Guest editorial: Perceptual organisation and object recognition—POOR is the acronym, rich the notion

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Abstract. Instead of studying perceptual organisation and object recognition in relative isolation, they can be viewed as two highly related sets of processes performed by the visual system to achieve its goal of acquiring information about the world.

Fifteen papers devoted to specific subproblems within this active area of research have been brought together in two successive issues of Perception. Collectively they demonstrate that focusing on the functional interrelationships between perceptual organisation and object recognition will enrich our understanding of each of the subprocesses involved.

The editorial provides an overview of the papers together with a discussion on how they relate to one another. If a general message is to be extracted from this set of papers, it is that the visual system's processes cannot be characterised in general by simple dichotomies such as analytic versus wholistic, bottom-up versus top-down, local versus global, low-level versus high-level, parallel versus serial, etc. Instead, it appears that a wide variety of mechanisms is available to the visual system. Therefore, a complete understanding of its functioning will require careful examination of the circumstances within which one processing mechanism seems to be selected over another, depending on the available information, the task demands, and perhaps even the observer's individual characteristics.

Introduction

Traditionally, research on perceptual organisation has been the privileged domain of Gestalt psychology, whereas the study of object recognition was almost exclusively inspired by cognitive psychology. This theoretical division of labour was still clearly present in Perceptual Organization, the collection of papers edited by Kubovy and Pomerantz (1981), which contained the state of the art until the late 1970s. The editors were quite explicit about this in their preface: "The cognitive psychologists' desire for a phenomenological and intellectual interaction with Gestalt psychology did not manifest itself in their publications" (page ix). Recently, however, the upsurge of interest in the computational approach has changed this picture dramatically. When one considers the visual system from a functional perspective, it makes much more sense to study both types of perceptual processes as highly related subsystems working towards the same goal of acquiring information about the world.

Although the origins of this alternative approach can be found in publications in the early 1980s (eg Barrow and Tenenbaum 1981; Marr 1982; Stevens 1981; Witkin and Tenenbaum 1983), it has been incorporated into psychological theorising only recently. In particular, Biederman's (1987) recognition-by-components (RBC) theory of object recognition has been seminal in this respect, because it has made extensive use of Lowe's (1987) nonaccidental properties (NAPs) to extract and identify parts of objects in the image. This is only one particular instance of a broader framework in which perceptual organisation is viewed as the ensemble of processes necessary to extract regularity from the image and to represent it in a useful format for later processes such as those involved in object recognition (see also Pentland 1986).
That this way of focusing on the interrelationships between both types of processes has really enriched the conception of each is what we hope to make clear by bringing together the papers in this special issue. One of the most drastic changes in recent years is the interdisciplinarity which is now dominating our field and which was almost absent a decade ago. The present selection of papers reflects this cross-fertilisation between disciplines as well as the diversity of style and contents which comes with it. In addition to the classic experimental psychology of visual processing (eg Theeuwes, Tsal, Humphreys et al, Kolinsky et al, Kimchi, Sekuler, Koenderink et al, Lawson et al), there is computational work (eg Watt, Van Gool et al), as well as some mathematically inspired, though very intuitively presented, work on visual shape (eg Van Effelterre). Furthermore, some papers include neurophysiological work (eg Fahle) or discussion of its relevance (eg Watt, Boucart et al, Van Effelterre, Lawson et al), whereas others are more phenomenologically oriented (eg Leeuwenberg et al, Boselie).

It has been our deliberate choice to have no more neurophysiological work in the present set of papers than the little bit referred to above. As reviewed by Plaut and Farah (1990), there are three main sources of evidence about the neural bases of perceptual organisation and object recognition: clinical studies of brain-damaged humans, lesion studies of animals, and single-cell-recording studies of animals. Yet, each of these has its own drawbacks that do not allow us to learn much about the essential aspects of interactions between processes.

