifications, and so on. We have found most of the commentaries helpful for shaping what TEC is meant

to be and what it's not. Our reply is organized into three main sections, the first dealing with TEC's scope (R1), the second with TEC's degree of specificity (R2), and the third with TEC's relation to other frameworks and approaches to perception and action (R3).

R1. The scope of TEC

R1.1. Limitations

There is widespread concern among a number of commentators that the approach we take is too narrow (if not narrow-minded), given the enormous complexity and richness of the phenomena to be explained, – that is, the ubiquity of tight couplings between perception and action that can be seen in all animals in their natural settings, – and given the intricacies of the dynamical changes that these couplings undergo in the stream of ongoing behavior. This concern comes in two flavors: Some claim that the *approach* we take is flawed in principle. Others claim that TEC's *coverage* of pertinent phenomena is arbitrary and far from complete.

R1.1.1. Approach. According to some commentaries, TEC is flawed in principle because, as far as theory goes, it still maintains a dualistic view of perception and action and, as far as methodology goes, it strongly relies on experimental paradigms with arbitrary assignments of isolated responses to isolated stimuli. With these characteristics, the argument goes, there is no way to adequately capture the various natural forms of mutual interaction between perception and action, or to do justice to the circular causality inherent in animals for acting and perceiving.

Shaw & Wagman emphasize that perceiving and acting unfold in circular causality over time. From this perspective, they criticize a concept of code which is central to TEC as "a time-free surrogate that must borrow its rate of unfolding from an yet unspecified dynamical process." Instead, with a side-view on physics, they argue for a field perspective for research on perception-action cycles, as proposed by Gibson (1966; 1979). Like physics, which has long been moving from (Newtonian) particles to (Einsteinian) fields as its primary objects of inquiry, research on perception and action should move ahead from shared codes to shared information fields in organism-environment ecosystems. A move along this line, they argue, would relieve us from both dualisms: perception/action and animal/environment.

A similar point is raised by **Richardson & Michaels** and by **Kim & Effken**. They both argue that the issue of linking perception to action may perhaps be a problem for the minds of certain (conceptually misguided) cognitive scientists, but definitely not for the minds of the animals under study. These animals and their ancestors would not have survived if they had not been furnished with tight and efficient couplings between perception and action from the outset. Hence, dualism does not exist in nature but only in our theories (which speak of codes for perception and action), and in our experiments (which require arbitrary mappings between isolated, particle-like stimuli and responses). The common call of these commentaries is to abandon dualisms and codes altogether and to adopt an ecological view that treats the animal and its environment as a single system, whose performance is analyzed in terms of notions like information, information fields, and affordances.

In the same vein, TEC is criticized for not being explicit on how the alleged representations (i.e., event codes) are individuated and grounded: in perception or action (**Galantucci et al.**), in information or reality (**Richardson & Michaels**). Instead, since "there is no event ontology and no information specifying these events," TEC must put all of the explanatory burden on the perceiver/actor's mental operations and their "old-fashioned associationistic" processes (Richardson & Michaels).

Vis-à-vis these critical objections, we try to delineate once more what TEC is meant to be and what it is not.

First. TEC focuses on perception and action planning in humans. TEC's functional architecture is meant to account for the operations involved in action selection and action preparation. In any case, we believe that this architecture is functional in humans. We have no speculations to offer at which point in evolution this architecture emerged.

Second. According to its thematic focus, TEC requires a methodological approach that allows one to study human perception and action planning under experimentally controlled conditions. In this context, we wish to defend the often criticized reaction-time tasks that are, in fact, paradigmatic for the evidence on which much of TEC is grounded. Depending on perspective, this task is criticized (or even exposed to ridicule) for being both too simple and too difficult. On the surface, pressing a key is, of course, an extremely simple action in terms of the spatiotemporal coordinations required for its execution. Hence, when compared to more natural and more complex interactions with the environment, key-presses appear to be extremely simple, if not simplified actions (cf., e.g., **Pisella et al.**). However, as other commentators point out, pressing a particular key in response to a certain stimulus on the basis of a previously agreed-upon, arbitrary mapping rule, is, at the same time, also a highly unnatural and artificial task to perform (cf., e.g., **Galantucci et al.**). Humans can do it on the spot, but monkeys have a hard time learning it. Still, despite these objections, we hold that the choice reaction-time task captures exactly the type of performance TEC is meant to account for, that is, the linking of perception with the planning and preparation of arbitrarily selected action. As we point out below (in sect. R2.4), such performance may appear to be unnatural from an evolutionary point of view, but it is certainly not unnatural to all of us every day.

Third. From these limitations in scope and method we can gather what TEC is *not* meant to be. TEC is not meant to account for the online interplay between perception and action. In other words, TEC does not speak to issues such as spatial and temporal coordination of actions and environmental events, or to the fine-grained time course of speech and language processing, as some suggest it should (**Pisella et al.; Galantucci et al**.). Of course, we agree that it is often not easy to delineate (offline) planning from (online) interaction, but we do believe that these two functions need to be distinguished (see sect. R2.2 and Fig. 1).

Fourth. According to its scope and mission, TEC does rely on dualism in method, but certainly not in theory. We cannot see what is wrong about methodological dualism, when the goal is to provide a functional analysis of how actions are selected under given circumstances. In order to achieve this goal, we need to individuate possible circumstances (in the environment) and possible actions (in the person), and we need to distinguish between the percep-

tion of these circumstances and the planning and execution of these actions. It may be true that these instances can never be so neatly individuated in natural perception-action cycles, but why should one worry about creating an artificial experimental situation for the sake of a functional analysis one wishes to perform? What we certainly need to do is resist the temptation of importing dualism from method into theory. This is exactly what TEC tries to achieve: avoid dualism in theory while recognizing the need for a dualistic approach in method.

In summary, TEC's scope is narrower than some of the commentators are implying. TEC is not a comprehensive framework for perception and action in general, but rather a specific framework for the cognitive basis of perception and action planning in humans. TEC's mission is to provide a functional analysis of the underlying processing architecture, not an ecological analysis of complex interactions between the perceiver/actor and his/her natural environment. Hence, if one envisages the broad scientific enterprise of developing a more comprehensive theory of relationships between perception and action in animals (e.g., **Hochberg; Cisek & Kalaska**), TEC may become part of this enterprise – co-existing with other frameworks that address other issues. We hold that it is both legitimate and productive to detach this part from the rest of the enterprise. Due to its enormous flexibility, human action is special, and it can be studied with a special methodology that cannot easily be applied to animals. It is, of course, an open question to what extent human action also calls for a special theory.

R1.1.2. Coverage. Some other commentators who are more sympathetic with our general approach still maintain that TEC's coverage of the perception-action domain is arbitrary and incomplete.

Early perception/late action. Some criticize TEC's deliberate silence on what we call early perception and late action, that is, on low-level operations on the input and output side. One critical argument is that important issues remain unaddressed when low-level operations are disregarded. For instance, **Vogt & Hecht** criticize that TEC leaves an explanatory gap between action planning and execution. A similar point is raised by **Westwood & Goodale** in a more general sense. They argue that "the computational complexity involved in getting from sensory input to useful motor output is "hidden" in what the authors refer to as "early" perceptual processes and "late" motor processes," and that, since TEC does not address these processes, it is rated as "clearly superficial."

Another criticism is that, by focusing on late perception and early action, TEC fails to recognize the fact that perception and action are no less tightly entwined at lower levels of processing and, therefore, misses the opportunity to extend its coverage to also include early perception and late action. Accordingly, a number of supplements to TEC are suggested. **Cisek & Kalaska** argue that TEC's emphasis on the perceptual consequences of action is certainly not unique to advance flexible action planning. Rather, the principle of predictive feedback control is already abundant in simple animals and their situated activity. Hence, the structures envisaged by TEC must, in evolutionary terms, be considered recent specializations of very old principles. Likewise, **Bryson**, after discussing evidence on neurons that reference common feature maps for action perception and action control, stresses "that perception and action are probably unified in a number of ways of which TEC is but one." A similar point is made by **Dinse** from a neurophysiological and neuroanatomical perspective. Based on work with modified action and on anatomical evidence, he emphasizes the importance of crosstalk, feedback connections, and strong interactions at many levels in sensory and motor streams, as well as the role of temporal overlap between low-level and high-level processing. On this evidence, he argues that common representations for perception and action are probably not limited to higher processing levels and brain areas. In a similar vein, **Vogt & Hecht** discuss a study whose results can be accounted for in terms of both high-level event codes and low-level sensorimotor interactions. In their view, TEC should be expanded to (or even be replaced by) a multi-level interaction framework that relies "on an integrated network of sensory-dominant and motor-dominant brain areas, with event codes as emergent properties of this network."

We have three comments to offer in reply to these challenges and suggestions. *First,* we would like to reiterate what was said above: TEC is deliberately specialized and selective in that it focuses on the cognitive underpinnings of human action planning. *Second,* we certainly admit that our target article is sometimes less clear about the notion of action planning than it should have been. As **Westwood & Goodale** point out, we were not always consistent in keeping what they call the "What" and the "How" of action planning and execution as separate as we surely should have done. *Third,* and most importantly, we are at this point not convinced that it would be wise to broaden TEC's framework as suggested. As said above, we do of course agree that there is much more to action representation and control than what TEC has to offer. We, too, take it for granted that tight couplings and strong interactions between perception and action are ubiquitous in the animal kingdom, and that they are, at least in higher animals, implemented at various levels of coding. We maintain, however, that strong interactions and tight couplings do not necessarily imply common codes for perception and action. Consider, for instance, a population of neurons in the motor cortex that code for both certain movement sequences and their triggering conditions (cf. **Bryson**'s discussion of Graziano's work). Such neurons may be said to embody tight couplings between input and output without, however, providing common codes for them. Common coding would only emerge in a system of such neurons if a similarity relation holds between the triggering conditions and the movement sequences they code for (as the case of mirror neurons seems to suggest). Hence, common coding is a special form of tight coupling – one that allows for mappings of input to output (and vice versa) *by virtue of similarity.* This is why we, for the time being, resist the temptation of expanding TEC as suggested. Since TEC relies on the notion of common coding, it applies to representational systems whose input and output share the same coding dimensions.

Stating facts/directing actions. A different, though related supplement is offered by **Millikan,** suggesting a more precise notion of (mental) representations. We admit that the target article is quite vague on this issue. Nevertheless, we are not sure what Millikan's suggestions lead to. If one considers, as she points out, mental representations as entities that have representing as their (proper) function, two questions emerge: One is, what the function of represent-

ing means for the representations. Millikan seems to suggest that there is some "system" that uses and interprets them. What system? What use? The second question is what is represented. Millikan offers what may be termed a dual-face view of representations: they state facts (about distal affairs) and they direct action (in accordance with these affairs). This dual-face nature of representations, she argues, must have emerged in the early evolution of animals – in any case much earlier than TEC posits. This view seems to imply that directing action cannot occur without stating facts about distal affairs. We hesitate to subscribe to this principle. Why should it not be possible that sensory input gets translated into motor output without any reference to distal affairs?

R1.2. Extensions

So far we have emphasized TEC's self-imposed limitations and have argued against a number of suggested extensions which we feel are inappropriate or at least premature at this point. In this section, we discuss other suggested extensions that we feel can in fact help to broaden the range of domains to which TEC's reasoning can be applied. We welcome these suggestions and invite further elaboration. We will go through the domains for the proposed extensions in order, beginning with those in TEC's close vicinity, proceeding to more remote fields.

R1.2.1. Neuroimaging of action. TEC outlines a functional architecture for perception and action planning without offering speculations about its implementation in the brain. Important extensions in this direction are provided in the brief review of recent neuroimaging studies on action perception and production provided by **Chaminade & Decety**. It appears that at this point two major conclusions can be drawn from this work. One is that natural action is specialized – in the sense that different brain structures are involved in the representation of biological and non-biological motion. The other is that the perception of natural action is supported by the same brain structures that are also involved in the generation of those actions (the premotor and parietal cortical areas). As **Chaminade & Decety** point out, these findings give strong support and provide important extensions to some of TEC's central claims. As we briefly discuss in the target article, related evidence has, over the past decade, also been accumulated in electrophysiological and TMS studies (Gallese et al. 2002; Jellema & Perrett, 2002; Rizzolatti et al. 2001). This evidence has been taken to indicate the existence of a *mirror system* in the brain that may work in two directions. One, where the perception of action is constrained by the perceiver's own action competencies. The other, where the execution of action may likewise be constrained by the actor's own perceptual experiences. The first direction is in line with motor theories of perception, the second in line with perceptual theories of action (cf., **Vogt & Hecht**).

R1.2.2. Anticipation and intention. TEC believes in a crucial role for the representation of action effects in action planning, and this applies to the representation of both expected and desired outcomes of actions (anticipation and intention, respectively). As **Hochberg** points out, this view has many predecessors. Accordingly, it isn't surprising that it gets broad support, partly from a systems-control perspective (e.g., **Cisek & Kalaska; Olivetti Belardinelli & Basso**), partly from an ecological perspective (e.g., **Kim & Effken**), and partly from a metaperspective that believes (or, hopes) that TEC may help to combine the systems control and ecological approaches (**Jordan**). Beyond this general support, **Rosenbaum** offers a specific computational demonstration of anticipation in action planning. Discussing the relative merits of forward and inverse approaches in motor planning, he points out that for both approaches a strong reliance on anticipation of the consequences of prospective motor acts is indispensable. Further, he provides a computational demonstration of end-state anticipation as a means of dealing with the redundancy problem in motor control. A demonstration like this suggests that TEC can be extended, as claimed in other commentaries (e.g., **Pisella et al.**), to also include "later" motor stages of action planning and become computationally more specific.

R1.2.3. Attention. Ivanoff & Klein address TEC's possible contributions to help clarify, or perhaps solve, a long-standing issue in the domain of visual attention. This issue refers to the role of (oculo-)motor factors for the orienting of attention in the visual field (Klein's oculomotor readiness hypothesis and Rizzolatti's premotor theory of attention; see Klein 1980; Klein & Pontefract 1994; Rizzolatti et al. 1987). As they point out, the evidence is ambiguous so far. A number of studies do support the claim that attention is driven by motor intentions, whereas others do not. As Ivanoff & Klein point out, TEC could perhaps inspire a solution to this conflict, because, rather than identifying attention with intention (as premotor theory does), TEC considers them to be two closely related, but still distinct processes. The closeness of this relationship might well depend on task settings, that is, on how closely the motor and the attentional tasks are coupled. This is certainly an interesting suggestion which could stimulate further research in this field.

R1.2.4. Language. Our insistence that TEC is not conceived to cover skills involved in the perception and production of spoken and written language does not, of course, imply that we are unwilling to follow invitations into this domain. For example, **Hochberg** invites us to do so because he believes that language provides prime examples of closely entwined perception and production skills – not only at the level of phonemes and syllables (as the motor theory of speech perception suggests), but also at the level of text and discourse. **Galantucci et al.**'s discussion of the motor theory of speech perception is certainly not meant as an extension to TEC but, rather, as an alternative approach from which one can learn why TEC is flawed. Still, as said above, though TEC is so far not conceived to address language processing, we are certainly open to extensions in this domain, too. One thing that we find attractive about motor theories of perception in general (i.e., not only in the speech domain, but also in domains like music, action, and attention), is their potential for offering a solution to the grounding problem, that is, the grounding of perception in action. In this regard, we certainly agree with one of **Galantucci et al.**'s key arguments.

Further, a strong case is made by **Hartsuiker & Pickering**, who claim that natural language processing is governed by theoretical principles similar to the ones TEC of-

fers for perception/action in general. They argue that language should not be excluded from TEC's scope for two reasons. One is that natural communication proceeds in dialogues, where one's speaking and one's listening to others tends to be closely linked and tightly coupled (not to mention one's listening to one's own speaking!). The other is that there is ample evidence for shared representations for comprehension and production in the language domain, as well as a crucial role of these shared representations in language-based communication and understanding. In sum, our target article is perhaps somewhat too much on the defensive vis-à-vis language and language processing, for this field seems to allow attractive extensions of TEC.

R1.2.5. Complex events. So far, TEC has mainly considered short-lived, particle-like events such as arrows or circles that come and go on a screen, or hands and fingers that go up and down on a key pad. Obviously, this is a serious limitation which needs to be overcome. Some commentators suggest pertinent extensions.

One such extension is suggested by **Lane et al.**, who use their CHREST model of active perception to demonstrate that the logic inherent in TEC's assumptions can also be applied to the sequential organization of active perception – such that the input information available at a given time is used to compute an output which, when executed, alters the input, and so on. CHREST seems to be related to TEC in at least two aspects: (1) action outcomes play a crucial role in both; (2) the same format is used for input and output representation. But one of the major differences is that CHREST is much more explicit about memory structures than TEC is (not to mention that CHREST is computationally much more specific). The interesting point here is not to compare one with the other but, rather, to realize that basic assumptions of TEC prove to be useful in a computational approach dealing with the perceptual exploration of complex scenes and events.

A similar point is raised by **Chown et al.** They take a look at TEC from the broader perspective of cognitive maps for navigation (their PLAN model). From this perspective, they argue, TEC needs to be extended in two important ways. One is that, since TEC fails to capture sequences of perception-action cycles as cognitive maps like PLAN do, TEC needs to go beyond individual cycles. Second, a mechanism for perceptual learning needs to be incorporated in TEC, perhaps based on Hebbian learning. This mechanism should be capable of generating more flexible, prototypic event codes than TEC's present scheme concerning feature combinations and abstractions allows for. Again, the point is not to compare the two approaches but rather to demonstrate that they are compatible with each other.

Zacks examines TEC from a still more remote perspective, namely, the perspective of research on the representational underpinnings of (relatively) large-scale events in everyday life like, for instance, making coffee, fixing a flat tire, or installing computer software. He finds much commonality between TEC and this research, for example, regarding crucial principles like common representations for perception and action, and reference to distal affairs. Remarkably, there appears to be no serious alternative to these two theoretical principles in this domain of study. Accordingly, there is an interesting lesson to be learnt from this comparison: The seemingly simple key-pressing tasks that support TEC can be regarded as down-scaled versions of tasks involving more natural, large-scale events. We take this as support for our claim that the traditional response-to-stimulus-mapping view should be replaced by an event-representation view.

However, as **Zacks** points out, there are also limitations to the parallels. In the processing of large-scale events, there is no equivalent to the pattern of activation-plus-integration that TEC suggests. We don't find this too surprising. The scheme of activation/integration should, in our view, be considered a short-lived automatic consequence of the presentation of brief stimuli – a sequence of processes that operates on a small time scale. For large-scale events that are extended over minutes and hours, we do not see anything equivalent.

R2. Specificity

A further recurrent theme in a number of commentaries is that TEC is underspecified and, hence – at least in its present form – not testable and falsifiable. **Hochberg** and **Sanders** raise this issue in a general sense. Others, like **Chaminade & Decety**, **Pisella et al.,** and **Westwood & Goodale**, criticize its underspecification with respect to presumably involved brain structures. More specific aspects of underspecification are addressed by **Oriet et al., Shaw & Wagman**, and **Wolters & Raffone**.

Yes, we agree that TEC is underspecified in many ways and, as we note in many places in the target article, it is deliberately so. Before going into details, we would like to say a few words about the virtue of vagueness in science – with special reference to TEC. We believe in this virtue for two reasons.

The first reason has to do with TEC's theoretical mission vis-à-vis the dominant traditional views in the field which treat perception and action as two more or less separate functions. One of TEC's central messages is that this view is mistaken and must be replaced by a new framework – as we outline it. Accordingly, TEC's main mission at this point is to stimulate deliberations and discussions about basic principles of perception/action architectures. We hold that global principles should be clarified before local theories are made. In fact, we see the world of cognitive science populated with too much precipitate overspecification in local models and theories, whose underlying global principles have not been discussed and clarified before.

The second reason has to do with TEC's strategic mission. As we state explicitly in the target article, we place it much more in the context of discovery and exploration than in the context of testing and falsification. Hence, its strategic goal is not only to stimulate discussion of theoretical principles, but also to act as a heuristic tool for stimulating new research and inviting new extensions and specifications. In the context of discovery and exploration, underspecification is a heuristic virtue, but overspecification is a deadly sin: Underspecified frameworks can act as sources of inspiration for new ideas and new research, whereas overspecified theories are bound to fall into oblivion.

However, we do not mean to imply that the goal of science is underspecification. In the following we shall go through some of TEC's central concepts and discuss a number of specifications suggested in the commentaries.

R2.1. Perception

Some commentators focus on the notion of perception as it is used in the TEC framework and how it could, or should, be used in a broader sense.

R2.1.1. Perception, action, and intention. It has often been claimed that the proper function of perception is not only to state facts about distal affairs but also to direct forthcoming action (as **Millikan** puts it so elegantly). Traditionally, due to their roots in epistemology, theories have emphasized the representational function of perceptual systems, that is, their role in stating facts. However, from time to time, their action-direction potential has been emphasized, too. More than a century ago, motor theories of perception were the first to emphasize the role of motor representations and, accordingly, the action-directing power of perception (Scheerer 1984). More recently, motor theories of perception have gained support in domains like speech perception (Liberman & Mattingley 1985; **Galantucci et al.**), and movement perception (**Chaminade & Decety**; Prinz 2002). A similar perspective is entailed in Gibson's notion of affordances, that is, information specifying the action-directing potential inherent in a given stimulus (Gibson 1966; 1979). In a similar vein, the action-directing capabilities of perception have recently become emphasized from an evolutionary point of view (e.g., **Cisek & Kalaska; Galantucci et al.**): Obviously, selective pressure has formed perceptual systems to optimize their capacity for directing overt action – in any case, more than their covert capacity for stating facts. Hence, one may argue that their proper function is much more related to the directing of action than to the stating of facts.

TEC is certainly sympathetic with this general perspective, but at the same time it goes one step beyond. It believes that perception may lead to, or often imply, intention and action, but TEC also stresses the fact that perception is *preceded by* intention, that is, that perception is inherently intentional by itself. In everyday life perceptual activities are always embedded in the dynamics of the perceiver's intentional situation, and so it is in any experimental setting. In each and every experiment, instructions come first and only then comes a stimulus that leads to a particular response according to instructions. However, theories of task performance tend to commence with the stimulus and forget about instructions (Broadbent 1993; Prinz 1997b). These theories fail to acknowledge the fact that the stimulus is always perceived with reference to the pre-established intentional state. As **Jordan** points out, TEC does not only acknowledge this fact but also offers a mechanism to account for the impact of intentional states on attentional selection in perception.

R2.1.2. Perception and awareness. Another burden from the epistemological heritage is that the notion of perception tends to go along with the notion of awareness, as **Westwood & Goodale** suggest. This is, of course, a heavy issue with deep philosophical implications, and space does not permit us to go into a principled discussion. The only thing we can offer is a pragmatic remark. The way TEC speaks about perception does not entail the notion that perceptual processing goes along with awareness. We hold that awareness may, under certain functional conditions, *emerge* in the course of perceptual processing, or, perhaps, as a result of it. At this time, we do not understand what these functional conditions are, and future theories of perception will have to work on identifying them. We hold that the criterion of awareness can, at best, be indicative of those (yet unknown) functional conditions. In other words, awareness can sometimes emerge in perception (as it can in any other cognitive function) without, however, playing a functional role in itself.

In our view, theories that believe in such a role make the mistake of taking method for theory. Naturally, the criterion of awareness (i.e., availability for verbal report) plays an enormously important methodological role in research with human participants. However, the importance of that methodological criterion must not be confused with the importance of that factor in theory. In fact, we are not dualists enough to believe that awareness can, in itself, play a role in perceptual processing. For instance, there is ample evidence of perception without awareness in a number of tasks that require perceptual identification (which, according to **Westwood & Goodale**, must rely on processing in the ventral stream; see e.g., Klotz & Neumann 1999). Hence, it seems that perceptual identification can be efficient in the absence of awareness.

