

THE IN A HURRY SERIES

# Perception *in a Hurry*

How your senses build reality

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# The Whole Thing in One Page

The world in front of you feels finished. Colour coats objects, voices come from mouths, the floor sits still beneath you, and your hand seems to occupy one unquestionable place. The usual picture is that the senses collect these facts and the brain receives them, much as cameras and microphones deliver recordings.

That picture misses the work. Light reaches the retina, pressure waves move the inner ear, molecules meet receptors in the nose and mouth, and forces deform bodily tissue. None arrives labelled *red*, *near*, *voice*, *coffee* or *my hand*. Receptors convert selected inputs into electrical and chemical signals, responding unevenly and often favouring change. Sensation begins with translation and loss.

Sensory evidence often supports more than one cause. A small retinal image may come from a small object nearby or a large one far away. One spectrum can reach the eye from different combinations of surface and illumination. At the ears, several sources arrive as mixtures. The nervous system exploits structure in the signal, organises fragments into objects and events, and uses context, learning and movement where evidence remains unsettled. Perception is the action-guiding result.

This is why the page stays white as the light changes, why a melody survives a change of key, and why a familiar voice can be followed through noise. The system preserves useful relations rather than copying every input. Contrast, adaptation and constancy discard information in order to keep what matters for discrimination and action.

The senses do not work as separate witnesses. Watching lips can alter a heard syllable. Vision and touch bargain over an object's shape. Coordinated sight and touch can shift felt hand location or make a rubber hand feel like part of the body. These are related, not identical, changes. The nervous system must decide which signals share a cause, how reliable each is, and where the body ends. There is no privileged count of the senses because balance, body position and internal state have their own

receptors, pathways and jobs alongside sight, hearing, smell, taste and touch.

Perception is active. Eyes jump, heads turn towards sounds, fingers trace edges, nostrils sample, and locomotion creates optic flow. Movement obtains evidence and changes it. Motor-related signals help distinguish self-caused change from change imposed by the world. Perception belongs to the body that samples and acts, not just to stationary receptors.

Experience hides this work. High-acuity vision covers a small central region, each eye has a blind spot, and attention can miss a conspicuous event. Brain injury can leave a person able to guess about visual events they do not report seeing, or unable to recognise an object they can still reach towards. Experiments show that expectation can sometimes produce false perceptual reports. That does not make ordinary perception a hallucination. Normal perception remains answerable to the world and repeatedly corrected by it.

Your senses build reality in the practical sense: they construct a stable, shared, action-ready world from partial evidence. The construction is neither a photograph nor a fantasy. Its success lies in how rarely you notice the join, and its limits appear wherever certainty exceeds the evidence that produced it.

That is the book.

## Why You Should Care

In a cinema, speech seems to leave the actor's mouth. The sound may be coming from loudspeakers behind the screen or along the walls, yet vision captures its location and the room remains coherent. The effect is so useful that nobody complains about being deceived. Your senses disagree, the nervous system settles the dispute, and experience presents the verdict without the minutes.

That small trick contains the reason to care about perception. Everything you know through experience has already passed through selection,

conversion and interpretation before it reaches a judgement you can inspect. Reasoning begins after the evidence has been formatted. You can question a conclusion, but the red of a warning light, the distance of a cyclist, the direction of a voice and the ownership of your hand arrive with a different force. They feel given.

Understanding how that force is produced improves more than party tricks. It changes how you judge certainty. Poor light, noise, haste, expectation and divided attention do not merely make a clear recording fuzzier. They alter which estimate wins. A driver may look towards a motorbike and fail to register it. Two witnesses can receive different evidence from the same event. A label can change the odour people report, and a visible mouth can change the syllable they hear. Confidence and perceptual accuracy can separate because confidence belongs to the finished result, not to an untouched copy of the input.

It also changes how you design things. Road markings, alarms, dashboards, classrooms, packaging, captions and virtual worlds all succeed or fail through thresholds, contrast, timing and multisensory agreement. Louder is not always clearer. More detail is not always more information. An alert that resembles the background, a chart whose colour differences collapse for some viewers, or a warning delivered while attention is occupied can be physically present and functionally absent. Human factors begin where the fantasy of the neutral observer ends.

Then there is other people's reality. Colour vision varies. Hearing changes across age and exposure. Some people cannot form a stable sense of bodily position without vision; others experience persistent sounds with no external source or fail to recognise familiar faces despite normal eyes. These are not weaker versions of one standard feed. They reveal that a perceptual world depends on biological equipment, learning, context and the tasks a life repeatedly demands. Shared reality is possible because different nervous systems are constrained by the same environment and can cross-check one another, not because they produce identical experience.

The limits matter. Perception research does not show that nothing is real,

that evidence is whatever you feel, or that every disagreement is equally valid. Construction is constrained. A wall stops both believers and sceptics. Instruments can extend the senses, repeated measurements can expose error, and action supplies consequences. The world pushes back, which is why perception works as well as it does and why correction is possible.

The deeper surprise is that error and competence come from the same machinery. Constancy lets a white shirt remain white across shade and sunlight, but context can make identical patches look different. Integration lets sight rescue speech in noise, but it also produces the McGurk illusion. Attention prevents overload, but it can remove a person in plain view from awareness. The system is not patched together with flaws around the edges. Its characteristic errors are the visible price of the operations that make a stable world possible.

Learn those operations and ordinary experience stops looking passive. Seeing becomes sampling. Hearing becomes source separation. Flavour becomes a coalition. The body becomes a negotiated location. Reality still stands, but the effortless route by which it becomes yours turns out to be one of the hardest jobs the nervous system performs.

## The Core Ideas

### **A sense begins by translating, not copying**

A camera can store a pattern of light because somebody has already decided what counts as a pixel, how exposure will be measured and how the result will be displayed. A biological sense has a harder first task. It must turn one kind of event in the world into activity a nervous system can use.

That conversion is transduction. In vision, photons alter light-sensitive molecules in rods and cones. In hearing, vibration bends microscopic bundles on hair cells in the cochlea. Odour molecules interact with receptors in the nose. Chemicals dissolved in saliva activate taste cells. Pressure, stretch, temperature and potentially damaging stimulation recruit different endings in skin and deeper tissue. Muscle spindles report changes related

to muscle length, while the inner ear's vestibular organs respond to head rotation, linear acceleration and gravity. None of these receptors receives an object. Each responds to a restricted variable.

The restriction is decisive. Human eyes detect a narrow band of electromagnetic radiation, ears a limited range of pressure changes, and noses only molecules that reach the olfactory surface in a usable form. The world contains ultraviolet radiation, ultrasound, magnetic fields and chemical differences that other animals can exploit and we cannot ordinarily sense. Even within our ranges, receptors differ in sensitivity and adapt to continuing stimulation. A sense is therefore an interface built from selective access, not an open window.

Transduction also changes the form of the evidence. Receptor activity becomes patterns across cells and time. Stronger stimulation may increase firing rates, recruit additional fibres or alter timing, but one spike does not carry a miniature colour, pitch or texture. Its meaning depends on which pathway it travels through and how its activity relates to other activity. The same electrical currency can support sight, smell or balance because the route and pattern, rather than the pulse alone, identify the evidence.

Vision demonstrates how much processing occurs before experience. The human retina contains around one hundred million photoreceptors, yet the optic nerve carries the output of roughly one million retinal ganglion cells. Convergence, comparison and parallel pathways begin extracting contrast, change and spatial relations before signals leave the eye. Calling the eye a camera misses this first computation. A camera sensor attempts to preserve an array. The retina reorganises an array for the next problem.

This gives the first distinction of the book. Sensation is the detection and neural encoding of stimulation. Perception is the organisation and interpretation by which that activity becomes a surface, voice, flavour, movement or body state. The line between them is useful rather than perfectly sharp, because interpretation begins early and recurrent signals run both ways. Still, it prevents a basic mistake: the nervous system never receives the finished world and then decides what to think about it. It

receives partial, transformed evidence and must build from there.

Receptor limits also explain why physical description and perceptual description cannot be collapsed. Two different light spectra can look identical when they produce the same cone-class responses under the same viewing conditions. A steady vibration can feel continuous even though sensory fibres signal with separate impulses. What matters is the pattern across a population, its timing, its adaptation state and the pathway carrying it. The stimulus constrains experience, but no sensation is printed on the stimulus waiting to be collected.

## **Signals constrain more than they specify**

A pattern on the retina has lost depth. A small image could come from a coin nearby or the Moon far away. A dark patch could be dark paint under bright light or pale paint in shadow. At the eardrums, voices, a fan and passing traffic add into changing mixtures. The signals constrain what can be present, but they do not always divide themselves into the objects, surfaces and events a person experiences.

This family of difficulties is called an inverse problem. Causes in the world produce sensory effects in the forward direction, while an observer sometimes has to work from effect towards a useful account of cause. The problem is task-specific rather than universal. Geometry, timing and environmental structure can sharply limit the possibilities. Binocular disparity, perspective, occlusion, texture and motion carry information about depth. Differences between the ears carry information about sound direction. The question is what the available structure settles and what remains open.

Organisation comes before many higher judgements. A visual border must be assigned to one side, fragments must be grouped into contours, and some region must become figure against ground. Proximity, similarity, good continuation, common motion and enclosure can support grouping, but none is an infallible rule. A moving cluster may become one object until another border or trajectory breaks it apart. Perception does not receive an inventory

of ready-made things. It finds candidate units in relations across space and time.

Context enters where local evidence is compatible with several organisations. A partly hidden letter is identified differently inside different words. A grey patch appears lighter beside black than beside white. Speech becomes easier to understand when the topic is known. Describing this as expectation corrupting sensation misses the ordinary function. Surrounding structure and learned regularities can improve a judgement when the current fragment is uncertain. They can also mislead it.