This might change quite soon, however, now that more global, functional approaches are becoming more widely used. In particular, we expect more directly relevant results from the very promising techniques of tracing trains of activities in ensembles of neurons supporting population encoding (eg Georgopoulos et al 1986) and looking at the synchronisation of oscillatory activity as a way of establishing spatial relations between local features (eg Gray et al 1989). For example, Hummel and Biederman (1992) in their update and connectionist implementation of RBC, called JIM (John and Inv's model), have been inspired by this work in their solution of the binding problem (ie, the representation of attribute conjunctions) which had plagued network models of perceptual organisation and object recognition for years. Moreover, PET scans and other functional imaging techniques might well provide us with the appropriate methods for mapping the functions of the visual system by comparing cortical activation across many conditions within a subject (eg Haxby et al 1991). A similar special issue within a couple of years from now would most probably contain such research too.

To get a better idea of what to expect, we will now provide a short overview of the individual papers and their interrelations. The way they are ordered in this special issue suggests a 'bottom-up' approach, with the hard-wired, primitive mechanisms to extract blobs, contours, and features (Watt, Boucart et al, Fahle) presented first, followed by the visual-attention mechanisms to select the information worth processing further (Theeuwes, Tsal, Humphreys et al, Kolinsky et al); next are the processes of perceptual organisation \textit{sensu stricto} such as the ones involved in processing wholistic/configural properties and hierarchical stimulus levels (Kimchi, Leeuwenberg et al), or occlusion and amodal completion (Boselie, Sekuler); and, finally, the issues in object recognition, from invariants in planar forms (Van Gool et al) to three-dimensional shape (Van Effelterre, Koenderink et al) and viewpoint-specific procedures (Lawson et al). However, as we will clarify shortly, there is a great deal of 'cross talk' between the different levels of processing which is inconsistent with a very rigid, strictly unidirectional flow of information.

Indeed, recent research has raised additional doubts in this respect. Peterson and Gibson (1993) have shown that even a prototypical perceptual-organisation process
like figure-ground segregation might be influenced by object-recognition processes. Moreover, Rock and his colleagues (Mack et al 1992; Rock et al 1992) have demonstrated convincingly that supposedly preattentive grouping mechanisms might not be operating in conditions of 'inattention', where the subjects do not expect to be tested about the perceptual organisation of the stimuli. It remains to be seen how damaging these results will turn out to be for the validity of the computational approach in human vision as a whole. To us at least, it shows what an incredible variety of mechanisms must be used by nature's own perceiving machine, a conclusion which is clearly supported by the papers in this special issue as well.

Overview of the papers and their interrelations
1. Watt starts from the idea that the initial stages of human vision are more concerned with the whole area of the image of an object than with the extraction of primitive features such as edges. He examines the principles of the filtering of images at different scales and their requirements to produce suitable responses under a range of different viewing and illumination conditions. More specifically, the general problem is that the local outputs of linear filters do not correspond to the whole region occupied by an object. Combination of information across space is required which, Watt argues, can be done in a bottom-up fashion by Gestalt-like clustering principles such as curvilinear grouping along a common axis and parallel grouping across a common orthogonal axis. This approach is confronted with severe problems if there is strong directional lighting and the object of interest stands in a cluttered scene. Watt also examines the computational nature of these problems and proposals for their solutions.

This first paper pretty much sets the stage for many of the other papers to follow, because it touches upon many of the issues pervading much of the research on perceptual organisation and object recognition. For example, does the visual system work with locally defined primitive features or are the more global spatial relations between them more basic? Does it work in a purely bottom-up fashion or has knowledge about specific objects an influence quite early on in the course of processing? These and other questions lie at the heart of the second paper as well.

2. Boucart et al review recent accounts of the mechanisms involved in the computation of contours and report an experiment designed to allow examination of two questions. First, they examine how physical parameters such as proximity and collinearity affect the integration of local contour elements into a coherent global contour enclosing object forms and, second, whether the top-down activation of stored representations of objects facilitates the bottom-up computation of contours. They conclude that the computation of contour information is more affected by physical constraints at the level of the early processes than by the higher-level processes involving activation of stored structural representations of objects. It is interesting to point out that Boucart and Humphreys (1992, 1994) have recently reported evidence which seems to be contradictory at first sight, namely that in some tasks concerned with global aspects of shape, subjects could not refrain from processing the meaning of the objects with that shape. However, it could be that this result is due to a 'horse race' between processes where object identity is automatically accessed before the response is formulated.

