Psychology Express

Cognitive Psychology

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Introduction

Not only is Psychology one of the fastest growing subjects to study at University worldwide it also one of the most exciting and relevant subjects. Over the past decade the scope, breadth and importance of psychology has developed considerably. Important research work from as far a field as the UK, Europe, US and Australia has demonstrated the exacting research base of the topic and how this can be applied to all manner of everyday issues and concerns. Being a student of psychology is an exciting experience- the study of mind and behaviour is a fascinating journey of discovery. Studying psychology at degree level brings with it new experiences, new skills and knowledge. As the Quality Assurance Agency (QAA, 2010) in the stressed:

> psychology is distinctive in the rich and diverse range of attributes it develops – skills which are associated with the humanities (e.g. critical thinking and essay writing) and the sciences (hypotheses-testing and numeracy). (page 5)

Recent evidence suggests that employers appreciate these skills and knowledge of psychology graduates but in order to reach this pinnacle you need to develop your skills, further your knowledge and most of all successfully complete your degree to your maximum ability. Your skills, knowledge and opportunities on your psychology degree will give you an edge in the employment field. The QAA (2010) stressed the high level of employment skills developed during a psychology degree:

> due to the wide range of generic skills, and the rigour with which they are taught, training in psychology is widely accepted as providing an excellent preparation for many careers. In addition to subject skills and knowledge, graduates also develop skills in communication, numeracy, teamwork, critical thinking, computing, independent learning and many others, all of which are highly valued by employers. (page 2)

This book, one in a comprehensive new series, helps you achieve these aspirations. It is not a replacement for every single text, journal article, presentation and abstract you will read and review during the course of your degree programme. It is in no way a replacement for your lectures, seminars or additional reading. A top rated assessment answer is likely to include considerable additional information and wider reading- and you are directed to some of these in this text. This revision guide is a conductor: directing you through the maze of your degree by providing an overview of your course, helping you formulate your ideas, and directing your reading.

Each book presents a summary coverage of the key concepts, theories, and research in the field, within an explicit framework of revision. The focus throughout all of the books in the series will be on how you should approach and consider your topics in relation to assessment and exams. Various features have been included to help you build up your skills and knowledge ready for

your assessments. More detail of these can be found in the guided tour for this book on page xii.

By reading and engaging with this book, you will develop your skills and knowledge base and in this way you should excel in your studies and your associated assessments.

This book is divided into twelve chapters and your course has probably been divided up into similar sections. However, all authors in the series and, me as editor have to stress a key point: do not let the purchase, reading and engagement with the material in this text restrict your reading or your thinking. In psychology, you need to be aware of the wider literature and how it interrelates and how authors and thinkers have criticised and developed the arguments of others. So even is an essay asks you about one particular topic you need to draw on similar issues raised in other areas of psychology. There are, of course, some similar themes that run throughout the material covered in this text but you can learn from the other areas of psychology covered in the other texts in this series: so learn not just from the material presented here but from the material presented elsewhere.

We hope you enjoy this text, which is part of a series of text books covering the complete knowledge base of psychology:

- *Biological Psychology*: covering the biological basis of behaviour, hormones and behaviour, socio-biology and evolutionary psychology and so on.
- *Cognitive Psychology* (Jonathan Catling and Jonathan Ling): including key material on perception, learning, memory, thinking and language.
- *Developmental Psychology* (Penney Upton): from pre-natal development through to old age, the development of individuals is considered. Childhood, adolescence and life-span development are all presented.
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- *Research methods in Psychology* (Steve Jones and Mark Forshaw): research design, experimental methods, discussion of qualitative and quantitative methods and ethics are all presented in this text.
- *Conceptual and Historical Issues in Psychology* (Brian Hughes): the foundations of psychology and its development from a mere interest into a scientific discipline. The key conceptual issues of current day psychology are also presented

This book, and the other companion volumes in this series, should be a one-stop to cover all of your study needs (there will also be further guidance on the website). It will, obviously, need to be supplemented with further reading and this text directs you towards suitable sources. Hopefully, quite a bit of what you read here you will already have come across and the text will act as a jolt and to set your mind at rest- you do know the material in depth. Overall, we hope that you find this book useful and informative and as a guide for both your study now and in your future as a successful psychology graduate.

Revision note

- *Use evidence based on your reading, not on anecdotes or your 'common sense'.*
- *Show the examiner you know your material in depth – use your additional reading wisely.*
- *Remember to draw on a number of different sources there is rarely one 'correct' answer to any psychological problem.*
- *Base your conclusions on research based evidence.*

Before you begin, you can use the **study plan** available on the companion website at **www.pearsoned.co.uk/pyschologyexpress** to assess how well you know the material in this book and identify the areas where you may want to focus your revision.

2

Perception

A printable version of this topic map is available from:
www.pearsoned.co.uk/psychologyexpress

Introduction

Perception is a complicated series of processes through which we acquire and interpret sensory information. This interpretation allows us to perceive our environment in a meaningful way. Most perception courses focus mainly on the architecture of the visual system and theories of vision, and we've duplicated that emphasis in this chapter. You will also see briefer sections on audition and olfaction, though nothing on haptics (touch) as this topic is dealt with only rarely.

Revision checklist

Essential points to revise are:

- ❑ The relationship between the physiology of the visual system and seeing
- ❑ Cognitive theories of vision
- ❑ How perception develops in neonates
- ❑ Influences on olfaction

Assessment advice

- Perception is a broad discipline. Although there is overlap between some elements, most perception courses often teach sub-topics in isolation from each other: one week you'll get a lecture on gestalt and the next on perceptual constancies. This means that many assessment questions will be along the lines of 'What does X theory tell us about the nature of vision?' Whenever answering a question like this, if you're asked about a theory *don't* just talk about that theory – although the bulk of your answer may well focus on this theory, it's also crucial (if you want to get the highest grades) to introduce alternative perspectives.
- This chapter will adopt the approach used by most perception modules, where topics are dealt with in isolation of each other, however where theories clearly contrast this will also be highlighted.

Sample question

Could you answer this question? Below is a typical essay question that could arise on this topic.

Sample question *Essay*

Does the gestalt approach provide a comprehensive view of visual perception?

Guidelines an answering this question are included at the end of this chapter, whilst guidance on tackling exam questions can be found on the companion website at:

www.pearsoned.co.uk/psychlolgyexpress.

Further reading Perception

Key reading

Foley,H.J. & Matlin, M.W. (2010). *Sensation and perception*. 5th ed. Harlow: Pearson.

Schiffman, H.R. (2008). *Sensation and perception: An integrated approach*. 6th ed. Chichester: John Wiley.

Sekuler, R. & Blake, R. (2005). *Perception*. 5th ed. London: McGraw-Hill.

The neurophysiology of the visual system

Neurophysiology is the study of the responses of the nervous system to external stimulation. The focus is particularly on transduction – the conversion of energy (light, sound, etc.) into electrical signals, and visual perception provides a good example of this. The human visual system can be thought of as consisting of three separate segments – the eye, the visual pathways and the visual centres of the brain.

The eye and the retina

The structure of the eye

Our eyes serve two functions:

- forming an image of an object
- transducing images into electrochemical signals which are sent to the cortex via neural pathways.