Hermann von Helmholtz called part of this process unconscious inference. A Bayesian model makes the logic explicit: compare how well different possible causes explain the evidence, taking account of how likely those causes were beforehand. A familiar word has an advantage when a syllable is muffled; clearer sound can overturn that advantage. Such models predict some perceptual judgements well. Success on a task does not prove that neurones write out Bayes' theorem or that every percept is the best statistical answer.

James Gibson supplied the strongest rival emphasis. Psychologists can make stimulation look impoverished by studying static snapshots and passive observers. Natural light contains structure generated by surfaces, movement and the observer's own motion. Optic flow can specify heading; changing occlusion reveals which surface lies in front; texture gradients reveal layout. For some tasks, the world supplies a relation useful for action without requiring a detailed reconstruction of hidden causes.

Perception exploits structured sensory information and learned regularities. The useful question is neither whether it is always direct nor whether it is always inferential. It is what the task makes available, how the system groups it, and which further operation closes the remaining gap.

Bistable figures make the unsettled part visible. The lines of a Necker cube support two depth arrangements, so experience alternates while the drawing remains fixed. You do not normally experience a probability cloud.

One organisation becomes dominant, then another. Perception commits because grasping, walking and speaking require a present answer. Reversal shows that the evidence constrained the result without determining one lasting interpretation.

## **Relations matter more than isolated amounts**

Imagine resting one hand in cool water and the other in comfortably warm water, then moving both into the same lukewarm bowl. The water can feel warm to one hand and cool to the other. Nothing contradictory has happened to the bowl. Each sensory system is responding relative to its recent state.

Adaptation is widespread because a constant input soon carries less news. Some receptors reduce their response rapidly; others maintain it for longer. The smell of a room fades, clothing disappears from awareness, and eyes adjust across enormous differences in illumination. This does not mean the stimulation has vanished. The system has changed its gain, preserving sensitivity to differences around the current background. A detector fixed for sunlight would be useless at dusk; one tuned for darkness would saturate at noon.

Relative coding begins at the edges. Neighbouring retinal channels influence one another, making changes in light stronger than uniform fields. Similar contrast operations occur at later visual stages and in other senses, though the mechanisms differ. Borders, ratios and departures from background can matter more than isolated energy. A shadow may be visible through a small local difference even when its luminance exceeds that of a bright-looking surface elsewhere.

Imagine a hearing test with a faint beep hidden in noise. On some trials there is no beep. An eager listener reports more beeps, including ones that were never played; a cautious listener misses more real ones. Neither result, by itself, tells us whose hearing is sharper. We need both successes and false alarms to distinguish sensitivity from the threshold for saying yes. Turning up the beep changes the evidence. Changing the penalty for a

wrong answer can change the reporting rule.

Psychophysics gave such distinctions a measurement language. In many ranges, the detectable change in a stimulus grows with the starting level. Adding one candle to a dark room can matter; adding one to a brightly lit stadium scarcely does. Weber's law captures this dependence on the baseline, within limits. Signal detection theory separates the listener's sensitivity from the decision criterion in the beep example. A threshold belongs to a person doing a particular task under particular conditions, not to the stimulus alone.

Perceptual constancy is the constructive payoff. The light reaching the eye from a page changes with cloud, lamp and angle, yet the page usually remains the same white object. A door keeps its rectangular shape as its retinal projection becomes a trapezoid. A voice keeps its identity across loudness and room acoustics. The system estimates stable properties by comparing signals across space, time and context. It discounts some variation as illumination, viewpoint or transmission rather than treating every change at the receptor as a change in the world.

Constancy is not one switch and never perfect. Colour constancy varies with the scene, available reference surfaces and adaptation. Size constancy can fail in unusual perspective. Loudness, pitch and flavour all show context effects of their own. Still, the shared problem is clear: raw stimulation changes whenever the observer or environment changes, while useful objects often persist.

The nervous system therefore discards information in a disciplined fashion. It compresses steady backgrounds, emphasises boundaries, groups related changes, rescales sensitivity and seeks invariants. These operations make experience stable enough to act on. They also generate after-effects and illusions when a display separates the operation from the condition it usually tracks. Error often exposes a useful relation applied outside its usual bargain.

After-effects reveal the recalibration. Stare at motion in one direction and a

stationary scene may drift the other way; adapt to a colour and a neutral surface can take on its opponent. Such effects are not photographs lingering intact. They arise because channels with different preferences change sensitivity by different amounts. The resulting imbalance makes an unchanged stimulus look changed. Adaptation keeps the code responsive, while the after-effect exposes the new reference point.

## **The senses negotiate one world**

A filmed mouth says one syllable while the soundtrack presents another. Many viewers report hearing a third. In the McGurk effect, visible articulation alters heard speech even when the acoustic signal has not changed. The result varies across people, languages, stimuli and conditions, but the basic lesson survives: speech perception is audiovisual when both kinds of evidence are available.

The nervous system faces two questions whenever signals coincide. Do they come from the same event? If so, how should they be combined? Timing, location and learned correspondence help answer the first. Reliability shapes the second. In a classic laboratory task, people judging an object's height combined visual and haptic information in a way close to the estimate that would minimise uncertainty. In audiovisual localisation, clear vision can pull a sound towards a visible event, while degrading the visual signal increases auditory influence. Vision does not dominate by royal right. It often wins spatial disputes because it is more precise for that task.

Combination is conditional. A flash and beep far apart may be treated as separate events; signals that coincide closely are more likely to be assigned a common cause. Bayesian causal-inference models put numbers on this choice between combining and separating cues. They help explain why a voice follows a moving mouth on screen but not an unrelated light across the room. The model describes a decision under specified conditions, rather than a circuit that must govern every sense.

Flavour is an everyday coalition hidden by language. What people call taste includes the basic gustatory qualities detected in the mouth, odours

reaching the nose from the back of the throat, texture, temperature and chemical sensations such as chilli heat or mint cooling. Block retronasal smell and food becomes strikingly flatter even though the tongue still detects sweet, sour, salty, bitter and umami. The percept belongs to no single organ. It is an event assembled across routes.

Your body is assembled in the same way. Vision shows where the hand appears to be. Proprioception reports limb configuration. Touch identifies contact. In the rubber-hand experiment, a visible model hand and the participant's hidden hand receive coordinated brushstrokes. The model can begin to feel like their own hand. Judgements of the real hand's location can shift too, but a shift in location is not proof of ownership. Researchers dispute how much expectation affects these measures. The striking result remains that coordinated sight and touch can alter an experience as intimate as which hand feels yours.

Multisensory perception solves coordination. One external event should not become five unrelated experiences, and one body should not fragment every time cues differ slightly. Integration creates a common place and moment from signals with different speeds, resolutions and noise. The price is capture: a precise cue can drag an uncertain one towards the wrong answer. The cinema voice moves to the mouth because, under normal conditions, that is the source worth trusting.

Integration also has to solve time. Light, sound, touch and internal signals travel through different receptors and pathways. The nervous system tolerates small arrival differences and learns recurring delays, otherwise one clap would fracture into several events. The acceptable window varies by task and can adapt. A distant firework offers the opposite case: the gap becomes too large to fuse, so flash and bang are consciously separated while still attributed to one cause.

## **Perception is an activity**

Your eyes are never still for long. Saccades shift the fovea from one useful location to another several times a second. Between them, smaller movements prevent a fixed retinal image from fading. The head turns to improve acoustic differences between the ears. Fingers change pressure and direction to test texture. A sniff controls when and how odour reaches receptors. Perception does not wait for the world to deliver a complete package. It asks questions by moving.

Movement creates information. As you walk, nearby surfaces sweep across the retina faster than distant ones. Expansion in the optic array can specify approach, while occlusion changes reveal depth order. Moving the head can resolve whether an ambiguous sound is in front or behind. Turning an object exposes hidden surfaces; running a thumb across it separates roughness from temperature or stickiness. Gibson's ecological approach is strongest here: the relation between organism and environment contains patterns that a static retinal picture omits.

Action also creates a bookkeeping problem. Every eye movement shifts the image. Every step moves the visual world. Speaking fills the ears with self-produced sound. Yet the room does not seem to jump whenever the eyes do. Motor systems provide advance information about intended movement, often called an efference copy or corollary discharge. Sensory systems can compare predicted self-caused change with incoming change. The match helps preserve stability; the mismatch can signal that something external moved.

There is no single master copy sent everywhere. Different motor-related pathways affect sensory processing and gaze control. Their shared problem is to distinguish change caused by the observer's sampling from change caused by the sampled world.

Development makes the dependence on action visible. In a 1963 experiment, pairs of kittens received closely matched visual stimulation, but one moved actively while the other was carried in a linked apparatus. The

active kittens performed better on tests of visually guided behaviour. Both had been exposed to light and movement; only one had controlled the relation between moving and seeing. The result concerns those animals and tests, not a recipe for raising children, but it separates exposure from experience that an animal can control.

Adults remain calibratable. Altered visual displays can initially make reaching clumsy, then performance improves as errors link new sensory consequences to action. When the alteration is removed, after-effects reveal the adjustment. Tool use, sports, musical performance and driving all refine perceptual variables that matter for action. Expertise is not magic eyesight. It is learned sampling and discrimination organised around a task.

This changes the unit of explanation. A sense organ plus a brain at rest is incomplete. Perception belongs to a loop containing receptors, neural processing, body, movement and environment. What you perceive includes what the world affords a body like yours: a step to climb, a gap to pass, a handle to pull. The next action tests the present estimate, and the resulting error trains the estimate that follows.