In addition to the dichotomies just mentioned (eg local/global, bottom-up/top-down, low/high level), which are touched upon in many other papers in this special issue, it is interesting to point to another relation between this study by Boucart et al and Watt's approach introduced before. Whereas Watt's filtering scheme is aimed at extracting two-dimensional blob-like structures which are then described by a bar
code to capture their orientation and one-dimensional ordering along an axis, Boucart et al's work on contours is more akin to object-recognition schemes based on the one-dimensional encoding of curvature changes along the contour (eg. Hoffman and Richards 1984). This axis/contour duality is a hot topic in recent debates on object recognition (eg. Ullman 1989). Leyton (1987) has used this duality in favour of his own theory of shape description because it is capable of incorporating both aspects into a single representation format.

3. **Fahle** discusses psychophysical and electrophysiological experiments suggesting that some form of perceptual learning might occur quite early during visual-information processing in the human cortex. More specifically, he shows that performance in a number of simple perceptual tasks such as discriminating vernier offsets and detecting jump displacements improves as a result of practice. In addition, he distinguishes between a fast phase of learning that takes place within less than 30 min and a slow phase that continues over 10 h of training. Fahle also demonstrates that the improvement is specific for relatively simple features, such as the orientation and position of the stimulus in the visual field. Finally, he presents some results from a visual search task with vernier stimuli to show that deviation from straightness is one of the elementary features probably detected early during visual pattern recognition. Visual search will, of course, be one of the main topics in the series of papers on visual attention which follow Fahle's paper.

No matter how low level these results may seem, Fahle interprets them as support for a new theory of visual object recognition that is based on multidimensional interpolation between stored templates. This theory is in clear opposition to the idea of invariance discussed in the paper by Van Gool et al, and much more akin to the idea of viewpoint-specific object description and recognition for which Lawson et al provide some empirical support and Van Effelterre proposes aspect graphs as a theoretically interesting representation format. Indeed, Fahle's paper is a clear instance of the potential scope of a single research effort as to the number of different levels of processing being implied.

4. **Theeuwes** offers an excellent review of the literature on endogenous ('bottom-up') and exogenous ('top-down') control of visual selection along with a speculative framework within which to interpret the major findings in this area. More specifically, he proposes that the visual system automatically calculates differences in basic features such as colour, shape, and brightness and that the visual information occupying the position of the highest saliency across these stimulus dimensions is then passed on to the central representation that is responsible for further stimulus analysis. We regard this paper as one of a series in which the authors struggle to integrate well-known empirical findings on top-down effects with the theoretically desirable computational architecture of bottom-up processing.

5. Indeed, in the next paper **Tsai** reviews evidence on early versus late selection and summarises some challenging results obtained in his own research demonstrating effects of attention on early perceptual processes. In particular, these studies show that directing attention to stimulus location influences perceived brightness, perceived length, and the overall perceptual organisation in well-known illusions (eg. Müller-Lyer) and ambiguous figures (eg. duck-rabbit). Careful methodological considerations allow Tsai to argue that these results provide strong support for early-selection views of attention, or, in other words, for facilitation even of early perceptual processing by top-down control of attention.

6. However, the visual system seems to have available the opposite mechanism too. **Humphreys et al** present two somewhat independent lines of evidence arguing in
favour of early, automatic, preattentive and parallel visual computation of three-dimensional spatial relations. On the one hand, they show that performance in a task in which subjects had to detect an odd part of cube-like figures, formed by the grouping of corner junctions, was unaffected by the number of corners present and the noncollinearity between them in the case of three-dimensional cubes, whereas the opposite was true for two-dimensional planes. On the other hand, visual search for size-defined targets appears to be affected by a size illusion induced by linear perspective cues from local background neighbourhoods. In general, these data suggest that early visual processes compute ‘quick and dirty’ three-dimensional shape representations from local areas at multiple locations in an image (see also Enns and Rensink 1991). Furthermore, these three-dimensional representations can, at least in some circumstances, dominate those coded in two dimensions.