R2.2. Action planning

Instead of addressing all the processes that bring about an action, TEC focuses on what we call "action planning." In our understanding, the term refers to processes that prepare the system to reach a particular goal, that is, to produce an intended effect. This preparatory function has three important implications. First, action planning needs to precede the action or action element that is planned. Under tight time constraints, as in typical reaction time experiments, planning, and execution may go hand in hand, that is, what is planned is carried out as soon as planning is completed or at least sufficiently progressed. Yet, in daily life many actions will be planned to some degree some time before the conditions for execution materialize. Thus, action planning (often) is an off-line process that, as **Wolters & Raffone** rightly emphasize, requires some kind of short-term memory capacity. As sensorimotor processing does not stop while planning is underway (e.g., planning an utterance does not require to stop walking), action planning seems to occupy an extra input-output loop; a loop that can be temporarily decoupled from on-line processing and reconnected to the processing stream whenever necessary (a strategical advantage emphasized by **Bryson**). This suggests an architecture such as sketched in Figure R1, where

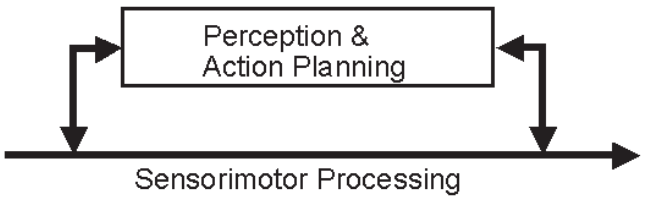

Figure R1. Sensorimotor processing and action planning take place in parallel. The on-line stream of sensorimotor processing is constrained by perceptions and action plans that are elaborated in parallel (though not necessarily synchronously).

an on-line stream of sensorimotor processing proper is constrained by perceptions and action plans worked out in a parallel, but not necessarily synchronous perception-action stream (we have to admit that our target article is less clear about this aspect than it should have been). This picture is not too different from that drawn by **Pisella et al.** Moreover, aspects of the former stream may be likened to Milner and Goodale's (1995) dorsal action stream, aspects of the latter to their ventral perception stream (see **Westwood & Goodale**).

Second, as action planning subserves a particular goal it can be expected to determine the major, goal-relevant features of a given action but it does not need to, and in many cases will not, specify all features of the (sub-)movements making up the action (Jeannerod 1984; Turvey 1977). Take, for example, the studies of Goodale et al. (1986) and Prablanc and Pélisson (1990), who asked participants to move their hand from a starting position to a goal location indicated by a small light. Unnoticed by the participants, in some trials the light made jumps of several degrees at the beginning of the movement. Nevertheless, the movements were carried out correctly and without any observable changes in their timing. As re-planning the movements should have produced some measurable time costs, this suggests that the changing movement parameters were not planned in advance and then re-planned but, rather, were specified by continuously fed-in visual information that steered the hand towards the target. To do so, however, relevant stimulus features must have been specified and linked to action parameters so as to delegate the movement's fine tuning to lower-level sensorimotor channels. Similar signs of control delegation are reported by **Pisella et al**. They show that moving a target stimulus can evoke fast adjustments of the participant's hand position even when target motion actually signaled stopping the movement. Although alternative interpretations are possible (e.g., participants may have forgotten or confused instructions, De Jong 2000; or have started to move before issuing the stop signal to the motor system, see Logan 1984), such an observation fits nicely with those of Goodale et al. (1986) and Prablanc and Pélisson (1990). However, why **Pisella et al.** feel that "automatic corrective movements contradict Hommel et al.'s claim that stimulus presentation is necessary but insufficient for response to occur" remains unclear to us. The sentence in our target paper that follows the one Pisella et al. refer to says, rather clearly, that "nothing will happen upon stimulus presentation until the participant has been instructed to respond in a particular way and he or she is willing to do so." Accordingly, we predict that Pisella et al.'s participants would not have made corrective movements had they not been instructed to carry out pointing movements toward the presented targets at all. If this not overly risky prediction holds, the corrective movements can be seen as a consequence and, in fact, as an indicator of the participants' action goals, which is in full agreement with TEC.

Third, planning an action requires knowledge about how a given goal can be achieved (Elsner & Hommel 2001; Hommel 1998a). Depending on the particular action and the environmental conditions, such knowledge may not be necessary for the mentioned fine-tuning via sensorimotor channels. Indeed, and here we agree with ecological approaches, there may be sufficient information "out there" to specify the parameters of a long jumper's final few strides to the take-off board (**Kim & Effken**; see also sect. R3.4). Yet, the actual and efficient use of this information depends on a whole number of preparatory processes: the very idea of jumping into that particular sand-pit, to do so by running towards it, to jump off with the dominant leg, to lean the body forward while in flight, and so forth. Most of these preparations are likely to be carried out way ahead of time of contact with the take-off board, so that anticipations of later parts of the action can shape earlier parts to make the whole action more efficient (**Rosenbaum**; Rosenbaum et al. 1990). Thus, they take place before the environmental or body-related information they refer to is available, which means that they must depend on some kind of internal knowledge – be it an internal model or stored instances of movements (**Rosenbaum**), or of movement-effect episodes (Hommel 1997; 1998a; **Kunde**).

To summarize, we distinguish between an on-line sensorimotor stream of information flow, that TEC does not cover, and a (potentially off-line) perception-action stream, that TEC does cover. We assume that while the former is affected and constrained by action planning, the planning processes themselves take place in the latter. Even if action planning may often be selective in not specifying kinematic peculiarities that can be more precisely specified by on-line environmental information, we would not feel comfortable with **Westwood & Goodale**'s distinction between "deciding *what* to do" (a job they seem to ascribe to Milner & Goodale's [1995] ventral pathway) and "specifying *how* to accomplish an intended action" (ascribed to the dorsal pathway). Let us take their example of picking up a cup of coffee. We can see that deciding to perform that action at all is a What-decision. But what about choosing the hand, the fingers performing the grip, the speed towards the cup, the force of the grip, the part of the cup that is grasped, the speed with which the cup is brought to the mouth – are these all What-decisions as well? If not, are they all *exclusively* performed via the dorsal pathway? Would that not imply that none of these decisions is open to voluntary, or at least not conscious, control? In our view, such a distinction raises more questions than it answers, and it becomes even worse if we consider the rather common situation that the cup is lifted without being looked at.

R2.3. Codes

TEC aims at describing relevant functional characteristics of the codes underlying perceptual and action-planning processes. In speaking of codes representing perceived and to-be-produced events, we make what is in our view a rather uncontroversial assumption: that perceiving an external event is associated with a correlated change in the perceiver's cognitive state (e.g., as indicated by neural activity) and that producing an external event is preceded by a correlated change in the actor's state. There are many ways to describe such changes and some levels of description may be better suited for particular purposes than others. Apart from the functional, analytic level of description we preferred in presenting TEC, one may focus on the activation levels of neuroanatomical structures (**Chaminade & Decety**; **Cisek & Kalaska**) or model neurons (**Wolters & Raffone**), interaction patterns between or within neural assemblies (**Chown et al.**), or characteristics and changes of cortical maps (**Dinse**), and one may even wish to consider concentration of neurotransmitters.

Although it is an all but trivial task to properly relate these different descriptions of representational codes to each other, many commentators demonstrate that it is feasible and, indeed, the whole idea underlying cognitive neuroscience strongly depends on this. Importantly, whatever the description level chosen, we do not regard neural codes to be properly characterized as "mental" (**Richardson & Michaels**) – a term that, apart from citations, we did not use at all – or "nondynamic" and "time-free" entities "that seem to sit outside of natural law" (**Shaw & Wagman**), and we see no reason why TEC would motivate such characterizations. Moreover, we do not see the codes assumed by TEC to be properly characterized as probabilistic anticipations on the basis of which people form "an expectation of what might occur" (**Kim & Effken**). Instead, we fully share **Millikan**'s view that the codes underlying perception and action planning have a double-faced function in both representing a particular state of affairs *and* telling what could be done about it. Hence, in Millikan's own words, "the same complete representation token can have two functions at once, being both a fact-presenter and an action-director." The only thing we need to add from a TEC point of view is that, given the assumption of distributed representations, it may still be possible to analytically or even physically (e.g., by means of single-cell recordings or through lesions) decompose those tokens into smaller units, that is, feature codes.

This assumed high degree of integration of perceptually derived and action-related codes distinguishes TEC from stage models with their implicit or explicit separation of codes. Therefore, we doubt that the mere observation that both types of models use the same term (**Proctor & Vu**) signals any deeper theoretical connection; in our view, this merely reflects that they both presuppose (as any approach in the wider field of cognitive neuroscience does) that there is some internal activity correlated with external events. With respect to the assumed integration of codes across perception and action **Pisella et al.** are concerned that TEC may not be able to account "for the fact that the same perceptual event can give rise to several actions (e.g., designating, grasping, squeezing)" and that "the perception of a distal stimulus" might "imply that one has already selected a given action to perform on or with this object." In our view, these commentators overlook major assumptions we have made. Most importantly, TEC's prototypical agent does not passively await some stimulus information and then makes a decision how to react thereupon. Outside psychological laboratories people commonly look out for particular stimulus events they are interested in, which means that perception is as intentional as action is (**Jordan**; see sect. 2.1). If so, the actual processing problem is exactly contrary to that posed by **Pisella et al.**; it consists of finding a stimulus that matches the current interests and action goals, not in checking out what action a given stimulus may afford. Hence, when looking for something to write, a pen simply matches one's current goals, and for neurophysiologically healthy adults there is no "necessity" to bother about, such as to suppress squeezing or throwing the pen. How this kind of goal-directed coding of perceptual events may be achieved has been discussed in section 3.2.3 of our target article.

Another concern raised by **Oriet et al.** (and, to some degree, by **Proctor & Vu** and **Sanders**) relates to the question: how original is our assumption of common codes? In particular, **Oriet et al.** ask "whether a common coding model can be distinguished from a classical model in which interactions between perception and action codes are postulated." Apart from the terminological confusion we discuss in R3.2, our first answer to this is: If one really postulates multi-lateral interactions between perception and action codes one would no longer defend a classical model, as it is this very uni-directional flow of information from input to output that, in our view, characterizes classical models (see **Proctor & Vu**). But, more concretely, assume a hypothetical, purely (classical) perceptual code P and a purely action-related code A. Let them represent, for a simplified example, the fact LEFT, so that P would become activated if a "left" stimulus is perceived and A would be activated if a "left" action is planned. Were they independent, it would be difficult to understand why left actions are primed by left stimuli, and vice versa, to name just one example from our empirical review. To account for such mutual priming one at least needs to connect P and A by some kind of association, which seems to be what **Oriet et al.** suggest. However, how would such an association account for the observation that planning a left action impairs the perception of left stimulus (Müsseler & Hommel 1997a; 1997b) – an effect that Oriet et al. were able to replicate and extend? That is, why should using A *interfere* with using P? To account for that, one would need to link P and A to a degree that gets at least very close to assuming some kind of functional unity. Once this point is reached, we suspect there is not much left for major theoretical arguments.

A final question with regard to the relationship between the codes used for perceptual events and for action plans is raised by **Sanders**, who asks whether "perception and action planning also share a common representation in a Sternberg classification task." The answer is as simple as it is general: That depends entirely on what the stimuli and the responses are. As perceptual events and action plans are coded in terms of distally defined features, code overlap (or partial code identity) exists to the degree that the distally defined features of the stimulus and response in question are the same.

R2.4. Features

TEC assumes that perceived and to-be-produced events are coded in terms of their distal features, that is, represented through activated and integrated feature codes. We took pains to point out that TEC allows for the coding of any feature, be it as "simple" as the pitch of a sine tone or as complex as a chair's "sit-on-ableness" – as long as it can be discriminated in perception and/or action planning. The reason for so liberally considering even "arbitrarily chosen, arbitrarily combined features," as criticized by **Galantucci et al.,** has to do with real life. In contrast to the seemingly naturalistic picture drawn in most ecologically inspired commentaries, mastering real life in modern Western cultures involves a multitude of tasks with arbitrary combinations of perceptual and action-related features. This includes, for example, pushing the right button to quiet the alarm clock in the morning, brewing coffee by using rather complex electronic equipment, and driving a car while navigating through a whole world of traffic lights and linguistic instructions. Most people manage to master these tasks, and we want to understand how they can. As the stimuli

they face are often arbitrary combinations of simple and complex features of perceivable events, and as the actions they perform are often arbitrary combinations of movement parameters and other movement elements, we think it is important to build a theory that helps understanding how people code both natural *and* artificial events. We definitely agree with ecological approaches that the search for effectively used information in perceptual events and produced actions is not easy, and we also agree that higher-order variables like tau (**Kim & Effken**) or even more complex derivates from motor competencies (**Galantucci et al.**) may be involved in specifying some parameters in jumping movements and speech perception, respectively. Yet, we doubt that accounting for the most of our everyday perceptions and actions will be possible without considering less "natural" stimuli and actions than those favored by ecological psychologists. This is why TEC allows for both arbitrary and "natural" feature combinations in perception and action planning.

A drawback of this liberal stance is that we are unable to provide *a priori* definitions or predictions of which features are coded under what circumstances (**Hochberg**; **Wolters & Raffone**). This is not so much a problem in experimenting, as participants can be instructed and tasks tailored to highlight particular features and make them task-relevant. However, outside the lab such tight control is not possible so that predictions necessarily lose precision. Moreover, it may be that the reliance on one or another feature depends on and, thus, varies with practice and expertise (**Sanders**) – just think of processing the taste of wines or the properties of snow. This is not a problem unique to TEC. What features people attend to, select, and eventually learn do always depend on a mixture of relatively easy to objectify task constraints and contextual circumstances, and much more difficult to determine individual factors having to do with abilities, skill level, learning history, attentiveness, and so forth. Hence, there will always be factors whose effects are easier to predict than of others, a problem TEC shares with any other model in perception, categorization, memory, or motor programming. Considering this, we are sceptical with regard to the possibility of identifying and codifying feature codes in an *a priori* fashion, as demanded by Hochberg or Wolters & Raffone. Instead, we prefer to stick to a circular definition: Feature codes can code anything that a perceiver-actor is able to discriminate in perceiving and/or producing an event. As our empirical review and the new evidence in the commentaries demonstrates, this does not necessarily prevent one from making successful predictions.

Another assumption we make is that feature codes refer to distally defined information, not to the sensory channels this information has been received by. **Vogt & Hecht** have taken this to mean that TEC only allows for coding "abstract" information and therefore is unable to account for surplus information if different channels are involved. This is true *only if* all sensory channels would deliver exactly the same type of information in exactly the same quality. As this is not a reasonable assumption – just consider localization by eye versus ear, or texture identification by eye versus hand – TEC is well equipped to deal with findings showing both transfer between, *and* various contributions from, different modalities. In a way, sensory channels are not too different from TV channels: the information they deliver points to external facts, not to the channels, and multiple channels increase the amount of information one gets. Along the same lines, TEC does not really introduce the problem of differentiating between seen and performed action, an issue raised by **Chaminade & Decety**. As long as the perceiver is not the actor it is very unlikely that the information about a seen and a performed action is identical; just think of the rather specific information delivered by kinesthetic channels, or the way action goals (which are absent when perceiving an action) "color" perception and action coding through feature weighting.

An interesting, additional issue with respect to feature codes is raised by **Meiran** and **Richardson & Spivey**. In our target article we focus on perceptual events and action plans, in other words, on events outside the body. But what about internal codes referring to intended (but not yet achieved) events, (perceived) emotions, semantic, linguistic, and other memory contents? Should TEC allow for such codes to become integrated into event codes, thereby coloring, so to speak, the coded perceived event or action plan? Albeit very briefly, we did signal this possibility in the target article (sect. 3.2.1) but did not develop this issue in the empirical review – simply because at that time we were unable to find data speaking to it. However, there are several recent observations that encourage us to more strongly consider the integration of such "internal," task-specifically weighted feature codes. For one, there is **Meiran**'s own recent work, in which he successfully applies his idea that stimuli are integrated with the context-dependent meaning of their response, to a number of findings in the area of task-switching (e.g., Meiran 2000b; Meiran et al. 2000; see also Hommel et al. 2000b). Indeed, the possibility of binding codes of already known stimulus and action features before an action takes place would provide ideal support for prospective memory: Once prepared, such a binding would be able to control the more or less automatic execution of an action under appropriate circumstances (Bargh & Gollwitzer 1994). Evidence for the integration of emotional information is also emerging. For instance, actions that are consistently followed by a mild electric shock (Beckers & De Houwer 2000) or a "grumpy" face (Van der Goten et al.; Hommel 2001) have been demonstrated to become increasingly compatible with word stimuli of negative emotional valence, and comparable effects occur for positive action effects. This suggests that actions become integrated with codes of positive or negative outcomes, which then play a role in stimulus-driven response selection (action induction). Interestingly, this fits well with Damasio's (1994) concept of a "somatic marker." Finally, as reported by **Richardson & Spivey**, even semantic and linguistic information has been found to become integrated with perceived events and action plans. Taken together, the evidence strongly supports our broad interpretation of what counts as an event feature.

R2.5. Events

In principle, TEC is intended to account for coding events of any sort and on any time scale. Yet, most examples in our empirical review refer to rather primitive stimulus signals and relatively simple laboratory actions – although we think that the range of actions is actually wider than some commentators admit and that, in contradiction to **Pisella et al.**'s implicit assumption that only pointing and grasping actions have goals, they were all goal-directed. Still, many perceived events and performed actions in our daily life are

richer and more complex, which raises the question of whether we can really extrapolate the available evidence to larger-scale events. There are two related issues that become increasingly important when turning to such events: (1) they often possess some kind of (at least perceived) hierarchical structure (**Zacks**), such as a scene consisting of parts and sub-parts, or a multi-layered action like preparing for an exam; and (2) that they typically comprise a number of sequential steps (**Chown et al.**), such as in making coffee or in watching a movie. A hierarchical and sequential structure introduces coding problems that go beyond TEC's present capabilities. Very likely, coding complex events involves some kind of schematizing (**Zacks**) or chunking (**Chown et al.**; **Lane et al.**; **Wolters & Raffone**) of their parts, and we agree with the commentators that TEC would (and should) benefit a lot from relating to available accounts of hierarchical event coding, such as PLAN, CHREST, and Zacks and Tversky's (2001) model. But TEC also has something to contribute to understanding the coding of multilayered events. For instance, TEC-driven studies have shown that the cognitive representations of elements of complex visual arrays are determined by whether, and how, their perceptual and action-related features overlap. In particular, houses of map-like configurations are integrated into the same cognitive cluster if they share shape- or color-related features (Gehrke & Hommel 1998; Hommel et al. 2000a) or the action they signal (Hommel & Knuf 2000; Hommel et al. 2001).

With respect to the coding of sequences, we see no difficulty in assuming that elements of a sequential action are temporarily linked and organized by means of syntactic structures, such as the action-sequencing cells discussed by **Bryson**. As the order of elements is a perceivable as well as plannable feature of events, we find it only natural that neural means exist to code these features. **Hartsuiker & Pickering** even report evidence that syntactic features obey the same processing rules and, thus, give rise to the same types of phenomena than the more content-related spatial and figurative features covered by our review. Other challenges may be more difficult to meet. For instance, if action sequences get longer only the first few elements tend to be fully prepared before the sequence is started, whereas later elements are planned while execution of the preceding elements is underway (e.g., Semjen & García-Colera 1986; Van Donkelaar & Franks 1991). In TEC terms this would imply a mixture of fully integrated action elements and elements that are only activated (or maintained), and we do not see how TEC could predict how many elements fall into each category or how such a composition would behave. Yet, irrespective of such open questions, we have seen no convincing argument that a TEC-inspired approach is *in principle* unable to deal with more complex actions. Quite to the contrary, the work on the processing of sentences and stories reviewed by **Zacks** suggests that TEC fares reasonably well if applied to events on larger time scales.

R2.6. Activation and integration

TEC distinguishes two basic representational states a feature code can take on, activation and integration. Facing a perceptual event or action opportunity one is currently not interested in leads to a brief and quickly decaying activation of the codes corresponding to this event's features (see Figure R2, feature code f_3 in Phase II). Interest in the event is associated with an (attentional-intentional) increase in the weights of its interest- or goal-related features (the feature-weighting principle), which again increases the net activation these codes reach when coding the event in question (see f_1 and f_2 in Phase II). This additional boost increases the likelihood of codes reaching an integration threshold that determines which codes become part of the integrated event code (see f_1 and f_2 in Phase III). If the binding dissolves, the activation of the previously bound codes will start decaying (see f_1 and f_2 in Phase IV) and eventually go back to baseline.

A whole number of commentaries addressed the several problems and virtues of these process-related assumptions. We have a twofold reply to their concerns. On the one hand, we are fully aware that TEC is still too underspecified to deal with the details of many empirical phenomena, and in several cases is simply too powerful (i.e., nonspecific) to allow for clear-cut predictions and rigorous experimental testing. In particular, this applies to temporal assumptions regarding when the hypothetical phases take place and their durations, as well as to the possible preconditions for these processes and for aspects of their temporal behaviour (**Diedrichsen & Hazeltine**; **Kunde**; **Oriet et al.**; **Zacks**). This is certainly a weakness we have to admit, but we think we can (and, for the moment, should) live with it. For one thing, these missing assumptions do not really touch TEC's basic architecture or the logic of its operations, and we therefore prefer to resolve the questions relating to them empirically. Indeed, it is not unlikely that as far as experimental tasks are concerned, the necessary temporal parameters are strongly dependent on the particularities of the task, the stimulus material, the type of responses, and the strategies of the participant. For instance, the time when integration starts and how long it takes may vary with the number of stimuli competing for integration, the complexity of a planned action, or the time-scale of the event in question

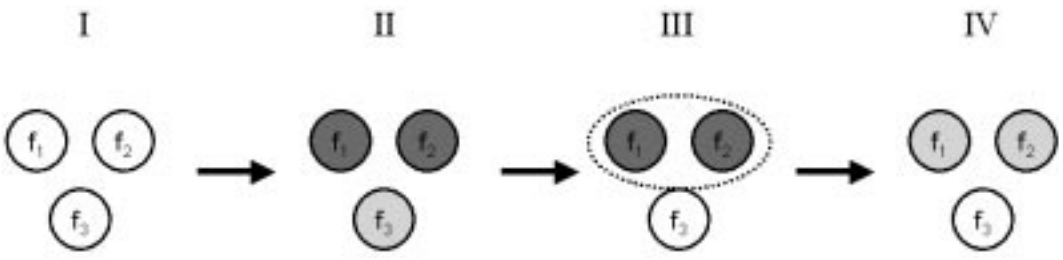

Figure R2. Four sequential phases of feature activation and integration where one feature (f_3) code rapidly decays after activation (Phase I) whereas activation for f_1 and f_2 increases (Phase II), yielding an integrated event code (Phase III) and starts to decay again (Phase IV).

(**Zacks**). How long it takes for a previously bound code to decay will depend on whether or not the perceiver-actor anticipates making use of this code in the near future. And people may be able to adjust, and therefore vary in, the size of their temporal "integration window," that is, the interval across which evidence is sampled into the same event file (Lupiáñez & Milliken 1999). We do not see how all these and other possible complications can be resolved on the basis of *a priori* theoretical principles, and therefore do not find it useful to unnecessarily restrict TEC's bandwidth by including some arbitrarily chosen specifications on the basis of preliminary evidence. Rather, we see TEC as a framework to motivate and guide the construction of a whole number of more task- or domain-specific TEC-type models that do lay down such specifications and can, therefore, be empirically tested with more rigor. We even consider it useful to construct competing TEC-type models, that is, models that share their basic architecture but differ with respect to their parameters.

On the other hand, the hypothesized picture of an interplay of activation and integration has recently found considerable support in quite a number of tasks and areas other than those considered in our review, spanning the integration of eye movements and linguistic material (**Richardson & Spivey**), dual-tasks combining eye and hand movements (Stuyven et al. 1999), judgments of object properties (Richardson et al. 2001; Tucker & Ellis 1998), and the integration of lexical and syntactic information (**Hartsuiker & Pickering**). Moreover, even the present version of TEC is not as underspecified as some commentators claim; there were quite a number of challenges we found not too difficult to deal with even in the absence of more task-specific versions.

For instance, although we consider it possible that additional assumptions and qualifications may be required to apply TEC to the behaviour of mentally ill people, we do not see how the observations of Müsseler and Hommel (1997a; 1997b) can be explained by conditioned blocking (**Oades & Kreul**). Blocking requires some amount of training, hence, a number of repetitions of particular stimuli and/or responses; yet, Müsseler and Hommel's action-effect blindness is a trial-to-trial phenomenon that appears in experiments with constantly changing combinations of stimuli and responses.

