

# Possible Levels of Perception and Control

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Chapter 3 was devoted mainly to getting across the idea of levels of perception and control. The basic idea was that a higher-level system acts to control its own perception by sending reference signals to lower systems—signals that tell *them* what to perceive. This is all neat and logical, but there's another approach that isn't so neat and logical: it's the one I actually used when trying to identify levels of perception during the 40 (and more) years of developing this theory. It's not easy to identify levels in a way that will hold up to close inspection. In 40 years of trying, I've come up with 11 levels, which is less than  $\frac{1}{3}$  of a level per year—and I've had to change my mind several times.

I will probably have to change it again.

What I'm trying to say is "Don't take these levels I propose too seriously." A lot of people talk about them, but few have tried to do any research to see if they're real. I think of them as a useful starting-point for talking about the hierarchy of control; they'll do until something better comes along.

## Getting Started with the Levels

The first time I felt any sense of progress in identifying actual levels of perception came when I was considering the perceptions we call "objects." Here is an object sitting on the table in front of me. It's obviously a perception. But what is this perception made of? Here is the computer mouse: I can see its shape, and the buttons on it, and the cable coming out of it. Is that all?

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Once you see an answer it's easy, but it took me a while to realize that I was asking the wrong question. What I really wanted to know is what this shape is made of *that isn't just another shape*. If I just stuck with looking at shapes, I would find myself looking at smaller and smaller shapes, down to the bump on one of the buttons, or a particular twist in the cable, or a speck of dirt (gotta wipe off that mouse). When I got to the smallest shapes I could see, I would be done, but I would still be talking about shapes, even if I started imagining shapes like molecules, atoms, and quarks. So what is a shape made of that is not another shape?

If you haven't seen the answer already, this is a good lesson in what it's like to try to analyze perceptions. You can be looking right at the answer, yet if you're observing in terms of the wrong level of perception it might as well not exist as far as conscious understanding is concerned. The answer is that the shapes are all made of sensations, which in themselves are not shapes.

My mouse is a sort of cream color (that's not a shape, I hope), but as I scan my eye over it I see that there are wide variations in shading and brightness, and even in color. There are dark lines on it where the pieces fit together; I think they're a kind of dark brown. And all around the body of the mouse, there is a blue color that is very different from the color of the mouse—it's the mouse pad on which it rests. There's a light blue color most of the way around, but a much darker blue in the shadow of the mouse. If I look very carefully at the edge where the mouse quits and the mouse pad begins, I don't really see anything—

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there's no line as in a cartoon, just a place where one color stops and another begins. There's no object to see where the edge is, and it's not a color, either. It's just an impression of edgeness. Under just the right lighting conditions, I might see a "Mach Band" at the edge, but it's such a minor effect that we can ignore it.

Basically the mouse ends where a sensation turns from cream into blue. If I put the mouse on a cream-colored background, its edge would be much harder to see. If I adjusted the illumination of background just so, in fact, the mouse would disappear, except for some shadings and lines floating in space like the smile of the Cheshire Cat. If there were no differences between the sensations within the boundary of the mouse and those outside it, there would be no perception of a mouse, at least no visual perception.

This useless observation turned out to be quite useful after all. Apparently, when we perceive an object, that perception couldn't exist if there weren't different sensations of things like color and shading in the visual field. If we analyze any object or set of objects into components, and don't end up with just more and smaller objects, we end up with a collection of different sensations. The old Gestalt psychologists started down this path, but never got far with it.

Mathematically, the way we say this is that object-perceptions are functions of sensation-perceptions. Imagine a black box into which comes some set of sensation signals, and out of which comes one signal that is an object perception. If you vary the

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input sensations, you will continue to see the same object as long as the variations are of certain kinds. But variations of different kinds would make the object perception start fading out—you'd see less and less of it, until there was no object at all. Changing the color of the background would eventually change your ability to see the object, if the background became exactly the color of the object. Of course with other kinds of changes in sensations—their locations relative to each other, for example—you might start seeing a different object, or several different objects, but those impressions would come from *other* object-recognizers that start to wake up as the sensations change toward the distributions they are organized to detect.