Active sampling is selective. Eye movements cluster around task-relevant objects, and the same picture produces different scan paths under different questions. Gaze and attention are not identical: attention can shift without an eye movement, and the eyes can land on an object without it becoming the focus of processing. Perception directs its best resolution towards what the task makes useful.

## **Awareness receives a selective result**

Detailed vision is concentrated around the fovea, a small central region. Each eye also has a blind spot where the optic nerve leaves the retina. You do not normally experience a sharp island of detail moving through blur or a hole beside it. Two eyes cover some gaps, surrounding structure supports completion, and eye movements place useful details where acuity is highest. Experience presents a stable scene rather than the sampling plan.

Peripheral vision adds a subtler limit. Away from fixation, nearby features

interfere with one another, a phenomenon called crowding. A letter that is detectable alone can become hard to identify among neighbouring letters. The periphery is not empty, yet its information is organised differently from foveal detail. This helps explain why a scene can feel populated and continuous while precise identification still requires a new fixation. Rich experience does not entail uniform resolution.

That stability encourages an overestimate. People feel as if they possess a detailed internal picture available all at once. Change-blindness experiments interrupt a scene with a blank or other visual transient, and observers can miss alterations that appear large once pointed out. In inattentional-blindness tasks, observers concentrating on one event can fail to report a conspicuous unexpected object. The famous gorilla demonstration is memorable because the missed event seems impossible after attention has been redirected to it.

Missing the gorilla is not evidence that the rest of the scene vanished from the brain. It is evidence that being in view and becoming available for report are different achievements. Change blindness adds a related warning: a detail must be represented and compared across moments before its alteration can be noticed. Task, timing and expectation affect both. The sense of having seen everything cannot tell you which of those operations succeeded.

Neurological cases separate functions more sharply. Damage involving primary visual cortex can remove ordinary reported vision from part of the field while leaving above-chance discrimination or localisation in some tasks. Lawrence Weiskrantz called this blindsight. Residual capacities are heterogeneous: they vary with lesion, stimulus, criterion and method, and some patients report degraded impressions rather than complete absence. The cases show that visual information can affect behaviour without the person's usual form of seeing, not that one intact unconscious pathway explains every result.

Spatial neglect reveals a different division. After certain brain injuries, a person may fail to attend or respond to one side of space even though the

eyes and early visual pathways remain capable of receiving input. In two classic cases, patients describing Milan's cathedral square from memory omitted details on the left of their imagined viewpoint, then omitted a different set after mentally turning around. The deficit concerned spatial representation and attention, not a dark patch painted over the retina.

Object recognition, face recognition, visually guided action and conscious description can also dissociate. The familiar verb *see* bundles together several achievements: detecting something, locating it, recognising it and using it. Brain injury can separate capacities that ordinary life makes feel indivisible. The divisions are not neat anatomical boxes, because pathways interact and damage rarely respects a textbook diagram. They are evidence that seeing involves more than one kind of work.

None of this settles why neural activity is accompanied by experience. That question belongs to consciousness. Here it changes a more practical assumption: awareness gives access to a selected result, not a diagnostic screen on which every visual computation can be inspected. The scene may be stable and useful even when the viewer cannot report a conspicuous event or say exactly how the hand found its target.

## **Reality is calibrated for use**

A newborn nervous system is neither blank nor finished. Receptors and pathways arrive with substantial organisation, while experience tunes them to the statistics of a body and environment. Binocular coordination, speech categories, source localisation and visually guided reaching all develop through structured input and action. Some systems have sensitive periods in which abnormal input can have lasting effects; others remain plastic throughout life. “Learned” and “innate” describe contributions, not rival teams from which one winner must be chosen.

George Stratton made the calibration problem personal in the 1890s by wearing an optical device that altered the orientation of his visual field. At first movement and appearance conflicted. With extended use, parts of experience and action became more workable, though the popular claim

that the world cleanly flipped upright oversimplifies uneven reports from a self-experiment. Later prism and goggle studies made the pattern measurable: altered feedback produces adjustment, and removing the alteration produces after-effects.

Calibration can cross modalities. Repeated exposure to a displaced audiovisual event can shift later localisation. Sensory substitution devices convert camera images into tactile or auditory patterns that trained users can exploit for some spatial tasks. They do not turn skin into a retina or reproduce typical vision. They show that the significance of a signal depends partly on learned regularities, action and the problems the signal helps solve.

Illusions belong inside this account, not in a cabinet of curiosities. An illusion is a stable mismatch between a perceptual judgement and a measured property under defined conditions. Some arise from contrast, some from perspective, some from cue conflict, some from assumptions about lighting or common cause. They do not share one mechanism. Their value is experimental: hold the stimulus constant, change context or expectation, and infer which operation altered the result.

Hallucinations require greater care. They are experiences occurring without the corresponding external stimulus, but they arise in sleep transitions, sensory loss, neurological illness, psychiatric conditions, drugs and other settings with different mechanisms and meanings. Experiments can induce false perceptual reports by pairing a cue with a faint signal until expectation sometimes wins when the signal is absent. Such results support models in which prior expectation and sensory evidence can be weighted differently. They do not reduce clinical hallucinations to one faulty dial, and they do not show that ordinary perception is the same event under better management.

The need to act brings us back to the first receptor. Its evidence is partial and transformed. If the nervous system waited for a complete description, action would never begin. It calibrates through development, combines cues, tests estimates through movement, emphasises stable relations and corrects errors when the world resists. The result is a reality fitted to the

scale and needs of a human body.

Fitted does not mean false. Edges, objects, voices and distances answer to external structure even though experience does not reproduce that structure in its physical form. Nor does fitted mean complete. The same compression that gives stability can hide change; the same prior that rescues a weak signal can create a false alarm. Perceptual success is practical, while perceptual accuracy remains corrigible: open to measurement and strongest when independent routes of evidence converge.

Individual histories therefore matter without making perception private beyond comparison. A wine expert can learn distinctions a novice misses; a radiologist can detect structure in images that initially look like grey noise; speakers of different languages learn different phoneme boundaries. Training changes sensitivity, search and category use. Yet expertise can also create expectation-driven errors. The proper conclusion is neither that everyone sees the same world nor that standards disappear. Performance improves when learning is tested against feedback and independent evidence.

## How It Actually Works

### **Light becomes a scene**

The cornea and lens focus light reflected from a surface into an inverted pattern on the retina. The inversion is an optical consequence, not a puzzle requiring a little person in the brain to rotate a screen. Orientation is established through relations among vision, gravity, touch and action. There is no internal image with a correct side waiting to be turned.

Rods and cones begin the conversion. Rods are highly sensitive and support vision in dim conditions. Ordinary colour vision depends on comparisons among cone signals. In typical human vision, three cone classes have overlapping spectral sensitivities and support daylight detail and colour. They are better described as short, medium and long wavelength sensitive than as blue, green and red, because each responds

across a range. Colour begins in comparisons among their outputs. A wavelength does not carry a colour name, and many different mixtures of wavelengths can produce the same cone responses.

The distribution is uneven. Cones are densely packed in the fovea, while rods dominate much of the surrounding retina and are absent from the foveal centre. Ganglion cells pool and compare photoreceptor signals through retinal circuits. Many respond to differences between a central area and its surround, which strengthens local contrast rather than reporting illumination point by point. Parallel outputs carry information related to brightness, colour, fine pattern, movement and change. By the time the optic nerve leaves the eye, the signal has already been reorganised.

Most fibres relay through the lateral geniculate nucleus of the thalamus before reaching primary visual cortex. Hubel and Wiesel found neurones in cat visual cortex that responded selectively to edges of particular orientations and positions. Human vision is not assembled by stacking one line detector on another in a tidy ladder, but the experiment established a durable principle: cortical responses are selective for features and relations, and visual areas contain organised maps and specialised computations.

An edge is still not an object. The system must group separated fragments, continue partly hidden contours and decide which side of a border owns it. Proximity, similarity, closure and common motion can favour one organisation; depth, attention and past experience can alter it. A row of dots becomes a line, a moving patch becomes one creature, and an outline can switch between figure and background. Modern work has mapped several contributing mechanisms, but perceptual organisation has not been reduced to one master law.

From there, interacting networks estimate surfaces, depth, motion, objects and spatial possibilities. Binocular disparity helps with nearby depth. Perspective, texture, shading, occlusion and motion contribute across larger ranges. No cue owns depth, and each can be misleading. Object recognition draws on shape, parts, viewpoint and learned categories. Networks extending towards temporal cortex are especially important for identifying

objects and faces; networks extending towards parietal cortex contribute strongly to spatial guidance and action. The streams exchange information and do not form two sealed visual brains.

Eye movements keep returning detail to selected locations. During each saccade, sensitivity to some visual change is reduced, and information before and after the movement is linked through position, expectation and stable structure in the environment. The result is not a stitched panoramic photograph. It is a scene whose relevant details can be sampled when needed, with enough continuity for action.

The blind spot shows the difference between retinal layout and experience. No photoreceptors occupy the optic disc, yet a patterned background usually appears continuous across it. With one eye, carefully arranged targets can vanish there. The normal percept draws on neighbouring pattern, the other eye and expectations about surface continuity. Researchers call this filling-in, but the phrase should not suggest a painter copying pixels into a hidden canvas. What is completed is the perceptual judgement that a surface continues.

## **Sound becomes sources**

Sound begins as pressure variation. The outer ear shapes it, the eardrum vibrates, and three small middle-ear bones transmit force to the fluid-filled cochlea. Inside, sound produces a travelling pattern along the basilar membrane. High frequencies peak nearer the base and lower frequencies farther towards the apex, creating a mechanical frequency analysis. Inner hair cells convert this motion into activity in the auditory nerve. Outer hair cells change cochlear mechanics and sharpen sensitivity; they are active participants, not spare microphones.