7. Issues of attentional control and the role of features versus groups in perceptual processing are considered in the study by Kolinsky et al too. They review evidence suggesting that unschooled adults who cannot read have serious difficulties at performing tasks which, like part verification, dimensional filtering, or orientation judgments, require attention to be paid to a specific aspect of the stimulus structure. Kolinsky et al provide direct evidence that unschooled adults do analyse visual stimuli into component parts or dimensions in a preattentive task. In particular, illusory conjunctions occurred in unschooled adults at about the same rate as in age-matched schooled adults in a series of four experiments testing separability either of parts or of dimensions as well as line-orientation registration. Kolinsky et al also discuss the relevance of these findings with respect to the level of processing responsible for illusory conjunctions, from early, preattentive accounts to higher-order guessing strategies and memory failures.

8. The issue of globality which is so much at the heart of the problem of perceptual organisation is explicitly clarified and examined in Kimchi’s paper. She has recently distinguished between two different notions of globality, one defined by the position in the hierarchical structure of the stimulus and another defined as a function of interrelations among component parts (Kimchi 1992). In the study reported here, the processing consequences of this distinction between global and wholistic or configurational properties, respectively, are examined in a series of five experiments. In general, the results of the first four experiments suggest that configurational properties such as closure and intersection dominate component properties such as line orientation and curvature sign. The final experiment, in which the two types of globality are manipulated orthogonally within one simple yet ingenious design, yielded a global-to-local advantage only when the task required classification based on line orientation, not when based on closure. On the basis of the similarity between findings on texture perception and findings on form perception, Kimchi suggests that the perceptual system seems to have a predisposition for configurational properties.

Kimchi also notes that previous work by Leeuwenberg and Van der Helm (1991) leads to the same conclusion that not all global properties are necessarily dominant. In their scheme, the specification of dominant properties can be derived from the simplicity of the pattern representations. More specifically, they suggested that the highest hierarchical level in the simplest pattern representation, which they call the ‘superstructure’ (as opposed to the ‘substructure’), dominates the classification and discrimination of visual forms, but that this superstructure is not necessarily more global or larger. Note, however, that Kimchi’s findings do not agree with their proposal that the superstructure always dominates classification and discrimination of visual forms.
9. These notions are developed further in Leeuwenberg et al.'s present contribution, which can be read as a postscript to and more detailed consideration of the consequences of their 1991 paper. In particular, they focus on two aspects of a comparison between Biederman's (1987) RBC approach and their own structural-information theory (SIT). First, they examine various definitions of object axes (like those proposed by RBC) and show that the more these definitions account for object regularity (hence, the more they agree with SIT), the better the resulting object representations predict object classification. Second, they critically examine the usefulness of NAPs and show that they are based more on the regularity of objects in the real world than on invariance as such, a conclusion which is again more in line with SIT than with RBC. An alternative view on the relation between invariance and NAPs is included in the paper by Van Gool et al.

The next two papers are particularly intertwined. Boselie and Sekuler both study the problem of occlusion and how the visual system amodally completes the stimulus behind the occluder (again a very classic phenomenon in the realm of perceptual organisation). More specifically, both papers are concerned with the role of local and global factors in visual occlusion.

10. It is interesting to point out that Boselie's thinking about these issues has changed quite drastically over the years he has been working on this. In fact, he has taken positions which cover the whole spectrum of theoretical possibilities. Originally, he was working in line with the global-minimum principle pervading Leeuwenberg's SIT (see eg Boselie and Leeuwenberg 1986). A couple of years later (Boselie 1988) he proposed a hybrid theory of occlusion phenomena with an equal role for global and local factors. Another couple of years later (eg Boselie and Wouterlood 1992; Wouterlood and Boselie 1992) he provided counterexamples against his own theory and formulated a good-continuation model of occlusion phenomena in a very restricted domain, namely patterns from which all global regularities have been removed. In the paper in this special issue he now shows that this strictly local model also describes correctly the preferred interpretations of many globally regular patterns.