The most interesting thing here is that while we can show that object perception depends on sensation perception, we can consciously experience *both* kinds of perception. I can look at the mouse and see a mouse, or I can look at the mouse and see cream and blue. And I can see a cream-and-blue mouse. So awareness isn't restricted to any one level of the hierarchy; we don't experience just the topmost level. We can experience *any* level of perception, and (within limits) more than one at a time. Don't ask me how this works; I don't know.

The general name for "object" perception is "configuration" perception, where the perception means a particular static arrangement of sensations. In the auditory mode of perception, a configuration could be something like a major chord, with the sensations of which it is made being pitches of sounds. If you vary the sensations so the different pitches change in the same

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ratio, the sense of a major chord stays constant. If you vary them in some other way, the major chord disappears, and perhaps some other chord-configuration begins to be heard, like a minor sixth. A trained musician can hear many different chord-configurations in a single collection of pitches. In the tactile world, a configuration might be the feel of a child's block in your hand, the sensations being such things as pressure, texture, and temperature sensations, as well as joint-angle sensations. In the taste modality, a taste-configuration like chocolate might be a function of sensations of salty, sweet, sour, and bitter. We can consciously sort some configurations into sensations more easily than others; tastes are harder than visual objects, but trained tasters can do it easily. A trained wine taster can tell you that there was a dirty sock in the vat (or at least some taste sensation that reminds her of a dirty sock).

This gives us two levels of perception, and two levels of control. To control a configuration—to turn a block so we see it corner on, for example—the actions we take consist of *altering sensations*. The shadings, edges, colors, and so on have to change until they are just right to give the appearance of a block as we look toward one corner. We *control* one level of perception by *varying* a lower level of perception. And of course to vary the lower level of perception, we must issue reference signals to control systems that act on the world to change perceptions of that level.

Thus we have two nice principles for identifying levels of perception relative to each other. A higher level of perception

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depends on the existence of perceptions of a lower level and can't exist without them. And to control a higher level of perception, we must *vary* perceptions of a lower level.

What lies below sensations, if anything? We can get a little help from neuroanatomy here. A sensation like warmth, it turns out, can be elicited by warming any of a large number of sensory receptors in different places on the skin. There are many more warmth receptors than different sensations of warmth, which doesn't distinguish *which* receptors were involved. So just as going from sensations to configurations involves a many-to-one transformation, so going from this lower level to sensations also involves a many-to-one transformation.

The lowest level of perception is the one that directly comes from the sensory nerve-endings. All that a sensory nerve-ending, all by itself, can report to the brain is *how much stimulation* is acting on it. If there's a small amount, the nerve signal goes blip.....blip.....blip, and if there's a lot it goes blipblip-blipblipblip. That's the language of nerve impulses: *how much* is represented by how fast the blips come. The nerve signal, in the language of blips, reports the *intensity of stimulation* of a single sensory nerve-ending. So we call this the level of intensity perception.

Now, looking back at my mouse, I can see that even if the whole field of view were cream-colored, I could still see the mouse if the background cream color were *brighter* or *darker* than the cream color of the mouse—if the *intensities* were different between the mouse and the background. Not only are

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sensations functions of intensity signals from many different sensory endings, but configurations can also be created from sets of different intensity signals, skipping the level of sensations. That's why we can see black and white pictures just as well as color pictures. Configurations are functions of sensations and intensities; sensations are functions of intensities only, since intensities are the lowest level of perception.

This gives us another principle to check out: a perception of a given level can be a function of perceptions of *any lower level*.

Just to finish this out, how do we control intensity sensations? Some of them we control directly, by contracting muscle fibers. The intensity signals that are directly affected are those representing tension in the tendons. There are also muscle-fiber-length signals generated in a somewhat more complex way; in fact I'm not quite sure what level to assign them to, if it matters.

When we control these basic intensity signals using the muscles, we also create a very large number of side-effects that affect other senses all over and inside the body. So control of intensity using muscles can also be a means of controlling other kinds of intensities—for example, light intensity, which we can control with our irises, eyelids, or oculomotor muscles. If you want to increase the intensity of a smell you can use muscles to sniff some air in; if you want to decrease it you can hold your breath. If you want to feel a greater intensity of effort, you just increase the muscle tension.