We also are unable to see why, and in what sense, the assumption of distal coding conflicts with the observation that action planning is affected by the relation between the hand's starting position (a well-defined distal event) and (other) stimuli (**Pisella et al.**). With respect to action planning TEC uses the terms "proximal" and "distal" to refer to specifications of a planned event in terms of muscle innervations and to-be-perceived, external attributes, respectively; this is not to be confused with "close to the body" versus "far from the body." Moreover, it is true that TEC has no full-fledged theory of attentional selection built in, which makes principled predictions about the coding of distractor stimuli difficult; yet, the observation that trajectories of hand movements are affected by concurrently coded stimuli (Pisella et al.) seems to be so much in line with TEC that we fail to see a challenge here (see also sect. 4.3.2 in the target article for how TEC accounts for effects that seem to indicate inhibition).

Oriet et al. report a number recent studies from their lab that replicate and considerably extend the observations of Müsseler and Hommel (1997a; 1997b). However, in contrast to Stoet and Hommel (1999) and Wühr and Müsseler (2001), they found reliable interference between a planned action and a masked stimulus not only before, or while, but even after the action was carried out. As they say, this is inconsistent with our assumption that elements belonging to an action plan become automatically desintegrated immediately after use. Instead, participants may have kept their plans active for some longer time than in our own studies. Yet, even in the studies mentioned by **Oriet et al.** dramatic reductions of the action-induced impairment of perceptual identification were observed as soon as the action was fully executed, and in some conditions the effect was indeed eliminated. Hence, the empirical differences are not as drastic as **Oriet et al.**'s commentary might suggest and it is not too difficult to explain them. Moreover, even though we agree with Oriet et al.'s general argument that more specification is needed for a more task-specific modeling, we think that they overestimate the degrees of freedom TEC provides for predicting and accounting for empirical findings. Activation and integration are states that are strictly bound to particular functions, and this in principle allows for independent testing of even post-hoc assumptions. For instance, if the observation of blindness effects after execution of an action really results from participants maintaining their action plans somewhat longer, one should find an increase or decrease of this pattern if one rewards for or punishes the maintenance of those action plans, respectively (e.g., by introducing a tertiary task in-between action execution and stimulus-related judgment calling for frequent repetitions versus alternations of the previously planned action). Moreover, if the plans are really maintained longer, one might find effects on the speed of responses carried out thereafter, for example, in the stimulus-judgment part of the task – especially if this part follows shortly after and especially in participants showing stronger indications of "maintenance." In a nutshell, TEC does not in fact "as easily account for a pattern of results as it can for the exact opposite pattern" (Oriet et al.) because the additional assumption one needs to make to account for an unexpected outcome is open to an independent empirical test.

Kunde also points to some, in his view, inconsistencies between TEC's predictions and its empirical observations. In particular, he discusses Craighero et al.'s (1999) finding that planning a grasping movement primes the processing of a "Go" stimulus that looks like the grasp object, and he asks whether TEC should not have predicted negative effects here. However, there were some major differences between Craighero et al.'s and Müsseler and Hommel's tasks. People in the former prepared one action directed towards an object, that is, a single sensorimotor event to be triggered by the "Go" stimulus. Here, the processing problem consisted in maintaining and then launching a single representation of an object-oriented movement, but no separate stimulus-related response was required. And action-congruent "Go" signals did not just feature-overlap with the goal object – they perfectly matched it, so that no coding conflict could arise. In contrast, the Müsseler and Hommel task requires the formation and maintenance of two different, independent cognitive structures, an action plan and a stimulus representation for later report. The processing problem in this case is therefore not restricted to one structure and mere maintenance, but includes keeping the two maintained structures separate. Also, the "object"

of the planned action was a response key, which feature-overlapped but was otherwise very different from the to-be-identified stimulus. Hence, in contrast to Craighero et al.'s task, where people might have used the same event code for coding both the stimulus and the planned action, the major problem for Müsseler and Hommel's participants consisted in creating one event code while maintaining another, and in keeping them apart although they are linked via a shared feature code. Accordingly, we do not consider the findings of Craighero et al. a real challenge to TEC. The same applies to Hommel and Schneider's (in press) observation that selecting a manual response primes the selection of a bar-marked element of a small search array. As reported in that study, there was strong evidence that the actual stimulus selection took place after response selection and execution was completed. Thus, under the assumption that plan elements were quickly unbound (Stoet & Hommel 1999), one would expect that the (decaying) activation of plan elements could bias the eventual stimulus selection. And this is what happened. The problem here is not that predictions from TEC would be ambiguous, it is just difficult to determine *a priori* precisely *when* the assumed processes take place if a task gets complicated.

The objections of **Diedrichsen & Hazeltine** are similar to **Kunde**'s, and so is our reply. We have already pointed out how Hommel and Schneider's (in press) findings fit into the picture. Our interpretation of Diedrichsen et al.'s (2000) observations is somewhat different. What they found is that the distractors that are compatible or incompatible with a target (and the implied response) have a stronger impact if they appear on the side where the correct response is carried out. In our view, during the first, activation phase target information is continuously fed into activation of the associated action-feature codes (Hommel 1998c; Hommel & Eglau, in press), which include response location. Activating location codes (access to which is shared by stimuli and responses) "backward-primes" the stimuli sharing the activated code, so that response-compatible distractors receive a processing advantage. We found a similar phenomenon under dual-task conditions: Hommel (1998c) observed that compatibility between the response of the secondary task (e.g., the verbal response "red") backward-primes the stimulus of the first task (e.g., a red-colored stimulus). Thus, these effects are not restricted to the spatial domain. Note, however, that all these priming-type effects are observed some time *before* the response in question is carried out. If we assume that in these reaction-time experiments response execution immediately follows response planning, this means that priming is observed in the earlier planning phase, that is, the activation phase. Accordingly, TEC would predict that the effects should differ from a situation in which people have several seconds to plan their response before facing the to-be-processed stimulus, as in Müsseler and Hommel's (1997a; 1997b) studies. And this is what Diedrichsen et al. (2000) observed.

We found **Diedrichsen & Hazeltine**'s limited success in applying TEC to the concurrent or temporally overlapping planning of multiple actions, more challenging. On the one hand, the findings of Stoet and Hommel (1999) can be replicated with combinations of eye and hand movements (Stuyven et al. 1999), which rules out **Kunde**'s objection that body instability may have played a role and demonstrates some degree of generality. On the other hand, however, the discussion of **Diedrichsen & Hazeltine** reveals the (admitted) difficulty in defining what an event is. The two actions planned in Stoet and Hommel's task were separated by several seconds, and therefore clearly required the creation of two different plans. However, with decreasing temporal separation it becomes unclear whether people still create two plans or somehow merge these into one coherent structure. Even if one introduces stimulus-onset asynchronies (SOAs), the often short interval between the actions may still motivate people to either use one coherent plan, or re-use the previous plan by only modifying the changed parameters (Rosenbaum et al. 1986). Then predictions from TEC become muddy, the more so as it does not provide the means to predict which strategy is used under which conditions. Which is one more reason to point out that we see TEC only as a guide to build task-specific models, not as a substitute for such models.

Finally, **Wolters & Raffone** have some objections to our distinction of activation and integration processes, and they discuss reasons why and how these two processes might interact. Indeed, it makes sense to assume that integrating a feature code into a coherent event code impacts upon its activation level and thereby prolongs its "lifetime." Conversely, it seems obvious that only (sufficiently) activated codes can become integrated. Yet, this does not, for one, rule out the possibility that activation and integration phases have different effects on other codes, and we think that the demonstration of both positive and negative effects of feature overlap supports our assumption that they do. Moreover, **Wolters & Raffone** argue that

> the selective allocation of a shared feature . . . to only one of two concurrently activated event representations, cannot be plausibly based on the oscillatory *synchronization within* and *desynchronization between* the two event representations: since synchronization implies a transitive relationship, shared nodes may lead to interference-prone coding and readout of the events.

However, apart from the fact that TEC is not tied to oscillatory synchronization as a physiological implementation of integration, the presence of interference between action planning and perceptual identification reported by Müsseler and Hommel (1997a; 1997b) in fact points to some kind of "interference-prone coding and readout of the events." Hence, rather than challenging TEC's assumptions **Wolters & Raffone**'s commentary in our view provides additional support for the logic underlying them.

R2.7. Control

TEC focuses on *how* events are cognitively coded but it doesn't have much to say about *what* events are considered under particular circumstances. Thus, it does not (yet) include an elaborated theory of selection, so it cannot satisfactorily deal with issues like the selection of targets from distractors (**Pisella et al.**), or the selection among competing goal-satisfying behavioral alternatives (**Olivetti Belardinelli & Basso**; **Bryson**; **Kunde**). However, it is also true that even the present version of TEC does have some control built in. In particular, we assume that goal-related features of objects and action plans are weighted more strongly than other features. This not only contextualizes the emerging representations of events, it also affects their impact on behavior by granting goal-relevant objects and action plans a processing advantage. As discussed by **Meiran**, feature weighting may suffice to explain great portions of inten-

tional task-switching – an ability commonly considered to reflect intentional control – and influential cognitive-control models such as that of Cohen and colleagues (Cohen et al. 1998; Cohen et al. 1990) operate basically on the same principle (Hommel et al. 2000b). With respect to input selection, the assumption that goal-related events receive selective top-down support which again biases the competition for selection, fits well with recent models of attentional selection, as those of Bundesen (1990) or Duncan and Humphreys (1989; Duncan 1993), and **Ivanoff & Klein** rightly point out further similarities with Norman's (1969) and Folk et al.'s (1992) ideas on attentional control. True, these connections need to be worked out in more detail in the future; but given that TEC was not meant to be a control model proper, it does not compare too badly with those that are.

R2.8. Neurophysiological and anatomical basis

TEC is formulated in purely functional terms with no particular connection to the brain hardware through which the hypothesized functions may be implemented – a decision regretted by some commentators (e.g., **Chaminade & Decety**; **Pisella et al.**). There are three reasons that in our view justify this decision *at this point.*

First, although some, certainly encouraging, neuroscientific studies on perception-action relationships are available already (and some were indeed considered in our target article), this area of research is still in its infancy. For instance, most of the relevant neuroscientific studies **Chaminade & Decety** and **Pisella et al.** discuss either just appeared or are still in press, and the validity of some central findings underlying Milner and Goodale's (1995) distinction between a perception and an action stream is under heated debate (e.g., Bruno 2001; Carey 2001; Rossetti & Pisella 2002). So, before trying to map psychological function to biological substrate it seems safe to await some degree of consolidation in findings and interpretations on the biological side.

Second, as with any research, what neuroscientific approaches can find is constrained by the methods they employ. The machinery and techniques dominating the current discussion of perception-action relationships (as well as the arguments of **Bryson**, **Chaminade & Decety**, **Cisek & Kalaska**, **Dinse**, and **Pisella et al.**) focus on the activation of either single cells, or cell assemblies, or whole cortical areas; or, as in patient or lesion studies, on the presence or absence of those areas. It makes sense to assume that the activation of those neuroanatomically defined units speaks to the functional process of activation postulated in TEC. However, we are not so sure whether they, in principle, can tell us something interesting about communication between units and integration of the information they deal with. This may work if integration is achieved by convergence on single grandmother cells or grandmother assemblies, which might be localized in a particular area or system, which can then be detected via brain imaging, lesions in this area, or single-cell recordings. Yet, if integration is achieved by coordinating the behavior of neurons or neuronal assemblies, as **Wolters & Raffone** or Singer (1994) suggest, it need not lead to any detectable increase, perhaps not even to a change, in brain activation (as timing and average firing rate are logically independent). If so, it may turn out to be extremely difficult, if not impossible, to "localize" integration processes in the brain, and conclusions based on techniques that focus on localization may have limited value. Therefore, it seems safe to wait and see how findings from neuroscientific "activation" analyses fit with results from techniques better suited to reveal communication processes, such as mass-cell recordings or magnetoencephalography.

Third, given these and other considerations, we as yet do not see the promise of over-additive insights when mapping functional process descriptions to brain structures. Of course, it is highly interesting to see that the general principles claimed in TEC also hold for, and prove to be useful to understand, the neurophysiological underpinnings of perception-action relationships. We are therefore grateful to the commentators for having pointed out these parallels and possible points of connection and correspondence between function and substrate; the review by **Chaminade & Decety,** especially, is very encouraging in this respect. We also have no reasons to object to the particular ways suggested by these commentators to map function to substrate, and to direct our attention to probable TEC-related systems in the following regions of the brain: in the parietal lobe, where information about stimulus-response relations may be stored (Chaminade & Decety, **Pisella et al.**); the prefrontal cortex, which may be involved in "contextualizing" and biasing events (**Cisek & Kalaska**; Cohen et al. 1998); the cerebellum, which may mediate perception-action integration (Pisella et al.) and forward-modeling of action (Cisek & Kalaska); and the basal ganglia, which may contribute to the selection of action plans (**Bryson**). Nevertheless, what would happen if these suggestions prove incorrect? What if, to take a fictitious example, we explicitly assumed that goal-related feature weighting is "performed by" the prefrontal cortex, and then be faced with indications that features are still weighted in patients or animals after complete removal of this cortical structure? Should we then give up the assumption of feature weighting or the assumed connection between weighting and prefrontal cortex? We believe that most people will find the latter more reasonable, simply because understanding a psychological process does not critically depend on the cortical location where the process takes place – if it can be localized at all.

These arguments are by no means intended to encourage mutual ignorance between psychological and biological approaches. On the contrary, we find the developing neuroscience of perception and action (for a label) extremely interesting and the emerging parallels to functional models very inspiring. Nor do we exclude more fruitful integration of functional and physiological ideas in the near future. It is just that we, at this point, do not yet see sufficient justification for (nor the synergetic effects of) tying TEC to particular cortical structures.

R3. Relations to other approaches

R3.1. Historical predecessors

In our target article, on several occasions we pointed out that TEC does not come out of the blue but, on the contrary, takes up a number of elements from other, in some cases surprisingly old, theoretical approaches. Yet, we may

have failed in making some important connections sufficiently obvious (**Hochberg**), such as the links with the Tolman theory of purposive behavior (discussed in more detail in Hommel 1998a) and Gibson's ecological approach (see sect. R3.4). **Sanders** mentions further interesting connections to the work of von Weizsäcker and Werner, and there are some more points of contact to other ideas that the interested reader will find elsewhere (Aschersleben & Prinz 1995; Elsner & Hommel 2001; Hommel 1997; 1998a; Müsseler 1999; Prinz 1984; 1987; 1992).

TEC's connection to Tolman (1932; 1959), also emphasized in the commentary of **Chown et al.**, is instructive with respect to three issues. First, apart from the distal coding issue discussed by **Hochberg**, TEC owes to Tolman the insight that feedback (i.e., action effect) does not only possess a motivational function (by rewarding or punishing for the action) but also provides *information* about what the action leads to (Tolman et al. 1932). Accordingly, it makes sense to assume that action effects do not only supply the glue for linking stimulus to response (Walker 1969), but that their representations become integrated with the response pattern itself. This way the effect code informs about means-end relations and thereby serves as both a forward model (**Cisek & Kalaska**; **Rosenbaum**) and a retrieval cue of the action (Harless 1861; James 1890; Lotze 1852).

Second, the major historical problem of Tolman's approach, at least in the area of learning theory, is that it nicely accounts for what rats (and, by inference, humans) may know about events and environmental conditions, but it fails to explain how and why it ever starts moving. Indeed, if one considers the information a rat or human acquires by observing another as pure "cognition," that is, as mere information laid down in some storage system, one needs to introduce additional processes that interpret and make use of this information to carry out some overt behavior. That is, one needs some machinery that translates perceptual codes into action patterns, as is postulated by classic stage theories of information processing (see sect. R3.2). This is certainly feasible, but then one faces all the problems translation approaches entail (as discussed in our target article), like explaining why some translations are easier than others, and why action planning affects perception. But such problems do not arise if one considers codes to have a direct, active impact on action control (**Millikan**), as TEC suggests.

Third, an important driving force for Tolman's cognitive approach was the difficulty to explain maze learning in animals on the basis of direct stimulus-response associations. For instance, if rats can transfer maze-specific knowledge acquired by wading to swimming, or vice versa (Macfarlane 1930), they do not seem to have learned particular stimulus-response chains. Instead, what they acquired must have included some kind of representation of the locations visited, or, as TEC suggests, a sequence of perception-action events. However, a real cognitive map is meant to include more than sequence-related knowledge; it actually implies the transformation of such knowledge into some more integrated representation. As TEC is not sufficiently developed to cover these kinds of transformation, it seems indeed promising to try connecting it with available ideas about how this might be achieved, as suggested by **Chown et al.**

R3.2. Stage models

Some commentators (**Oriet et al.**; **Proctor & Vu**; **Sanders**) were skeptical about whether we did full justice to stage models of information processing and suggested that our discussion may have over-emphasized differences and under-emphasized commonalities between the stage approach and TEC. Interestingly, one of the major problems associated with stage accounts shows up in these commentaries themselves. According to both Donders' (1862) classical paper and Sternberg's (1969) foundation of the influential additive-factors logic (AFL), the term "stages" refers to cognitive processes. Thus, if two experimental factors produce a statistical interaction, one would be led to believe that they affect and, hence, are associated with, the same process. Logically speaking, identifying *processes* – the task AFL was developed for and, as **Sanders** points out, was very successful in – has no implications with respect to the attributes and the location of the *codes* these processes operate on. Assume, for instance, that additive-factors experiments would have revealed an interaction between factors presumably having to do with stimulus selection and factors presumably having to do with response selection. Given these findings, AFL would suggest that we think of stimulus and response selection being carried out by the same process, so that, if this process were capacity-limited, one may expect the concurrent selection of stimuli and responses to be difficult. So far so good. But would that have any implication as to what the selected codes look like and whether stimuli and responses are coded separately? Surely not, as the same process may work on codes anywhere in the system under analysis. And, indeed, it would be unfair to expect an approach developed to identify processes to deliver information about the architecture and functional location of the codes these processes operate on.

Among other things, it was the silence of stage approaches with respect to the latter that motivated us to develop TEC. For instance, we find it disappointing that about 70 years of research on the Psychological Refractory Period only allows us to confirm the assumption about some kind of bottleneck associated with the response-selection or "decision" stage that has existed since the very first studies onward (for an overview, see Pashler 1994) – without knowing *how* this stage really works and *in which way* it creates the bottleneck. True, localizing effects somewhere in the processing stream (or, better: stream of processes) provides an important starting point for analysis, but we are afraid that the actual analyses typically stopped right after the localizing was done. For these reasons, we are surprised to learn that TEC, with its emphasis on the architecture of, and interactions between codes, is not considered that different from existing stage models. However, close reading reveals that the assumed commonality results from a misinterpretation of AFL and the stage concept. For instance, **Sanders** writes that "the response selection stage has always been considered as a typical perceptual-motor interaction site," or, "according to stage theory 'late perceptual and early response products' typically reside in the response selection stage." It is obvious that in these sentences the term "stage" refers to functional locations or subsystems and, hence, used in a manner that is not covered by, and not consistent with AFL. Indeed, Sanders himself later admits that "stage theory has usually not had much to say about the contents and struc-

tures involved in stages." **Oriet et al.** also speak of perception and action as "systems" and thereby seem to refer to the location of codes rather than to the sequence of processes. We doubt that this is consistent with what the "classical model" they defend aims at.

We found ourselves similarly confused by **Proctor & Vu**'s view that TEC focuses "on that portion of information processing typically attributed to a central processing stage called response selection, response determination, response choice, or stimulus-response translation." For one thing, we were unable to find a single stage model where perceptual identification and action planning are handled by the same stage, whereas we had no problem in finding popular models that attribute these two processes to separate stages (for a selection, see Kornblum et al. 1990; Pashler 1994; Posner 1978; Proctor et al. 1990; Sanders 1983; Stoffels et al. 1989; Van Selst & Jolicoeur 1997; Welford 1952). Indeed, stage models would run into a lot of trouble if they really unified perceptual and action-planning *stages,* because this would predict all sorts of interactions between manipulations of "perceptual" and "action-related" factors that one does not (and presumably will not) find empirically; and in the *absence* of which the cited stage models are in fact founded! These kinds of problems do not arise from assuming common coding of perception and action plans, – which speaks for **Sanders**' suggestion to view stage theory and TEC as in some sense complementary.

R3.3. Ecological approaches

The major goals of ecological approaches to human perception and action are to identify and characterize environmental (e.g., optical) variables that support behavior, and to describe the control laws or strategies employed to link variables and movements in an efficient, presumably task-dependent way. These goals stand in obvious contrast to those of modern cognitive psychology, which aims at understanding the relationship between cognitive processes and behavior. Both logically and empirically, there is of course some overlap between these approaches but it is true that ecological approaches emphasize the *What,* cognitive approaches the *How,* of information usage. We see no reason why either interest should not be scientifically legitimate and, in fact, see them as complementary in several ways. Yet, discussions between proponents of the two approaches are often dominated by the overarching idea that one approach must be more "correct" than the other (e.g., Meijer & Roth 1988; Weimer & Palermo 1974; 1982; Whiting 1984). The ecologically inspired commentaries on our target paper follow this tradition.

Galantucci et al. base their critical remarks on the observation that "in the tasks that support TEC, experimenters devise stimuli that can be described by sets of arbitrarily chosen, arbitrarily combined features (e.g., a letter is red or green; a rectangle is on the right or left side of a computer screen)," and they feel that "these sets are not up to the task of constituting percepts or action plans in nature." It appears that the validity of this description depends on how one conceives of "nature." TEC aims at accounting for how people master their daily life in and outside psychological labs in a world full of arbitrary combinations between features and between parameters of actions (see sect. R2.4). One may call this world "unnatural," and the perception-action codings it requires "unreal," but that does not save one from explaining how people can do rather well in perceiving and intentionally acting in it. In contrast to ecological models, TEC seems to be reasonably well prepared for such explaining. The remaining arguments of **Galantucci et al.** do not seem to contradict TEC: We neither assume that "percepts are . . . necessarily linear combinations of . . . features" (see sect. R2.4), nor find it unreasonable to assume that perception is in some sense "grounded" in action – an old idea explicitly endorsed in Hommel (1997; 1998a).

Kim & Effken criticize us for having "adopted the stimulus-response connection as . . . model for the perceiving-acting relation." If this were so, we would understand why Kim & Effken point out that "this model is fatally flawed" because "rarely is action interpretable as responses elicited by stimuli or in the presence of stimuli" and "neither is the perceiving-acting relation interpretable as a unidirectional effect of one upon the other." However, given that we took pains to reveal the *implausibility* of models based on stimulus-response connections (see sects. 2.1.1, 2.1.4, and 2.2.3.1 of our target article) and strongly argue *against* an uni-directional effect of stimuli on responses (a feature of TEC emphasized by **Proctor & Vu**), we find it very difficult to see where Kim & Effken are aiming at. Another issue they raise refers to the specification of future events. They feel that we "resort to cognitive representations of a common event code" because of our "incomplete understanding of ecological information." They then go on to point out that environmental information, such as time-to-contact (parameter tau), can specify the future state of affairs regarding both perception and action planning, so that resort to cognitive representations can be avoided. On the one hand, we agree with Kim & Effken that some aspects of sensorimotor coupling (the lower branch in Fig. 1) are likely to be controlled by the kind of information they have in mind. On the other hand, we have argued in section R2.2 that this kind of environmental control covers only a small part of what action control requires. Accordingly, as long as ecological approaches are unable to specify exactly *how* perceptual information, together with further disclosing "goals and effectivities," bring about actions such as preparing a cup of coffee, we find it not unreasonable to resort to such "mysterious or arcane explanatory devices" as codes in a human brain.

Richardson & Michaels have a somewhat more liberal attitude towards representations but they do not want them to be "mental" – a term that we did not find useful and, therefore, did not use. Instead, they ask for more consideration of the "specificational sense" of information and the codes it gives rise to, a theme also picked up by **Shaw & Wagman**. We agree with the general, in our view very healthy, ecological strategy of not complicating matters: if information is out there why not use it? But again, many aspects of our daily actions (even in long-jumping) cannot be specified by environmental information because this information is simply not "out there" (see sects. R2.2, R2.4). In contrast to ecological studies and models we do want to address the control of these aspects as well, which in the terminology of ecological psychology does require resort to "indicational information" as defined by Kelso and Kay (1987). Whether this makes TEC "void of explanatory power" should, in our view, be judged with respect to the empirical findings it correctly predicts, not by its fit with the aesthetical norms cultivated by a particular approach.