Pitch cannot be read from position in the cochlea alone. Timing in auditory nerve activity and relations among frequencies also contribute. A violin and a clarinet can play the same note and still be recognisably different: they distribute energy differently among the accompanying frequencies, and their sounds begin and fade differently. Those differences give the note its

timbre. Frequencies that begin together and change together provide evidence of a shared source, helping hearing organise a mixture into things that are making sounds.

Location is reconstructed from differences between the ears and from the filtering imposed by head and pinnae. For low-frequency components, tiny arrival-time differences are informative. For higher frequencies, the head casts an acoustic shadow that creates level differences. Pinna shape helps distinguish elevation and front from back. Moving the head supplies further evidence. These cues can conflict, and room reflections make the problem harder.

At a crowded table, no voice arrives in its own private channel. Conversations, cutlery and room noise add together at each ear. Auditory scene analysis separates candidate sources by combining clues from pitch, timing, location and timbre; attention helps select the voice to follow. This organisation can favour continuity even when the evidence is briefly obscured: a tone may seem to continue through an interrupting noise. Hearing has to decide what persists behind the interruption, much as vision does when a person passes behind a pillar.

Speech adds a moving target. The acoustic form of a consonant changes with the sounds around it, the speaker and the rate of speech. Listeners use transitions, rhythm, lexical context and visible articulation to recover categories that feel crisp despite variable evidence. This can improve recognition in noise and can also pull an ambiguous sound towards an expected word. The frequency trace constrains recognition without completing it.

## Molecules become odour and flavour

Smell starts when airborne molecules reach olfactory receptors high in the nasal cavity. Linda Buck and Richard Axel identified a large receptor-gene family that helped explain how a finite set of receptor types could distinguish a vast range of compounds. Odours are generally represented by combinations of receptor activity, not by one receptor assigned to coffee and another to smoke. Sensory neurones carrying the same receptor type converge onto glomeruli in the olfactory bulb, creating organised patterns that are transformed further across distributed brain regions.

The route matters. Orthonasal smell enters through the nostrils and samples the outside world. Retronasal smell travels from the mouth towards the nose during eating and contributes much of what is called flavour. A blocked nose therefore leaves sweet or salty detection partly intact while stripping away many food identities. The chilli burn belongs mainly to trigeminal chemical sensing, as does the cooling of menthol. Texture, temperature, chewing sounds and expectation join the result.

Taste cells sit in taste buds across several oral surfaces, not in a tongue map with separate zones. Sweet, bitter, umami, sour and salty are the five established basic qualities. Their detection involves different receptor and cellular mechanisms, although salt remains especially complicated and much of the detailed cellular evidence comes from other mammals. These signals contribute to evaluating food and chemical conditions. They do not dictate liking: learning, internal state and culture help decide what becomes attractive or repellent.

Olfaction resists a neat spatial scale like wavelength or sound frequency. Molecules with similar structures can smell different, while different structures can converge on similar qualities. Mixtures can suppress, blend or form a new perceptual object. That unruliness is useful: it prevents a vision-based theory of perception from pretending that every sense solves the same problem in the same format.

Sniffing is part of the code. The timing and strength of inhalation affect

delivery, while repeated exposure quickly changes sensitivity. Naming an odour can also be difficult even when recognition is good: a smell may seem familiar before its source can be retrieved. Labels, colour and expectation alter reports because odour evidence is high-dimensional and often ambiguous, not because language can make any molecule smell like anything. Chemical input remains the boundary on interpretation.

## **Contact becomes a body**

Skin contains several classes of mechanoreceptor with different depths, receptive fields and adaptation rates. Some respond well to sustained pressure and edges, others to motion across the skin, vibration or skin stretch. Temperature and damaging stimulation use additional receptors and pathways. Touch is therefore a collection of channels whose activity is combined into contact, texture, shape and movement.

Spatial detail depends on receptor density and cortical allocation. Fingertips and lips discriminate fine separations better than the back. Somatosensory cortex contains orderly body maps, but the famous homunculus is a distorted functional map rather than a tiny person. Maps change with use, injury and context, and neighbouring regions interact. The felt body is distributed across somatosensory, parietal, insular, motor and other networks.

Active touch changes the evidence. Press too lightly and a surface may reveal little; press too hard and compliant material changes under the finger. Sliding exposes texture through vibration, enclosing estimates volume, and wielding an object can make its tip perceptually available through forces at the hand. A blind person's cane does not become biologically part of the arm, but skilled use relocates useful attention towards the contact point at the far end.

Proprioception supplies information about limb position and movement through muscle spindles, tendon organs, joint signals, skin stretch and motor-related information. Vibrating a muscle tendon can make an unmoving limb feel as if it is changing position, showing how strongly

spindle signals contribute. Vision can correct proprioception, and proprioception can support action when the limb is unseen. Neither is an infallible body ruler.

Body ownership and body schema are related but distinct. Ownership is the sense that this body part is mine. Body schema is the changing representation used to guide posture and action, often without awareness. A questionnaire asking whether the rubber hand feels like yours tests something different from asking where your hidden finger is. Everyday reaching normally brings these answers into agreement through repeated contact and movement. You need to locate the hand to guide it; knowing that it is yours is a further aspect of bodily experience.

## **Balance and the body within**

The vestibular organs provide information about head motion and gravity. Three semicircular canals in each inner ear signal rotation in different planes through fluid movement that deflects sensory hair bundles. The otolith organs contain tiny crystals whose weight and inertia help reveal linear acceleration and head tilt. Because gravity and acceleration can create similar forces, vestibular signals are interpreted with vision, proprioception and motor context.

The vestibulo-ocular reflex moves the eyes to stabilise an image while the head turns. It is fast because waiting for conscious correction would leave the world smeared. Persistent conflict among visual, vestibular and expected motion cues can contribute to nausea and disorientation. A ship's cabin may look still while the inner ear reports movement; a virtual scene may move while the body does not. Sensory conflict is an important model of motion sickness, not a complete account of every case. Susceptibility, posture, expectation and adaptation also matter.

Interoception covers sensing, interpreting and integrating signals from within the body, including cardiovascular, respiratory, gastrointestinal, thermal and metabolic states. Much of this regulation never becomes conscious. A heartbeat, breathlessness, fullness or nausea is a perceptual outcome built

from bodily signals, context and expectation. The field's measurements remain difficult: counting heartbeats without external measurement, for example, can mix prior belief with sensory access. There is no single interoceptive accuracy score that captures the whole interior.

Internal perception also depends on action and prediction. Breathing can be voluntarily changed yet is regulated automatically; exertion makes heart and lung signals more intense; hunger and satiety combine mechanical, hormonal, metabolic and learned cues. Emotion can alter bodily state and attention to that state, while bodily signals can influence feeling and decision. These relationships are reciprocal and variable. Treating every sensation as a direct message from one organ, or every feeling as a misread body signal, goes beyond the evidence.

This broadens the answer to how many senses humans have. The number depends on whether a sense is counted by receptor type, physical stimulus, pathway, conscious quality or functional job. Five names are useful for conversation and poor as a scientific inventory.

## **A moment becomes an action**

Imagine a glass beginning to slip from your hand. Skin deformation can supply an early warning, and tactile signals can trigger an automatic increase in grip. The correction need not wait for vision, hearing and balance to agree on a complete account of the event. Those other signals can still help guide the wider action: where to move the glass, whether it has struck the table, whether the body is steady. The nervous system can begin solving an urgent local problem before it has assembled everything you could say about it.

The changed grip immediately changes the evidence. If the slip stops, the next signals differ; if it continues, more correction is needed. Attention can turn towards the hand, expectations can narrow the likely problem, and vision can help guide a safer placement. Motor commands alter muscles while motor-related signals anticipate some of their sensory consequences. There is no clean point at which perception finishes and action begins. Each

action changes the next sample, so success depends on a continuing exchange rather than one completed verdict.

Predictive coding offers one influential account of recurrent processing. Higher levels are proposed to predict activity at lower levels, while mismatches help update the model. Rao and Ballard showed that such a computational system could reproduce some contextual response properties of visual neurones. Later physiology has found responses compatible with sensory prediction errors, but definitions vary and similar response patterns can reflect different computations. Prediction is a useful operation. “The brain is a prediction machine” is not a completed or uniquely supported explanation.

The ecological alternative starts outside the head. The slipping glass creates lawful changes in skin deformation and, when visible, relative motion. The nervous system need not infer every hidden property to act; it can exploit information that directly specifies a useful relation. Real performance likely uses both kinds of resource: structured information available through movement and learned models that handle uncertainty, delay and missing evidence.

Time itself must be estimated. Neural signals do not arrive at one central clock, and events in different senses are processed at different speeds. The system links them within task-dependent windows and can recalibrate recurring delays. This lets a speaker’s lip movement and voice belong to one utterance without demanding simultaneous neural arrival. It also means perceived order can change near threshold. The experienced present is a coordinated working interval, not an infinitesimal timestamp copied from the world.

## **When the construction breaks**

Damage can spare sensation while disrupting what sensation becomes. In visual agnosia, eyes and early visual responses may remain, yet objects are hard to recognise through sight. Prosopagnosia affects face recognition more selectively, though severity and associated deficits vary. Such cases show that acuity and recognition answer different questions. A sharp retinal image does not guarantee an identified person.

Some patients have shown a further dissociation between describing an object's orientation and shaping the hand to act on it. The classic patient DF struggled to describe visual form yet could perform some visually guided actions more successfully. Her performance helped establish the distinction between vision for recognition and vision for action. It did not divide sight into two sealed systems: delay, available feedback and the task changed what she could do. The same visual information can be transformed differently for naming, comparing, reaching and grasping.