We'll skip the non-visual parts which are primarily concerned with the protection, maintenance and shape of the eye and focus on those responsible for image formation.

The image forming system

This consists of the cornea, pupil and lens (see Figure 2.1). Light enters through the cornea and is bent inward through the pupil to the lens which focuses light on to the retina. The crystalline lens is most important for accommodation (focusing) to ensure clear images and can change shape to alter the eye's optical power. Problems like myopia and sclerosis occur when the lens loses flexibility.

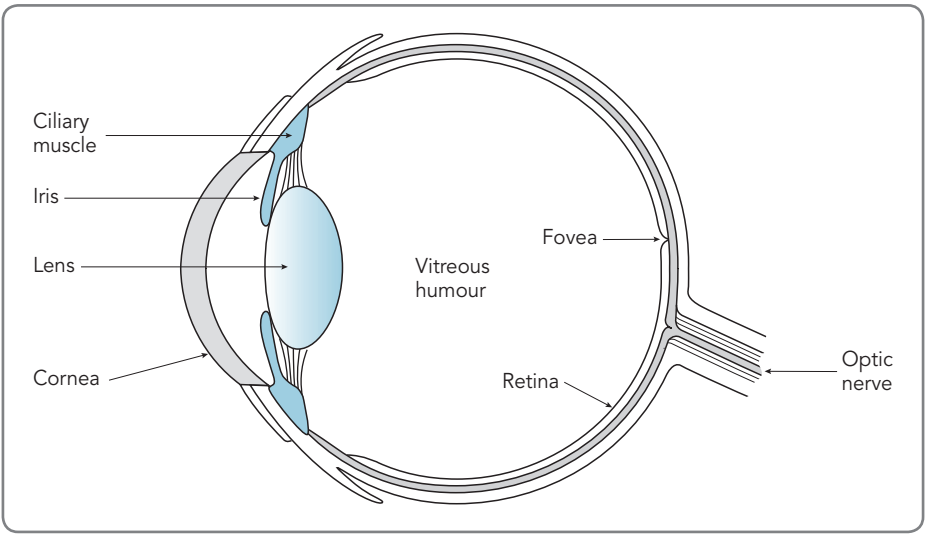

Figure 2.1 **The structure of the eye**

The transduction system: the retina

Located at the back of the eye, the retina is an outgrowth of the brain consisting of a thin and complex network of photoreceptor cells. The fovea (also called the macula) is a small depression in the retina densely packed with photoreceptors. The fovea has the best detail and the best colour sensation of anywhere in the eye, though it is less sensitive at low light levels. For the sharpest image, light is deflected on to the fovea.

There are three types of photoreceptor or retinal ganglion cells, the first two named for their appearance:

- *Rods*: operate at low light intensities, responsible for seeing at night, sensations are colourless. The human eye has about 120 million rods.
- *Cones*: operate at high light intensities, best during daylight, lead to colour sensations. Each eye has 8 million cones. Few cones are found around the periphery of the retina – where there is no colour vision.
- *Photosensitive ganglion cells*: help moderate circadian rhythms and pupil reaction, not involved directly with vision. Only discovered in humans by Zaidi et al. in 2007.

The optic disk (blind spot)

The optic disc is the point at which the axons of the retinal ganglion cells collect together and connect to the main body of the brain. There are no photoreceptor cells in this region, so this area of the retina is 'blind'.

Pathways leading to the visual cortex

Several pathways lead from the retina to the visual cortex (see Figure 2.2).

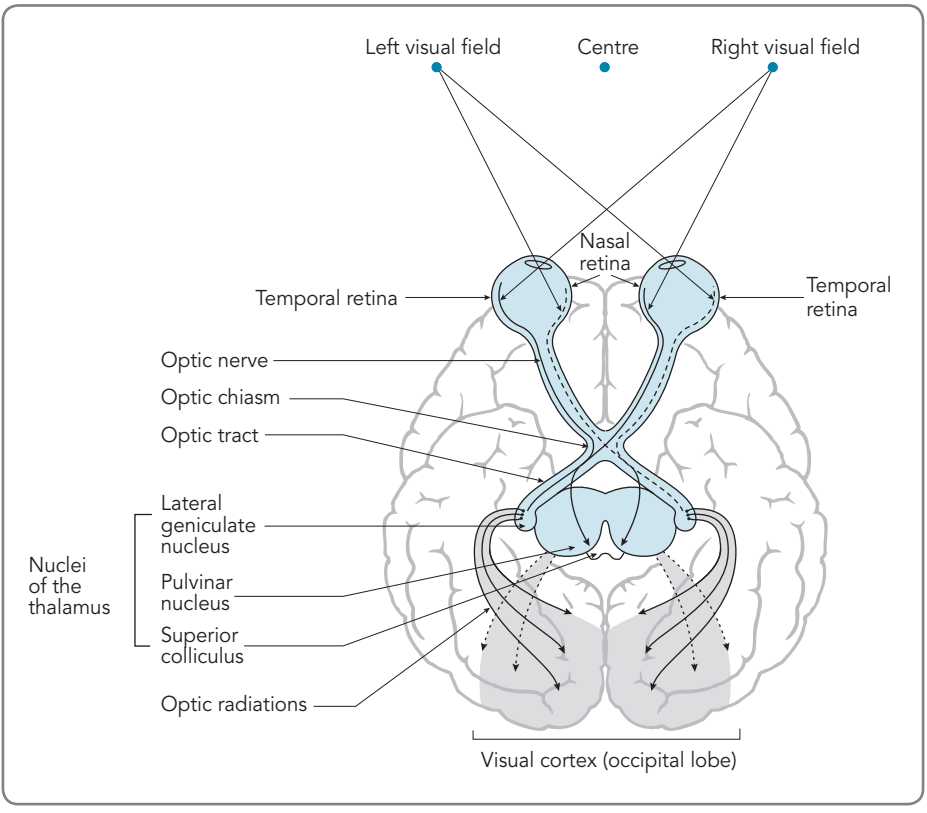

Figure 2.2 **Visual pathways**

The optic nerve

The optic nerve is the collection of axons leading to the visual centres of the brain from the eye. The optic nerve consists of retinal ganglion cells forming a cable of about a million axons. Axons are unmyelinated (that is, they have no outer cover) to reduce space. Fibres from different parts of the retina meet in the optic nerve in a very ordered fashion. The optic fibres transmit neural messages to the optic chiasm.

The optic chiasm

Optic neurons from each eye join at the optic chiasm. Some fibres within each optic nerve cross over and send impulses to the opposite side of the cerebral hemisphere. These are known as contralateral fibres, fibres that remain on the same side are the ipsilateral fibres. This means that messages dealing with any given region of the visual field arrive at a common destination in the visual

cortex, regardless of the eye they came from. Both sets of fibres continue into the brain via the optic tracts. The optic tracts now contain fibres from both eyes.

The lateral geniculate nuclei

The left and right lateral geniculate nuclei (LGN) are the first relay station of fibres from the eyes on the way to the visual cortex. Here, axons from the retina terminate on the dendrites and cell bodies of new neurons. It is the axons of these cells that continue to the cortex.

In humans, the LGN has six layers which contain cell bodies and are stacked.