In contrast to the skeptical attitude one gathers from the ecologically motivated commentaries on TEC, we actually see no unsolvable problems in aligning our approach with recent developments in ecological theorizing. For instance, Warren (1998) suggests distinguishing between *model-based* and *information-based* control of action. The former is guided by representations that are informed by environmental states of affairs and frequently updated (i.e., by "event models" as defined by Stränger & Hommel 1996), but they can be used off-line to plan actions in the absence of suitable external information. The latter, in contrast, represents the type of on-line sensorimotor coupling that ecological accounts commonly focus on. Obviously, this distinction closely resembles Milner and Goodale's (1995) distinction of a perceptual and an action stream, and our own distinction between perception and action planning on the one hand, and sensorimotor processing on the other. Thus, we would think that sensorimotor processing streams can indeed be coupled to particular environmental variables (if present and sufficiently informative) by means of particular control laws or strategies (Fajen 2001); yet, it is the perception-action system addressed by TEC that is responsible, among other things, for selecting and implementing the most goal-satisfying strategy along the lines described elsewhere (Elsner & Hommel 2001; Hommel 1997; 1998a).

R3.4. Milner & Goodale's two-visual-pathways model

Pisella et al. and **Westwood & Goodale** felt uneasy about our treatment, or the lack of it, of Milner and Goodale's (1995) distinction of a ventral processing stream underlying conscious visual perception and a dorsal stream driving "the transformation of visual information into spatially calibrated motor outputs." On the one hand, it is difficult to provide a fair comparison of a general framework for perception and action planning such as TEC, and an approach dealing with only one sensory modality and a very limited set of motor responses, such as manual pointing, aspects of grasping, and orienting one's hand. Obviously, the aims of the two approaches are different and so are both their level of specificity and the type of phenomena they refer to. Accordingly, TEC will be of little help in explaining many results that support Milner and Goodale's two-stream model, and the two-stream model will often face insurmountable problems if it comes to phenomena that we brought forward to support TEC. On the other hand, however, there are several aspects of Milner and Goodale's (1995) approach that, in our view, fit rather nicely with the picture drawn by TEC. According to their model, the dorsal pathway is strictly on-line and, hence, provides motor systems with up-to-date details about the environmental circumstances and the movement-related characteristics of goal-relevant objects. Such a pathway seems a perfect complement to what we think are the main attributes of perception and action planning: its (potential) off-line character, selectivity, and dependency on knowledge.

Accordingly, we tend to think of Milner and Goodale's dorsal stream as the sensorimotor pathway sketched in Figure 1. In contrast, the ventral stream of their model seems to share several attributes with the perception-action system TEC proposes. It is assumed to work off-line, to mediate associate learning and make use of its results, and to make sure that the animal's behavior meets emotional needs and social requirements. These features would make the ventral stream a perfect candidate for mediating perception and action planning along the lines of TEC. The major difference between our conception and that of Milner and Goodale (1995) and **Westwood & Goodale** lies in the question of what should be called "action planning" and "action control" – apart from the, in our view, secondary question: which neural structures are associated with conscious experience. Indeed, we doubt that it is appropriate to equate the "transformation of visual information into spatially calibrated motor outputs" with either term, a view that **Pisella et al.** seem to share. Somewhere in the system it needs to be determined what is transformed into what, when it is transformed, and to what end the transformations are carried out, all processes of action planning proper. If we understand Milner and Goodale (1995, especially p. 202) correctly, they would not suspect these decisions to be made within the ventral stream. This brings them to the unfortunate situation of having to admit that the real planning of an action – the processes that precede and control the planned sensorimotor transformations – actually take place outside the stream they devote to action but within a stream they devote to perception, a position **Westwood & Goodale** seem to endorse.

Things get even more problematic if we think of delayed actions, or actions in the absence of visual information. In such cases, Milner and Goodale (1995, p. 171) claim, a "stored percept of the object" from the ventral stream is used to feed the dorsal pathway, which allows for less, but often sufficiently precise performance. Although this is a reasonable assumption to make, in our view it further undermines the seemingly clear-cut distinction between a perceptual and an action pathway. A more transparent conceptualization that keeps many of the virtues of Milner and Goodale's approach seems to us the distinction between an on-line sensorimotor-transformation channel on the one hand and an off-line perception-action channel on the other, as proposed by **Pisella et al.** and TEC.

R4. Concluding remarks

Thinking over our reply, we find ourselves in a somewhat ambiguous situation. At one level, we have defended the virtue of vagueness, but at the same time, at another level, we have offered a number of clarifications and specifications of what TEC is meant to be. This may be confusing at first glance, but actually we see no contradiction at all.

By emphasizing the importance of global, underspecified principles, we do not mean to say that the goal of science is underspecification – the less specified the better. In fact, we believe that science needs both weakly specified global principles and well-specified local theories in accordance with these principles. As regards global principles, we have two closing comments to offer (which, we believe, are of deep wisdom and thus cannot be contested . . .): *First,* everything is a matter of degree. In order to fulfill their heuristic functions, global frameworks need to be underspecified *to an appropriate degree.* To be sure, being somewhat vague can be productive, but being too vague will certainly be detrimental. *Second,* everything is a matter of time. A global framework like TEC is not made for eternity. It is tailored to speak to the present state-of-the-art in the field, and we believe that it can play an important heuristic role *for a while.* When this while is over, TEC is bound to

die and fall into oblivion. However, we are confident that by then promising theoretical and experimental offspring will be emerging from it.

NOTE

1. We acknowledge the precedence of both Freud's *Instincts and Their Vicissitudes* (1915) and Neisser's *Stimulus Information and Its Vicissitudes* (a term Neisser borrowed from Freud for his monograph "Cognitive psychology," 1967).

References

Letters "a" and "r" appearing before authors' initials refer to target article and response, respectively.

Abeles, M. (1991) *Corticonics: Neural circuits of the cerebral cortex.* Cambridge University Press. [aBH]

Ach, N. (1905) *Über die Willenstätigkeit und das Denken.* Vandenhoeck & Ruprecht. [aBH]

Adams, J. A. (1971) A closed-loop of motor learning. *Journal of Motor Behavior* 3:111–50. [aBH, AFS]

Albus, J. S. (1971) A theory of cerebellar function. *Mathematical Biosciences* 10:25–61. [PC]

Allport, D. A. (1987) Selection for action: Some behavioral and neurophysiological considerations of attention and action. In: *Perspectives on perception and action,* ed. H. Heuer & F. Sanders. Erlbaum. [aBH]

(1993) Attention and control: Have we been asking the wrong questions? A critical review of twenty-five years. In: *Attention and performance XIV,* ed. D. E. Meyer & S. Kornblum. MIT Press. [aBH]

Allport, D. A., Styles, E. A. & Hsieh, S. (1994) Shifting intentional set: Exploring the dynamic control of tasks. In: *Attention and performance XV,* ed. C. Umiltà & M. Moscovitch. MIT Press. [aBH, NM]

Allport, D. A., Tipper, S. P. & Chmiel, N. R. J. (1985) Perceptual integration and postcategorical filtering. In: *Attention and performance II,* ed. M. I. Posner & O. S. Marin. Erlbaum. [aBH]

Amazeen, E. & Turvey, M. T. (1996) Weight perception and the haptic size weight illusion are functions of the inertia tensor. *Journal of Experimental Psychology: Human Perception and Performance* 22:213–32. [MJR]

Andersen, R. A. (1988) The neurobiological basis of spatial cognition: Role of the parietal lobe. In: *Spatial cognition: Brain bases and development,* ed. J. Stiles-Davis, M. Kritchivsky & U. Belugi. Erlbaum. [aBH]

Anderson, J. R. (1993) *Rules of the mind.* Erlbaum. [aBH]

Arnoult, M. D. (1957) Stimulus predifferentiation: Some generalizations and hypotheses. *Psychological Bulletin* 54:339–50. [aBH]

Aschersleben, G. (2000a) Effects of training on the timing of simple repetitive movements. (submitted). [aBH]

(2000b) Knowledge of results and the timing of actions. (Paper No. 1/2000). Max-Planck-Institut für Psychologische Forschung. [aBH]

(in press) Temporal control of movements in sensorimotor synchronization. *Brain and Cognition.* [aBH]

Aschersleben, G., Gehrke, J. & Prinz, W. (2001) Tapping with peripheral nerve block: A role for tactile feedback in the timing of movements. *Experimental Brain Research* 136:331–39. [aBH]

(in press) A psychophysical approach to action timing. In: *Psychophysics beyond sensation: Laws and invariants in human cognition,* ed. C. Koernbach, E. Schröger & H. Müller. Erlbaum. [aBH]

Aschersleben, G. & Müsseler, J. (1999) Dissociations in the timing of stationary and moving stimuli. *Journal of Experimental Psychology: Human Perception and Performance* 25:1709–20. [aBH]

Aschersleben, G. & Prinz, W. (1995) Synchronizing actions with events: The role of sensory information. *Perception and Psychophysics* 57:305–17. [arBH]

(1997) Delayed auditory feedback in synchronization. *Journal of Motor Behavior* 29:35–46. [aBH]

Aschersleben, G., Stenneken, P., Cole, J. & Prinz, W. (2002) Timing mechanisms in sensorimotor synchronization. In: *Attention and performance XIX: Common mechanisms in perception and action,* ed. W. Prinz & B. Hommel. Oxford University Press. [aBH]

Atkeson, C. G. (1989) Learning arm kinematic and dynamics. *Annual Review of Neuroscience* 12:157–83. [DAR]

Atkinson, R. C. & Shiffrin, R. M. (1968) Human memory: A proposed system and its control processes. In: *The psychology of learning and motivation,* ed. K. W. Spence & J. D. Spence. Academic Press. [MOB]

Babcock, M. K. & Freyd, J. J. (1988) The perception of dynamic information in static handwritten forms. *American Journal of Psychology* 101:11–130. [aBH]

Ballard, D. H., Hayhoe, M. M., Pook, P. K. & Rao, R. P. N. (1997) Deictic codes for the embodiment of cognition. *Behavioral and Brain Sciences* 20(4):723–67. [DCR]

Bandura, A. (1977) *Social learning theory.* Prentice Hall. [aBH]

Bandura, A. & Walters, R. H. (1963) *Social learning and personality development.* Holt, Rinehart, & Winston. [aBH]

Bargh, J. A. (1996) Automaticity in social psychology. In: *Social psychology: Handbook of basic principles,* ed. E. T. Higgins & A. W. Kruglanski. Guilford Press. [aBH]

Bargh, J. A. & Barndollar, K. (1996) Automaticity in action: The unconscious as repository of chronic goals and motives. In: *The psychology of action: Linking cognition and motivation to behavior,* ed. P. M. Gollwitzer & J. A. Bargh. Guilford Press. [aBH]

Bargh, J. A. & Gollwitzer, P. M. (1994) Environmental control of goal-directed action: Automatic and strategic contingencies between situations and behavior. *Nebraska Symposium on Motivation* 41:71–124. [rBH]

Barker, R. G. (1963) The stream of behavior as an empirical problem. In: *The stream of behavior,* ed. R. G. Barker. Appleton. [aBH]

Barker, R. G. & Wright, H. F. (1954) *Midwest and its children: The psychological decay of an American town.* Row, Peterson. [JMZ]

Barsalou, L. W. (1999a) Perceptual symbol systems. *Behavioral and Brain Sciences* 22(4):577–660. [DCR]

(1999b) Language comprehension: Archival memory or preparation for situated action? *Discourse Processes* 28(1):61–80. [DCR]

Basso, D. & Bisiacchi, P. S. (1999) Il dilemma del commesso viaggiatore: Uno studio computerizzato. *A. I. P. Associazione Italiana di Psicologia, Congresso Nazionale della Sezione Psicologia Sperimentale, Capri Novantanove,* 155–57. A. I. P. (Associazione Italiana di Psicologia Press). [MOB]

Bechara, A., Damasio, H., Tranel, D. & Anderson, S. W. (1998) Dissociation of working memory from decision making within the human prefrontal cortex. *Journal of Neuroscience* 18:428–37. [PC]

Beck, J. (1982) Textural segmentation. In: *Organization and representation in perception,* ed. J. Beck. Erlbaum. [aBH]

Beckers, T. & De Houwer, J. (2000) Persistent integration of action-effect codes in the cognitive representation of actions: A conditioning perspective. Poster presented at Attention & Performance XIX, Kloster Isee, Germany. [rBH]

Bender, S., Müller, B., Oades, R. D. & Sartory, G. (2001) Conditioned blocking and schizophrenia: A replication and study of the role of symptoms, age, onset-age of psychosis and illness-duration. *Schizophrenia Research* 49:157–70. [RDO]

Bernstein, N. A. (1967) *The coordination and regulation of movements.* Pergamon Press. [N-GK]

Bock, J. K. (1986) Syntactic persistence in language production. *Cognitive Psychology* 18:355–87. [RJH]

(1996) Language production: Methods and methodologies. *Psychonomic Bulletin and Review* 3:395–421. [RJH]

Branigan, H. P., Pickering, M. J. & Clelland, A. A. (2000) Syntactic co-ordination in dialogue. *Cognition* 75:B1-B13. [RJH]

Brewer, B. (1993) The interpretation of spatial vision and action. In: *Spatial representation. Problems in philosophy and psychology,* ed. N. Eilan, R. McCarthy & B. Brewer. Blackwell. [aBH]

Bridgeman, B. (1983) Mechanisms of space constancy. In: *Spatially oriented behavior,* ed. A. Hein & M. Jeannerod. Springer. [aBH]

Bridgeman, B., Kirch, M. & Sperling, A. (1981) Segregation of cognitive and motor aspects of visual function using induced motion. *Perception and Psychophysics* 29:336–42. [aBH]

Broadbent, D. E. (1958) *Perception and communication.* Pergamon Press. [aBH, JI]

(1971) *Decision and stress.* Academic Press. [aBH]

(1993) A word before leaving. In: *Attention and performance XIV,* ed. D. E. Meyer & S. Kornblum. Erlbaum. [rBH]

Brooks, R. A. (1986) A robust layered control system for a mobile robot. *IEEE Journal of Robotics and Automation* RA-2:14–23. [JB]

Bruno, N. (2001) When does action resist visual illusions? *Trends in Cognitive Sciences* 5:379–82. [rBH]

Brunswik, E. (1944) Distal focussing of perception. Size constancy in a representative sample of situations. *Psychological Monographs* 56(1). [aBH]

Bryson, J. & Stein, L. A. (2001) Modularity and design in reactive intelligence. In: *Proceedings of the 17th International Joint Conference on Artificial Intelligence (IJCAI01), Seattle.* Morgan Kaufmann. [JB]

Buccino, G., Binkofski, F., Fink, G. R., Fadiga, L., Fogassi, L., Gallese, V., Seitz, R. J., Zilles, K., Rizzolatti, G. & Freund, H.-J. (2001) Action observation activates premotor and parietal areas in a somatotopic manner: An fMRI study. *European Journal of Neuroscience* 13(2):400–404. [TC]

Bundesen, C. (1990) A theory of visual attention. *Psychological Review* 97:523–47. [rBH]

Burnod, Y, Baraduc, P., Battaglia-Mayer, A., Guignon, E., Koechlin, E., Ferraina, S., Lacquaniti, F. & Caminiti, R. (1999) Parieto-frontal coding of reaching: An integrated framework. *Experimental Brain Research* 129:325–46. [SV]

Cadwallader, M. (1975) A behavioral model of consumer spatial decision making. *Economic Geography* 51:339–49. [MOB]

Caessens, B. & Vandierendonck, A. (2001) Inhibition and blindness to response compatible stimuli: A reappraisal. (submitted). [WK]

Caminiti, R., Ferraina, S. & Battaglia-Mayer, A. (1998) Visuomotor transformations: Early cortical mechanisms of reaching. *Current Opinion in Neurobiology* 8:753–61. [SV]

Campbell, B. A., Krauter, E. E. & Wallace, J. E. (1980) Animal models of aging: Sensory-motor and cognitive function in the aged rat. In: *The psychology of aging: Problems and perspectives,* ed. W. Stein. Elsevier/North Holland. [HRD]

Cantor, J. H. (1965) Transfer of stimulus pretraining to motor paired-associate and discrimination learning tasks. In: *Advances in child development and behavior, vol. 2,* ed. L. Lipsitt & C. C. Spiker. Academic Press. [aBH]

Carey, D. P. (2001) Do action systems resist visual illusion? *Trends in Cognitive Sciences* 5(3):109–113. [rBH]

Carlson, N. R. (2000) *Physiology of behavior.* Allyn and Bacon. [aBH]

Carpenter, R. H. S. (1988) *Movement of the eyes.* Pion. [aBH]

Carpenter, W. B. (1874) *Principles of mental physiology, with their applications to the training and discipline of the mind and the study of its morbid conditions.* Appleton. [aBH]

Chaminade, T., Meary, D., Orliaguet, J.-P. & Decety, J. (in press) Is perceptual anticipation a motor simulation? A PET study. *NeuroReport.* [TC]

Chaminade, T., Meltzoff, A. N. & Decety, J. (in press) Does the end justifies the means? A PET exploration of the mechanisms involved in imitation. *Neuroimage.* [TC]

Chase, W. G. & Simon, H. A. (1973) The mind's eye in chess. In: *Visual information processing,* ed. W. G. Chase. Academic Press. [PCRL]

Cheng, P. C.-H. (1996) Scientific discovery with law encoding diagrams. *Creativity Research Journal* 9:145–62. [PCRL]

(1998) A framework for scientific reasoning with law encoding diagrams: Analysing protocols to assess its utility. In: *Proceedings of the Twentieth Annual Meeting of the Cognitive Science Society,* pp. 232–35. Erlbaum. [PCRL]

Cheng, P. C.-H., McFadzean, J. & Copeland, L. (2001) Drawing on the temporal signature of induced perceptual chunks. In: *Proceedings of the Twenty-third Annual Meeting of the Cognitive Science Society, Edinburgh, UK,* pp. 200–205, ed. J. D. Moore & K. Stenning. Erlbaum. [PCRL]

Cherry, E. C. (1953) Some experiments on the recognition of speech, with one and with two ears. *Journal of the Acoustical Society of America* 25:975–79. [aBH]

Chown, E., Kaplan, S. & Kortenkamp, D. (1995) Prototypes, location, and associative networks (PLAN): Towards a unified theory of cognitive mapping. *Cognitive Science* 19:1–51. [EC]

Chur, L., Spengler, F., Jürgens, M. & Dinse, H. R. (1996) Environmental enrichment counteracts decline of sensorimotor performance and deterioration of cortical organization in aged rats. *Society for Neuroscience Abstracts* 22:102. [HRD]

Cisek, P. (1999) Beyond the computer metaphor: Behaviour as interaction. *Journal of Consciousness Studies* 6:125–42. [PC]

(in press) Embodiment is all in the head. *Behavioral and Brain Sciences.* [PC]

Clark, A. (1997) *Being there: Putting brain, body, and the world together again.* MIT Press. [DCR]

Cohen, C. E. & Ebbesen, E. B. (1979) Observational goals and schema activation: A theoretical framework for behavior perception. *Journal of Experimental Social Psychology* 15:305–29. [aBH]

Cohen, J. D., Braver, T. S. & O'Reilly, R. C. (1998) A computational approach to prefrontal cortex, cognitive control, and schizophrenia: Recent developments and current challenges. In: *The prefrontal cortex: Executive and cognitive functions,* ed. A. C. Roberts, T. W. Robbins & L. Weiskrantz. Oxford University Press. [rBH]

Cohen, J. D., Dunbar, K. & McClelland, J. L. (1990) On the control of automatic processes: A parallel distributed processing account of the Stroop effect. *Psychological Review* 97:332–61. [rBH]

Colby, C. L. (1998) Action-oriented spatial reference frames in the cortex. *Neuron* 20:15–24. [aBH]

Conditt, M. A., Gandolfo, F. & Mussa-Ivaldi, F. A. (1997) The motor system does not learn the dynamics of the arm by rote memorization of past experience. *Journal of Neurophysiology* 78:554–60. [DAR]

Constantinidis, C., Franowicz, M. N. & Goldman-Rakic, P. S. (2001) The sensory nature of mnemonic representation in the primate prefrontal cortex. *Nature Neuroscience* 4:311–16. [PC]

Conway, B. A., Halliday, D. M., Farmer, S. F., Shahani, U., Maas, P., Weir, A. I. & Rosenberg, J. R. (1995) Synchronization between motor cortex and spinal motoneural pool during the performance of a maintained motor task in man. *Journal of Physiology* 489:917–24. [aBH]

Corbetta, M., Akbudak, E., Conturo, T. E., Snyder, A. Z., Ollinger, J. M., Drury, H. A., Linenweber, M. R., Petersen, S. E., Raichle, M. E., Van-Essen, D. C. & Shulman, G. L. (1998) A common network of functional areas for attention and eye movements. *Neuron* 21(4):761–73. [JI]

Cowan, N. (2001) The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences* 24:87–186. [PCRL]

Cowey, A. (1985) Aspects of cortical organization related to selective attention and selective impairments of visual perception. In: *Attention and performance XI,* ed. M. I. Posner & O. S. M. Marin. Erlbaum. [aBH]

Craighero, L., Fadiga, L., Rizzolatti, G. & Umiltà, C. (1999) Movement for perception: A motor-visual attentional effect. *Journal of Experimental Psychology: Human Perception and Performance* 25(6):498–511. [rBH, WK, SV]

Craik, K. J. W. (1943) *The nature of explanation.* Cambridge University Press. [EC]

Cutting, J. E. & Proffitt, D. R. (1981) Gait perception as an example of how we may perceive events. In: *Intersensory perception and sensory integration,* ed. R. Walk & H. Pick. Plenum Press. [aBH]

Damasio, A. R. (1994) *Descartes' error.* Putnam. [rBH]

Davies, P. (1988) *The cosmic blueprint.* Simon & Schuster. [RES]

Decety, J. (in press) Is there such a thing as a functional equivalence between imagined, observed, and executed action? In: *The imitative mind: Development, evolution, and brain bases,* ed. A. N. Meltzoff & W. Prinz. Cambridge University Press. [aBH]

Decety, J., Chaminade, T., Grèzes, J. & Meltzoff, A. N. (in press) A PET exploration of the neural mechanisms involved in reciprocal imitation. *Neuroimage.* [TC]

Decety, J. & Grèzes, J. (1999) Neural mechanisms subserving the perception of human actions. *Trends in Cognitive Neuroscience* 3:172–78. [aBH]

Decety, J., Grèzes, J., Costes, N., Perani, D., Jeannerod, M., Procyk, E., Grassi, F. & Fazio, F. (1997) Brain activity during observation of actions: Influence of action content and subject's strategy. *Brain* 120(10):1763–77. [TC]

De Groot, A. D. & Gobet, F. (1996) *Perception and memory in chess: Heuristics of the professional eye.* Van Gorcum. [PCRL]

De Jong, R. (1993) Multiple bottlenecks in overlapping task performance. *Journal of Experimental Psychology: Human Perception and Performance* 19:965–80. [aBH]

(2000) An intention-activation account of residual switch costs. In: *Control of cognitive processes: Attention and performance XVIII,* ed. S. Monsell & J. Driver. MIT Press. [rBH]

De Jong, R., Liang, C-C. & Lauber, E. (1994) Conditional and unconditional automaticity: A dual-process model of effects of spatial, stimulus-response correspondence. *Journal of Experimental Psychology: Human Perception and Performance* 20:731–50. [aBH]

De Jong, R. & Sweet, J. B. (1994) Preparatory strategies in overlapping-task performance. *Perception and Psychophysics* 55:142–51. [aBH]

Della Malva, C. L., Stuss, D. T., D'Alton, J. & Willmer, J. (1993) Capture errors and sequencing after frontal brain lesion. *Neuropsychologia* 31(4):363–72. [MOB]

Derwort, A. (1938) Untersuchungen über Zeitverlauf figurierter Bewegungen bei Menschen. *Pflügers Archiv für die gesammte Physiologie* 240:261–75. [AFS]

Descartes, R. (1664) *L'homme.* Theodore Girard. [aBH]

Desimone, R. & Ungerleider, L. G. (1989) Neural mechanisms of visual processing in monkeys. In: *Handbook of neuopsychology, vol. 2,* ed. F. Boller & J. Grafman. Elsevier. [aBH]

Desmurget, M. & Grafton, S. T. (2000) Forward modelling allows feedback control for fast reaching movements. *Trends in Cognitive Sciences* 4(11):423–31. [LP]