In addition to the obvious relationships with the other papers dealing with general issues of local versus global processing and Sekuler's paper on the same specific problem, Boselie's paper touches upon two other topics shared with other papers in this issue. First, smooth continuation plays a key role in his model of occlusion. This is clearly related to collinearity as it appears in the studies by Humphreys et al and Boucart et al and somewhat more distantly to closure as it appears in Kimchi's research. Second, Boselie discusses Rock's (1983) coincidence principle, which is akin to Lowe's (1987) nonaccidentalness as it appears in the papers by Leeuwenberg et al and Van Gool et al.

11. Sekuler presents results from a primed-matching paradigm (Sekuler and Palmer 1992) suggesting that global processes may play a role quite early in amodal completion. Sekuler further suggests that local processes dominate only under limited conditions of figural regularity and orientation. She interprets these data as inconsistent either with purely local or with purely global theories of completion.

The apparent difference between her and Boselie's conclusions might be due to any of the many differences between their research paradigms and stimuli. For example, the data produced by the different paradigms cannot be meaningfully compared because measurements have been made in different time domains. The whole process in the traditional describe/draw paradigm (as used by Boselie) takes at least a number of seconds and is likely to be affected by cognitive as well as perceptual processes. On the other hand, in most experiments with the primed-matching paradigm (as used by Sekuler), primes are usually presented for only several hundred milliseconds,
minimising the possibility of cognitive influences. Both researchers acknowledge that dominance relations might change over time. In addition, Sekuler's and Boselie's research is focused on different aspects of visual completion; Sekuler explicitly states that her model of completion applies only after the initial determination of which figures are occluded and require completion, whereas Boselie's model also covers this.

Sekuler also discusses the implications of her research for object perception and representation in general. More specifically, she speculates on a possible scheme of on-line development of perceptual representations requiring interactions between bottom-up and top-down information which might be tapped by her primed-matching technique designed to study exactly this kind of microgenesis. In doing so, she refers to Tsai's and Watt's research which suggests that the extent to which specific features or spatial scales are encoded may be controlled by a priori expectations about the object. In addition to these interrelations, Sekuler's experiments share the interest in the influence of orientation with many other papers in which this stimulus attribute plays some role, either as the most commonly studied orientation in the plane (e.g., Fahle, Kolinsky et al., Watt, Kimchi), or as orientation before and after reflection (Boucart et al.), or as orientation in depth (Lawson et al.).

The next two papers are quite similar in their aim and approach but rather different in their particular contents. Both present some mathematically elegant work in an intuitive way, using as little technical mathematics as possible, and show that it has proven very useful in current computer-vision approaches of object recognition and that it might be interesting to consider in research on human vision as well. The major purpose in these tutorials is to provide perceptual scientists with the necessary background to start using these mathematical ideas as a source of inspiration for their own research. In addition to examples from the computer-vision literature, both papers refer to a large number of psychological papers to indicate the relations with these approaches.

12. The first of these papers is about the mathematics of invariance under a group of transformations as a potentially useful source of information to explain the remarkable capability of the human visual system to recognise objects from changing viewpoints. Van Gool et al. explain the basic philosophy and trade-offs underlying this approach and show how well-known Euclidean concepts such as area, distance to a line, and curvature underlie invariance for the relatively simple case of planar-object recognition under arbitrary viewpoints. The notion of nonaccidentalness is used to demonstrate that the invariants may become even simpler when additional constraints are used. Especially in those cases, these invariants may well be the kind of information that human vision uses to support object recognition.

As mentioned before, Van Gool et al.'s view on the relation between invariance and nonaccidentalness differs from the treatment in Leeuwenberg et al.'s paper, where it is used to compare critically Biederman's RBC with SIT. On a more fundamental level, the invariance approach can be contrasted with the idea that objects are recognised from different viewpoints because multiple views are stored for each object in memory (see Fahle, Lawson et al.). Of course, there must be a way to economise on the storage space required for such a mechanism. This is exactly what the aspect-graph approach, introduced by Van Effelterre, claims to offer.