- Layers 1 and 2 (at the bottom) contain the largest cells, termed magnocellular layers; these are associated with the perception of movement.
- Layers 3 to 6 are the smaller parvocellular layers, associated with perception of colour and fine detail.
- Between these layers are koniocellular cells, believed to be connected to colour perception and the somatosensory system.

Axons carrying information from neighbouring regions of retina meet in neighbouring parts of the LGN. Thus the LGN recreates a 'map' of the image from the retina; this is known as retinotopic mapping.

Cells in the LGN are primarily concerned with differing light intensities between adjoining regions of the retina. Whilst this action is similar to that of retinal cells, LGN cells amplify differences in illumination detected by the retina. Whilst the LGN conducts some early visual processing, it also receives outputs from the other senses. Therefore it may be involved in filtering messages from the eyes according to other sensory inputs and hence may be involved in visual orienting.

Superior colliculus

This structure lies under the cerebrum and helps guide visual attention. If an object suddenly appears in the extremity of the visual field, it is the superior colliculus that guides eye movements so that the novel object can be observed optimally (i.e. using foveal vision).

The visual cortex

The visual cortex is located at the back of the cerebral hemispheres in the occipital lobes. Most visual processing takes place in the primary visual cortex (also known as the striate cortex or V1 area) and the extrastriate visual cortical areas (e.g. V2, V3, V4 and V5 regions).

The layout of cells in the primary visual cortex is highly ordered:

- cells are layered
- respond to stimulation of a restricted area of retina
- are highly organised with cells responding to particular stimulation producing a topographical map so each cerebral hemisphere deals with half of the visual field.

Mapping is spatially distorted so that the majority of the cortex is devoted to central (foveal) rather than peripheral vision – this is why we are better at picking out details from the centre of a scene rather than the periphery.

Thus far we have only considered where in the visual field cortical neurons are looking, but we also need to think about what each cell is looking for.

Organisation within the visual cortex

Cells in the cortex are organised in columns (Hubel & Wiesel, 1977). Activation of these cells is dependent upon the input (e.g. length, width of stimulus), with different cells firing in response to specific inputs.

Cells in the visual cortex

Three main types of cell exist in the visual cortex:

1 Simple cells

- respond to particular stimuli (e.g. an edge or a line)
- only fire if an image falls exactly on a cell's receptive field (a region of the cell that responds to a specific stimulus)
- as responses are so specific, simple cells can signal the orientation of a stimulus falling within a particular region of the receptive field.

2 Complex cells

- also respond to particular orientations
- do not have such well-defined on and off areas; it is harder to predict what stimulus will cause activation
- respond most vigorously to a beam of light moving across the visual field.

3 Hypercomplex cells

- these cells detect lines of specific length
- recent research indicates these are subclasses of simple and complex cells.

Perceptual integration

One thing worth considering is how all this perceptual processing leads to a perception of the world that is so seamless. How does it become such a well-integrated whole if analysis is conducted across many regions of the brain, each of which has a separate analytical role? Current thought is that other, secondary, brain regions must be involved – in vision this blending of information is likely to be done in the visual association cortex, perhaps by guidance from the prefrontal cortex (Gazzaley & D'Esposito, 2007).

Further reading The biology of the visual system

Topic	*Key reading*
Visual cortex	Lennie, P. (1998). Single units and visual cortical organization. *Perception*, 27, 889–935.
Visual system	Nicholls, J.G., Martin, A.R. & Wallace, B.G. (1992). *From neuron to brain*. 3rd ed. Sunderland, MA: Sinauer.
Photo sensitive retinal ganglion cells	Zaidi, F.H., Hull, J.T., Peirson, S.N., et al. (2007). Short-wavelength light sensitivity of circadian, pupillary, and visual awareness in humans lacking an outer retina. *Current Biology*, *17*, 2122–8. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2151130/

Test your knowledge

The biology of the visual system

2.1 Name the image-forming structures of the eye.

2.2 What are the three types of retinal cells and what are their functions?

2.3 What does retinotopic mapping mean?

2.4 Describe the main types of cells in the V1 area.

Answers to these questions can be found on the companion website at: **www.pearsoned.co.uk/psychologyexpress**.

? *Sample question* *Essay*

Describe the organisation of the visual system from eye to cortex.

Cognitive theories of vision

Perceptual organisation is the process of organising components of a scene into separate objects. This segregation is crucial to object recognition. Several theories have attempted to explain how we do this.

Gestalt principles of perception

The gestalt approach focuses on form, arguing that it cannot be comprehended by merely looking at individual components. Form is dependent on the relationship *between* individual elements, rather than the elements themselves. The gestalt approach is holistic, in the sense that the whole is different to the sum of its parts.

Gestalt theory attempts to explain how the human perceptual system uses a range of principles to detect form, known as the *gestalt principles of organisation*. These principles are a series of factors believed to aid the perception of forms and promote their grouping. They call this detection of form (i.e. object shape) figure-ground segregation. These principles were, according to the gestaltists, innate.

Gestalt principles of organisation

These were developed principally by Wertheimer, though more recent work by Rock and Palmer (1990) has added further ones (connectedness and common region, see below). The fundamental gestalt principle of perceptual organisation is Prägnanz. In this law, the simplest and most stable interpretations are favoured: elements of this law can be seen in all of the laws outlined in the list below.

- Proximity: the tendency to group objects that are close to one another together as a perceptual unit or group.
- Similarity: alike items tend to be grouped.
- Closure: contours close to one another are likely to be united.
- Good continuation: two (or more) neighbouring components of a scene are grouped when they appear to be connected by say a straight or smooth line.
- Common fate: objects moving in the same direction will be perceived as related.
- Common region: elements will be grouped together when they are enclosed by a defined boundary.
- Uniform connectedness: elements that appear to be connected are more likely to be grouped.
- Meaningfulness or familiarity: objects are more likely to form groups when the elements appear meaningful.

CRITICAL FOCUS

The Gestalt approach

Problems with innate view

The gestaltists believed that perceptual organisation resulted from innate processes. Although some perceptual abilities do appear to have an innate component (see the section Developmental aspects of perception, p. 00), there is other evidence to support the idea that perception has a learnt component. For example, Segall, Campbell and Herskovits (1966) found that people from environments where straight lines are rare, such as rural South Africa, were less susceptible to the Müller–Lyer illusion than people from Western cultures. This influence of environmental knowledge is a problem for the gestalt approach which argues that perception is bottom-up – understanding a scene comes from application of the organisational principles – rather than being top-down, based on prior knowledge.

Difficulties applying laws

The fundamental principle of Prägnanz is not always easy to demonstrate in practice – people may view the same figure in very different ways (see e.g., Quinlan & Wilton, 1998) or perceptions of the same figure might change over time. This is hard to reconcile with the idea that we have an innate drive towards simplicity. The primacy of the laws has also been questioned by Julesz (1975) who found that participants also grouped forms according to their colour and brightness, rather than only using gestalt principles.

Descriptive rather than explanatory

The gestalt approach describes rather than explains. Although some gestaltists attempted to explain their theories by electrical field forces in the brain, empirical investigations have failed to support these. Where presented, explanations tend also to be post hoc: the description of form is always prior to the explanation of why the form is perceived. This makes it hard to generate predictions from this theory.