Desmurget, M., Grea, H., Grethe, J. S., Prablanc, C., Alexander, G. E. & Grafton, S. T. (2001) Functional anatomy of nonvisual feedback loops during reaching: A positron emission tomography study. *Journal of Neuroscience* 21(8):2919–28. [LP]

Deubel, H. & Schneider, W. X. (1996) Saccade target selection and object recognition: Evidence for a common attentional mechanism. *Vision Research* 36(12):1827–37. [JI]

Deubel, H., Schneider, W. X. & Paprotta, I. (1998) Selective dorsal and ventral processing: Evidence for a common attentional mechanism in reaching and perception. *Visual Cognition* 5(1–2):81–107. [JI]

Deutsch, J. A. & Deutsch, D. (1963) Attention: Some theoretical considerations. *Psychological Review* 20: 80–90. [aBH]

Dewey, J. (1896) The reflex arc concept in psychology. *Psychological Review* 3:357–70. [aBH]

DeYoe, E. A. & Van Essen, D. C. (1988) Concurrent processing streams in monkey visual cortex. *Trends in Neuroscience* 11:219–26. [aBH]

Diedrichsen, J., Hazeltine, E., Kennerley, S. & Ivry, R. B. (in press) Moving to directly cued locations abolishes spatial interference during bimanual actions. *Psychological Science.* [JD]

Diedrichsen, J., Ivry, R. B., Cohen, A. & Danziger, S. (2000) Asymmetries in a unilateral flanker task depend on the direction of the response: The role of attentional shift and perceptual grouping. *Journal of Experimental Psychology: Human Perception and Performance* 26(1):113–26. [JD, rBH]

Dinse, H. R. (1994) A time-based approach towards cortical functions: Neural mechanisms underlying dynamic aspects of information processing before and after postontogenetic plastic processes. *Physica D* 75:129–50. [HRD]

(2001) The aging brain. In: *The neurosciences at the turn of the century. Proceedings of the Fourth Meeting of the German Neuroscience Society, vol. 1,* ed. N. Elsner & G. W. Kreutzberg. Thieme. [HRD]

Dinse, H. R. & Krüger, K. (1994) Timing of processing along the visual pathway in the cat. *NeuroReport* 5:893–97. [HRD]

Dinse, H. R. & Merzenich, M. M. (2001) Adaptation of inputs in the somatosensory system. In: *Perceptual learning,* ed. M. Fahle & T. Poggio. MIT Press. (in press). [HRD]

Dinse, H. R., Zepka, R. F., Jürgens, M., Godde, B., Hilger, H. & Berkefeld, T. (1995) Age-dependent changes of cortical and thalamic representations revealed by optical imaging and electrophysiological mapping techniques: Evidence for degenerative and use-disuse-dependent processes. *Homeostasis in Health and Disease* 36:S1, 49. [HRD]

Di Pellegrino, G., Fadiga, L., Fogassi, V., Gallese, V. & Rizzolatti, G. (1992a) Understanding motor events: A neurophysiological study. *Experimental Brain Research* 91:176–80. [aBH, CO]

Di Pellegrino, J. W., Klatzky, R. L. & McCloskey, B. P. (1992b) Time course of preshaping for functional responses to objects. *Journal of Motor Behaviour* 21:307–16. [aBH]

Domjan, M., Cusato, B. & Villareal, R. (2000) Pavlovian feed-forward in the control of social behavior. *Behavioral and Brain Sciences* 23:235–82. [MOB]

Donders, F. C. (1862) Über die Schnelligkeit psychischer Processe. *Archiv für Anatomie und Physiologie,* 657–81. [rBH]

(1868a/1969) Die Schnelligkeit psychischer Processe. *Reichert's und Dubois-Reymond's Archiv für Anatomie, Physiologie und Wissenschaftliche Medizin,* 657–81. (1969 English edition : On the speed of mental processes. *Acta Psychologica* 30:412–31.) [aBH]

(1868b) Over de snelheid van psychische processen. Onder-zoekingen gedaan in het physiologisch laboratorium van de Utrechtse Hoogeschool. *Tweede Reeks* 11:92–130. [AFS]

Dretske, F. I. (1981) *Knowledge and the flow of information.* MIT Press. [aBH, RGM]

(1986) Misrepresentation. In: *Belief: Form, content, and function,* ed. R. Bogdan. Oxford University Press. [RGM]

(1988) *Explaining behavior.* MIT Press. [RGM]

(1995) *Naturalizing the mind.* MIT Press. [RGM]

Duhamel, J.-R., Colby, C. L. & Goldberg, M. E. (1992) The updating of the representation of visual space in parietal cortex by intended eye movements. *Science* 255:90–92. [PC]

Duncan, J. (1993) Selection and input and goal in the control of behavior. In: *Selection, awareness, and control,* ed. A. Baddeley & L. Weiskrantz. Clarendon Press. [rBH]

Duncan, J. & Humphreys, G. W. (1989) Visual search and stimulus similarity. *Psychological Review* 96:433–58. [rBH, WK, LP]

(1992) Beyond the search surface: Visual search and attentional engagement. *Journal of Experimental Psychology: Human Perception and Performance* 18:578–88. [LP]

Eckhorn, R., Frien, A., Bauer, R., Woelbern, T. & Kehr, H. (1993) High frequency (60–90Hz) oscillations in primary visual cortex of awake monkey. *NeuroReport* 4:243–46. [aBH]

Edelman, G. M. (1996) *Bright air, brilliant fire.* Basic Books. [RES]

Egeth, H. E. (1966) Parallel vs. serial processes in multidimensional stimulus discrimination. *Perception and Psychophysics* 1:245–52. [aBH]

Ehrenstein, W. H. (1994) The Simon effect and visual motion. *Psychological Research* 56:163–69. [aBH]

Ellis, R. & Tucker, M. (2000) Micro-affordances: The potentiation of components of action by seen objects. *British Journal of Psychology* 91(4):451–71. [TC]

Elsner, B. (2000) *Der Erwerb kognitiver Handlungsrepräsentationen.* Wissenschaftlicher Verlag. [aBH]

Elsner, B. & Hommel, B. (2000) Effect anticipation and action control. *Journal of Experimental Psychology: Human Perception and Performance* 27:229–40. [arBH]

Engel, A. K., König, P., Kreiter, A. K. & Singer, W. (1991) Interhemispheric synchronization of oscillatory neuronal responses in cat visual cortex. *Science* 252:1177–79. [aBH]

Enright, S. J. & Beech, A. R. (1993) Further evidence of reduced cognitive inhibition in obsessive-compulsive disorder. *Personality and Individual Differences* 14:387–95. [RDO]

Epstein, W. (1973) The process of "taking-into-account" in visual perception. *Perception* 2:267–85. [aBH]

Eskander, E. N. & Assad, J. A. (1999) Dissociation of visual, motor and predictive signals in parietal cortex during visual guidance. *Nature Neuroscience* 2:88–93. [PC]

Fabre-Thorpe, M., Delorme, A., Marlot, C. & Thorpe, S. (2001) A limit to the speed of processing in ultra-rapid categorization of novel natural scenes. Journal of *Cognitive Neuroscience* 13(2):171–80. [MOB]

Fadiga, L., Fogassi, L., Gallese, G. & Rizzolatti, G. (2000) Visuomotor neurons: Ambiguity of the discharge or "motor" perception? *International Journal of Psychophysiology* 35:165–77. [PC, aBH]

Fadiga, L., Fogassi, L., Pavesi, G. & Rizzolatti, G. (1995) Motor facilitation during action observation: A magnetic stimulation study. *Journal of Neurophysiology* 73:2608–11. [aBH]

Fagot, C. (1994) *Chronometric investigations of task switching.* Ph. D. thesis, University of California, San Diego. [NM]

Fahen, B. R. (2001) Steering towards a goal by equalizing taus. *Journal of Experimental Psychology: Human Perception and Performance* 27:229–40. [rBH]

Fehrer, E. & Raab, E. (1962) Reaction time to stimuli masked by metacontrast. *Journal of Experimental Psychology* 63:143–47. [aBH]

Feigenbaum, E. A. & Simon, H. A. (1984) EPAM-like models of recognition and learning. *Cognitive Science* 8:305–36. [PCRL]

Felleman, D. J. & Van Essen, D. C. (1991) Distributed hierarchical processing in the primate cerebral cortex. *Cerebral Cortex* 1:1–47. [HRD]

Ferlazzo, F., Padovani, T., Couyoumdijan, A. & Olivetti Belardinelli, M. (2001) Head-centered meridian effect on auditory spatial attention orienting. *The Quarterly Journal of Experimental Psychology: A.* (in press). [MOB]

Ferraro, F. R., Jones, D. & McManus, G. (1996) Relationship of Maudsley obsessive-compulsive inventory and negative priming: Some preliminary evidence. *Brain and Cognition* 32:284–85. [RDO]

Fischer, M. H. (1999) An investigation of attention allocation during sequential eye movement tasks. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology* 52A(3):649–77. [JI]

Fitts, P. M. & Seeger, C. M. (1953) S-R compatibility: Spatial characteristics of stimulus and response codes. *Journal of Experimental Psychology* 46:199–210. [aBH, RWP]

Folk, C. L., Remington, R. W. & Johnston, J. C. (1992) Involuntary covert orienting is contingent on attentional control settings. *Journal of Experimental Psychology: Human Perception and Performance* 18(4):1030–44. [rBH, JI]

Fowler, C. A. & Turvey, M. T. (1982) Observational perspective and descriptive level in perceiving and acting. In: *Cognition and the symbolic processes, vol. II,* ed. W. B. Weimer & D. S. Palermo. Erlbaum. [aBH]

Fox, E. (1995) Negative priming form ignored distractors in visual selection: A review. *Psychonomic Bulletin and Review* 2:145–73. [aBH]

Fraisse, P. (1980) Les synchronisations sensori-motrices aux rythmes [The sensorimotor synchronization of rhythms]. In: *Anticipation et comportement,* ed. J. Requin. Centre National. [aBH]

Freeman, A. & Oster, G. L. (1998) Cognitive therapy and depression. In: *International handbook of cognitive and behavioral treatments for psychological disorders,* ed. V. E. Caballo. Pergamon/Elsevier. [MOB]

Freud, S. (1915/1956) Instincts and their vissicitudes. In: *Collected papers of Sigmund Freud. Vol. IV.* Hogarth Press. (1956 edition). [rBH]

Freyd, J. J. (1987) Dynamic mental representations. *Psychological Review* 94:427–38. [aBH]

Frith, C. D. (1992) *The cognitive neuropsychology of schizophrenia.* Erlbaum. [RDO]

Frith, C. D., Blakemore, S.-J. & Wolpert, D. (2000) Abnormalities in the awareness and control of action. *Philosophical Transactions of the Royal Society of London B* 355:1771–88. [LP]

Fuster, J. M. (2000) Prefrontal neurons in networks of executive memory. *Brain Research Bulletin* 52:331–36. [PC]

Gallese, V., Fadiga, L., Fogassi, L. & Rizzolatti, G. (1996) Action recognition in the premotor cortex. *Brain* 119:593–609. [aBH, RDO]

(2002) Action representation and the inferior parietal lobule. In: *Attention and performance, vol. XIX: Common mechanisms in perception and action,* ed. W. Prinz & B. Hommel. Oxford University Press. [rBH]

Gallistel, C. R. (1990) *The organization of learning.* MIT Press. [JH]

Garrett, M. F. (2000) Remarks on the architecture of language processing systems. In: *Language and brain,* ed. Y. Grodzinsky, L. Shapiro & D. Swinney. Academic Press. [RJH]

Gehrke, J. (1995) *Sensorimotor synchronization: The intensity of afferent feedback affects the timing of movements* (Paper 15/1995). Max Planck Institute for Psychological Research. [aBH]

(1996) Afferente Informationsverarbeitung und die Synchronisation von Ereignissen [Processing of afferent information and the synchronization of events]. Unpublished dissertation, Munich, Germany. [aBH]

Gehrke, J. & Hommel, B. (1998) The impact of exogenous factors on spatial coding in perception and memory. In: *Spatial cognition: An interdisciplinary*

approach to representing and processing spatial knowledge, ed. C. Freksa, C. Habel & K. F. Wender. Springer. [rBH]
Gewirtz, J. L. & Stingle, K. G. (1968) Learning of generalized imitation as the basis for identification. *Psychological Review* 75:374–97. [aBH]
Gibson, E. J. (1969) *Principles of perceptual learning and development.* Prentice-Hall. [aBH, AFS]
(1977) The theory of affordances. In: *Perceiving, acting, and knowing,* ed. R. E. Shaw & J. Bransford. Erlbaum. [aBH, AFS]
Gibson, E. J. & Levin, H. (1975) *The psychology of reading.* MIT Press. [AFS]
Gibson, J. J. (1950) *The perception of the visual world.* Houghton Mifflin. [aBH, N-GK]
(1966) *The senses considered as perceptual systems.* Houghton Mifflin. [arBH, N-GK, MJR, RES]
(1979) *The ecological approach to visual perception.* Houghton Mifflin. [JH, arBH, N-GK, MJR, RES]
Gibson, J. J. & Gibson, E. J. (1955) Perceptual learning: Differentiation or enrichment? *Psychological Reviews* 62:32–41. [aBH]
Glenberg, A. (1997) What memory is for. *Behavioral and Brain Sciences* 20(1):1–55. [DCR]
Gobet, F., Lane, P. C. R., Croker, S. J., Cheng, P. C.-H., Jones, G., Oliver, I. & Pine, J. M. (2001) Chunking mechanisms in human learning. *Trends in Cognitive Science* 5:236–43. [PCRL]
Gobet, F. & Jansen, P. (1994) Towards a chess program based on a model of human memory. In: *Advances in computer chess,* ed. H. J. van den Herik, I. S. Herschberg & J. W. Uiterwijk. University of Linburgh Press. [PCRL]
Gobet, F. & Simon, H. A. (2000) Five seconds or sixty? Presentation time in expert memory. *Cognitive Science* 24:651–82. [PCRL]
Godde, B., Spengler, G. & Dinse, H. R. (1996) Associative pairing of tactile stimulation induces somatosensory cortical reorganization in rats and humans. *NeuroReport* 8:281–85. [HRD]
Godde, B., Stauffenberg, B., Spengler, F. & Dinse, H. R. (2000) Tactile coactivation induced changes in spatial discrimination performance. *Journal of Neuroscience* 20:1597–604. [HRD]
Gollwitzer, P. M. (1996) The volitional benefits of planning. In: *The psychology of action: Linking cognition and motivation to behavior,* ed. P. M. Gollwitzer & J. A. Bargh. Guilford Press. [aBH]
Goodale, M. A. (1997) Visual routes to perception and action in the cerebral cortex. In: *Handbook of neuropsychology, vol. 11, section 16: Action and cognition,* ed. M. Jeannerod. Series editors: F. Boller & J. Grafman. Elsevier. [SV]
(1998) Visuomotor control: Where does vision end and action begin? *Current Biology* 8:489–91. [DAW]
Goodale, M., Pélisson, D. & Prablanc, C. (1986) Large adjustments in visually guided reaching do not depend on vision of the hand or perception of target displacement. *Nature* 320:748–50. [rBH]
Goodwin, B. (1994) *How the leopard changed its spots: The evolution of complexity.* Charles Scribner's. [RES]
Gopher, D. & Sanders, A. F. (1984) S-Oh-R: Oh stages! Oh resources! In: *Cognition and motor behavior,* ed. W. Prinz & A. F. Sanders. Springer. [AFS]
Gordon, P. C. (1990) Perceptual motor processing in speech. Stimulus-response compatibility: An integrated perspective. In: *Stimulus-response compatibility: An integrated perspective,* ed. R. W. Proctor & T. G. Reeve. North-Holland. [aBH]
Gordon, R. D. & Irwin, D. E. (1996) What's in an object file? Evidence from priming studies. *Perception and Psychophysics* 58:1260–77. [aBH]
(1998) Eye movements, attention and trans-saccadic memory. *Visual Cognition* 5:127–55. [aBH]
(2000) The role of physical and conceptual properties in preserving object continuity. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 26:136–50. [aBH]
Gould, S. J. & Lewontin, R. C. (1979) The spandrels of San Marco and the Panglossian paradigm: A critique of the adaptationist programme. *Proceedings of the Royal Society of London B* 205:581–98. [RES]
Grafton, S. T., Arbib, M. A., Fadiga, L. & Rizzolatti, G. (1996) Localization of grasp representations in humans by positrone emission tomography. 2. Observation compared with imagination. *Experimental Brain Research* 112:103–11. [aBH]
Gray, C. M., Engel, A. K., Koenig, P. & Singer, W. (1992) Synchronization of oscillatory neuronal responses in cat striate cortex: Temporal properties. *Visual Neuroscience* 8(4):337–47. [aBH]
Graziano, M. S. A. & Gandhi, S. (2000) Location of the polysensory zone in the precentral gyrus of anesthetized monkeys. *Experimental Brain Research* 135(2):259–66. [JB]
Graziano, M. S. A., Taylor, C. S. R. & Moore, T. (2001) Brain mechanisms for monitoring and controlling the body. (personal communication). [JB]
Greene, P. H. (1982) Why is it easy to control your arms? *Journal of Motor Behavior* 14:260–86. [aBH]
(1988) The organization of natural movement. *Journal of Motor Behavior* 20:180–85. [aBH]
Greenwald, A. G. (1970) Sensory feedback mechanisms in performance control: With special reference to the ideomotor mechanism. *Psychological Review* 77:73–99. [aBH, AFS]
(1972) On doing two things at once: Time sharing as a function of ideomotor compatibility. *Journal of Experimental Psychology* 94:52–57. [aBH]
Greenwald, A. G. & Shulman, H. G. (1973) On doing two things at once: II. Elimination of the psychological refractory period effect. *Journal of Experimental Psychology* 101(1):70–76. [WK]
Grèzes, J. & Decety, J. (2001) Functional anatomy of execution, mental simulation, observation and verb generation of actions: A meta-analysis. *Human Brain Mapping* 12(1):1–19. [TC]
(2002) Does visual perception of objects afford action. Evidence from a neuroimaging study. *Neuropsychologia* 40:212–22. [TC]
Grossberg, S. (1969) On learning of spatiotemporal patterns by networks with ordered sensory and motor components. I. Excitatory components of the cerebellum. *Studies in Applied Mathematics* 48:105–32. [PC]
Grossberg, S. & Kuperstein, M. (1989) *Neural dynamics of adaptive sensory-motor control: Expanded edition.* Pergamon Press. [aBH]
Guiard, Y. (1983) The lateral coding of rotations: A study of the Simon effect with wheel-rotation responses. *Journal of Motor Behavior* 15:331–42. [aBH]
Gurney, K., Prescott, T. J. & Redgrave, P. (1998) The basal ganglia viewed as an action selection device. In: *The Proceedings of the International Conference on Artificial Neural Networks, Skovde, Sweden.* [JB]
Haber, R. N. (1969) Introduction. In: *Information-processing approaches to visual perception,* ed. R. N. Haber. Holt, Rinehart, & Winston. [aBH]
Haig, A. R., Gordon, E., De Pascalis, V., Meares, R. A., Bahramali, H. & Harris, A. (2000) Gamma activity in schizophrenia: Evidence of impaired network binding? *Clinical Neurophysiology* 111:1461–68. [RDO]
Hall, G. (1991) *Perceptual learning and associative learning.* Clarendon Press. [aBH]
Harless, E. (1861) Der Apparat des Willens. *Zeitschrift für Philosophie und philosophische Kritik* 38:50–73. [rBH]
Hartston, H. J. & Swerdlow, N. R. (1999) Visiospatial priming and Stroop performance in patients with obsessive-compulsive disorder. *Neuropsychology* 13:447–57. [RDO]
Hartsuiker, R. J. & Kolk, H. H. J. (2001) Error monitoring in speech production: A computational test of the perceptual loop theory. *Cognitive Psychology* 42:113–57. [RJH]
Hayes-Roth, B. & Hayes-Roth, F. (1979) A cognitive model of planning. *Cognitive Science* 3:275–310. [MOB]
Hazeltine, E., Diedrichsen, J., Kennerley, S. & Ivry, R. B. (in preparation) Bimanual interference during reaching movements is primarily related to response selection, not the specification of motor parameters. [JD]
Hebb, D. O. (1949) *The organization of behavior.* Wiley. [EC]
Hecht, H., Vogt, S. & Prinz, W. (2001) Motor learning enhances perceptual judgement: A case for action-perception transfer. *Psychological Research/Psychologische* Forschung 65:3–14. [SV]
Heider, F. (1926/1959) Thing and medium. *Psychological Issues* 1959, Monograph 3. (Original work published in 1926). [aBH]
(1930/1959) The function of the perceptual system. *Psychological Issues* 1959, Monograph 371–394. (Original work published 1930). [aBH]
Heister, G., Ehrenstein, W. H. & Schroeder-Heister, P. (1986) Spatial S-R compatibility effects with unimanual two-finger choice reactions for prone and supine hand positions. *Perception and Psychophysics* 40:271–78. [aBH]
(1987) Spatial S-R compatibility with unimanual two-finger choice reactions: Effects of irrelevant stimulus location. *Perception and Psychophysics* 42:195–201. [aBH]
Helmholtz, H. von. (1909) *Handbuch der Physiologischen Optik,* (third edition). Voss. [aBH]
Henderson, J. M. (1994) Two representational systems in dynamic visual identification. *Journal of Experimental Psychology: General* 123:410–26. [aBH]
Henderson, J. M. & Anes, M. D. (1994) Roles of object-file review and type priming in visual identification within and across eye-fixations. *Journal of Experimental Psychology: Human Perception and Performance* 20:826–39. [aBH]
Heptulla-Chatterjee, S., Freyd, J. J. & Shffrar, M. (1996) Configural processing in the perception of apparent biological motion. *Journal of Experimental Performance: Human Perception and Performance* 22:916–29. [aBH]
Hershberger, W. A., ed. (1989) *Volitional actions: Conation and control.* North-Holland. [aBH]
Heuer, H. (1993) Structural constraints on bimanual movements. *Psychological Research/Psychologische Forschung* 55(2):83–98. [JD]
Hick, W. E. (1952) On the rate of gain of information. *Quarterly Journal of Experimental Psychology* 4:11–26. [aBH, RWP]