13. An aspect graph is a representation of three-dimensional objects consisting of all its topologically stable image contours (i.e., aspects) and the transitions between them (i.e., visual events). In other words, the idea is to represent only the basically different views of an object and to disregard all intermediate views which differ only in more detailed aspects. Van Effelterre introduces the necessary mathematics to express these notions of 'major' and 'minor' differences in more precise terms, based on results in
topology, singularity theory, and differential geometry. In our view, he succeeds in doing this in a highly intuitive way, with a large number of figures to demonstrate his points. Van Effelterre also reviews the literature on the use of this approach in human vision as well as computer vision, from Koenderink's original idea (see eg Koenderink and van Doorn 1976, 1979) until the recent work by Perrett and his colleagues (see eg Perrett and Harries 1988; Perrett et al 1992).

14. The paper by Koenderink et al is a sequel to an earlier paper by the same authors (Koenderink et al 1992) in which they presented an important technique for reconstructing a three-dimensional object from a set of local slant estimates at many different points on a flat picture of a three-dimensional object. In this follow-up investigation, Koenderink et al have presented their subjects two new images under three different conditions, in which the images could be viewed monocularly, binocularly, or through an ingenious device invented in the last century, called a synopter. In addition to providing an important methodological breakthrough in our ability to study the perception of three-dimensional form, this paper demonstrates empirically how perceived three-dimensional form from a given visual image can vary across different viewing conditions. Koenderink et al also provide an interesting historical discussion of how optical devices other than stereoscopes can be used to enhance the visual perception of surface relief.

Whereas Koenderink et al's work is concerned with the perception of the form of three-dimensional objects and the global spatial relations between local surface patches, Lawson et al focus on the recognition of the identity of three-dimensional objects, a task which obviously taps higher-order cognitive processes because meaning comes into play.

15. Lawson et al report on a series of experiments to investigate the effects of depth rotation on the efficiency of recognising familiar objects in a sequence of very briefly flashed line drawings of them. In addition to manipulation of the type of sequence (structured versus random) and the degree of local similarity between successive pictures, in this study the identification rates obtained under apparent object rotation are compared with ratings of perceived object motion and identification in repeated static views. In general, the results suggest that object recognition is based on the matching of image descriptions to view-specific stored representations and that the priming effects obtained under sequential viewing conditions are strongly influenced by the visual similarity of different views of objects.

The latter conclusion could be verified in more detail if one used a format similar to one proposed in the aspect-graph approach (Van Effelterre) to capture the degree of similarity in more precise terms. The former conclusion about multiple views is exactly the approach Fahle used in the third paper of this series to interpret his results on specific learning patterns in tasks which require discrimination of simple, low-level features.

Now that we are back where we started, it seems that we should try to evaluate whether there is some general conclusion to be drawn from this set of papers, in addition to each individual paper’s contributions. Is the whole more than the sum of its parts?

Conclusion
One way to try to answer this question is to bring together all dichotomies that researchers in this special issue, as well as in the broader domain of perceptual organisation and object recognition, have used to describe the mechanisms of human vision. We have mentioned most of them in our overview of the papers, but we now try to do this exhaustively in table 1. Other dichotomies in addition to those listed in
the table pervade our current way of thinking about the visual system (e.g., qualitative/quantitative, low/high spatial frequencies, identity/position, likelihood/simplicity), but we have chosen to select only the ten most popular ones.

Obviously, papers in this issue seem to support each other’s results or appear at least to be very complementary (e.g., Fahle-Lawson et al; Humphreys et al-Boucart et al; Kimchi-Leeuwenberg et al; Van Effelterre-Lawson et al). However, there are also some apparent contradictions. Two obvious examples are repeated here, but others could be focused on as well.

First, whereas Tsal’s research suggests top-down effects of attention even on early perceptual judgments of simple features such as brightness and length, the results obtained in the study by Humphreys et al seem to imply preattentive encoding of even supposedly later three-dimensional spatial relations. Treisman (1993) has argued recently that such results are not necessarily contradictory. It is quite possible that there is a dichotomy between preattentive and attentive processing levels but a continuum between divided and focused attention depending on the task (see also Theeuwes’s paper). For example, Tsal’s tasks seem to require narrowly focused attention, whereas alignment and shape judgments such as those in the Humphreys et al study could be done with a broad setting of the attention window.