Other problems with the gestalt approach

Any theory of form perception must explain how form information is presented within the visual system, both initially and leading up to and including recognition. Gestaltists fail to say *why* these rules are necessary, and they have also been criticised as using vague language, with Bruce, Georgeson and Green (2003) arguing that it is difficult to understand clearly what is meant when gestaltists refer to a 'good' or 'simple' shape.

Conclusions

The gestalt approach is a plausible account of some of the processes of form perception. There is also evidence that some of the gestalt principles hold for other domains, such as music and haptics.

The focus on stimulus characteristics to understand the larger whole has had implications for more recent work which has continued this stimulus-based (bottom-up) interest. Some of the strategies (e.g. proximity) forwarded by the gestaltists were used by Marr (1982) as part of his computational approach to vision (see below). Gestalt principles have also been utilised in the work examining aesthetics in human–computer interaction.

Further reading Gestalt theory

Topic	*Key reading*
Discussion of the gestalt approach	Rock, I. (1995). *Perception*. New York: Scientific American.
Gestalt and neuropsychology	Herrmann, C. S. & Bosch, V. (2001). Gestalt perception modulates early visual processing. *Neuroreport*, *12*, 901–4.

Test your knowledge

Gestalt theory

2.5 How did the gestaltists suggest form is extracted?

2.6 Describe the law of Prägnanz.

2.7 What is figure-ground segregation?

2.8 List four shortcomings of gestalt theory.

Answers to these questions can be found on the companion website at: **www.pearsoned.co.uk/psychologyexpresss**.

? *Sample question* *Essay*

Does the gestalt approach provide a comprehensive view of visual perception?

Direct perception and constructivism

The direct perception approach

Gibson (e.g. 1979) developed direct perception as an ecological approach to space perception. He argued attention should be on cues present in the environment rather than taking the retinal image as the starting point for perceptual processing.

According to Gibson, information is detected rather than processed: the visual environment provides sufficient information to allow interaction with the environment without the need for any further internal processing. Stimuli are not described in terms of passive images on the retina (cf. Marr's computational approach, below) but in terms of actively sampled information in the environment, termed the optic array.

Gibson argued that individuals perceive objects, not the planes, lightness discontinuities or primitive object shapes proposed by other theories. Because direct perception relies on information presented in the environment and rejects the idea of active processing it is a bottom-up theory.

Several cues exist that give an observer information about the environment. These include:

- *Optic flow pattern*: the apparent motion of objects in the environment caused by the relative motion between the observer and the scene.
- *Texture gradient*: these provide information about distance; elements become more densely packed, and decrease in size as distance increases.
- *Horizon ratio*: if two objects standing on the ground are the same size, their horizon ratios will be the same. This allows observers to judge the relative size of objects.

- *Direct perception* is an ecological approach: Gibson argued we should examine perception in the real world. His theory makes strong links between perception and action where the individual and the environment interact. For Gibson the end result of perception is not an internal representation of the visual environment but an awareness of possibilities to interact with the environment. These opportunities are termed affordances – a branch can be graspable, a fruit can be eaten.

CRITICAL FOCUS

The direct perception approach

Direct perception is both radical and controversial. Gibson emphasised the significance of environmental cues on perception which are neglected by other approaches. Although research on illusions (see the constructivist approach, below) does initially appear to contradict direct perception, Gibson stated that picture perception is indirect and so conclusions about real-world perception drawn from the use of pictures will be invalid: making inappropriate judgements is unsurprising, and unlikely to occur with more ecologically valid stimuli.

A strength of direct perception is in the way it focused later researchers on the interaction of individuals with their environments, away from the growing tendency to examine perception out of context with simple stimuli such as bars and grids.

Nonetheless, there are several limitations to Gibson's theory. Fodor and Pylyshyn (1981) argued that some of the terms used by Gibson, such as 'directly detected' and 'invariant', are so broadly defined as to be almost meaningless. In addition, the argument that anything we perceive is due to invariant properties of stimulation that require no further processing is difficult to accept because it implies we have invariants specifying friends' faces that do not require any stored memory that will enable us to recognise each of them appropriately.

Perceptual processes are also significantly more complicated than implied by Gibson. Marr (1982), Ullman (1980) and others have also pointed out that the detection of physical invariants such as image surfaces and optic flow is in itself an information-processing problem that requires significant effort.

The constructivist approach

Constructivist theory, or intelligent perception, proposes that the perceiver has an internal constructive (problem-solving) process which transforms an incoming stimulus into a percept. The constructivist approach is therefore active. Perception is an end product of a series of interactions between the initial stimulus, internal representations, memory and expectations. If these expectations are incorrect, misperceptions (e.g. visual illusions) occur.

Depth perception and constructivism: illusions

The retinal image is two-dimensional, and so the perceiver has to add depth to create a third dimension. This is accomplished by a range of cues including size constancy, perspective and stereopsis. Gregory (1997) investigated how such cues aid perception by examining the conditions in which they broke down to give perceptual errors.

Gregory (1997) argued that visual illusions, such as the Müller–Lyer and Poggendorff, occur when there is a conflict between cues in the scene and the retinal images (see Figure 2.3). The fact that children are less susceptible to some illusions gives further to support to the constructivist approach because they will have had less experience of using cues to estimate alignment or length (e.g., Leibowitz & Gwozdecki, 1967).

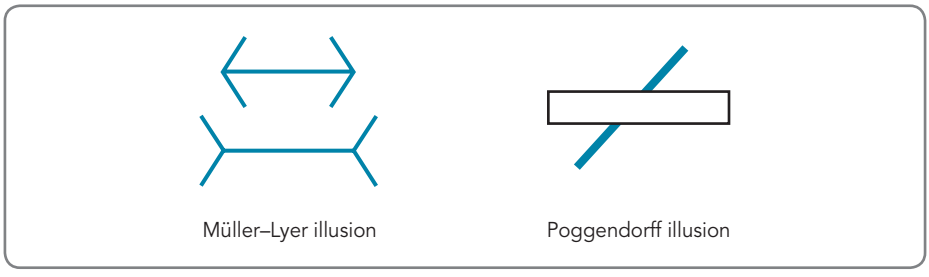

Figure 2.3 **The Müller–Lyer and Poggendorff illusions**

CRITICAL FOCUS

The constructivist approach

The constructivist approach has led to the discovery of a range of visual cues which influence perception. However, the strong view of this theory has been criticised. For example, the explanations forwarded for the operation of visual illusions are often unsatisfactory or contradictory – Gregory explains the Müller-Lyer illusion by reference to depth cues existing within the shapes, though Day (1972) argues it is the presence of conflicting cues rather than depth cues specifically that cause the illusion.

Others have criticised the artificial nature of the tasks used to produce perceptual errors, as well as the reliance on very brief presentations of stimuli. Recent work has tried to reconcile the constructivist and direct perception approaches (Norman, 2002), though fundamentally the constructivist view is that perception guides behaviour (Möller, 2000).

Further reading Direct perception and constructivism

Topic	*Key reading*
Constructivism	Gregory, R.L. (1997). *Eye and brain: The psychology of seeing*. Oxford: Oxford University Press.
Direct perception	Michaels, C.F. & Carello, C. (1981). *Direct perception*. Englewood Cliffs, NJ: Prentice-Hall.
Constructivism and direct perception	Norman, J. (2002). Two visual systems and two theories of perception: An attempt to reconcile the constructivist and ecological approaches. *Behavioral and Brain Sciences*, *25*, 73–144.