Percepts can also persist without the usual external cause. Tinnitus is the experience of sound without a corresponding sound source and often follows changes in the auditory system. Charles Bonnet syndrome can produce visual hallucinations after vision loss, often with preserved insight that the images are not real. Hallucinations also occur in many other settings, each requiring its own explanation. Reduced input can alter the balance of spontaneous activity, expectation and error correction, but “the brain fills the gap” is a sketch rather than a mechanism.

The important comparison is with illusion. An illusion is typically a systematic misperception of a present stimulus under defined conditions. A hallucination occurs without the corresponding external stimulus. A delusion is a belief, not a sensory event, though the categories can interact. Distinguishing them prevents a loose theory of “the brain making things up” from replacing careful description.

## How we know

Perception is studied by controlling stimulation and measuring detection, discrimination, localisation, identification, confidence or action.

Psychophysics links physical change to behaviour and separates sensitivity from reporting criterion. Eye tracking reveals sampling; electrophysiology and single-cell recording reveal timing and selectivity; imaging maps distributed activity; stimulation and temporary disruption test causal contributions. Lesions and sensory disorders expose dissociations, while computational models force verbal theories to make quantitative predictions.

Each method reaches a different level. A neurone recorded in an anaesthetised animal does not establish a human experience. A brain image showing correlated activity does not identify a necessary mechanism. A model fitting one task does not prove its neural implementation. Reports are indispensable for conscious perception and vulnerable to wording, expectation and response strategy.

Classic findings also travel unevenly. Many experiments use small adult samples, restricted displays and vision-heavy tasks. A result can vary with language, development, culture, sensory history or the exact stimulus. Famous patients reveal possible dissociations without defining every brain, and body-ownership measures can disagree with one another. Confidence comes from convergence: controlled behaviour, physiology, intervention, natural action and replication pointing towards the same bounded claim.

## What People Get Wrong

### “Your eyes work like cameras”

The comparison survives because eyes and cameras contain lenses and light-sensitive surfaces. It then smuggles in a second claim: that seeing consists of recording a picture and delivering it to an observer somewhere inside the head.

The eye does not preserve a neutral frame. The retina adapts, pools

signals, compares neighbouring regions and sends several transformed outputs through a severe anatomical bottleneck. Acuity is concentrated near fixation, the optic disc contains no photoreceptors, and the eyes move repeatedly. Borders must be grouped into figures, depth must be estimated and surfaces must remain stable across movement. These are perceptual results, not copied properties of one retinal image.

Cameras also construct outputs, through exposure, demosaicing, white balance, compression and display, so the metaphor has become less innocent as cameras have become computational. The difference is purpose. A camera can retain an array for later viewing. A visual system must guide a moving body now.

This matters because camera language makes error look like dirt on a lens. Many failures arise later: the wrong grouping, depth estimate, source, expectation or allocation of attention can win even when the eye receives usable light. Sharper optics do not solve every problem of seeing.

## **“Humans have five senses”**

Sight, hearing, smell, taste and touch are a useful schoolroom list. They are not a scientific census. Touch alone divides into channels for pressure, vibration, stretch, temperature and damaging stimulation. Proprioception contributes limb position and movement. The vestibular organs detect head rotation, acceleration and orientation relative to gravity. Interoception gathers evidence from within the body. Researchers can split or group them by receptor, pathway, input, conscious quality or function.

Claims that humans have exactly five, nine or thirty-three senses should trigger one question: counted by what rule? No privileged level turns every receptor class into one sense while combining all the others consistently. Vision contains several receptor types and processing streams, yet ordinary language calls it one. Temperature and pressure share the skin, yet follow distinguishable mechanisms.

The five-sense model survives because experience supplies convenient nouns and it is easy to teach. Its weakness appears when it makes balance

seem mysterious, body position seem like thought, or hunger seem like a message with no sensory basis.

This is not a contest for the largest number. It is a reminder to name the evidence needed for the job. A fall can involve vision, vestibular signals, proprioception and touch even though none fits neatly inside the familiar five.

## **“Each sense works alone”**

Textbook chapters encourage this mistake. Vision, hearing and touch are introduced one at a time because anatomy is easier to teach that way. Experience is already integrated. A visible mouth can change a heard syllable. A precise visual location can pull an uncertain sound towards it. Smell entering from the mouth joins taste, texture and temperature as flavour. Sight and touch can shift where a hand feels located.

Integration is not a late committee meeting at which five complete reports are compared. Cross-modal effects occur at several stages, and the system must decide whether signals share a cause and how much weight each deserves. Timing, location, reliability and learned correspondence matter. Cues are sometimes fused, sometimes recalibrated and sometimes kept apart.

The claim that one sense always dominates also fails. Vision often captures spatial location because it is precise there. In darkness or visual noise, hearing can carry more weight. Touch can correct sight when judging an object's form under poor viewing. The winner depends on the task and evidence.

This matters whenever information is designed or disputed. A beep can help when timing and meaning agree; it can confuse when it seems to belong to another event. Two agreeing senses do not automatically provide two independent witnesses. They may already have changed one another before the person reports what happened.

## **“Illusions prove the senses are unreliable”**

An illusion is memorable because the percept persists after the trick is explained. Identical lines still look different; a stationary pattern still appears to drift after motion adaptation. The natural verdict is that perception has been caught lying.

Most illusions are more informative than that. They isolate operations that normally improve performance: contrast, constancy, grouping, perspective, cue weighting or adaptation. A lightness illusion can result from a system estimating illumination rather than reporting local luminance. A size illusion can exploit perspective cues that usually track depth. An audiovisual illusion can reveal an integration rule that usually locates one event more accurately than either noisy signal alone.

Illusions vary across viewers and settings. Some exploit displays rarely encountered outside a laboratory; others expose principles of daily perception. Neither supplies a global error rate for the senses.

The better question is precise: what property was measured, what did the observer report, and which normal operation produced the mismatch? That turns a curiosity into an experiment. A system that ignored context and never adapted might avoid several textbook illusions while becoming much worse at recognising surfaces, voices and movement in a changing world.

## **“You see everything in front of you”**

A visual scene feels continuously detailed, which makes this belief hard to dislodge. Yet high acuity occupies a small central region, peripheral identification is limited by crowding, and each eye has a blind spot. Eye movements sample selected locations. Attention determines which visible events become available for report, comparison and later recall.

Change blindness and inattention blindness make the limit dramatic. Observers can miss a large alteration across an interruption or fail to report an unexpected person while concentrating on another task. These experiments do not show that the rest of the scene was wholly unprocessed.

They show that physical visibility, neural response, conscious access and durable representation are different achievements.

The myth survives because access is confused with possession. You can inspect a new part of the scene quickly, so the world acts as an external store. That availability feels like an equally detailed picture already held inside. After attention shifts, the missed event becomes obvious, and hindsight makes it seem obvious earlier.

The correction matters for driving, inspection, testimony and interface design. Looking towards an object is not the same as identifying it. A warning can occupy the screen yet fail to enter the active task. Presence must be tested by performance, not inferred from confidence that the scene was open before the eyes.

## **“Construction means reality is subjective”**

The phrase *the brain constructs reality* is easily stretched into a claim that everyone invents a private world beyond comparison. That conclusion does not follow. Construction names the work required to turn restricted signals into estimates. It does not remove the external causes constraining those signals.

People differ because receptors, learning, bodies, attention and context differ. A colour-vision variation can alter discriminations. Expertise can reveal structure a novice misses. Expectations can bias an ambiguous signal. Yet walls resist movement, instruments measure wavelengths and pressure, repeated trials reveal error, and several observers can compare reports under controlled conditions. The world supplies common constraints and consequences, not identical experience.

There is also no clean alternative called *direct access* in which physical properties arrive in their original form. Colour is not a pigment copied into cortex, pitch is not a tiny frequency, and body ownership is not written on the skin. Mediation is unavoidable for a biological system.

Treating construction as licence for relativism protects bad estimates from

correction. Treating perception as a transparent copy hides variation. Experience depends on a particular nervous system, but its success can still be tested against shared structure, independent measurement and action.

## **“Hallucination is perception with the input turned off”**

The slogan is attractive because perception uses expectation and hallucination can occur without a matching external source. It suggests one continuum governed by prior belief. Experiments in conditioned false perception support that mechanism in defined tasks, and reduced sensory input can contribute to some hallucinations. The category remains heterogeneous.

Visual hallucinations after sight loss, voices associated with psychosis, sleep-related experiences, drug effects, tinnitus and neurological events differ in content, circuitry, insight, time course and cause. Some occur beside continuing input. Others involve unusual salience, internally generated activity, altered monitoring or failed updating. One formula cannot carry all of that.

Ordinary perception is repeatedly constrained by signals and action. Hallucination is not the same calculation after somebody removes a cable, and a shared component does not erase a clinically important difference. A model of expectation bias may help explain one hallucination without explaining the person's wider condition.

Construction is required whenever signals are incomplete; it is not itself hallucination. A present stimulus misread and an experience without a matching source remain different phenomena even when mechanisms overlap.

# Use It

## Separate the signal from the estimate

When two people disagree about what they saw, heard or felt, begin one step earlier than the verdict. Ask what physical signal reached each person, through which receptor, from what position and under what conditions. Then ask what estimate each nervous system had to make from it.

This separates failures that otherwise collapse into *wrong*. The signal may have been weak: low contrast, background noise, brief exposure or an odour below reliable threshold. The signal may have been ambiguous: one silhouette, syllable or bodily sensation fitted several causes. The context may have favoured one interpretation. The person may have used a cautious or liberal reporting criterion, or attention may have been elsewhere. Later memory change is a separate problem.