The second contrast is between the two papers on occlusion. On the one hand, Boselie shows that a model of occlusion which works with strictly local factors such as good continuation is supported by the data of his experiments, even when the shapes are globally regular. On the other hand, Sekuler presents data which are incompatible with explanations based exclusively on local or exclusively on global factors. In her paper, Kimchi has succeeded in removing apparent conflicts and conceptual confusion in the literature by distinguishing between two different usages of ‘global’. In doing so, she has convincingly argued that one cannot demonstrate wholistic processing (i.e., first usage) by findings of global advantage (i.e., second usage). Although such a strategy might be very successful in general, it is not clear how it would apply to this particular conflict since Boselie and Sekuler seem to agree about their definitions of local and global factors in occlusion. We have already commented on other possible reasons for their different results.

As Newell (1973) noted more than twenty years ago in his attempt at an overview of papers presented at a symposium to ‘put it all together’, current researchers in perceptual organisation and object recognition—as well as others in cognitive science

Table 1. Ten popular dichotomies in the field of perceptual organisation and object recognition and their use in papers of this special issue.

| Paper number |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|--------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Two-dimensional/three-dimensional | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Analytic/wholistic | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Axis/contour | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Bottom-up/top-down | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Early/late selection; endogenous/exogenous | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Features/groups or configurations | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Local/global | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Low-level/high-level | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Parallel/serial | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| Viewpoint-specific/viewpoint-independent | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |

Note: The paper numbers refer to their order in this issue: 1 Watt, 2 Boucart et al, 3 Fahle, 4 Theeuwes, 5 Tsal, 6 Humphreys et al, 7 Kolinsky et al, 8 Kimchi, 9 Leeuwenberg et al, 10 Boselie, 11 Sekuler, 12 Van Gool et al, 13 Van Effelterre, 14 Koenderink, 15 Lawson et al.
then and now—seem to try to make sense out of the phenomena by the construction of binary oppositions much like playing the twenty-questions game with nature. The interrelations between the papers in this special issue leave us with a puzzling but challenging picture of the wide range of mechanisms which seem to be available to the visual system. Indeed, the apparent conflicts between them make it very hard to see how all of these can be embodied in one single system which is not confronted with the same Gordian knot as the researchers studying it. No wonder that some scientists have given up trying to integrate parts of what we know about the visual system by means of overarching principles and have started regarding it as 'a bag of tricks' used to 'digest' the visual information [eg Ramachandran (1985) in his guest editorial of a previous special issue in *Perception*].

The way Koenderink et al interpret their results about differences between subjects and between conditions within subjects might have some more general implications in this respect. Perhaps the visual system is able to use a variety of sources of information and mechanisms to process them, by putting different weights on the various sources of information and compromising between different mechanisms, depending on the task. Obviously, this leads to problems for empirical research in which only a few particular tasks (mostly only one) are used, but it does lead to success for the visual system most of the time.

Therefore, a more optimistic view based on the same state of affairs could be that the human visual system is just like that: "If you can think of five ways that the brain can do something, it does it in all five, plus five you have not thought of yet" (Schneider 1988, pages 51–52). It would be interesting to see how many more mechanisms of perceptual organisation and object recognition, in addition to those reported in this special issue, we will have discovered in another ten years from now.

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Once we had decided to publish the papers based on these presentations and found *Perception* willing to do so (March 1993), we formulated a strict timetable to get the shortest publication lag possible. Authors were given 3–4 months to submit a first draft. All seventeen of them were read by Johan Wagemans, one or two workshop participants, and one or two external reviewers. The authors received our decision and recommendations for revision by October 1993 and were then given another 2–3 months to submit the final revision. Two papers were dropped during this process. We would like to thank all authors and reviewers for adhering to these procedures and deadlines. In addition, we would like to thank the editors of *Perception* and the staff at Pion involved in this project for their kind collaboration.

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