Test your knowledge

Direct perception and constructivism

2.9 What did Gibson mean when he said perception was direct?

2.10 Outline two strengths and two weakness of the direct perception approach.

2.11 How do constructivists argue illusions operate?

2.12 Outline two criticisms of the constructivist approach to perception.

Answers to these questions can be found on the companion website at: **www.pearsoned.co.uk/psychologyexpress**.

? *Sample question* *Essay*

Critically evaluate the contribution of direct perception to our understanding of visual perception.

The Computational theory of vision

The computational approach developed by Marr (1982) is based on the information-processing perspective which divides processes into a series of (definable) steps, part based on the information available from the environment (similar to direct perception theory) and part on calculation of these inputs.

Marr sought to avoid general theoretical debates to focus on understanding specific problems, the most fundamental being that of recognition: when we recognise things what is it that we are we doing? What is it that allows us to read very different types of handwriting, letters in different fonts and recognise caricatures with apparent ease?

Marr's theory of object recognition

Marr's (1982) theory proceeds from the two-dimensional information presented on the retina through a series of stages to a three-dimensional perceptual representation (see Figure 2.4).

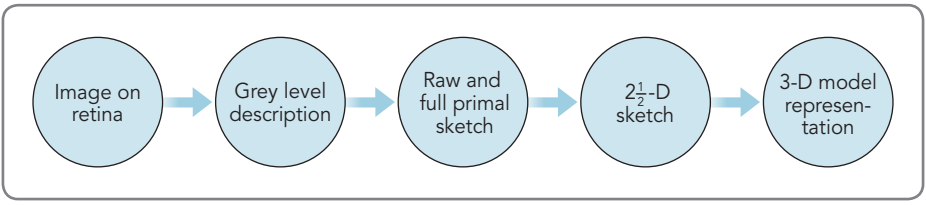

Figure 2.4 **Stages in Marr's computational theory of vision.**

1. **Grey level description**. The intensity of light at each point in the visual field is made explicit. Colour information is not processed.
2. **Raw primal sketch**. The representation of the image in terms of edges, which are computed by detecting differences in light intensity. The visual system applies rules – termed natural constraints – about the environment, such as the idea that gradual changes in shading are associated with shadows and sharp changes are usually edges. The visual system also identifies primitives such as blobs, bars and terminations that are combined with information about the location of edges as the raw primal sketch.
3. **Full primal sketch**. Raw elements are assembled to represent larger structures in the full primal sketch. Marr suggested we use simple grouping processes (analogous to those suggested by gestalt theorists) to link these features together to give a basic object outline. A problem here is that the visual system needs to decide what an edge is. For example, two similarly coloured objects which are illuminated similarly may be difficult to discriminate.
4. **2½-D sketch**. This describes the layout of structures in the world from a single perspective by integrating a variety of cues. In addition to the structures obtained from the primal sketch, perception of the scene is developed through analysis of depth and object motion. Reconstructing depth from flat retinal images is difficult. Numerous methods are used to accomplish depth perception, including stereopsis, shading and structure from motion. Through these, the 2½-D sketch can compute all necessary information about objects (outline, distance, size etc.). This representation is 2½-D because the sketch is viewer-centred and is superficial in that it does not draw any conclusions about three-dimensional structures.
5. **3-D model representation**. This aspect of Marr's theory is the least well-developed. In this stage, object recognition and computation of a three-dimensional image requires information about an object's identity and therefore stored knowledge. At this stage there will be a range of processes

that aid such categorisation, some of which Marr and Nishihara (1978) developed into a theory of object recognition. Marr argues that people recognise objects from their individual components – the process likely to underlie our ability to recognise people from their caricatures.

CRITICAL FOCUS

Marr's computational theory of vision

Marr's model is *relatively* simple, though each stage involves significant computation. Marr and Hildreth (1980) developed a computer programme that was able to produce a raw primal sketch. Although plausible for machine vision, this approach bears little relation to human vision, especially on a physical level, so at best provides only a partial solution, particularly given its focus on bottom-up processing. Nonetheless, Marr stimulated much theoretical and empirical work, both in neuroscience (see, e.g. Deco & Rolls, 2007) and artificial intelligence, such as automatic face recognition (Bicego et al., 2008).

Further reading Computational theory of vision

Topic	*Key reading*
Detailed introduction to computational theory	Bruce, V., Georgeson, M.A. & Green, P.R. (2003). *Visual perception: Physiology, psychology and ecology.* Hove: Psychology Press.
Detailed discussion of computational approach	Frisby, J.P. & Stone, J.V. (2010). *Seeing: The computational approach to biological vision.* Cambridge, MA: MIT Press.
Application of computational theory	Sarkar, S. & Boyer, K.L. (1993). Perceptual organization in computer vision. *IEEE Transactions on Systems, Man & Cybernetics*, *23*, 383–99.

Test your knowledge

Computational theory of vision

2.13 What are the three levels of theory Marr described?

2.14 What are the stages of Marr's computational theory of vision?

2.15 What is the difference between a raw and a full primal sketch?

2.16 Describe top-down and bottom-up processing.

Answers to these questions can be found on the companion website at: **www.pearsoned.co.uk/psychologyexpress**.

? *Sample question* — *Essay*

Critically evaluate the contribution of Marr's computational theory to the understanding of vision.

Overall conclusions on theories of vision

Several theories have attempted to explain the process of visual perception. These can be viewed as forming a continuum from those reliant entirely on information present in the environment, like direct perception, to those that adopt a bottom-up perspective, such as the computational approach. However, what must be understood is that all these theories are only partial explanations – vision works through cues in the optic array, but also operates through comparing differences in shading gradients and comparing percepts with memories. Other approaches also make useful contributions, such as the gestalt emphasis on stimulus configuration for object perception. Further theories like Biederman's (recognition by components (RBC)) which suggests objects are analysed into primitives to aid recognition, and Triesman's (feature integration theory (FIT)) that focuses on the attentional aspects of vision both include aspects of top-down (knowledge-based) processing largely neglected by Marr.

Developmental aspects of perception

A fundamental question asked in perceptual development is 'What can a newborn infant perceive?' In trying to answer this, researchers have investigated the extent to which infants are born with perceptual capabilities or if they are acquired through experience (i.e. the nature/nurture debate). There are a range of views:

1. **Empiricists**: infants are a 'tabula rasa' (blank slate) upon which experiences are imprinted.
2. **Nativists**: many perceptual abilities are present at birth, e.g. for the gestalt school, the tendency to organise is innate.
3. **Current status**: combination of both approaches – babies are born with some abilities, but they also have a great capacity for learning (e.g. Mehler & Dupoux, 1994).

Researchers have attempted to pinpoint the contribution of each influence.

Methods of investigating newborns' perception

Habituation and the preferential looking technique

Infants spend less time looking at familiar stimuli. Therefore if the infant spends little time looking at a new stimulus, it means they cannot discriminate between this and the previous stimulus. This technique is effective for finding out the extent of the difference there needs to be between two stimuli for an infant to detect difference. Habituation is useful for testing ability to discriminate colour, brightness and shape (e.g. Fantz, 1961). Results show that by 1 month infants can distinguish between objects (i.e. they show a preference for a particular

object) and by 3 months they can recognise their mothers' faces (and also show preference for all faces).