Hinde, R. A. (1966) *Animal behaviour: A synthesis of ethology and comparative psychology.* McGraw-Hill. [PC]
Hochberg, J. E. (1968) In the mind's eye. In: *Contemporary theory and research in visual perception,* ed. R. N. Haber. Holt, Rinehart & Winston. [JH]
(1970) Attention, organization and consciousness. In: *Attention: Contemporary theory and analysis,* ed. D. J. Mostofscky. Appleton-Century-Crofts. [JH]
(1978) *Perception, 2nd edition.* Prentice-Hall. [aBH]
(1997) The affordances of perceptual inquiry: Pictures are learned from the world, and what that fact might mean about perception quite generally. *The Psychology of Learning and Motivation* 36:15–44. [JH]
Hochberg, J. E. & Brooks, V. (1996) The perceptin of motion pictures. In: *Handbook of perception and cognition: Cognitive ecology,* ed. M. Friedman & E. Carterette. Academic Press. [JH]
Hoffman, J. (1993) *Vorhersage und Erkenntnis. Die Funktion von Antizipationen in der menschlichen Verhaltenssteuerung* [*Prediction and knowledge. The function of anticipation for human action control*]. Hogrefe. [aBH, WK]
Hoffman, J. & Sebald, A. (2000) Lernmechanismen zum Erwerb verhaltenssteuernden Wissens. [Learning mechanisms for the acquisition of action-controlling knowledge]. *Psychologische Rundschau* 51:1–9. [WK]
Hommel, B. (1993) Inverting the Simon effect by intention: Determinants of direction and extent of effects of irrelevant spatial information. *Psychological Research/Psychologische Forschung* 55:270–79. [aBH]
(1996a) The cognitive representation of action: Automatic integration of perceived action effects. *Psychological Research/Psychologische Forschung* 59:176–86. [aBH]
(1996b) S-R compatibility effects without response uncertainty. *Quarterly Journal of Experimental Psychology* 49A:546–71. [aBH]
(1997) Toward an action concept model of stimulus-response compatibility. In: *Theoretical issues in stimulus-response compatibility,* ed. B. Hommel & W. Prinz. North-Holland. [arBH]
(1998a) Observing one's own action – and what it leads to. In: *Systems theory and a priori aspects of perception,* ed. J. S. Jordan. North-Holland. [arBH]
(1998b) Event files: Evidence for automatic integration of stimulus-response episodes. *Visual Cognition* 5:183–216. [aBH, JI, RWP]
(1998c) Automatic stimulus-response translation in dual-task performance. *Journal of Experimental Psychology: Human Perception and Performance* 24:1368–84. [rBH]
(2001a) The prepared reflex: Automaticity and control in stimulus-response
(2001b) Intentional control of automatic stimulus-response translation. In: *Interaction between dissociable conscious and nonconscious processes,* ed. Y Rossetti & A. Revonsuo. MIT Press. [aBH]
Hommel, B. & Eglau, B. (in press) Control of stimulus-response translation in dual-task performance. *Psychological Research.* [rBH]
Hommel, B., Gehrke, J. & Knuf, L. (2000a) Hierarchical coding in the perception and memory of spatial layouts. *Psychological Research* 64:1–10. [rBH]
Hommel, B. & Knuf, L. (2000) Action related determinants of spatial coding in perception and memory. In: *Spatial cognition II: Integrating abstract theories, empirical studies, formal methods, and practical applications,* ed. C. Freska, W. Brauer, C. Habel & K. F. Wender. Springer. [rBH]
Hommel, B., Knuf, L. & Gehrke, J. (2001) Action-induced cognitive organization of spatial maps. (submitted). [rBH]
Hommel, B., Pösse, B. & Waszak, F. (2000b) Contextualization in perception and action. *Psychologica Belgica* 40:227–45. [rBH, WK]
Hommel, B. & Prinz, W., eds. (1997) *Theoretical issues in stimulus-response compatibility.* North-Holland. [aBH]
Hommel, B. & Schneider, W. X. (in press) Visual attention and the selection of manual responses: Distinct mechanisms operating on the same codes. *Visual Cognition.* [JD, arBH, WK]
Houghton, G. & Hartley, T. (1995) Parallel models of serial behavior: Lashley revisited. *PSYCHE* 2(25). http://psyche.cs.monash.edu.au/ [JB]
Howard, I. P. (1982) *Human visual orientation.* Wiley. [aBH]
Howard, I. P. & Templeton, W. B. (1966) *Human spatial orientation.* Wiley. [aBH]
Hull, C. L. (1952) *A behavior system: An introduction to behavior theory concerning the individual organism.* Yale University Press. [aBH]
Hyman, R. (1953) Stimulus information as a determinant of reaction time. *Journal of Experimental Psychology* 45:188–96. [RWP]
Iacoboni, M., Woods, R. P., Brass, M., Bekkering, H., Mazziotta, , J. C. & Rizzolatti, G. (1999) Cortical mechanisms of human imitation. *Science* 286(5449):2526–28. [TC]
Imamizu, H., Miyauchi, S., Tamada, T., Sasaki, Y., Takino, R., Putz, B., Yoshioko, T. & Kawato, M. (2000) Human cerebellar activity reflecting an acquired internal model of a new tool. *Nature* 403(6766):192–95. [LP]
James, W. (1890/1981) *The principles of psychology.* Macmillan/Harvard University Press. (Original work published 1890). [arBH, WK]
Jeannerod, M. (1983) How do we direct our actions in space? *In: Spatially oriented behavior,* ed. A. Hein & M. Jeannerod. Springer. [aBH]
(1984) The contribution of open-loop and closed-loop control modes in prehension movements. In: *Prepatory states and processes: Proceedings of the Franco-American conference,* ed. S. Kornblum & J. Requin. Erlbaum. [rBH]
(1988) *The neural and behavioural organization of goal-directed movements.* Oxford University Press. [aBH]
(1990) The representation of the goal of an action and its role in the control of goal-directed movements. In: *Computational neuroscience,* ed. E. L. Schwartz. MIT Press. [aBH]
(1997) *The cognitive neuroscience of action.* Blackwell. [aBH, SV]
(1999) To act or not to act: Perspectives on the representation of actions (The 25th Bartlett Lecture). *Quarterly Journal of Experimental Psychology* 52:1–29. [aBH]
(2001) Neural simulation of action: A unifying mechanism for motor cognition. *Neuroimage* 14(1):S103-S109. [TC]
Jeannerod, M., Arbib, M. A., Rizzolatti, G. & Sakata, H. (1995) Grasping objects: The cortical mechanisms of visuomotor transformation. *Trends in Neurosciences* 18:314–20. [SV]
Jellema, T. & Perrett, D. I. (2002) Coding of visible and hidden actions. In: *Attention and performance, vol. XIX: Common mechanisms in perception and action,* ed. W. Prinz & B. Hommel. Oxford University Press. [rBH]
Johansson, G. (1950) *Configurations in event perception.* Almquist and Wiksells. [aBH]
(1973) Visual perception of biological motion and a model for its analysis. *Perception and Psychophysics* 14:201–11. [aBH]
Jordan J. S., Kerzel, D., Stork, S., Knuf, L. & Müsseler, J. (2002) Action planning affects spatial localization. In: *Attention and performance XIX: Common mechanisms in perception and action,* ed. W. Prinz & B. Hommel. Oxford University Press. [JSJ]
Jürgens, M. & Dinse, H. R. (1997a) Use-dependent plasticity of SI cortical hindpaw neurons induced by modification of walking in adult rats: A model for age related alterations. *Society for Neuroscience Abstracts* 23:1800. [HRD]
(1997b) Differential effects of the Ca^{2+}-influxblocker nimodipine on receptive field properties and response latencies of somatosensory cortical neurons in aged rats. *Institut für Neuroinformatik, Ruhr-Universität Bochum, Internal Report* 97–10:1–23. [HRD]
Jusczyk, P. (1986) Speech perception. In: *Handbook of perception and human performance. Vol. 2: Cognitive processes and performance,* ed. K. R. Boff, L. Kaufman & J. P. Thomas. Wiley. [BG, aBH]
Kadar, E. & Shaw, R. E. (2000) Toward an ecological field theory of perceptual control of information. *Ecological Psychology* 12(2):141–80. [RES]
Kaelbling, L. P., Littman, M. L. & Moore, A. W. (1996) Reinforcement learning: A survey. *Journal of Artifical Intelligence Research* 4:237–85. [EC]
Kahneman, D. (1973) *Attention and effort.* Prentice Hall. [aBH]
Kahneman, D. & Treisman, A. M. (1984) Changing view of attention and automaticity. In: *Varieties of attention,* ed. R. Parasuraman, R. Davies & J. Beatty. Academic Press. [aBH]
Kahneman, D., Treisman, A. & Gibbs, B. (1992) The reviewing of object files: Object-specific integration of information. *Cognitive Psychology* 24:175–219. [aBH, JI, RDO]
Kalaska, J. F., Scott, S. H., Cisek, P. & Sergio, L. E. (1997) Cortical control of reaching movements. *Current Opinion in Neurobiology* 7:849–59. [PC]
Kalaska, J. F., Sergio, L. E. & Cisek, P. (1998) Cortical control of whole-arm motor tasks. In: *Sensory guidance of movement, Novartis Foundation Symposium No. 218,* ed. M. Glickstein. Wiley. [PC]
Kandel, S., Orliaguet, J.-P. & Boë, L.-J. (1995) Visual perception of motor anticipation in handwriting: Influence of letter size and movement velocity. In: *Studies on perceptiona and action, vol. III,* ed. B. G. Bardy, R. J. Bootsma & Y. Guiard. Erlbaum. [aBH]
(2000) Detecting anticipatory events in handwriting movements. *Perception* 29(8):953–64. [TC]
Kaplan, S., Weaver, M. & French, R. (1990) Active symbols and internal models: Towards a cognitive connectionism. *AI and Society* 4:51–71. [EC]
Katz, D. (1960) Sozialpsychologie. In: *Handbuch der Psychologie,* 2nd edition, ed. D. Katz & R. Katz. Schwabe. [aBH]
Keele, S. W. (1968) Movement control in skilled motor performance. *Psychological Bulletin* 70:387–403. [aBH]
Keele, S. W., Cohen, A. & Ivry, R. (1990) Motor programs: Concepts and issues. In: *Motor representation and control. Attention and performance XIII,* ed. M. Jeannerod. Erlbaum. [aBH]
Kelso, J. A. S. (1995) *Dynamic patterns: The self organization of brain as behavior.* MIT Press. [RES]
Kelso, J. A. S. & Kay, B. A. (1987) Information and control: A macroscopic analysis of perception-action coupling. In: *Perspectives on perception and action,* ed. H. Heuer & A. F. Sanders. Erlbaum. [rBH]
Kerzel, D., Jordan, J. S. & Müsseler, J. (2001) The role of perceptual anticipation in the localization of the final position of a moving target. *Journal of Experimental Psychology: Human Perception and Performance* 27(4):829–40. [JSJ]

Kim, J.-N. & Shadlen, M. N. (1999) Neural correlates of a decision in the dorsolateral prefrontal cortex of the macaque. *Nature Neuroscience* 2:176–85. [PC]

Kim, N.-G. & Effken, J. A. (1995) How the future is specified: A hypothesis. In: *Studies in perception and action III,* ed. B. G. Bardy, R. J. Bootsma & Y. Guiard. Erlbaum. [N-GK]

Kim, N.-G., Effken, J. A. & Carello, C. (1998) Perceiving the severity of contacts between two objects. *Ecological Psychology* 10:93–127. [N-GK]

Kim, N.-G., Effken, J. A. & Shaw, R. (1995) Perceiving persistence under change and over structure. *Ecological Psychology* 7:217–56. [N-GK]

Kim, N.-G. & Turvey, M. T. (1998) Optical flow fields and Bernstein's "modeling of the future." In: *Progress in motor control,* ed. M. L. Latash. Human Kinetics. [N-GK]

Kim, N.-G., Turvey, M. T. & Carello, C. (1993) Optical information about the severity of upcoming contacts. *Journal of Experimental Psychology: Human Perception and Performance* 19:179–93. [N-GK]

Kinsbourne, M. (1982) Hemispheric specialization and the growth of human understanding. *American Psychologist* 37(4):411–20. [EC]

Klatzky, R. L., Pellegrino, J., McCloskey, B. P. & Doherty, S. (1989) Can you squeeze a tomato? The role of motor representations in semantic sensibility judgments. *Journal of Memory and Language* 28:56–77. [aBH]

Klein, R. M. (1980) Does oculomotor readiness mediate cognitive control of visual attention? In: *Attention and performance, vol. VIII,* ed. R. S. Nickerson. Erlbaum. [arBH, JI]

Klein, R. M. & Pontefract, A. (1994) Does oculomotor readiness mediate cognitive control of visual attention? Revisited! In: *Attention and performance XV: Conscious and nonconscious information processing,* ed. C. Umiltà & M. Moscovitch. MIT Press. [rBH, JI]

Klotz, W. & Neumann, O. (1999) Motor activation without conscious discrimination in metacontrast masking. *Journal of Experimental Psychology: Human Perception and Performance* 25:976–92. [rBH]

Knuf, L. (1997) Ideomotorische Phänomene: Neue Fakten für ein altes Problem. Entwicklung eines Paradigmas zur kinematischen Analyse induzierter Mitbewegungen. Unpublished doctoral dissertation, University of Munich, Germany. [aBH]

Knuf, L., Aschersleben, G. & Prinz, W. (2000) An analysis of ideomotor action. *Journal of Experimental Psychology: General* 130:779–98. [aBH]

Koenderink, J. J. (1990) The brain, a geometry engine. Special Issue: Domains of mental functioning: Attempts at a synthesis. *Psychological Research* 52:122–27. [aBH]

Kohler, I. (1964) The formation and transformation of the perceptual world. *Psychological Issues* 3:1–173. [aBH]

Köhler, W. (1929) *Gestalt psychology.* Liveright. [aBH]

Konorski, J. (1967) *Integrative activity of the brain.* Chicago University Press. [aBH]

Kornblum, S., Hasbroucq, T. & Osman, A. (1990) Dimensional overlap: Cognitive basis for stimulus-response compatibility – A model and taxonomy. *Psychological Review* 97:253–70. [arBH, RWP, AFS]

Kortenkamp, D., Bonasso, R. P. & Murphy, R., eds. (1998) *Artificial Intelligence and mobile robots: Case studies of successful robot systems.* MIT Press. [JB]

Kowler, E. (1990) *Eye movements and their role in visual and cognitive processes.* Elsevier. [aBH]

Kringelbach, M. & Engell, A. (1997) Development and plasticity in the brain. *Psyke and Logos* 18:266–86. [MOB]

Kritikos, A. (in preparation) Perceptual processing and the modulation of distractor interference in reach-to-grasp paradigms. [LP]

Kugler, P. N. & Turvey, M. T. (1987) *Information, natural law, and the self-assembly of rhythmic movements.* Erlbaum. [MJR, RES]

Kunde, W. (2001) Response-effect compatibility in manual choice reaction tasks. *Journal of Experimental Psychology: Human Perception and Performance* 27:387–94. [WK]

Kunde, W., Hoffmann, J. & Zellmann, P. (in press) The impact of anticipated action effects on action planning. *Acta Psychologica.* [WK]

LaBerge, D. & Samuels, S. J. (1974) Toward a theory of automatic information processing in reading. *Cognitive Psychology* 6:293–323. [JI]

Lackner, J. R. & DiZio, P. (1994) Rapid adaptation to Coriolis force perturbations of arm trajectory. *Journal of Neurophysiology* 72:299–313. [PC]

Lakoff, G. (1999) *Philosophy in the flesh.* Basic Books. [DCR]

Lamme, V. (2000) Neural mechanisms of visual awareness: A linking proposition. *Brain and Mind* 1:385–406. [MOB]

Lane, P. C. R., Cheng, P. C.-H. & Gobet, F. (2000) CHREST+: Investigating how humans learn to solve problems using diagrams. *Artificial Intelligence and the Simulation of Behaviour (AISB) Quarterly* 103:24–30. [PCRL]

(2001) Learning perceptual chunks for problem decomposition. In: *Proceedings of the Twenty-third Annual Meeting of the Cognitive Science Society, Edinburgh, UK,* pp. 528–33, ed. J. D. Moore & K. Stenning. Erlbaum. [PCRL]

Lashley, K. S. (1951) The problem of serial order in behavior. In: *Cerebral mechanisms in behavior,* ed. L. A. Jeffress. Wiley. [JB]

Lee, D. N. (1976) A theory of visual control of braking based on information about time-to-collision. *Perception* 5:437–59. [aBH, N-GK]

Lee, D. N., Lishman, J. R. & Thomson, J. A. (1982) Regulation of gait in long jumping. *Journal of Experimental Psychology: Human Perception and Performance* 8:448–59. [N-GK]

Leslie, A. M., Xu, F., Tremoulet, P. D. & Sholl, B. J. (1998) Indexing and the object concept: Developing "what" and "where" systems. *Trends in Cognitive Sciences* 2:10–18. [aBH]

Levelt, W. J. M. (1989) *Speaking. From intention to articulation.* MIT Press. [BG, RJH, aBH]

Lewin, K. (1926) Vorsatz, Wille und Bedürfnis. *Psychologische Forschung* 7:330–85. [aBH]

Liberman, A. M. (1957) Some results of research on speech perception. *Journal of the Acoustical Society of America* 29(1):117–23. [BG]

(1982) On finding that speech is special. *American Psychologist* 37:148–67. [aBH]

(1996) *Speech: A special code.* MIT Press. [BG]

Liberman, A., Cooper, F. S., Shankweiler, D. P. & Studdert-Kennedy, M. (1967) Perception of the speech code. *Psychological Review* 74:431–61. [BG, JH]

Liberman, A. M. & Mattingly, I. G. (1985) The motor theory of speech perception revisited. *Perception* 21:1–36. [rBH]

(1989) A specialization for speech-perception. *Science* 243(4890):489–94. [BG]

Lindenberger, U., Marsiske, M. & Baltes, P. B. (2000) Memorizing while walking: Increase in dual-task costs from young adulthood to old age. *Psychology and Aging* 15:417–36. [HRD]

Livesey, P. J. (1986) *Learning and emotion: A biological synthesis. Evolutionary processes, vol. 1.* Erlbaum. [JB]

Logan, G. D. (1984) On the ability to inhibit simple and choice reaction time responses: A model and a method. *Journal of Experimental Psychology: Human Perception and Performance* 10:276–91. [rBH]

Logan, G. D. & Gordon, R. D. (2001) Executive control of visual attention in dual task situations. *Psychological Review* 108:393–434. [NM]

Lonstein, J. S. & Stern, J. M. (1997) Role of the midbrain periaqueductal gray in maternal nurturance and aggression: *C-fos* and electrolytic lesion studies in lactating rats. *Journal of Neuroscience* 17(9):3364–78. [JB]

Lotze, R. H. (1852) *Medicinische Psychologie oder Physiologie der Seele.* Weidmann. [arBH, AFS]

Lupiañez, J. & Milliken, B. (1999) Inhibition of return and the attentional set for integrating vs. differentiating information. *Journal of General Psychology* 126:392–418. [rBH]

MacCorquodale, K. & Meehl, P. E. (1954) Edward C. Tolman. In: *Modern learning theory: A critical analysis of five examples,* ed. W. K. Estes, S. Koch, K. MacCorquodale, P. E. Meehl, C. G. Mueller, Jr., W. N. Schoenfeld & W. S. Verplanck. Appleton-Century-Crofts. [EC]

Macfarlane, D. A. (1930) The role of kinesthesis in maze learning. *University of California Publications in Psychology* 4:277–305. [rBH]

Mackay, D. (1987) *The organization of perception and action: A theory of language and other cognitive skills.* Springer. [RJH, aBH]

Mackay, D., Allport, A., Prinz, W. & Scheerer, E. (1987) Relationships and modules within language perception and production: An introduction. In: *Language perception and production: Relationships between listening, speaking, reading, and writing,* ed. A. Allport, D. MacKay, W. Prinz & E. Scheerer. Academic Press. [aBH]

MacKay, D. & Mittelstaedt, H. (1974) Visual stability and motor control (reafference revisited). In: *Cybernetics and bionics,* ed. D. Keidel et al. Oldenbourg. [aBH]

Mark, L. S. (1987) Eye-height-scaled information about affordances: A study of sitting and climbing. *Journal of Experimental Psychology: Human Perception and Performance* 13:361–70. [MJR]

Marr, D. C. (1969) A theory of cerebellar cortex. *Journal of Physiology* 202:437–70. [PC]

Marr, D. C. (1982) *Vision.* W. F. Freeman. [N-GK, AFS]

Mashhour, M. (1964) *Psychophysical relations in the perception of velocity.* Almquist. [aBH]

Massad, C. M., Hubbard, M. & Newston, D. (1979) Selective perception for events. *Journal of Experimental Social Psychology* 15:513–32. [aBH]

Massaro, D. (1990) An information-processing analysis of perception and action. In: *Relationships between perception and action: Current approaches,* ed. O. Neumann & W. Prinz. Springer. [aBH]

Mates, J. & Aschersleben, G. (2000) Sensorimotor synchronization: The influence of temporally displaced auditory feedback. *Acta Psychologica* 104:29–44. [aBH]

Mates, J., Radil, T. & Pöppel, E. (1992) Cooperative tapping: Time control under different feedback conditions. *Perception and Psychophysics* 52:691–704. [aBH]

Matin, L. (1982) Visual localization and eye movements. In: *Symposium on the study of motion perception,* ed. W. A. Wagenaar, A. H. Wertheim & H. W. Leibowitz. Plenum Press. [aBH]