Having reached the bottom with intensity (how-much)

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perceptions, we can go back upward, numbering the levels: first level, intensities. Second level, sensations. Third level, configurations. A higher-level perception can't exist without lower-level ones being present in the right combinations; to control a higher-level perception it's necessary to vary lower-level perceptions. And a perception of a given level can be a function of perceptions at any lower level. That's not a bad theoretical haul for just sitting here and looking at a computer mouse (and remembering a few helpful facts).

### The Whole Array of Levels

We've worked our way down and up again to level three, configurations. Intensities, sensations, configurations. What comes next?

What is it that we perceive that depends on the existence of different configurations, sensations, and intensities? What is it that we can control only by varying intensities, sensations, or configurations? What is it that can be composed of different configurations, different sensations, or different intensities? And since the answer could include just about anything in human experience, we also have to ask, "What is the *least* step upward we can take? What kind of perception depends on these lower-level ones, with *no other levels in between*?"

That one took a while, but the answer seems fairly good: transitions.

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#### 4. *Transitions.*

The most familiar transition perception is what we call “motion.” A series of different configurations, if they are similar enough and occur rapidly enough (but not too rapidly), introduce the sense of motion into a scene—that’s what movies and television depend on. But we don’t need a series of distinct steps to create a sense of motion. The second hand on a clock creates a continuing impression of rotation. A cloud drifting by gives a small perception of motion; a low-flying fighter jet gives a much larger perception of motion. In fact, just about any kind of perception from configurations to intensities can, by changing, give rise to a sense of motion. And “motion” is not the only kind of transition. When you run hot water into your lukewarm bath, you can feel the water “warming up,” and it is specifically the rate of change of temperature that you sense. The pitch of a sound can be rising or falling. You may wish that a bad taste were fading from your mouth faster. “Morphing” a picture (changing one form into another continuously, as in some TV commercials and cartoons) creates a sense of transition as the shape changes, without any movement of the whole object, or any rotation. When you give your sweetie a squeeze, it is the change of pressure that conveys the affection.

From here on I will just describe the levels as I see them. Their plausibility varies a lot, and since their reality depends on reports of subjective impressions, there’s nothing to “prove” here. I hope that others agree that the world comes apart in these ways, since they are supposed to be common categories of all human experience.

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## 5. *Events.*

I'm not too sure about this one, but it does seem to fit the requirements. An event can't exist unless there is some set of transition, configuration, sensation, or intensity perceptions. To control an event (make it happen), you must vary transitions and so forth. And an event can consist of transitions alone, configurations alone—perceptions of any lower level in any combination. An event is a familiar space-time package of perceptions that follows one particular pattern: the bounce of a ball, the explosion of a firecracker, the opening of a door, the serve in a tennis game, a fragment of a song, a spoken word. As long as the correct set of transitions and so on is occurring, we get the sense of *the same event in progress*. I think that a “morpheme” in linguistics is an event in the sense meant here. An event has a beginning, a middle, and an end, but it is perceived as a single unitary event that occurs at one moment of time—sometimes a rather long moment, as in saying “supercallifragilisticexpialidocious.” Actually, that's probably a sequence of events; it's *too* long to be perceived as a unit.

## 6. *Relationships.*

Once again we shift directions, or change the subject. Now we're talking about a perception that depends on the existence of more than one lower-level perception at the same time, and specifically on *independent* lower-level perceptions—*independent* except for the relationship between them. When a dog is “chasing” a cat, the relationship we perceive is “chasing.” From another point of view we can also see the relationship “fleeing”—

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which is logically related to chasing, but only at a higher level of perception. “Near” is one relationship, “far” is another, at this level. When one event occurs, and then another one occurs, we tend to perceive the relationship of causation: the first event causes the second event. Then we have all the prepositions which almost all refer to relationships: in, on, beside, inside, left of, above, before, at the same time as, without, bigger than, sweeter than, brighter than, more painful than, sadder than (these aren’t all prepositions), surrounding, and because of. At least those. If you start looking at spatial relationships alone, you can spend all day enumerating them, starting with the relationship between your right little finger and your nose, or between your nose and the southeast corner of the room. These perceptions of relationship are created by relationship-perceivers; we can notice far more of them than we are equipped to control.