Conditioning

This is a more difficult method to employ, but is useful in determining whether children have perceptual constancies. For example, by giving them a 'peek-a-boo' response as a reward, Bower (1965) conditioned infants to turn to the left whenever they saw a 30 cm cube presented 1m away. Infants responded to a 90 cm cube 3 m away, indicating that infants have size constancy.

Physiological responses

Heart rate increases in response to scary noises or sights. Thus if a child is held over a drop and her heart rate increases, she is able to see (and understand) distance.

None of the above methods can be used without difficulty as infants can easily become distracted and sometimes responses can be ambiguous. Nonetheless, if similar findings are obtained using different techniques then greater confidence can be placed in them.

Nature/nurture and visual perception

The infant visual system is functional, but tends to be inferior to that of an adult. For instance, Atkinson and Braddick (1981) found newborns had much poorer acuity, and only detected lines 30 times wider than those an adult could pick up.

Infant visual perception has been widely investigated, for example in pattern perception (especially human faces) and space perception (especially depth perception and size, constancies). We'll focus on the latter topic.

Spatial perception in newborns

There has been a focus on 'constancies'. Shape constancy was investigated by Slater and Morison (1975), who habituated infants to a shape before showing them the same shape from a novel angle. The infants were uninterested, which shows they have shape constancy from birth. Distance constancy also appears to be innate (Bower, 1965).

KEY STUDY

Gibson and Walk (1960) investigated depth perception using a visual cliff. They argued that if depth perception is absent, a child would crawl off the edge of the cliff. Infants as young as 6 months would not crawl over the edge, which indicates binocular disparity is fully developed early on. Other research that monitored heart rates supports this conclusion.

Other approaches to study nature/nurture in visual perception

What's the case for environmental influences on perception? Investigations into the effect of the environment have usually been conducted on animals for ethical reasons and have either deprived sensory experience or manipulated it.

Absence of stimulation

Animals are reared in dark conditions for several months from birth before being tested using lights or patterned stimuli. Such animals have difficulty discriminating between patterns. Although they can detect light, neurons in the retina and visual cortex show atrophy.

Hubel and Wiesel (e.g., 1962) concluded that light stimulation is needed to develop the visual system. In particular, there appears to be a 'critical period' during which external stimulation is needed. In kittens this is 4-6 weeks for vision. If deprived of visual stimulation during this critical period there will be a subsequent loss of perceptual ability.

Manipulation of experience

Where exposure is manipulated, there is a significant influence on later visual ability. For example, Leventhal and Hirsch (1977) found kittens raised without exposure to patterned stimuli could still detect orientation but this was only binocular. Similarly, restricting vision to horizontal lines leads to an inability to detect vertical ones (Stryker & Sherk, 1975).

Limited stimulation in humans

While it is unethical to deliberately deprive humans, naturally occurring deprivation can occur. Infants who have had to wear an eye patch after surgery for cataracts in their first year of life have reduced acuity in the deprived eye. This indicates that there is a critical period in infant development for visual perception, although recent work suggests that there are different critical periods for different aspects of perception (Lewis & Maurer, 2005).

Overall implications and summary

Extensive experience is not absolutely necessary for normal perception. However, certain types of stimulation are needed during critical periods. These critical periods are likely to occur in most modalities and for all species. Recent work indicates that there is some degree of hardwiring for facial processing that is qualitatively different to that present for other visual stimuli (Park et al., 2009), though work with monkeys shows these are also likely to require appropriate stimulation to function effectively (Sugita, 2008).

Perception is therefore shaped by a number of influences: sensory apparatus present at birth, basic sensory inputs (e.g., visual information) and subsequent experiences (e.g., knowledge can facilitate recognition – a farm scene would facilitate recognition of a cow).

Further reading Developmental aspects of perception

Topic	*Key reading*
Sensitive periods in child development	Lewis, T.L. & Maurer, D. (2005). Multiple sensitive periods in human visual development: Evidence from visually deprived children. *Developmental Psychobiology, 46*, 163–183.
Detailed discussion of perceptual development	Spelke, E.S. (1990). Principles of object perception. *Cognitive Science 14*, 29-56.
Overview of perception	Kellman, P.J. & Arterberry, M.E. (1998). *The cradle of knowledge: Development of perception in infancy.* Cambridge, MA: MIT Press.
Perceptual capacities of infants	Smith, P.K., Cowie, H. & Blades, M. (2003). *Understanding children's development.* 4th ed. Oxford: Blackwell.

Test your knowledge

Development aspects of perception

2.17 Describe three methods of examining infant perceptual development.

2.18 What evidence is there to support the presence of depth perception in infants?

2.19 Define critical periods.

2.20 How might a newborn's perceptual development be influenced by experience?

Answers to these questions can be found on the companion website at: **www.pearsoned.col.uk/psychologyexpress**.

Sample question *Essay*

Evaluate the extent to which environmental factors influence perceptual development.

Other senses

Hearing

Hearing is the perceptual experience of sound, and has both a signalling function – to alert to danger – and communication. Human hearing is very sensitive, able to detect sounds between 20 and 20,000 Hz and having a dynamic range between 1,000 and 5,000 Hz of 150 dB.

The auditory system: structure and function

The auditory system must perform three functions before we can hear: deliver acoustic information to the receptors, transduce sounds into electrical signals and process the signals to indicate qualities of sounds such as location, volume and pitch.

Outer ear

Sound passes through the pinna (ears) into the auditory canal. Sound waves resonate along this to the tympanic membrane, or eardrum.

Middle ear

The middle ear is a cavity containing three small bones or ossicles – the malleus, incus and stapes – which transmit vibrations from the tympanic membrane to the membrane covering the oval window which leads to the inner ear. These ossicles increase the strength of sound-related vibrations from the air to allow them to transmit through the oval window to the fluid in the cochlea.

Inner ear

The fluid-filled cochlea contains the organ of Corti which contains inner and outer hair cells. These cells are covered in cilia which bend in response to movements by the organ of Corti, and the basilar and tectorial membranes. The motion of the cilia leads to the transduction of sounds. Early theorists such as Helmholtz (see also Braun, 1996) suggested that hearing worked via the vibration of these cilia, however current theories propose that hearing works through detecting a wave of sound travelling through the structures of the ear.

Auditory pathways

The auditory nerve carries electrical signals from the cochlea to the cochlear nucleus and then to the olivary nucleus in the brainstem, the inferior colliculus of the midbrain and the medial geniculate nucleus of the thalamus. Neurones then connect with the primary auditory receiving area in the temporal lobe of the cortex, known as A1, which in turn links to other auditory regions in the temporal lobe.

Subjective dimensions of sound

Early theories of hearing assumed a direct relationship between environmental sounds and their mental representation, so that for instance the physical dimension of frequency corresponded with the subjective dimension of pitch. Research shows that the experience of sounds is both complex and subjective (von Békésy, 1960), and that perception of loudness and pitch are influenced by other variables including intensity, perceived location, auditory adaptation and auditory fatigue. Disorders including autism (Khalfa et al., 2004) and psychiatric illness (Iakovides et al., 2004) may also influence hearing.