The distinction is useful in design and disagreement because it identifies a repair. Improve lighting when the signal is poor. Change viewing position when the geometry is ambiguous. Remove the label when testing expectation. Repeat the trial when noise may dominate. Compare independent measurements when the consequence matters.

Do not use the framework to dismiss experience. A person reports the result available to them, often accurately. The gain comes from refusing to treat the force of that result as a complete record of how it was produced.

## Move before deciding

Perception operates in bodies that turn, approach, touch, sniff and wait. Move the head to localise a sound, change the angle to separate reflection from surface, step closer before deciding that a distant mark is damage, or handle an object when appearance under one light is inconclusive.

Movement works because it creates lawful change. A reflection slides differently from a mark on the material. Near surfaces move across the visual field faster than distant ones. A sound's relation to the ears changes

as the head turns. Texture becomes legible when a finger moves across it. Repeated sniffing changes delivery and adaptation, so pausing can reveal more than inhaling harder.

A critical object should remain identifiable across expected viewpoints, not merely in a designer's screenshot. Warnings should survive glare, motion and divided attention. Virtual environments should respect the sensory consequences of movement enough to avoid persistent conflict.

There is a limit. Movement does not guarantee truth; it can add blur, expectation and new ambiguity. The rule is to seek a transformation that distinguishes rival causes. Do not collect more of the same evidence. Create evidence that should change differently depending on which explanation is right.

## **Find the comparison doing the work**

Perception rarely reports an isolated amount. Brightness depends on surrounding light, temperature on recent adaptation, loudness on background and timing, and apparent size on distance and context. Before accepting a perceptual judgement as a direct measure, identify its reference.

This matters when change is gradual. A room's smell fades without the molecules leaving. A slowly rising volume becomes ordinary. Colour under a shop lamp can seem stable until the object is carried outside. The nervous system adjusts its range to preserve sensitivity, so baseline drift can hide a hazard or exaggerate contrast.

Design against the reference, not against an abstract threshold. Test text against its background, an alarm against the noise in which it must be heard, and a product colour under the illuminants in which it will be judged. When monitoring change over time, use a stable comparator or instrument rather than trusting adaptation to preserve an absolute scale.

Ask: compared with what, and after what exposure? It can explain why the same room, meal, workload or bodily sensation feels different on two

occasions without assuming that either report is dishonest. The signal enters a system carrying a history.

## **Cross-check the senses without assuming one is right**

When sight, sound, touch or balance disagree, people tend to appoint a winner. Vision receives the job most often. That is sensible for some spatial tasks and dangerous as a rule.

Instead ask which cue is more precise for the present question and whether the cues belong to one cause. A visible speaker can improve speech recognition in noise, but a dubbed voice may be pulled towards the wrong mouth. Touch may reveal a ridge hidden by glare, while vision may correct a misleading pressure pattern. A stationary cabin and a moving vestibular signal can both be accurate descriptions of different aspects of a ship.

Cross-checking works best when measurements remain partly independent. A caption generated from the same faulty audio is not a second witness. Two observers standing together may share the same occlusion. A dashboard that expresses one sensor through colour, tone and vibration adds channels but not independent evidence. Redundancy can improve access while leaving the underlying measurement wrong.

In practical terms, combine modalities for accessibility and urgency, then test conflict cases. Make the timing and location agree when signals should fuse. Make them distinct when they should remain separate. When a person reports dizziness, distorted flavour or an altered body position, do not assume the most familiar sense supplies ground truth. The disagreement may be the useful information.

## **Treat vividness as a result, not a receipt**

A percept can be immediate and wrong, or hesitant and right. Certainty belongs to the completed experience; it does not expose signal strength or rejected alternatives.

This matters when presentation changes what a signal seems to contain. A

clear label can pull an ambiguous odour towards a named source. Visible articulation can change the syllable a listener hears. A familiar layout can hide a changed element because expectation supplies continuity. Confidence is not worthless. In ordinary conditions, vivid perception is often excellent evidence. It becomes dangerous when treated as proof that no interpretation occurred.

Use confidence as one measurement among others. Ask whether the signal was strong, whether another cause fits, whether attention was occupied, whether the result repeats, and whether action or an instrument confirms it. Increase the burden when the cost of error is high. A faint warning, a medical image, a night-time road and a disputed recording deserve different checking from choosing a shirt.

The discipline is symmetrical. Do not distrust an experience merely because perception is constructive. Demand better evidence where conditions make construction vulnerable, and accept strong convergence when the world keeps producing the same result through different routes.

## **The limits**

Perception science cannot provide a view from nowhere. Instruments also select, transduce, calibrate and display. They improve on unaided senses because their transformations can be specified, repeated and compared, not because they escape mediation. A thermometer does not feel temperature; it creates a trace whose relation to physical conditions has been tested.

Nor does skilled perception guarantee correct judgement. A familiar pattern can hide a change, and an expected word can seem present in unclear speech. Training can improve discrimination while strengthening expectations. Expertise still needs feedback and external checks.

Finally, construction does not explain consciousness. This book has shown how signals become organised, integrated and available for action and report. Why any of that is accompanied by experience remains the neighbouring book's harder question.

## The one thing to keep

Back in the cinema, knowing where the loudspeakers are will not reliably move the actor's voice away from the mouth. You can understand the construction and still experience its result. The same is true of many illusions: explanation gives you a better account of what is happening without obliging the percept to change. Knowledge does not become a remote control for the senses.

That is a useful limit to discover. The aim is not to stand outside perception, watching your brain work, or to distrust every colour and sound because each has been processed. It is to recognise what kind of confidence an experience can earn. A clear view in familiar conditions deserves more trust than a glimpse in poor light. Two measurements from independent routes can settle what one vivid impression cannot. The conditions of the encounter matter, even when the experience conceals them.

Keep the distinction between the world, the signal and the percept. The world supplies constraints; the sense organ transforms a fraction of them; the nervous system makes something usable from the result. Movement can improve that evidence. Context can rescue it or bias it. Another observer can reveal a difference worth investigating rather than a person to dismiss.

Your senses have not built the cinema, the actor or the air carrying the sound. They have built your access to those things, quickly enough and coherently enough for the film to absorb you. Its apparent ease is the achievement. When the lights come up, the room will still look finished. You now have a reason to notice the conditions that made it look that way, and somewhere to start when the first look gets it wrong.

## Terms

These are the working words used throughout this book that prevent several different problems from being hidden inside the single claim that something was sensed.

## **Perceptual organisation**

The grouping of sensory elements into figures, surfaces, objects and events. Proximity, continuity, common motion, border ownership, context and attention can alter which organisation becomes perceptually dominant.

## **Sensation**

Detection and neural encoding of stimulation. The term is often contrasted with perception, though the boundary is porous because comparison and transformation begin within receptor organs and early pathways.

## **Perception**

The organisation of sensory evidence into objects, events, qualities, body states and possibilities for action. It includes interpretation without implying conscious deliberation or unconstrained invention.

## **Transduction**

Conversion of one form of energy or chemical interaction into neural activity. Photoreceptors, hair cells and chemoreceptors transduce different inputs into signals the nervous system can compare and route.

## **Receptor**

A specialised cell or ending responsive to a restricted range of events. Receptors select what can enter a sensory system and shape the first transformation of that evidence.

## **Receptive field**

The region or pattern of stimulation that changes a neurone's activity. Receptive fields may be spatial, spectral or bodily, and often reveal comparison rather than passive registration.

## **Psychophysics**

The study of relationships between controlled physical stimulation and reported or behavioural responses. It measures thresholds, discrimination and bias while avoiding the claim that experience can be read directly from energy.

### **Absolute threshold**

The lowest stimulus level detected under a stated procedure, often defined by a chosen success rate. It is a probabilistic boundary affected by noise, adaptation, attention and decision criterion.

### **Just-noticeable difference**

The smallest change that can be discriminated reliably under defined conditions. It often grows with the starting level, showing why perception commonly depends on ratios and comparisons.

### **Signal detection theory**

A framework separating sensitivity to evidence from the criterion used to report it. Hits, misses, false alarms and correct rejections reveal why willingness and ability are different quantities.

### **Adaptation**

A change in sensitivity or response following continuing or recent stimulation. Adaptation can preserve useful range and highlight change, while shifting how the same physical input is experienced.

### **Contrast**

A difference between neighbouring or successive signals that becomes perceptually salient. Contrast can concern light, colour, sound, temperature or texture and often matters more than isolated magnitude.

## **Constancy**

Relative stability of perceived properties despite changes in the signal caused by illumination, viewpoint, distance or transmission. Constancy is an achieved estimate rather than perfect invariance.

## **Fovea**

The small central retinal region supporting the highest visual acuity and dense cone sampling. Eye movements repeatedly place selected details there, so detailed seeing depends on active sampling.

## **Blind spot**

The retinal area where optic-nerve fibres leave the eye and no photoreceptors exist. Its usual invisibility demonstrates how surrounding, binocular and temporal evidence makes missing input unobtrusive.

## **Saccade**

A rapid eye movement shifting the fovea to a new location. Sensitivity to some visual changes falls around saccades, while stabilising processes help successive views belong to one scene.

## **Crowding**

Difficulty identifying a peripheral object when nearby features surround it, despite the object being detectable alone. Crowding limits reading and recognition beyond what acuity by itself predicts.

## **Depth cue**

Information related to spatial layout, including occlusion, binocular disparity, perspective, texture, shading and motion. Cues differ in reliability and usually work together rather than as independent rulers.

## **Optic flow**

The changing pattern of light across the retina as an observer or scene moves. Its structure can support heading, time-to-contact and layout without reconstructing every object first.

## **Tonotopy**

An orderly mapping of sound frequency across the cochlea and parts of the auditory pathway. It reflects mechanical filtering of vibration before pitch becomes a conscious quality.