Are they real? Well, go over to where the distance between the television set and the wall is, and put your finger on it (on the distance, that is). When speaking of relationships, people begin to get the idea that the perceptions are inside of them, rather than existing in that “real external world.”

### *7. Categories.*

As I write this I’m in the middle of a long argument on the internet (See *Control Systems Group and Network*) about just what a category is, so don’t expect everyone to agree with this definition. I’ll just say what I think it is, as a perception.

A category is a perception that arises when any one of some

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set of lower-level perceptions is present. That is, if there is a certain dog, *or* a jackknife with a particular nick in its handle, *or* a pair of worn socks, *or* a particular inflection of the voice, *or* the initials WTP present in lower-level perceptions, I experience the category, "mine." These things have nothing to do with each other, but they are all "mine." That is basically how I see categories being formed. Often they make more sense: "anything with three legs," for example. But they are basically arbitrary.

We form category perceptions, I think, in order to symbolize things. Instead of pointing to one cat, then another cat, then another thing that might be mistaken for a dog, and so on, we use the written configuration "cats," and by convention understand that this verbal configuration belongs to the same category as the set of individual, unique, configuration perceptions. I can either show you an example of the animal, or utter the word-event "cat," and you will perceive the category I intend for you to perceive because the vocal word-event also belongs to the same category.

Below this level, all the perceptions are continuously variable (with "events" being questionable, which is why I'm diffident about it). At the category level, we suddenly begin to talk in either-or terms. Either something is a cat, or it isn't. At the level of configurations we might get a bit of catness and a bit of dogness out of some odd creature at an animal show, but at that level every perception is unique. However, at the category level, we don't hesitate: it's a dog, we say. Or it's a cat. That little word "a" tells us we're talking about a category, not a specific

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configuration, a specific animal. In a roomful of cats, in fact, it's very difficult to refer in words to any specific animal. You have to keep adding details from lower levels of perception: the one near the south window, with white markings on black, that's chewing on the orange cat from the left side, as opposed to the one chewing on the orange cat from the right side. When you're trying to refer to a specific perception of a specific cat, you have to start looking at all the differences. When you talk about "cats," you're ignoring the differences.

When we speak or otherwise use symbols, we are referring to category perceptions almost exclusively. And of course they are categories of relationships, events, transitions, and so on.

### *8. Sequences.*

At this level, what we perceive is ordering in time. "John hit Mary" is perceived as a different ordering from "Mary hit John." In addition, the significance of the different orderings is important to higher level systems, but this is the level where we perceive ordering *per se*; without this perceptual ability we would see no difference between the two sentences if they were spoken; the words would just be three events. Ordering of events makes a considerable difference; in an old calculus book, its author, speaking of the ordering of matrix operations, said "Consider the following two events: taking out liability insurance, and running your car into the car of a struggling young attorney."

A sequence is a list of perceptions that occur in a fixed order, like a recipe for baking a cake or instructions for knitting or

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crocheting patterns. The speed makes no difference; only the ordering matters; what happens first, second, third, and so on. You open the door and *then* go through it, not the other way around. We probably perceive and control sequence because ordering *does* make a difference.

### 9. Programs.

A program is a structure of tests and choice-points connecting sequences. From this innocent definition we can derive mathematics, language, logic, and all rule-driven procedures. If this perception occurs, do that step; otherwise do the other step. It is the choice-point that distinguishes a program from a sequence, the point where the if-then process could go any of several directions, depending on the states of lower-level perceptions. A picture of a program looks like a network, not a list, and you can't say what path will be followed through the network until you run the program—unless you can predict perfectly what all the lower-level perceptions will be at every choice-point.

To *control a perception* of a program is to vary the lower-level perceptions to keep the program going right. Long division is a nice example that we all had to learn once. There are no instructions for what numbers to write down in what order. What you write down depends on the numbers you are given. There are rules that say what to do if one number is larger or smaller than another, but you don't know what the action will be until you see the numbers that develop as the program runs. We all perceive the structure of a long-division program, but it's not any fixed sequence of actions. The program level is where

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we think rationally and reason out what to do to achieve our goals.