Auditory scene perception

When we hear sounds they are rarely presented in isolation: sounds come from a range of sources at different amplitudes and frequencies. To make sense of this, we must analyse the information presented. Auditory scene analysis is a complicated process in which the sounds presented are compared to knowledge about the events that might have generated them (Bregman, 1990). Auditory scenes are interpreted in two ways – by auditory grouping using schemas derived from prior knowledge and by using grouping mechanisms similar to those proposed by the gestaltists for visual perception. Therefore, sounds are interpreted through the use of a combination of bottom-up and top-down processes.

Further reading Audition

Topic	*Key reading*
Auditory scene analysis	Bregman, A.S. 1990. *Auditory scene analysis*. Cambridge, MA: MIT Press.
Speech understanding	Greenberg, S. (1996). Understanding speech understanding: Towards a unified theory of speech perception. *Proceedings of the ESCA Workshop on the Auditory Basis of Speech Perception*, Keele University, 1996, pp. 1–8.
Psychoaccoustics	Moore, B.C.J. (2004). *An introduction to the psychology of hearing*. London: Academic Press.

Test your knowledge

Hearing

2.21 What are the structures and function of the inner ear?

2.22 Describe the auditory pathways in the brain.

2.23 What factors can influence subjective perception of sound?

Answers to these questions can be found on the companion website at: **www.pearsoned.col.uk/psychologyexpress**.

Sample question *Essay*

How does the ear help us to hear?

Taste and smell: the chemical senses

Although smell and taste are linked, smell is 10,000 times more sensitive than taste. Some animals are more sensitive than others to odours – rats are around 8 times more sensitive to odours than humans, dogs approximately 90 times.

Animals with high olfactory acuity are known as macrosmatic. They usually have a large olfactory epithelium compared to humans. Humans are microsmatic, having little olfactory sensitivity compared to other species (though some people may be macrosmatic compared to others).

Although in many animals odours play a significant role in attraction, in humans the link is more contentious. Research on the effects of odour on mood and on menstrual synchrony between women in close proximity (the 'McClintock effect') has also been criticised.

What are we smelling?

There are three characteristics of detectable odours:

- *Volatile* – must easily evaporate at normal temperatures so that molecules of the substance can be carried through the air
- *Water-soluble* – molecules must pass through mucus coating the inner surface of the nasal cavity to reach the olfactory cells
- *Lipid-soluble* – the olfactory hairs are composed primarily of lipids and the surface of the olfactory cells also contain lipids.

Anatomy of olfaction

Odours are detected by the olfactory mucosa located high in the nasal cavity. The olfactory mucosa is linked up to the olfactory bulb, an outcropping of the brain, where odour processing begins. Vertebrates' noses appear to connect to two sensory channels, olfaction and the vomeronasal system.

In the olfactory system, neurons' cilia contain olfactory receptor proteins that transport odourant molecules. Several types of proteins exist which allow sensation of a wide range of odours. In addition to these, free nerve endings enable responses to intense odours (e.g. ammonia).

The role of vomeronasal organs (VNO) is less clear. Although they generate electrical signals, they bypass the olfactory bulb but link to the limbic system, the area of the brain concerned with emotional responses. Damage to the VNO system in animals produces disturbances in sexual behaviour, so some have theorised this is the organ upon which pheromones act.

What determines what we smell?

Several variables impact on our ability to detect odours.

- *Pathology*. Olfaction degrades when we have a cold as the mucus in the nasal cavity becomes too thick for odour molecules to penetrate. Pathology can also lead to changes in sensitivity with Alzheimer's disease (Waldton, 1974), brain tumours and schizophrenia all associated with disturbances to smell.
- *Age*. In a study with 1.2 million participants, Wysocki and Gilbert (1989) found olfaction was best in people aged from mid-20s to late 40s. From 60, sense of smell tends to worsen, though there are large individual differences.

- *Sex*. Women are better than men at recognising most common odours; men tend to be better detecting stronger odours (Cain, 1982). Brand and Millot (2001) argue this is for evolutionary reasons due to a sexual division of labour.
- *Smoking*. Higher levels of smoking leads to greater impairment. Smoking affects non-smokers, though it returns to normal on cessation. Air pollution also influences olfaction.
- *Visual impairment*. Blind people may have better olfaction than sighted.
- *Smell and memory*. Smell and memory are closely linked, with odour memory showing less decay than other sensory memory. The 'Proust effect' is where a memory associated with an odour can be invoked by that odour.

Research has shown that recall can be enhanced if learning was done in the presence of an odour and that same odour is presented at the time of recall – useful for exam revision!

Further reading Olfaction

Topic	*Key reading*
Mood and olfaction	Black, S.L. (2001). Does smelling granny relieve depressive mood? Commentary on 'Rapid mood change and human odors'. *Biological Psychology*, *55*, 215–18.
Sex differences in ocular detection	Brand, G. & Millot, J-L. (2001). Sex differences in human olfaction: Between evidence and enigma. *Quarterly Journal of Experimental Psychology B*, *54B*, 259–70.
Physiology of olfaction	Brewer, W.J., Castle, D. & Pantelis, C. (2006). *Olfaction and the brain*. Cambridge: Cambridge University Press.

Test your knowledge

Olfaction

2.24 Define macrosmatic, microsmatic and anosmia.

2.25 What are the three characteristics of detectable odours?

2.26 List four variables that could influence smell.

Answers to these questions can be found on the companion website at: **www.pearsoned.col.uk/psychologyexpress**.

Sample question *Essay*

Review the research that has examined individual differences in olfaction.

Chapter summary – pulling it all together

- Can you tick all of the points from the revision checklist at the beginning of this chapter?
- Attempt all of the Test yourself questions.
- Attempt the three essay questions within the chapter using the guidelines below.
- Go to the companion website at **www.pearsoned.col.uk/psychologyexpress** to access more revision support online, including interactive quizzes, sample questions with answer guidelines, 'You be the marker' exercises, flashcards and podcasts you can download.

Answer guidelines

Sample question *Essay*

Does the gestalt approach provide a comprehensive view of visual perception?

Approaching the question

This question is asking you to assess the value of the gestalt approach. Like many questions you'll be given at higher levels of study, you'll need to give both sides of the argument, before drawing some conclusions based on the balance of evidence. It's easy to get sidetracked into giving a very full account of gestalt theory, but the real marks are to be gained in addressing the *contribution* of the theory, not the fine detail.

Important points to include

To answer this question an overview of the gestalt approach is necessary. This overview will cover the key theorists, the concentration on form, and – briefly – the gestalt principles, the most important of which is Prägnanz. The next part of your answer should evaluate the contribution of the theory to visual perception: that it is generally a plausible account of some perceptual processes, and has made a significant contribution to research on visual perception in its focus on stimulus characteristics as part of a bottom-up approach to perception. There are several problems with the theory, and these include the innate perspective it takes and the often descriptive nature of the theory. When it comes to the conclusion, refer back to the question – is it a *comprehensive* view? Although the theory has made a significant contribution to theoretical approaches to visual perception, the gestalt approach does not give a comprehensive view

to the different stages of visual perception, unlike other theories such as Marr's computational approach.

Make your answer stand out

Most people answering a question on gestalt will have a reasonable idea of some of the principles and perhaps one or two of the criticisms of the theory. Better answers will give more comprehensive coverage to both theory and shortcomings, the very best answers will make reference specific researchers, and, in particular draw on more recent research that has used the Gestalt approach, such as work on human–computer interaction (e.g. Tractinsky & Hassenzahl, 2005).