May, C. P., Kane, M. J. & Hasher, L. (1995) Determinants of negative priming. *Psychological Bulletin* 118:35–54. [aBH]
McCann, R. S. & Johnston, J. C. (1992) Locus of the single-channel bottleneck in dual-task interference. *Journal of Experimental Psychology: Human Perception and Performance* 18:471–84. [aBH]
McClelland, J. L. (1979) On the time relations of mental processes: An examination of systems of processes in cascade. *Psychological Review* 86:287–330. [AFS]
McKoon, G., Ratcliff, R. & Seifert, C. (1989) Making the connection: Generalized knowledge structures in story understanding. *Journal of Memory and Language* 28:711–334. [JMZ]
Meijer, O. G. & Roth, K., eds. (1988) *The motor-action controversy.* North-Holland. [rBH]
Meiran, N. (2000a) Modeling cognitive control in task-switching. *Psychological Research* 63:234–49. [NM]
(2000b) Reconfiguration of stimulus task-sets and response task-sets during task switching. In: *Control of cognitive processes: Attention and performance XVIII,* ed. S. Monsell & J. Driver. MIT Press. [arBH]
Meiran, N., Adi-Japha, E. & Kessler, Y. (in preparation) A general model-based analytic framework for task switching in speeded classification tasks. [NM]
Meiran, N., Chorev, Z. & Sapir, A. (2000) Component processes in task switching. *Cognitive Psychology* 41:211–53. [rBH, NM]
Meltzoff, A. N. (1995) Understanding the intentions of others: Re-enactment of intended act by 18-months-old children. *Developmental Psychology* 31:838–50. [aBH]
Meltzoff, A. N., Kuhl, P. K. & Moore, M. K. (1991) Perception, representation, and the control of action in newborns and young infants: Towards a new synthesis. In: *Newborn attention: Biological constraints and the influence of experience,* ed. M. J. Weiss & P. R. Zelazo. Ablex Press. [aBH]
Meltzoff, A. N. & Moore, M. K. (1977) Imitation of facial and manual gestures by human neonates. *Science* 198:75–78. [aBH]
Meltzoff, A. N. & Prinz, W. (in press) *The imitative mind: Development, evolution, and brain bases.* Cambridge University Press. [aBH]
Merigan, W. H. & Maunsell, J. H. (1993) How parallel are the primate visual pathways? *Annual Review of Neuroscience* 16:369–402. [aBH]
Metzger, W. (1975) *Gesetze des Sehens.* Waldemar Kramer. [aBH]
Meyer, D. E. & Gordon, P. C. (1985) Speech production: Motor programming of phonetic features. *Journal of Memory and Language* 24:3–26. [aBH]
Meyer, D. E. & Kieras, D. E. (1997) A computational theory of cognitive processses and multiple task performance: Part 1, Basic mechanisms. *Psychological Review* 104:3–75. [aBH]
Miall, R. C. & Wolpert, D. M. (1996) Forward models for physiological motor control. *Neural Networks* 9:1265–79. [PC]
Michaels, C. F. (1988) S-R compatibility between response position and destination of apparent motion: Evidence of the detection of affordances. *Journal of Experimental Psychology: Human Perception and Performance* 14:231–40. [aBH]
Michaels, C. F. & Carello, C. (1981) *Direct perception.* Prentice Hall. [aBH, MJR]
Michaels, C. F. & Stins, J. F. (1997) An ecological approach to stimulus-response compatibility. In: *Theoretical issues in stimulus-response compatibility,* ed. B. Hommel & W. Prinz. North-Holland. [aBH, MJR]
Middleton, F. A. & Strick, P. L. (2000a) Basal ganglia and cerebellar loops: Motor and cognitive circuits. *Brain Research Reviews* 31:236–50. [PC]
(2000b) Basal ganglia output and cognition: Evidence from anatomical, behavioral, and clinical studies. *Brain and Cognition* 42(2):183–200. [JB]
Miller, G. A., Galanter, E. & Pribram, K. H. (1960) *Plans and the structure of behavior.* Holt, Reinhart & Winston. [aBH, JI, WK]
Miller, J. (1982) Discrete versus continuous stage models of human information processing: In search of partial output. *Journal of Experimental Psychology: Human Perception and Performance* 8:273–96. [AFS]
(1988) Discrete and continuous models of human information processing: In search of partial output. *Acta Psychologica* 67:191–257. [AFS]
Miller, J., van der Ham, F. & Sanders, A. F. (1995) Overlapping stage models and the additive factor method. Acta Psychologica 90:11–28. [AFS]
Miller, N. E. & Dollard, J. (1941) *Social learning and imitation.* Yale University Press. [aBH]
Millikan, R. G. (1984) *Language, thought, and other biological categories.* MIT Press. [RGM]
(1993) *White Queen psychology and other essays for Alice.* MIT Press. [RGM]
(1996) Pushmi-pullyu representations. In: *Philosophical perspectives,* vol. IX, ed. J. Tomberlin. Ridgeview. [RGM]
(forthcoming) *Varieties of meaning: The Jean Nicod Lectures.* MIT Press. [RGM]
Milner, A. D. & Dijkerman, H. C. (in press) Direct and indirect visual routes to action. In: *Varieties of unconscious processing: New findings and new comparisons,* ed. B. de Gelder, E. H. F. de Haan & C. A. Heywood. Oxford University Press. [LP]
Milner, A. D. & Goodale, M. A. (1995) *The visual brain in action.* Oxford University Press. [arBH, LP, SV, DAW]
Mink, J. W. (1996) The basal ganglia: Focused selection and inhibition of competing motor programs. *Progress in Neurobiology* 50(4):381–425. [JB]
Mischel, W. (1996) From good intentions to willpower. In: *The psychology of action: Linking cognition and motivation to behavior,* ed. P. M. Gollwitzer & J. A. Bargh. Guilford Press. [aBH]
Monsell, S. & Driver, J., eds. (2000) *Control of cognitive processes. Attention and performance XVIII.* MIT Press. [aBH, NM]
Morin, R. E. & Grant, D. A. (1955) Learning and performance on a keypressing task as a function of the degree of spatial stimulus-response correspondence. *Journal of Experimental Psychology* 49:39–47. [aBH]
Morris, M. W. & Murphy, G. L. (1990) Converging operations on a basic level in event taxonomies. *Memory and Cognition* 18:407–18. [JMZ]
Movellan, J. R. & McClelland, J. L. (2001) The Morton-Massaro law of information integration. *Psychological Review* 108:103–48. [MOB]
Münsterberg, H. (1888) *Beiträge zur Experimentellen Psychologie. Heft 1: Über willkürliche und unwillkürliche Vorstellungsverbindungen.* Mohr. [aBH]
Murray, J. D. (1990) *Mathematical biology.* Springer Verlag. [RES]
Müsseler, J. (1995) *Wahrnehmung und Handlungssteuerung. Effekte kompatibler und inkompatibler Reize bei der Initiierung und Ausführung von Reaktionssequenzen* [Perception and action planning. Effects of compatible and incompatible stimuli on initiation and execution of reaction sequences.] Shaker. [aBH]
(1999) How independent from action control is perception? An event-coding account for more equally-ranked crosstalks. In: *Cognitive contributions to the perception of spatial and temporal events,* ed. G. Aschersleben, T. Bachmann & J. Müsseler. Elsevier. [arBH]
Müsseler, J. & Hommel, B. (1997a) Blindness to response-compatible stimuli. *Journal of Experimental Psychology: Human Perception and Performance* 23(3):861–72. [JD, arBH, CO]
(1997b) Detecting and identifying response-compatible stimuli. *Psychonomic Bulletin and Review* 4:125–29. [arBH]
Müsseler, J. & Prinz, W. (1996) Action planning during the presentation of stimulus sequences: Effects of compatible and incompatible stimuli. *Psychological Research* 59:48–63. [aBH]
Müsseler, J., Steininger, S. & Wühr, P. (2001) Can actions really affect perceptual processing? *The Quarterly Journal of Experimental Psychology. Section A: Human Experimental Psychology* 54:137–54. [aBH, WK]
Müsseler, J., Van der Heijden, A. H. C., Mahmud, S. H., Deubel, H. & Ertsey, S. (1999) Relative mislocalizations of briefly presented stimuli in the retinal periphery. *Perception and Psychophysics* 61:1646–61. [aBH]
Müsseler, J., Wühr, P. & Prinz, W. (2000) Varying the response code in the blindness to response-compatible stimuli. *Visual Cognition* 7:743–67. [aBH]
Murthy, V. N. & Fetz, E. E. (1992) Coherent 25- to 35 Hz oscillations in the sensori-motor cortex of awake behaving monkeys. *Proceedings of the National Academy of Science USA* 89:5670–74. [aBH]
Nadel, J. & Butterworth, G., eds. (1999) *Imitation in infancy.* Cambridge University Press. [aBH]
Nattkemper, D. & Prinz, W. (2001) Impact of task demands on spatial stimulus-response compatibility. (submitted). [aBH]
Navon, D. & Gopher, D. (1979) On the economy of the human processing system. *Psychological Review* 86:214–25. [aBH, AFS]
Neafsey, E. J., Bold, E. L., Haas, G., Hurley-Gius, K. M., Quirk, G., Sievert, C. E. & Terreberry, R. R. (1986) The organization of the rat motor cortex: A microstimulation mapping study. *Brain Research* 396:77–96. [HRD]
Neill, W. T. (1997) Episodic retrieval in negative priming and repetition priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 23:1291–305. [aBH]
Neisser, U. (1963) Decision-time without reaction-time: Experiments in visual scanning. *American Journal of Psychology* 76:376–85. [aBH]
(1967) *Cognitive psychology.* Appleton-Century-Crofts. [JH, rBH]
(1985) The role of invariant structures in the control of movement. In: *Goal-directed behavior: The concept of action in psychology,* ed. M. Frese & J. Sabini. Erlbaum. [aBH]
Nelson, J. I., Salin, P. A., Munk, M. H. J., Arzi, M. & Bullier, J. (1992) Spatial and temporal coherence in cortico-cortical connections: A cross-correlation study in areas 17 and 18 in the cat. *Visual Neuroscience* 9:21–37. [aBH]
Neumann, O. (1987) Beyond capacity: A functional view of attention. In: *Perspectives on perception and action,* ed. H. Heuer & A. F. Sanders. Erlbaum. [aBH]
(1990) Visual attention and action. In: *Relationships between perception and action: Current approaches,* ed. O. Neumann & W. Prinz. Springer. [aBH]
(1996) Theories of attention. In: *Handbook of perception and action. Vol. 3: Attention,* ed. O. Neumann & A. F. Sanders. Academic Press. [aBH]
Newell, A. & Simon, H. A. (1972) *Human problem solving.* Prentice-Hall. [JMZ]
Nickerson, R. S. (1972) Binary-classification reaction time: A review of some

studies of human information-processing capabilities. *Psychonomic Monograph Supplements* 4:275–88. [aBH]
Norman, D. A. (1969) *Memory and attention: An introduction to human information processing.* Wiley. [rBH, JI]
Norman, D. A. & Shallice, T. (1986) Attention to action: Willed and automatic control of behaviour. In: *Consciousness and self regulation,* ed. R. J. Davidson, G. E. Schwartz & D. Shapiro. Plenum. [MOB]
Oades, R. D., Zimmermann, B. & Eggers, C. (1996) Conditioned blocking in patients with paranoid, non-paranoid psychosis or obsessive-compulsive disorder: Association with symptoms, personality and monoamine metabolism. Journal of Psychiatric Research 30:369–90. [RDO]
Ohlsson, C. R. & Gettner, S. N. (1995) Object-centered direction selectivity in the macaque supplementary eye-field. *Science* 269:985–88. [aBH]
Olivetti Belardinelli, M. (1974/1986) *La costruzione della realtà come problema psicologico.* Boringhieri. (3rd enlarged edition, 1986). [MOB]
(1981–82) Lernen und motiviertes Verhalten: Ein Kognitiv-systhemisches Modell. *Verhalten* 3:95–120. [MOB]
Olivetti Belardinelli, M., Del Gratta, C., Di Matteo, R., Ferretti, A. & Romani, G. (2001) Intermodal analysis of sensory image generation by means of fMRI. Paper presented at the 8th EWIC, Saint-Malo, April 1–3, 2001. Submitted to *Neuroimage.* [MOB]
O'Regan, J. K. & Noë, A. (2001) A sensorimotor account of vision and visual consciousness. *Behavioral and Brain Sciences* 24(5). [JH, N-GK]
Paillard, J. (1949) Quelques données psychophysiologiques au déclenchement de la commande motrice [Some psychophysiological data relating to the triggering of motor commands]. *L'Année Psychologique* 48:28–47. [aBH]
Paillard, J., ed. (1991) *Brain and space.* Oxford University Press. [aBH]
Palmer, S. E. (1982) Symmetry, transformation, and the structure of perceptual systems. In: *Organization and representation in perception,* ed. J. Beck. Erlbaum. [aBH]
Park, J. & Kanwisher, N. (1994) Negative priming for spatial locations: Identity mismatching, not distractor inhibition. *Journal of Experimental Psychology: Human Perception and Performance* 20:613–23. [aBH]
Pashler, H. (1989) Dissociations and dependencies between speed and accuracy: Evidence for a two-component theory of divided attention in simple tasks. *Cognitive Psychology* 21:469–514. [aBH]
(1994) Dual-task interference in simple tasks: Data and theory. *Psychological Bulletin* 116:220–44. [rBH]
Passingham, R. (1993) *The frontal lobes and voluntary action.* Oxford University Press. [aBH]
Payne, B R., Lomber, S. G., Villa, A. E. & Bullier, J. (1996) Reversible deactivation of cerebral network components. *Trends in Neurosciences* 19:535–42. [MOB]
Perani, D., Fazio, F., Borghese, N. A., Tettamanti, M., Ferrari, S., Decety, J. & Gilardi, M. C. (2001) Different brain correlates for watching real and virtual hand actions. *Neuroimage* 14(3):749–58. [TC]
Perrett, D. I., Harris, M. H., Bevan, R., Thomas, S., Benson, P. J., Mistlin, A. J., Citty, A. J., Hietanen, J. K. & Ortega, J. E. (1989) Framework of analysis for the neural representation of animate objects and actions. *Journal of Experimental Biology* 146:87–113. [aBH]
Perrett, D. I., Hietanen, J. K., Oram, M. W. & Benson, P. J. (1992) Organisation and functions of cells responsive to faces in the temporal cortex. *Philosophical Transactions of the Royal Society of London* 335:25–30. [JB]
Peters, E. R., Pickering, A. D., Kent, A., Glasper, A., Irani, M., David, A. S., Day, S. & Hemsley, D. R. (2000) The relationship between cognitive inhibition and psychotic symptoms. *Journal of Abnormal Psychology* 109:386–95. [RDO]
Phaf, H. & Wolters, G. (1997) A constructivist and connectionist view on conscious and nonconscious processes. *Philosophical Psychology* 10:287–307. [GW]
Piaget, J. (1946) *La formation du symbole chez l'enfant.* Delachaux & Niestlé. [aBH]
Pickering, M. J. & Branigan, H. P. (1998) The representation of verbs: Evidence from syntactic priming in language production. *Journal of Memory and Language* 39:633–51. [RJH]
Pickering, M. J. & Garrod, S. C. (submitted) Towards a mechanistic psychology of dialogue. Unpublished manuscript. [RJH]
Pisella, L., Grea, H., Tilikete, C., Vighetto, A., Desmurget, M., Rode, G., Boisson, D. & Rossetti, Y. (2000) An automatic pilot for the hand in the posterior parietal cortex: Toward a reinterpretation of Optic Ataxia. *Nature Neuroscience* 3(7):629–741. [LP]
Pisella, L. & Rossetti, Y. (2000) Interaction between conscious identification and non-conscious sensorimotor processing: Temporal constraints. In: *Beyond dissociation: Interaction between dissociated implicit and explicit processing,* ed. Y. Rossetti & A. Revonsuo. Benjamins. [LP]
Pleger, B., Dinse, H. R., Ragert, P., Schwenkreis, P., Malin, J. P. & Tegenthoff, M. (2001) Shifts in cortical representations predict human discrimination improvement. *Proceedings of the National Academy of Sciences USA* 98:12255–60. [HRD]
Pomerantz, J. R. & Kubovy, M. (1981) Perceptual organization: An overview. In: *Perceptual organization,* ed. M. Kubovy & J. R. Pomerantz. Erlbaum. [aBH]
Posner, M. I. (1973) *Cognition: An introduction.* Scott Foresman. [EC]
(1978) *Chronometric explorations of mind.* Erlbaum. [arBH, RWP]
(1980) Orienting of attention. *Quarterly Journal of Experimental Psychology* 32:3–25. [aBH]
(1986) Empirical studies of prototypes. In: *Noun classes and categorization,* ed. C. Craig. John Benjamins. [EC]
Posner, M. I. & Cohen, Y. (1980) Attention and the control of movement. In: *Tutorials in motor behavior,* ed. G. E. Stelmach & J. Requin. North-Holland. [aBH]
(1984) Components of visual orienting. In: *Control of language processes. Attention and performance, vol. X,* ed. H. Bouma & D. G. Bouwhuis. Erlbaum. [aBH]
Posner, M. I. & Mitchell, R. F. (1967) Chronometric analysis of classification. *Psychological Review* 74:392–409. [aBH]
Posner, M. I., Nissen, M. J. & Klein, R. M. (1976) Visual dominance: An information-processing account of its origins and significance. *Psychological Review* 83:157–71. [aBH]
Postman, L. (1955) Association theory and perceptual learning. *Psychological Review* 62:438–46. [aBH]
Powers, W. T. (1973) Feedback: Beyond behaviorism. *Science* 179:351–56. [PC]
Prablanc, C. & Pélisson, D. (1990) Gaze saccade orienting and hand pointing are locked to their goal by quick internal loops. In: *Attention and performance XIII,* ed. M. Jeannerod. Erlbaum. [rBH]
Prescott, T. J., Gurney, K., Gonzalez, F. M. & Redgrave, P. (forthcoming) The evolution of action selection. In: *Towards the whole Iguana,* ed. D. McFarland & O. Holland. MIT Press. [JB]
Pribram, K. H. (1971) *Languages of the brain. Experimental paradoxes and principles in neuropsychology.* Prentice Hall. [aBH]
Prinz, W. (1983) *Wahrnehmung und Tätigkeitssteuerung.* Springer. [AFS]
(1984a) Attention and sensitivity in visual search. *Psychological Research* 45:355–66. [rBH]
(1984b) Modes of linkages between perception and action. In: *Cognition and motor processes,* ed. W. Prinz & A. F. Sanders. Springer. [aBH]
(1987) Ideo-motor action. In: *Perspectives on perception and action,* ed. H. Heuer & A. F. Sanders. Erlbaum. [arBH]
(1990) A common coding approach to perception and action. In: *Relationships between perception and action: Current approaches,* ed. O. Neumann & W. Prinz. Springer. [aBH]
(1992) Why don't we perceive our brain states? *European Journal of Cognitive Psychology* 4:1–20. [arBH, SV]
(1997a) Perception and action planning. *European Journal of Cognitive Psychology* 9:129–54. [aBH]
(1997b) Why Donders has led us astray. In: *Theoretical issues in stimulus-response compatibility,* ed. B. Hommel & W. Prinz. North-Holland. [arBH]
(2002) An experimental approach to imitation. In: *The imitative mind: Development, evolution, and brain bases,* ed. A. M. Meltzoff & W. Prinz. Cambridge University Press (in press). [arBH]
Prinz, W., Aschersleben, G., Hommel, B. & Vogt, S. (1995) Handlungen als Ereignisse. In: *Das Gedächtnis, Probleme, Trends, Perspektiven,* ed. D. Dörner & E. v. d. Meer. Hogrefe. [aBH]
Proctor, R. W. & Reeve, T. G. (1986) Salient-feature coding operations in spatial precuing tasks. *Journal of Experimental Psychology: Human Perception and Performance* 12:277–85. [RWP]
Proctor, R. W. & Reeve, T. G., eds. (1990) *Stimulus-response compatibility.* Elsevier. [aBH]
Proctor, R. W., Reeve, T. G. & Weeks, D. J. (1990) A triphasic approach to the acquisition of response-selection skill. *The Psychology of Learning and Motivation* 26:207–40. [rBH]
Proctor, R. W., Van Zandt, T., Lu, C. H. & Weeks, D. J. (1993) Stimulus-response compatibility for moving stimuli: Perception of affordances or directional coding? *Journal of Experimental Psychology Human Perception and Performance* 19:81–91. [aBH]
Proctor, R. W. & Vu, K.-P. L. (in press a) Action selection. In: *Experimental psychology,* ed. A. F. Healy & R. W. Proctor. (Volume 3 of the *Comprehensive handbook of psychology,* Editor-in-Chief I B. Weiner). Wiley. [RWP]
(in press b) Eliminating magnifying and reversing spatial compatibility effects with mixed location-relevant and irrelevant trials. In: *Common mechanisms in perception and action,* ed. W. Prinz & B. Hommel. Oxford University Press. [RWP]
Purves, D. (1988) *Body and brain.* Harvard University Press. [RES]
Pylyshyn, Z. (2001) Visual indexes, preconceptual objects, and situated vision. *Cognition* 80(1–2):127–58. [DCR]
Quinn, J. T. & Sherwood, D. E. (1983) Time requirements of changes in program and parameter variables in rapid ongoing movements. *Journal of Motor Behavior* 15:163–78. [aBH]

Rachlin, H. C. (1966) Scaling subjective velocity, distance, and duration. *Perception and Psychophysics* 1:77–82. [aBH]
Radvansky, G. A. (1999) Memory retrieval and suppression: The inhibition of situation models. *Journal of Experimental Psychology: General* 128:563–79. [JMZ]
Rayner, K. (1984) Visual selection in reading, picture perception, and visual search. A tutorial review. In: *Control of language processes. Attention and performance, vol. X,* ed. H. Bouma & D. G. Bouwhuis. Erlbaum. [aBH]
Redding, G. & Wallace, B. (1997) *Adaptive spatial alignment.* Erlbaum. [aBH]
Redgrave, P., Prescott, T. J. & Gurney, K. (1999) The basal ganglia: A vertebrate solution to the selection problem? *Neuroscience* 89:1009–23. [JB]
Reed, E. S. (1982) An outline of a theory of action systems. *Journal of Motor Behavior* 14:98–134. [aBH]
(1993) The intention to use a specific affordance. In: *Development in context: Acting and thinking in specific environments,* ed. R. H. Wozniak & K. W. Fischer. Erlbaum. [aBH]
(1996) *Encountering the world: Toward an ecological psychology.* Oxford University Press. [aBH]
Reinke, H. & Dinse, H. R. (1996) Functional characterization of cutaneous mechanoreceptor properties in aged rats. *Neuroscience Letters* 216:171–74. [HRD]
Rescorla, R. A. (1991) Associative relations in instrumental learning: The Eighteenth Bartlett Memorial Lecture. *Quarterly Journal of Experimental Psychology* 43B:1–23. [aBH]
Restle, F. (1982) Coding theory as an integration of Gestalt Psychology and information processing theory. In: *Organization and representation in perception,* ed. J. Beck. Erlbaum. [aBH]
Richardson, D. C. & Spivey, M. J. (2000) Representation, space and Hollywood Squares. Looking at things that aren't there anymore. *Cognition* 76(3):269–95. [DCR]
Richardson, D. C., Spivey, M. J. & Cheung, J. (2001) Motor representations in memory and mental models: Embodiment in cognition. *Proceedings of the Twenty-third Annual Meeting of the Cognitive Science Society,* pp. 867–72. Erlbaum. [rBH, DCR]
Ridderinkhof, K. R., van der Molen, M. W. & Bashore, T. R. (1995) Limits on the application of the additive factors logic: Violations of stage robustness suggest a dual-process architecture to explain flanker effects on target processing. *Acta Psychologica* 90:29–48. [AFS]
Riehle, A., Gruen, S., Diesmann, M. & Aertsen, A. (1997) Spike synchronization and rate modulation differentially involved in motor cortical function. *Science* 278:1950–53. [aBH]
Rifkin, A. (1985) Evidence for a basic level in event taxonomies. *Memory and Cognition* 13:538–56. [JMZ]
Riggio, L., Gawryszewski, L. & Umiltà, C. (1986) What is crossed in crossed-hand effects? *Acta Psychologica* 62:89–100. [aBH]
Rizzolatti, G. & Craighero, L. (1998) Spatial attention: Mechanisms and theories. In: *Advances in psychological science, vol. 2: Biological and cognitive aspects,* ed. M. Sabourin, F. Craik & M. Robert. Psychology Press. [aBH]
Rizzolatti, G., Fadiga, L., Gallese, V. & Fogassi, L. (1996) Premotor cortex and the recognition of motor actions. *Cognitive Brain Research* 3:131–41. [aBH, SV]
Rizzolatti, G., Fogassi, L. & Gallese, V. (1997) Parietal cortex: From sight to action. *Current Opinions in Neurobiology* 7:562–67. [aBH]
(2001) Neurophysiological mechanisms underlying the understanding and imitation of action. *Nature Reviews Neuroscience* 2:661–670. [rBH]
Rizzolatti, G., Luppino, G. & Matelli, M. (1998) The organization of the motor cortical system: New concepts. *Electroencephalography and Clinical Neurophysiology* 106:283–96. [SV]
Rizzolatti, G., Riggio, L., Dascola, I. & Umiltà, C. (1987) Reorienting attention across the horizontal and vertical meridians: Evidence in favor of a premotor theory of attention. *Neuropsychologia* 25(1A):31–40. *Special Issue: Selective visual attention.* [arBH]
Rizzolatti, G., Riggio, L. & Sheliga, B. M. (1994) Space and selective attention. In: *Attention and performance XV: Conscious and nonconscious information processing,* ed. C. Umiltà & M. Moscovitch. MIT Press. [aBH]
Roberts, S. (1987) Evidence for distinct serial processes in animals: The multiplicative factors method. *Animal Learning and Behavior* 15:135–73. [AFS]
Roelfsema, P. R., Engel, A. K., Koenig, P. & Singer, W. (1997) Visuomotor integration is associated with zero time-lag synchronization among cortical areas. *Nature* 385:157–61. [aBH, RDO]
Rogers, R. D. & Monsell, S. (1995) The cost of a predictable switch between simple cognitive tasks. *Journal of Experimental Psychology: General* 124:207–31. [NM]
Rosch, E. (1978) Principles of categorization. In: *Cognition and categorization,* ed. E. Rosch & B. Lloyd. Erlbaum. [EC]
Rosen, R. (1991) *Life itself.* Columbia University Press. [N-GK]
Rosenbaum, D. A. (1980) Human movement initiation: Specification of arm, direction, and extent. *Journal of Experimental Psychology: General* 109:444–74. [aBH]
(1987) Successive approximations to a model of human motor programming. *Psychology of Learning and Motivation* 21:153–82. [aBH]
(1991) *Human motor control.* Academic Press. [aBH]
Rosenbaum, D. A., Marchak, F., Barnes, H. J., Vaughan, J., Slotta, J. D. & Jorgensen, M. J. (1990) Constraints for action selection: Overhand versus underhand grips. In: *Attention and performance XIII: Motor representation and control,* ed. M. Jeannerod. Erlbaum. [rBH]
Rosenbaum, D. A., Meulenbroek, R. G., Vaughan, J. & Jansen, C. (2001) Posture-based motion planning: Applications to grasping. *Psychological Review* 108:709–34. [DAR]
Rosenbaum, D. A., Weber, R. J., Hazelett, W. M. & Hindorff, V. (1986) The parameter remapping effect in human performance: Evidence from tongue twisters and finger fumblers. *Journal of Memory and Language* 25:710–25. [arBH]
Rosenbloom, P. S. & Newell, A. (1987) An integrated computational model of stimulus-response compatibility and practice. *Psychology of Learning and Motivation* 21:3–49. [aBH]
Rosenblueth, A., Wiener, N. & Bigelow, J. (1943) Behavior, purpose and teleology. *Philosophy of Science* 10:18–24. [PC]
Rossetti, Y. & Pisella, L. (2002) Several "vision for action" systems: A guide to dissociating and integrating dorsal and ventral functions. In: *Common mechanisms in perception and action: Attention and performance, vol. XIX,* ed. W. Prinz & B. Hommel. Oxford University Press. [LP]
Rossetti, Y., Pisella, L. & Pelisson, D. (2000) Eye blindness and hand sight: Temporal constraints and visuo-motor network. *Visual Cognition* 7(6):785–809. [LP]
Rossetti, Y. & Revonsuo, A., eds. (in press) *Interaction between dissociable conscious and nonconscious processes.* John Benjamins. [aBH]
Rossetti, Y., Stelmach, G., Desmurget, M., Prablanc, C. & Jeannerod, M. (1994) Influence of viewing the static hand prior to movement onset on pointing kinematics and accuracy. *Experimental Brain Research* 101:323–30. [LP]
Rowe, J. B., Toni, I., Josephs, O., Frackowiak, R. S. & Passingham, R. E. (2000) The prefrontal cortex: Response selection or maintenance within working memory? *Science* 288:1656–60. [PC]
Ruby, P. & Decety, J. (2001) Effect of subjective perspective-taking during simulation of action: A PET investigation of agency. *Nature Neuroscience* 4(5):546–50. [TC]
Rumelhart, D. E. (1977) Understanding and summarizing brief stories. In: *Basic processes in reading: Perception and comprehension,* ed. D. Laberge & S. J. Samuels. Erlbaum. [JMZ]
Runeson, S. (1974) Constant velocity – not perceived as such. *Psychological Research* 37:3–23. [aBH]
Runeson, S. & Frykholm, G. (1981) Visual perception of lifted weights. *Journal of Experimental Psychology: Human Perception and Performance* 7:733–40. [aBH]
(1983) Kinematic specification of dynamics as an informational basis for person-and-action perception: Expectation, gender, recognition, and deceptive intention. *Journal of Experimental Psychology* 112:585–615. [MJR]
Ruthruff, E., Miller, J. & Lachmann, T. (1995) Does mental rotation require central mechanisms? *Journal of Experimental Psychology: Human Perception and Performance* 21:552–70. [aBH]
Sakata, H., Taira, M., Murata, A. & Mine, S. (1995) Neural mechanisms of visual guidance of hand action in the parietal cortex of the monkey. *Cerebral Cortex* 5(5):429–38. [aBH, CO]
Salmoni, A. W., Schmidt, R. A. & Walter, C. B. (1984) Knowledge of results and motor learning: A review and critical appraisal. *Psychological Bulletin* 95:355–86. [aBH]
Sanders, A. F. (1967) Some aspects of reaction processes. *Acta Psychologica* 27:115–30. [AFS]
(1977) Structural and functional aspects of the reaction process. In: *Attention and performance, vol. 6,* ed. S. Dornic. Erlbaum. [AFS]
(1980) Stage analysis of reaction processes. In: *Tutorials in motor behavior,* ed. G. E. Stelmach & J. Requin. North-Holland. [arBH]
(1983) Towards a model of stress and human performance. *Acta Psychologica* 53:61–97. [aBH, RDO, AFS]
(1990) Issues and trends in the debate on discrete vs. continuous processing of information. *Acta Psychologica* 74:123–67. [aBH]
(1995) Discrete vs. continuous processing: The fate of an incompletely processed perceptual dimension. *Acta Psychologica* 90:211–27. [AFS]
(1997) A summary of resource theories from a behavioral perspective. *Biological Psychology* 45:5–18. [AFS]
(1998) *Elements of human performance. Reaction processes and attention in human skills.* Erlbaum. [aBH, AFS]
Scannell, J. W., Burns, G. A., Hilgetag, C. C., O'Neil, M. A. & Young, M. P. (1999) The connectionist organization of the cortico-thalamic system of the cat. *Cerebral Cortex* 9:277–99. [HRD]