### *10. Principles.*

These are what we are trying to maintain when we carry out specific logical or rational programs. Here is where we find honesty, and conservation of energy, and successive approximation, and safety first. We can make the logical world conform to these principles by choosing what programs of action, what reasoning processes and rules, to put into effect at a given time. A principle is no particular rule-driven process; it is something that can be exemplified by a particular process, but there are also other processes that would be equally good examples. Most principles are hard to quantify; what, exactly, constitutes a “neat” room? What particular sentences should one utter to demonstrate “candor?” What is “responsible” behavior?

Here we find moral principles and reference conditions: thou shalt not (X), where X is some generalization, rather than any specific action. The commandment does not say “Thou shalt not stick a knife in John’s heart.” It just says “Thou shalt not murder,” and it’s up to you, or someone, to decide what specific programs of action that forbids. If you have a good logical case, or a good lawyer, the jury may decide that the specific act you performed does not come under the principle of murder, but of self-defense, and home you go.

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## *11. System Concepts.*

Sets of principles are brought together into one coherent kind of perception that I call system concepts. When we speak of “government,” meaning our government, we think of principles like “my country right or wrong,” and “no taxation without representation,” and “government of laws, not men.” The system concept is the overriding idea of some organized entity; the principles at the level below are the details that make it what it is. The science of physics is a grand system concept built on most carefully crafted principles that are many and consistent with each other. Other system concepts, like “self,” also grow out of sets of principles, but are seldom as well worked out as the principles of physics. Some system concepts are important and lofty, like religions, and others are perfectly mundane, like a bowling league.

If we couldn't perceive system concepts, we couldn't speak about “a person” except as an object, or a set of habits, or a set of traits. The sense of personality that one gets, different for different people, is, I think, perceived at the system concept level. When someone rants and raves about “the system,” he or she is urging that we should fix an error at the system concept level.

While the behavior of people who support particular system concepts does have effects, like creating collections of rules and customs or artifacts like tools and buildings, system concepts are basically perceptions residing in the heads of the people who perceive them. If you didn't perceive and in some way

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support a system concept like the law, it would not exist for you. You could appreciate that it existed for other people, but it would be like understanding that some ancient race worshipped the Moon Goddess with all the principles and rules of Moon Goddess morality and customs. You might have to be wary when you're around Moon Goddess worshippers, lest you get in trouble with them, but since the perception of the Moon Goddess has no reality for you, you'd just be going through the motions. The system concepts that govern our lives the most directly are those in which we believe, that seem completely real to us, and that we will exert a lot of effort to maintain. And those that cause the most trouble between people are those that are different enough to require conflicting principles and conflicting rules.

Note that both system concepts and principles are *above* the level of rational thinking, the program level. We select and use programs in support of principles, and we select and use principles in support of system concepts.

## Wrapping Up

Are there any more levels? I don't know. Are the levels defined here correct? I don't know that, either. All I can say is that this collection of levels seems to cover a very wide range of human perception and control. It brings to our attention the fact that some perceptions depend on others—a fact that would be far from obvious if we just looked at experience raw, where all the levels are mixed together and there is nothing to indicate that one is of a different type from another. It emphasizes the fact

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that *all* of experience is perception. This list of levels doesn't leave very much that we can just take for granted as the way the world is, "out there." And I think it gives us some direction in which to look when things go wrong.

Rather than slavishly memorizing these levels, I hope people will pay more attention to the *idea* of levels of perception. We control some kinds of perception as a way of controlling higher-level kinds; it's seldom that we control one perception just for its own sake. This whole idea of a hierarchy of perception and control is a system concept, built on principles that are built on rule-driven processes, and so on down to the bottom. Like all ideas, it's the product of a human brain or mind trying to bring order and sense into experience, to see life as being coherent, and to find overriding concepts that make it hang together, to give it beauty and worthiness and make the whole process seem worth bothering with.

WTP

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