## **Auditory scene analysis**

The grouping of one mixed pressure waveform into likely sources and streams. Timing, pitch, onset and location help a voice remain perceptually distinct from surrounding sound.

## **Olfaction**

The sense initiated when airborne molecules reach receptors in the olfactory epithelium. Odour identity depends on patterns across receptor types, context, learning and sampling through sniffing.

## **Retronasal smell**

Olfactory stimulation created when volatile molecules pass upwards from the mouth into the nasal cavity while eating. It supplies much of flavour while being commonly mistaken for taste.

## **Gustation**

Taste produced by chemicals acting on receptor cells in the mouth. Sweet, sour, salty, bitter and umami are useful major qualities, not a final inventory of oral chemistry.

## **Somatosensation**

Sensory processing related to skin, muscles, joints and bodily tissues, including touch, pressure, vibration and temperature. The category contains distinct channels rather than one uniform sense.

## **Proprioception**

Information about body position and movement arising from muscles, tendons, joints, skin and motor-related signals. It guides action even when limbs are not visible or consciously attended.

## **Vestibular sense**

Sensing of head rotation, linear acceleration and orientation relative to gravity through the inner ear. Vestibular evidence works with vision and proprioception to stabilise gaze and balance.

## **Interoception**

Detection and interpretation of the body's internal condition, including cardiac, breathing, gastrointestinal, thermal and metabolic signals. Much remains outside awareness, and no single task measures interoceptive ability as a whole.

## **Multisensory integration**

The conditional combination of evidence from different senses into one estimate. Reliability, timing, location and inferred common cause influence whether cues are fused, kept separate or recalibrated.

## **Prior**

In Bayesian models, information about what was likely before the present evidence arrived. A prior can represent learned regularity without proving that the brain performs one literal calculation everywhere.

## Go Deeper

These four books disagree usefully about what perception requires, while covering the experiments, lived cases and neglected senses this hour could only compress.

### **E. Bruce Goldstein and Laura Cacciamani, Sensation and Perception, 11th edition**

Begin here for the broad map. Goldstein and Cacciamani move from psychophysics and sensory physiology through vision, hearing, touch, smell, taste and multisensory perception, with experiments tied closely to daily experience. The textbook format means definitions, diagrams and chapter summaries appear more often than in a narrative book, and the price can be unfriendly. Its advantage is coverage. Use it when one claim in this book needs the full mechanism, a demonstration or the research sequence behind it. Cengage's eleventh edition carries a 2022 copyright date.

### **James J. Gibson, The Ecological Approach to Visual Perception**

Read Gibson for the strongest challenge to the idea that perception begins with impoverished input inside a passive observer. First published by Houghton Mifflin in 1979, the book directs attention towards structured light, movement, surfaces, affordances and the information available to an animal exploring an environment. Its vocabulary is distinctive and its opposition to internal representations can feel more absolute than later readers will accept. That is why it belongs here. It forces any inference-led account to show what remains materially ambiguous rather than assuming that every useful fact must be reconstructed inside the head.

## **Oliver Sacks, The Mind's Eye**

Read Sacks for people rather than a system. Published by Alfred A. Knopf in 2010, these essays follow lives changed by failures of recognition, reading, stereoscopic vision, visual imagery and sight itself, including Sacks's experience of losing part of his visual field. Case histories cannot by themselves establish a universal architecture, and Sacks writes as a physician and storyteller rather than as an experimental manual. Their value is different. They show how a selective loss can alter identity, skill and daily action while leaving other capacities unexpectedly intact. The book makes distributed perception human without turning impairment into spectacle.

## **A. S. Barwich, Smellosophy: What the Nose Tells the Mind**

Use Barwich to escape a vision-centred theory of all senses. Published by Harvard University Press in 2020, the book combines philosophy, history, laboratory science and interviews with researchers and perfumers. Smell resists neat maps from molecule to quality: mixtures, receptor patterns, learning and context complicate any search for one fixed odour code. That difficulty becomes productive. Barwich shows how instruments, experimental choices and scientific metaphors shape what investigators think a sensory system should explain. The book is denser than Sacks and more argumentative than Goldstein, but it corrects the habit of treating olfaction as blurred vision performed by the nose.

# Notes and Sources

## The Whole Thing in One Page and Why You Should Care

**The central model.** The book's description of perception as organised, constrained and action-guiding is a synthesis rather than a quotation from one school. Sensory physiology establishes selective transduction and early transformation. Gestalt and modern organisation research explain grouping and figure-ground assignment. Helmholtzian and Bayesian accounts formalise some uses of context and uncertainty. Gibson's ecological account and later sensorimotor work emphasise structured information, movement and practical relations. Predictive processing supplies one recurrent model but is not treated as a settled universal architecture. The book asks which resource a defined perceptual task requires rather than forcing every sense into one theory.

**Cinema and audiovisual capture.** The apparent location of a cinema voice is a familiar form of visual capture of sound. McGurk and MacDonald's 1976 experiment established that visible articulation can alter the syllable people report hearing. Alais and Burr's localisation work showed reliability-dependent weighting under controlled audiovisual conditions. Neither effect is universal in strength, and the manuscript avoids implying that sight always dominates hearing.

**Design and witness examples.** The examples involving road markings, alerts, displays and eyewitness conditions apply established principles of threshold, contrast, attention, signal detection and cue combination. They are practical illustrations, not claims that one laboratory illusion predicts a person's performance in every real event. No numerical accident, legal or eyewitness-accuracy claim depends on them.

## Core Idea 1: transduction and selective access

**Receptors and coding.** Goldstein and Cacciamani provide the broad sensory physiology used throughout. Adrian and Zotterman's recording from a single sensory end organ is an early foundation for relating stimulation, impulse rate and adaptation. The manuscript uses *electrical currency* as explanatory compression. It does not imply that spike rate alone encodes every sensory variable; timing, population pattern, pathway and recurrent processing also matter.

**Retinal numbers.** Curcio and colleagues' 1990 study estimated an average of about 92 million rods and 4.6 million cones in the adult retinas examined. Curcio and Allen reported substantial variation in ganglion-cell counts. The rounded comparison in the text is anatomical, not a fixed compression ratio or a measure of information lost. These are historical tissue measurements, not a census of every human retina.

**Human colour receptors.** Stockman and Sharpe establish overlapping spectral sensitivities rather than three narrow red, green and blue detectors. CIE's *International Lighting Vocabulary* defines metamers by matching tristimulus values under specified conditions. The relevant equality is the cone-class response, not merely the proportions between unequal responses.

## Core Idea 2: ambiguity, context and inference

**Inverse problems and structured information.** The small-object and large-object example illustrates projective ambiguity, while surface and illumination illustrate the separation needed for lightness and colour constancy. These are defined inverse problems, not proof that all stimulation is impoverished. Gibson's ecological account shows that movement and natural sensory arrays can make useful relations directly available. *Recovering a cause* does not mean reconstructing a complete physical description before action; the result may be partial and task-specific.

**Unconscious inference.** Helmholtz developed an inferential account of perception in *Treatise on Physiological Optics*. The manuscript uses

unconscious inference as a historical lineage for context-sensitive estimation, not as a claim that his mechanism has become the settled modern account.

**Bayesian language.** Knill and Pouget review Bayesian approaches to neural coding and perceptual uncertainty. Ernst and Banks found near-optimal visual-haptic integration in a defined size-discrimination task, and Körding and colleagues modelled the decision to combine or separate multisensory cues. These results support quantitative descriptions of particular behaviours. They do not establish that every percept is statistically optimal, that every prior is consciously represented, or that neurones implement one literal Bayesian algorithm.

**Ecological information.** Gibson supplies the account of optic flow, invariant structure and affordances. The book retains his corrective against treating the observer as motionless and the stimulus as necessarily impoverished. It does not adopt the stronger claim that all perceptual ambiguity disappears in natural activity.

**Perceptual organisation.** Wagemans and colleagues review classical and modern evidence on grouping, contour completion, border ownership and figure-ground organisation. Proximity, similarity, good continuation, common fate and closure describe robust influences rather than exceptionless laws. Past experience, attention, shape and depth also contribute, and no single Gestalt principle supplies a complete neural mechanism.

### **Core Idea 3: relations, adaptation and constancy**

**Adaptation.** Adrian and Zotterman support the early physiological account of response changing during continuing stimulation. Adaptation is not one process with one timescale. Receptors, synapses and central networks can change sensitivity over milliseconds to days, and different senses preserve steady information to different degrees. The cool, warm and lukewarm water demonstration is illustrative and depends on safe, moderate temperatures.

**Contrast and lightness.** Land and McCann provide a major experimental and computational treatment of lightness as spatial comparison rather than

point-by-point luminance registration. The manuscript does not present Retinex as the final mechanism of colour constancy. Constancy depends on illumination, spatial context, adaptation and task, and it can fail.

**Weber and signal detection.** Weber's law is a bounded approximation: over some ranges, the discriminable increment grows with baseline intensity. The faint-beep test is hypothetical, not a reported experiment. It illustrates the distinction between sensory sensitivity and the criterion for reporting a signal; false alarms must be considered alongside detections. Goldstein and Cacciamani give the broader psychophysical framework.

**After-effects.** Motion and colour after-effects illustrate differential adaptation among channels. They do not imply that a complete image remains stored in the receptor organ. The precise loci and contributions differ among effects.

## **Core Idea 4: multisensory events and the body**

**Audiovisual speech.** McGurk and MacDonald established cross-modal influence in speech, but subsequent work finds substantial variation with language, stimulus, attention and individual history. The text therefore says that many viewers report a changed syllable and does not assign a universal percentage.