Go to the companion website at **www.pearsoned.co.uk/psychologyexpress** to access more revision support online, including interactive quizzes, sample questions with answer guidelines, 'you be the marker' exercises, flashcards and podcasts you can download.

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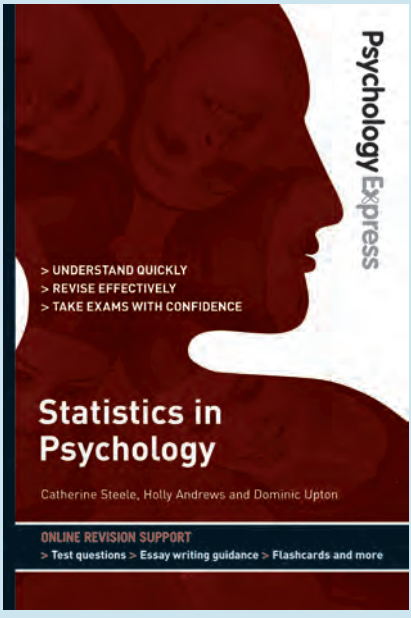

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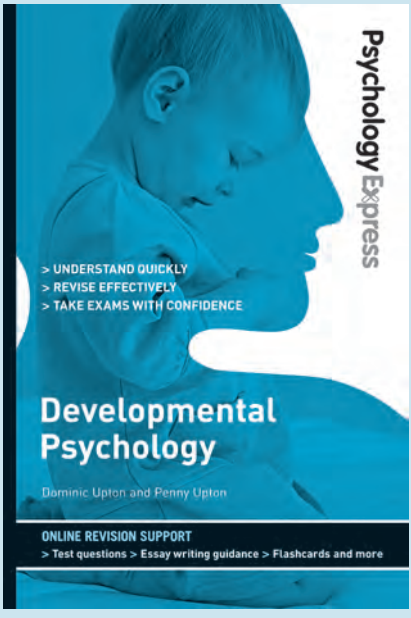

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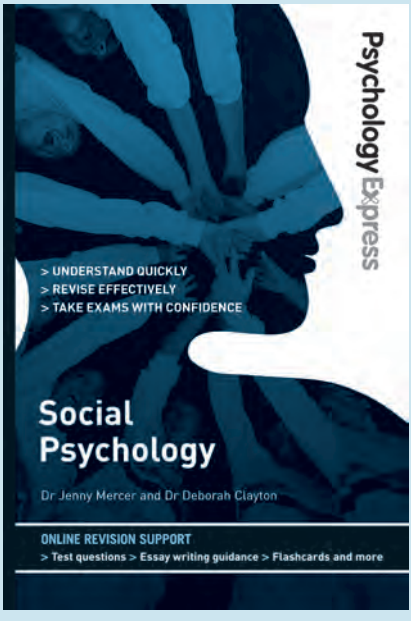

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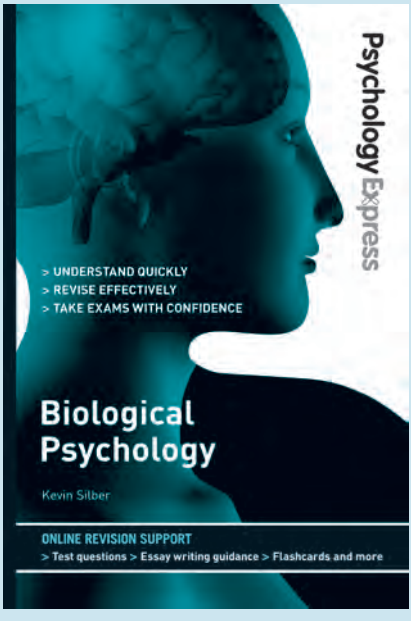

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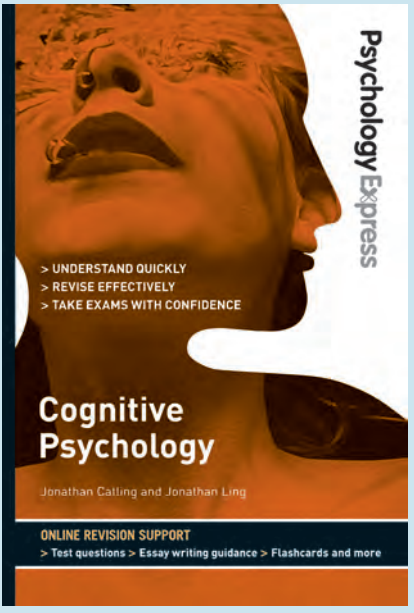

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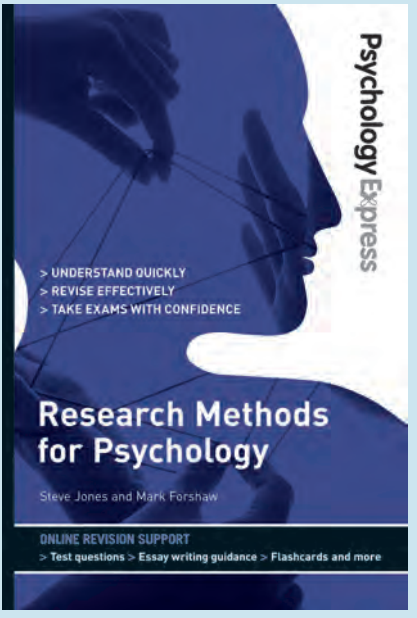

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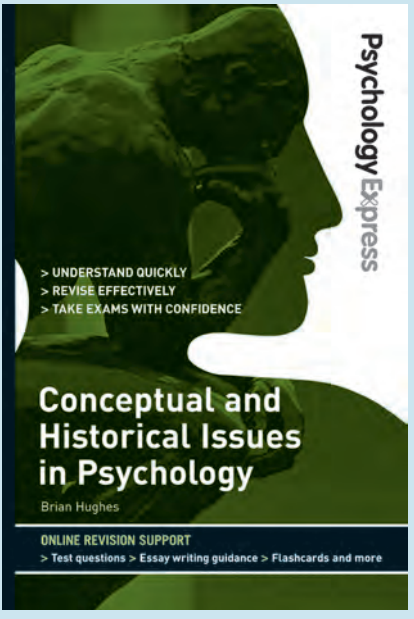

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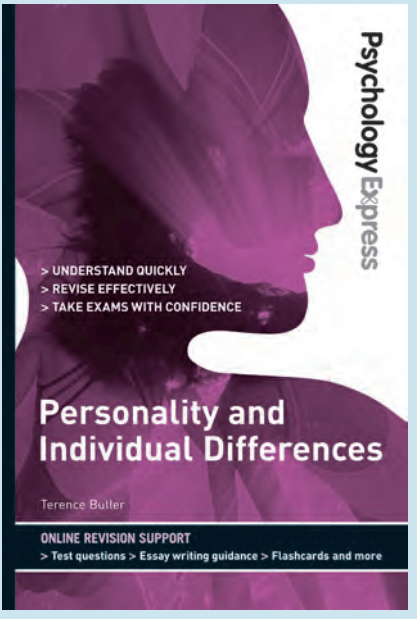

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