Schank, R. (1972) Conceptual dependency: A theory of natural language processing. *Cognitive Psychology* 3:552–631. [JMZ]

Schank, R. C. & Abelson, R. P. (1977) *Scripts, plans, goals, and understanding: An inquiry into human knowledge structures.* Erlbaum. [JMZ]

Scheerer, E. (1984) Motor theories of cognitive structure: A historical review. In: *Cognition and motor processes,* ed. W. Prinz & A. F. Sanders. Springer. [arBH]

Schmidt, R. A. (1975) A schema theory of discrete motor skill learning. *Psychological Review* 82:225–60. [aBH]

(1988) *Motor control and learning, 2nd edition.* Human Kinetics Publishers. [aBH]

Schubö, A. (1998) *Interferenz von Wahrnehmung und Handlungssteuerung.* Shaker. [aBH]

Schubö, A., Aschersleben, G. & Prinz, W. (2001) Interactions between perception and action in a reaction task with overlapping S-R assignments. *Psychological Research* 65:145–57. [aBH, CO]

Schurman, T., Klein, H., Beneke, M. & Traber, J. (1987) Nimodipine and motor deficits in the aged rat. *Neuroscience Research Communications* 1:9–15. [HRD]

Schyns, P., Goldstone, R. L. & Thibaut, J. P. (1988) The development of features in object concepts. *Behavioral and Brain Sciences* 21:1–54. [GW]

Seifert, C. M., McKoon, G., Abelson, R. P. & Ratcliff, R. (1986) Memory connections between thematically similar episodes. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 12:220–31. [JMZ]

Semjen, A. & Garcia-Colera, A. (1986) Planning and timing of finger-tapping sequences with a stressed element. *Journal of Motor Behavior* 18:287–322. [rBH]

Shadmehr, R. & Mussa-Ivaldi, F. A. (1994) Adaptive representation of dynamics during learning of a motor task. *Journal of Neuroscience* 14:3208–24. [PC]

Shallice, T. (1982) Specific impairments in planning. *Philosophical Transactions of the Royal Society of London B* 298:199–209. [MOB]

(1988) *From neuropsychology to mental structure.* Cambridge University Press. [MOB]

Shaw, R. E. & Bransford, J. (1977) *Perceiving, acting, and knowing: Toward an ecological psychology.* Erlbaum. [MJR]

Shaw, R. E., Flascher, O. M. & Kadar, E. E. (1995) Dimensionless invariants for intentional systems: Measuring the fit of vehicular activities to environmental layout. In: *Global perspectives on the ecology of human-machine systems,* ed. J. Flach, P. Hancock, J. Caird & K. Vicente. Erlbaum. [RES]

Shaw, R. E., Kadar, E. E., Sim, M. M. & Repperger, D. W. (1992) The intentional spring: A strategy for modeling systems that learn to perform intentional acts. *Journal of Motor Behavior* 24:3–28. [RES]

Shaw, R. E. & Kinsella-Shaw, J. (1988) Ecological mechanics: A physical geometry for intentional constraints. *Human Movement Science* 7:155–200. [MJR]

Shaw, R. E. & Todd, J. (1980) Abstract machine theory and direct perception. *Behavioral and Brain Sciences* 3:400–401. [RES]

Shebilske, W. L. (1977) Visuomotor coordination in visual direction and position constancies. In: *Stability and constancy in visual perception: Mechanisms and processes,* ed. W. Epstein. Wiley. [aBH]

Sheliga, B. M., Riggio, L. & Rizzolatti, G. (1994) Orienting of attention and eye movements. *Experimental Brain Research* 98:507–22. [JI]

Shiffrar, M. (2001) Movement and event perception. In: *Handbook of perception,* ed. E. B. Goldstein. Blackwell. [TC]

Shiffrar, M. & Freyd, J. J. (1990) Apparent motion of the human body. *Psychological Science* 1:257–64. [TC, aBH]

(1993) Timing and apparent motion path choice with human photographs. *Psychological Science* 4:379–84. [TC]

Shiffrin, R. M. & Schneider, W. (1977) Controlled and automatic human information processing, II. *Psychological Review* 84:127–90. [aBH]

Simon, J. R., Hinrichs, J. V. & Craft, J. L. (1970) Auditory S-R compatibility. Reaction time as a function of ear-hand correspondence and ear-response-location correspondence. *Journal of Experimental Psychology* 86:97–102. [aBH]

Singer, W. (1994) The organization of sensory motor representations in the neocortex: A hypothesis based on temporal coding. In: *Conscious and nonconscious information processing: Attention and performance XV,* ed. C. Umiltà & M. Moscovitch. MIT Press. [arBH]

Smolensky, P. (1988) On the proper treatment of connectionism. *Behavioral and Brain Sciences* 11:1–74. [EC]

Spengler, F., Godde, B. & Dinse, H. R. (1995) Effects of aging on topographic organization of somatosensory cortex. *NeuroReport* 6:469–73. [HRD]

Sperry, R. W. (1952) Neurology and the mind-brain problem. *American Scientist* 40:291–312. [BG]

Spijkers, W., Heuer, H., Steglich, C. & Kleinsorge, T. (2000) Specification of movement amplitudes for the left and right hands: Evidence for transient parametric coupling from overlapping-task performance. *Journal of Experimental Psychology: Human Perception and Performance* 26(3):1091–105. [JD]

Spivey, M. J. & Geng, J. J. (2001) Oculomotor mechanisms activated by imagery and memory: Eye movements to absent objects. *Psychological Research* 65:235–41. [DCR]

Spivey, M. J., Tyler, M., Richardson, D. C. & Young, E. (2000) Eye movements during comprehension of spoken scene descriptions. *Proceedings of the Twenty-second Annual Meeting of the Cognitive Science Society.* Erlbaum. [DCR]

Stagner, R. (1977) Homeostasis, discrepancy, dissonance. *Motivation and Emotion* 1:103–38. [MOB]

Stanfield, R. A. & Zwaan, R. A. (2001) The effect of implied orientation derived from verbal context on picture recognition. *Psychological Science* 12(2):153–56. [DCR]

Steininger, S. (1999) *Handeln und Wahrnehmen: Eine experimentelle Analyse einer Wahrnehmungsbeeinträchtigung bei simultan ausgeführten Handlungen.* [Acting and perceiving: An experimental analysis of impaired perception with concurrent action.] Doctoral thesis. Shaker. [WK]

Sternberg, S. (1967) Two operations in character recognition: Some evidence from reaction-time measurements. *Perception and Psychophysics* 2:45–53. [aBH]

(1969) The discovery of processing stages: Extensions of Donders' method. *Acta Psychologica* 30:276–315. [arBH, AFS]

(1975) Memory's scanning: New findings and current controversies. *Quarterly Journal of Experimental Psychology* 27:1–42. [AFS]

Stevanovski, B., Oriet, C. & Jolicoeur, P. (2001a) Blinded by headlights. (submitted). [CO]

(2001b) Blinded by headlights. Paper presented at the 11th Annual Meeting of the Canadian Society for Brain, Behaviour, and Cognitive Science, Quebec City, Canada. [CO]

Stevens, J. A., Fonlupt, P., Shiffrar, M. & Decety, J. (2000) New aspects of motion perception: Selective neural encoding of apparent human movements. *NeuroReport* 11(1):109–15. [TC]

Stock, A. & Hoffman, J. (2002) Intentional fixation of behavioral learning or how R-E learning blocks S-R learning. *European Journal of Cognitive Psychology* 14(1):1–27. [WK]

Stoet, G. (1998) The role of feature integration in action planning. Unpublished doctoral dissertation, University of Munich, Germany. [aBH]

Stoet, G. & Hommel, B. (1999) Action planning and the temporal binding of response codes. *Journal of Experimental Psychology: Human Perception and Performance* 25:1625–40. [JD, arBH, WK, CO, DCR]

Stoffels, E. J., van der Molen, M. W. & Keuss, P. G. J. (1989) An additive factor analysis of the effect(s) of location cues associated with auditory stimuli on stages of information processing. *Acta Psychologica* 70:161–97. [rBH]

Stränger, J. & Hommel, B. (1996) The perception of action and movement. In: *Handbook of perception and action. Vol. 1: Perception,* ed. W. Prinz & B. Bridgeman. Academic Press. [arBH]

Stratton, G. M. (1897) Vision without inversion of the retinal image. *Psychological Review* 4:341–60, 463–81. [aBH]

Straube, E. R. & Oades, R. D. (1992) *Schizophrenia: Empirical research and findings.* Academic Press. [RDO]

Sturgill, D. S. & Ferraro, F. R. (1997) Predicting negative priming: Effects of stereotypy, cognitive failures and anxiety. *Personality and Individual Differences* 23:291–304. [RDO]

Stürmer, B. (1997) *Organisationsprinzipien an der Schnittstelle zwischen Wahrnehmung und Handlung: Kompatibilitätseffekte unter Verwendung dynamischer Reiz- und Reaktionseigenschaften.* [Principles of organization at the gap between perception and action: Compatibility effects with dynamic stimulus and response features.] Shaker. [aBH]

Stürmer, B., Aschersleben, G. & Prinz, W. (2000) Correspondence effects with manual gestures and postures: A study on imitation. *Journal of Experimental Psychology: Human Perception and Performance* 26:1746–59. [aBH]

Stuyven, E., Dejonckheere, P. & Ghyselinck, M. (1999) The influence of spatial compatibility on exogenous and endogenous saccades. In: *Proceedings of the Eleventh Conference of the European Society for Cognitive Psychology,* ed. A. Vandierendonck, M. Brysbaert & K. Van der Goten. Academia Press. [rBH]

Taira, M., Mine, S., Georgopoulos, A. P., Murata, A. & Sakata, H. (1990) Parietal cortex neurons of the monkey related to the visual guidance of hand movement. *Experimental Brain Research* 83:29–36. [aBH]

Tanji, J & Shima, K. (1994) Role for supplementary motor area cells in planning several movements ahead. *Nature* 371:413–16. [JB]

Taylor, J. L. & McCloskey, D. (1990) Triggering of preprogrammed movements as reactions to masked stimuli. *Journal of Neurophysiology* 63:439–46. [LP]

Teichner, W. H. & Krebs, M. J. (1974) Laws of visual choice reaction time. *Psychological Review* 83:29–36. [aBH]

Ten Hoopen, G., Akerboom, S. & Raaymakers, E. (1982) Vibrotactual choice reaction time, tactile receptor systems and ideomotor compatibility. *Acta Psychologica* 50:143–57. [aBH]

Thayer, J. F. & Lane, R. D. (2000) A model of neurovisceral integration in emotion

regulation and dysregulation. *Journal of Affective Disorders* 61:201–16. [MOB]
Theeuwes, J. (1993) Visual selective attention: A theoretical analysis. *Acta Psychologica* 83:93–154. [AFS]
Thelen, E., Schöner, G., Scheier, C. & Smith, L. B. (2001) The dynamics of embodiment: A field theory of infant perseverative reaching. *Behavioral and Brain Sciences* 24(1):1–34; discussion 34–86. [HRD]
Thelen, E. & Smith, L. B. (1994) *A dynamic systems approach to the development of cognition and action.* MIT Press. [aBH]
Theios, J. (1975) The components of response latency in simple human information processing tasks. In: *Attention and performance V,* ed. P. M. A. Rabbitt & S. Dornic. Academic Press. [aBH]
Thompson, D. W. (1942) *On growth and form.* Dover. [RES]
Tipper, S. P., Howard, L. A. & Houghton, G. (1998) Action-based mechanisms of attention. *Philosophical Transactions of the Royal Society of London B* 353:1385–93. [LP]
Toates, F. (1998) The interaction of cognitive and stimulus-response processes in the control of behaviour. *Neuroscience and Biobehavioral Reviews* 22:59–83. [PC]
Tolman, E. C. (1932) *Purposive behavior in animals and man.* Appleton-Century-Crofts. [JH, rBH]
(1948) Cognitive maps in rats and men. *Psychological Review* 53:189–208. [EC, JH]
(1959) Principles of purposive behavior. In: *Psychology: A study of science, vol. 2,* ed. S. Koch. McGraw-Hill. [rBH]
Tolman, E. C., Hall, C. S. & Bretnall, E. P. (1932) A disproof of the law of effect and a substitution of the laws of emphasis, motivation and disruption. *Journal of Experimental Psychology* 15:601–14. [rBH]
Treisman, A. (1960) Contextual cues in selective listening. *Quarterly Journal of Experimental Psychology* 12:242–48. [JI]
(1988) Features and objects: The Fourteenth Bartlett Memorial Lecture. *The Quarterly Journal of Experimental Psychology* 40A:201–37. [aBH]
(1992) Perceiving and re-perceiving objects. *American Psychologist* 47:862–75. [aBH]
(1996) The binding problem. *Current Opinion in Neurobiology* 6:171–78. [aBH]
Treisman, A. M. & Gelade, G. (1980) A feature-integration theory of attention. *Cognitive Psychology* 12:97–136. [aBH]
Tucker, M. & Ellis, R. (1998) On the relations between seen objects and components of potential actions. *Journal of Experimental Psychology: Human Perception and Performance* 24(3):830–46. [TC, rBH, DCR]
Turvey, M. T. (1977) Preliminaries to a theory of action with reference to vision. In: *Perceiving, acting, and knowing. Toward an ecological psychology,* ed. R. Shaw & J. Bransford. Erlbaum. [arBH, MJR]
(1992) Affordances and prospective control: An outline of the ontology. *Ecological Psychology* 4:173–87. [N-GK]
(1996) Dynamic touch. *American Psychologist* 51:1134–52. [MJR]
Turvey, M. T. & Fitzpatrick, P. (1993) Commentary: Development of perception-action systems and general principles of pattern formation. *Child Development* 64:1175–90. [RES]
Umiltà, C. & Nicoletti, R. (1990) Spatial stimulus-response compatibility. In: *Stimulus-response compatibility: An integrated perspective,* ed. R. W. Proctor & T. G. Reeve. North-Holland. [RWP]
Ungerleider, L. G. & Mishkin, M. (1982) Two cortical visual systems. In: *Analysis of visual behavior,* ed. D. Ingle, M. A. Goodale & R. J. W. Mansfield. MIT Press. [aBH]
Van der Goten, K., Caessens, B., Lammertyn, J., De Vooght, G. & Hommel, B. (2001) The functional basis of backward-compatibility effects: Selecting emotional actions primes the perception of emotional words. (submitted). [rBH]
Van der Heijden, A. H. C. (1992) *Selective attention in vision.* Routledge. [aBH, AFS]
Van der Heijden, A. H. C., Müsseler, J. & Bridgeman, B. (1999a) On the perception of position. In: *Cognitive conributions to the perception of spatial and temporal events,* ed. G. Aschersleben, T. Bachmann & J. Müsseler. Elsevier. [aBH]
Van der Heijden, A. H. C., Van der Geest, J. N., De Leeuw, F., Krikke, K. & Müsseler, J. (1999b) Sources of position-perception error for small isolated targets. *Psychological Research* 62:20–35. [aBH]
Van Donkelaar, P. & Franks, I. M. (1991) Preprogramming vs. on-line control in simple movement sequences. *Acta Psychologica* 77:1–19. [rBH]
Van Leeuwen, C. & Raffone, A. (2001) Coupled nonlinear maps as models of a perceptual pattern and memory trace dynamics. *Cognitive Processing* 2:67–116. [MOB]
Van Leeuwen, C., Steyvers, M. & Nooter, M. (1997) Stability and intermittency in large-scale coupled oscillator models for perceptual segmentation. *Journal of Mathematical Psychology* 41:1–26. [GW]
Van Selst, M. & Jolicoeur, P. (1997) Decision and response. *Cognitive Psychology* 33:266–307. [rBH]
Viviani, P. & Stucchi, N. (1989) The effect of movement velocity on form perception: Geometric illusions in dynamic displays. *Perception and Psychophysics* 46:266–74. [aBH]
Viviani, P. & Stucchi, N. (1992) Motor-perceptual interactions. In: *Tutorials in motor behavior, II,* ed. G. E. Stelmach & J. Requin. Elsevier. [aBH]
Viviani, P., Baud-Bovy, G. & Redolfi, M. (1997) Perceiving and tracking kinesthetic stimuli: Further evidence of motor-perceptual interactions. *Journal of Experimental Psychology: Human Perception and Performance* 23:1232–52. [aBH]
Viviani, P. & Terzulo, C. A. (1982) Trajectory determines movement dynamics. *Neuroscience* 7:431–37. [aBH]
Von Hofsten, C. (1985) Perception and action. In: *Goal-directed behavior: The concept of action in psychology,* ed. M. Frese & J. Sabini. Erlbaum. [aBH]
Von Holst, E. & Mittelstaedt, H. (1950) Das Reafferenzprinzip. *Naturwissenschaften* 37:464–76. [PC, aBH]
Von Weizsäcker, V. (1940) *Der Gestaltkreis.* Springer. [AFS]
Vu, K.-P. L. & Proctor, R. W. (2001) Determinants of right-left and top-bottom prevalence for two-dimensional spatial compatibility. *Journal of Experimental Psychology: Human Perception and Performance* 27:813–28. [RWP]
Walker, E. L. (1969) Reinforcement – "The one ring." In: *Reinforcement and behavior,* ed. J. T. Tapp. Academic Press. [rBH]
Wallace, R. A. (1971) S-R compatibility and the idea of a response code. *Journal of Experimental Psychology* 88:354–60. [aBH]
(1972) Spatial S-R compatibility effects involving kinesthetic cues. *Journal of Experimental Psychology* 93:163–68. [aBH]
Ward, L. M. (1982) Determinants of attention to local and global features of visual forms. *Journal of Experimental Psychology: Human Perception and Performance* 8:562–81. [aBH]
Warren, W. H. (1984) Perceiving affordances: Visual guidance of stair climbing. *Journal of Experimental Psychology: Human Perception and Performance* 10:683–703. [MJR]
(1998) Visually controlled locomotion: 40 years later. *Ecological Psychology* 10:177–220. [rBH]
Warrick, M. J. (1947) *Direction of movement in the use of control knobs to position visual indicators.* USAF AMC Report No.694-4C, Wright Airforce Base, Ohio, USA. [AFS]
Weimer, W. R. & Palermo, D. S., eds. (1974) *Cognition and the symbolic processes, vol. 1.* Erlbaum. [rBH]
(1982) *Cognition and the symbolic processes, vol. 2.* Erlbaum. [rBH]
Weiss, P. (1967) One plus one does not equal two. In: *The neurosciences,* ed. G. Querton, T. Melnechuk & F. Schmitt. Rockefeller University Press. [RES]
Welch, R. B. (1978) *Perceptual modification. Adapting to altered sensory environments.* Academic Press. [aBH]
(1986) Adaptation of space perception. In: *Handbook of perception and human performance, vol. 1: Sensory processes and perception,* ed. K. R. Boff, L. Kaufman & J. R. Thomas. Wiley. [aBH]
Welford, A. T. (1952) The "psychological refractory period" and the timing of high-speed performance – a review and a theory. *British Journal of Psychology* 43:2–19. [rBH]
(1968) *Fundamentals of skill.* Methuen. [aBH, RWP]
(1976) *Skilled performance: Perceptual and motor skills.* Scott-Foresman. [RWP]
(1980) Choice reaction time: Basic concepts. In: *Reaction times,* ed. A. T. Welford. Academic Press. [aBH]
Werner, H. & Wapner, S. (1952) Towards a general theory of perception. *Psychological Review* 59:324–38. [AFS]
Whiting, H. T. A., ed. (1984) *Human motor actions – Bernstein reassessed.* North-Holland/Elsevier. [rBH]
Williams, L. M. (1996) Cognitive inhibition and schizophrenic symptom subgroups. *Schizophrenia Bulletin* 22:139–51. [RDO]
Wise, S. P. & Murray, E. A. (2000) Arbitrary associations between antecedents and actions. *Trends in Neurosciences* 23:271–76. [PC]
Wolff, P. (1987) Perceptual learning by saccades: A cognitive approach. In: *Perspectives on perception and action,* ed. H. Heuer & A. F. Sanders. Erlbaum. [aBH]
(1999) Space perception and intended action. In: *Cognitive contributions to the perception of spatial and temporal events,* ed. G. Aschersleben, T. Bachmann & J. Müsseler. Elsevier. [aBH]
Wolpert, D. M. & Kawato, M. (1998) Multiple paired forward and inverse models for motor control. *Neural Networks* 11:1317–29. [DAR]
Wühr, P. & Müsseler, J. (2001) Time course of the blindness to response-compatible stimuli. *Journal of Experimental Psychology: Human Perception and Performance* 27(5):1260–70. [JD, arBH, CO]
Yaniv, I., Meyer, D. E., Gordon, P. C., Huff, C. A. & Sevald, C. A. (1990) Vowel similarity, connectionist models, and syllable structure in motor programming of speech. *Journal of Memory and Language* 29:1–26. [aBH]
Zacks, J. M. & Tversky, B. (2001) Event structure in perception and conception. *Psychological Bulletin* 127:3–21. [rBH, JMZ]

Zacks, J. M., Tversky, B. & Iyer, G. (2001) Perceiving, remembering, and communicating structure in events. *Journal of Experimental Psychology: General* 130:29–58. [JMZ]

Ziessler, M. (1990) Task dependent formation of object features. *Studia Psychologica* 32:41–52. [GW]

Zinyuk, L., Kubik, S., Kaminsky, Y., Fenton, A. A. & Bures, J. (2000) Understanding hippocampal activity by using purposeful behavior: Place navigation induces place cell discharge in both task-relevant and task-irrelevant spatial reference frames. *Proceedings of the National Academy of Sciences USA* 97:3771–76. [JH]

Zwaan, R. A. & Radvansky, G. A. (1998) Situation models in language comprehension and memory. *Psychological Bulletin* 123:162–85. [JMZ]