**Reliability weighting.** Ernst and Banks, Alais and Burr, and Körding and colleagues provide the main evidence for cue weighting and common-cause inference. *Near optimal* is retained only for the tasks in which the observed combination approached the statistically efficient estimate. It is not converted into a general claim that human perception always makes the best possible calculation.

**Flavour.** The NIDCD's account distinguishes gustatory qualities from retronasal odour, chemical irritation, texture and temperature. Chandrashekar and colleagues review mammalian taste-cell mechanisms; much detailed cellular evidence comes from non-human mammals. Five established basic qualities should not be mistaken for an exhaustive classification of every oral sensation. Barwich explains why odour quality

resists a simple physical axis.

**Rubber hand.** Botvinick and Cohen's demonstration combined synchronous sight and touch. Rohde, Di Luca and Ernst showed that judged hand location and reported ownership can dissociate. Lush, and Roseboom and Lush, argue that suggestion and demand characteristics complicate interpretation. Ehrsson and colleagues' reanalysis found no specific relationship between hypnotic suggestibility and the synchronous-versus-asynchronous illusion contrast. The dispute concerns the contribution of expectation and the interpretation of measures, not a demonstrated disappearance of the phenomenon. Location shifts and ownership reports are therefore kept separate throughout.

**Proprioceptive illusion.** Goodwin, McCloskey and Matthews showed that tendon vibration can produce compelling movement and position illusions. This establishes an important contribution from muscle-spindle signals, not a claim that proprioception comes from one receptor class alone.

## **Core Idea 5: active sensing and calibration**

**Movement and optic structure.** Gibson and O'Regan and Noë support the emphasis on active exploration. The sensorimotor account is treated as a theory that clarifies the dependence of perception on skilful action, not as a settled solution to visual consciousness.

**Motor-related prediction.** Corollary discharge and efference-copy language names a family of motor-related signals used in gaze, posture and sensory prediction. The book states the functional logic and avoids assigning it to one master pathway. Detailed anatomy differs by species, movement and sensory system.

**The kitten experiment.** Held and Hein compared kittens receiving coupled visual exposure while only one animal controlled locomotion in the apparatus. The active animals developed better performance on the tested visually guided behaviours. This concerns controlled sensorimotor development in that animal model; it is not evidence that passive kittens had no visual capacities or a prescription for human childhood.

**Stratton's altered vision.** The two-part 1897 report describes a self-experiment, not a group trial. The seventh-day account records periods of visual harmony alongside continuing errors of movement extent and mismatches in felt body position. It supports uneven adaptation rather than a clean, universal moment when the world flipped upright. The original printed pages, including 463-464 and 480-481, were consulted.

## **Core Idea 6: access, attention and dissociation**

**Fovea, blind spot and saccades.** Goldstein and Cacciamani provide the general account of acuity, retinal organisation, saccadic sampling and filling-in. The blind spot is normally inconspicuous because the other eye, surrounding structure and continued sampling provide useful evidence. The text does not imply that the brain paints a pixel-perfect patch into an internal screen.

**Change blindness.** Rensink, O'Regan and Clark used a flicker paradigm in which observers often required attention to detect a changed scene element. Simons and Chabris found inattentional blindness for an unexpected event while observers performed a counting task. These paradigms establish limits on reportable access under defined conditions. They do not show that nothing outside attention is processed or represented.

**Blindsight.** Weiskrantz and colleagues documented residual visual discrimination in part of the field after occipital damage. Derrien and colleagues' review shows that performance, reported awareness, lesion anatomy and proposed mechanisms vary among patients and tasks. The term does not mean normal vision concealed from report, and above-chance forced-choice performance is not interchangeable with ordinary seeing.

**Representational neglect.** Bisiach and Luzzatti described two patients who omitted the side of an imagined Milan square contralateral to their lesion and changed which details were omitted after an imagined change in viewpoint. This supports a disorder of spatial attention or representation

beyond loss of retinal input. Two cases cannot determine one universal neglect mechanism.

**Recognition and action.** Whitwell, Milner and Goodale review patient DF and find a robust but modest dissociation between impaired object-form perception and better visually guided action, with performance depending on task and delay. Berlucchi and Aglioti review distributed bodily and action-related representations. Sacks supplies lived cases of selective visual loss and compensation. The book uses dissociations to reject one undivided faculty of sight while avoiding two sealed visual systems or a rigid box diagram of the brain.

## **Core Idea 7: plasticity, illusion and hallucination**

**Development and plasticity.** The text treats innate organisation and experience-dependent calibration as interacting contributions. Sensitive periods are system-specific. It does not imply that adult perception is indefinitely malleable or that training transfers to unrelated abilities.

**Predictive coding.** Rao and Ballard showed that a hierarchical predictive-coding model could account for some contextual properties of visual cortical responses. Furutachi and Hofer's 2026 review finds a large physiological literature but stresses varied definitions, inconsistent evidence and the possibility that prediction-error-like responses reflect different computations. The manuscript therefore treats prediction as one recurrent operation and predictive processing as an influential, disputed framework rather than a settled account of all perception.

**Conditioned false perception.** Powers, Mathys and Corlett induced hallucination-like reports in a Pavlovian conditioning task and modelled them as increased weighting of prior expectation. The result concerns a defined laboratory behaviour in selected groups. It does not establish one mechanism for voices, visual hallucinations, tinnitus, sleep-transition experiences, sensory-release hallucinations or drug effects.

**Illusion, hallucination and delusion.** The working distinction is descriptive. An illusion misperceives a present stimulus under stated conditions; a

hallucination lacks the corresponding external stimulus; a delusion is a belief. Clinical phenomena can interact, and terminology can vary with discipline. The book does not offer diagnosis or treatment advice.

**Interoception.** Khalsa and colleagues provide the working definition and the warning that interoception includes multiple bodily systems, dimensions and levels of awareness. Murphy's 2024 review highlights continuing conceptual and measurement problems, especially reliance on heartbeat-counting tasks. Such performance can reflect beliefs, timing knowledge and strategy alongside sensory access. No single score represents interoception as a whole.

## The operating sequence

**Vision.** Stockman and Sharpe support cone sensitivity; Hubel and Wiesel support selective cortical receptive fields in cats; Land and McCann support relational lightness processing. The dorsal and ventral pathway account is stated as an interacting functional emphasis, not as two independent brains or a complete hierarchy.

**Hearing.** Bregman's *Auditory Scene Analysis* supplies the account of grouping a sound mixture into perceptual sources. Cochlear place and neural timing both contribute to pitch; head-related filtering and differences between the ears contribute to location. The violin and clarinet comparison illustrates how frequency composition and temporal shape distinguish timbre even at the same pitch.

**Smell and taste.** Buck and Axel's 1991 receptor-gene work was conducted in rat olfactory tissue. It established a molecular starting point for later accounts of combinatorial odour coding; the text does not transfer its gene counts to humans. Convergence in the olfactory bulb follows the broader sensory-physiology synthesis. The NIDCD and Chandrashekar and colleagues support the distinction between taste, smell and other oral sensations.

**Touch and body.** Mechanoreceptor classes, somatosensory maps, active touch and proprioception follow the broad synthesis in Goldstein and

Cacciamani, with Goodwin and colleagues and Botvinick and Cohen supplying the key demonstrations. The cane example is illustrative of skilled distal attention and does not claim biological incorporation of the tool.

**Vestibular and internal sensing.** Rabbitt explains semicircular-canal mechanics and the frequency-dependent relation between head motion and afferent responses. Rotation is the appropriate general description here: the initiating mechanics involve angular acceleration, but the neural signal cannot be reduced to a universal acceleration reading. Otoliths respond to gravity and linear acceleration. Sensory conflict is one important contributor to motion sickness, not a complete account of individual susceptibility.

**Sensory substitution.** Bach-y-Rita and colleagues reported that trained users could exploit tactile image patterns for selected discrimination and spatial tasks. The manuscript does not describe this as recovered sight, claim equivalence to typical vision or infer one route by which every substitution system is learned.

**Charles Bonnet syndrome.** Pang's clinical review supports the bounded description of visual hallucinations associated with visual impairment, often beside retained insight that the images are not externally real. Definitions, case ascertainment and individual experience vary. The book makes no diagnostic, prevalence, prognosis or treatment claim.

**Clinical examples.** Agnosia, prosopagnosia, neglect, blindsight, tinnitus and Charles Bonnet experiences appear only to reveal distinctions among detection, recognition, action, report and internally generated experience. Cases vary and do not support a diagnosis from one symptom.

**The slipping glass.** This is an imagined example, not a reported incident. Johansson and Westling recorded tactile afferents during human precision grip and showed that slip-related cutaneous signals can trigger automatic force adjustment. Grip correction need not wait for agreement among all senses. The surrounding action loop is a synthesis; it should not be read as a serial programme followed identically on every occasion.

**External validity.** Classic perceptual results often come from restricted

stimuli, small adult samples and laboratory tasks dominated by vision. Where the manuscript transfers a result to everyday life, it carries over the mechanism at a modest level rather than a prevalence, effect size or universal response. Language, culture, development, sensory loss, expertise and task design can alter performance. Named clinical cases establish possible dissociations, not population frequencies or one necessary architecture.

## What People Get Wrong and Use It

The seven corrections synthesise the sources above. *Camera*, *five senses* and *separate channels* are rejected as incomplete models rather than as claims no competent scientist has ever used. The practical lenses extend source, signal, context, cue weighting, movement and confidence into questions a reader can apply. They are methods for checking perceptual conditions, not guarantees against error.

*Vividness is a result, not a receipt* is the book's own formulation. It means that phenomenological force does not reveal the processing history of an experience. It does not mean vivid experience should be ignored, that testimony has no evidential value, or that external instruments are infallible.

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