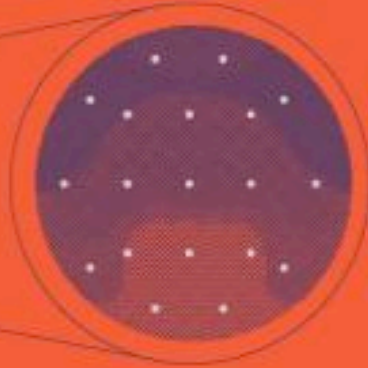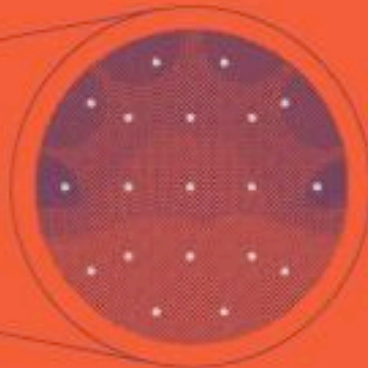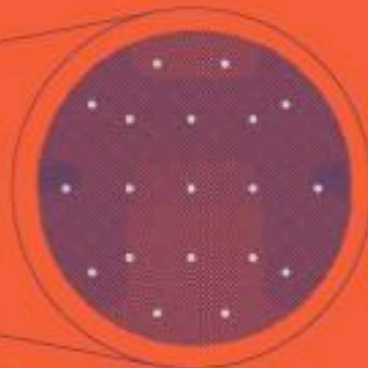normal consciousness

loss of consciousness

ESSENTIAL SOURCES
in the SCIENTIFIC STUDY of CONSCIOUSNESS

anesthetic steady consciousness

recovery of consciousness

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1 Introduction: Treating Consciousness as a Variable: The Fading Taboo

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Consciousness is both the most obvious and the most hotly debated topic in psychology and brain science. All healthy humans are conscious of sights and sounds, of some mental images, of inner speech and emotional feelings, and of some of our goals and beliefs. Essentially all biopsychological experiments involve consciousness in one way or another. Yet for most of this century, scientists have been hesitant to explore the issue directly.

This hesitation is historically new. More than two millenia ago, philosophers in Asia and Greece began the written record of human thought by exploring conscious experiences. Most of our basic mental concepts have their origin in this long tradition. Modern scientific psychology and neurology began in about 1800 with the study of human conscious experience, and some works from that era, such as William James's *Principles of Psychology* (1890/1983) are still widely read today. Until the twentieth century, scientists were deeply involved in efforts to understand consciousness.

That receptive attitude changed radically in the years just after 1900, when a great shift occurred toward scientific physicalism—the idea that all human activities must be explained by physical brain processes or by physical stimuli and responses. In brain science this philosophy was popularized by I. P. Pavlov, and in the new discipline of psychology, by behaviorists like John B. Watson and later B. F. Skinner and many others. Although consciousness did not go away, so little physical evidence was known about it that serious scientists tended to avoid it altogether. The universal fact of human consciousness came to resemble a scientific taboo.

The neglect of consciousness is now fading rapidly. After almost a century, an accelerating series of significant papers has begun to appear in leading journals such as *Science* and *Nature*, reporting marked progress in understanding conscious vision in the cortex, conscious memories mediated by the hippocampus, and more. In all cases, conscious events are compared to unconscious ones: conscious vision is contrasted with unconscious visual activity, and conscious (explicit) memories with unconscious ones. But that is only the tip of the iceberg. Since the early 1980s, thousands of studies of conscious and unconscious processes have appeared in the brain and psychological literature, under various headings. There is little doubt that we are again looking at questions that were familiar to William James and his generation, but now with better evidence and theory than ever before.

Evidence

Many scientists question whether there is any evidence about conscious experience *as such*. In this volume we approach this issue by selecting studies that *treat consciousness as a variable*. They include the following comparisons:

Between conscious and unconscious streams of stimulation

Between conscious and unconscious elements in memory

Between forms of brain damage that selectively impair conscious processes and those that do not

Between wakefulness compared to deep sleep, coma, and anesthesia

Between new and habituated events

Many comparison cases like these have been studied. In each of them, consciousness is treated as an experimental variable, just as in any other topic of scientific study. We believe that such comparisons are the key to the evidence.

Although many studies explore consciousness in this way, this fact may not be obvious because the word "consciousness" is

Table 1.1

Some widely studied polarities between matched conscious and unconscious phenomena

Conscious	Unconscious
1. Explicit cognition	Implicit cognition
2. Immediate memory	Longer term memory
3. Novel, informative, and significant events	Routine, predictable, and nonsignificant events
4. Attended information	Unattended information
5. Focal contents	Fringe contents (e.g., familiarity)
6. Declarative memory (facts, etc.)	Procedural memory (skills, etc.)
7. Supraliminal stimulation	Subliminal stimulation
8. Effortful tasks	Spontaneous/automatic tasks
9. Remembering (recall)	Knowing (recognition)
10. Available memories	Unavailable memories
11. Strategic control	Automatic control
12. Grammatical strings	Implicit underlying grammars
13. Intact reticular formation and bilateral intralaminar thalamic nuclei	Lesioned reticular formation, or bilateral intralaminar nuclei
14. Rehearsed items in Working Memory	Unrehearsed items
15. Wakefulness and dreams (cortical arousal)	Deep sleep, coma, sedation (cortical slow waves)
16. Explicit inferences	Automatic inferences
17. Episodic memory (autobiographical)	Semantic memory (conceptual knowledge)
18. Autonoetic memory	Noetic memory
19. Intentional learning	Incidental learning
20. Normal vision	Blindsight (cortical blindness)

sometimes still avoided. Instead, investigators talk about "explicit" versus "implicit" cognition, or "attended" versus "unattended" stimulation. Table 1.1 shows some of the popular substitutes for "conscious" and "unconscious."

Notice, by the way, that any theory of the conscious component of human cognition must somehow explain all of these contrasts. The problem is therefore very strongly bounded. One cannot simply make up a theory to explain one of the contrasts and expect it to explain the others. (See Baars 1988, 1997, and 2002 for many detailed examples).

This profusion of terms tends to hide underlying similarities. All words on the left side of table 1.1 refer to reportable, broadly conscious processes. All those on the right side refer to very similar processes that are not reportable and not conscious. This simple fact is easily lost in the great variety of technical synonyms. But it is now increasingly being recognized. One aim of this volume is to call attention to such fundamental similarities.

It is relatively easy to scour any major research literature for studies that compare conscious and unconscious events. For this volume we did not find it difficult to find seventy seminal articles that do just that. Indeed, our problem was to winnow down hundreds of candidate articles to a more practical number; many excellent articles had to be left out. Contrary to traditional opinion, therefore, our empirical knowledge about consciousness is quite extensive. (See Baars 1988, 1997, and in press.)

It Has Been Historically Difficult to Think of Consciousness as a Variable

Scientifically it seems obvious that we can only study something as an empirical variable, comparing more of it to less of it. A number of historic breakthroughs in science emerged from the realization that some previously assumed constant, like atmospheric pressure or gravity,

was actually a variable. The first step is always to find at least one comparison condition: earth gravity compared to near-zero gravity in space, or sea-level air pressure compared to an artificial vacuum. Discovering comparison conditions is often a wrenching process. In the case of gravity, it required a great leap of imagination for natural philosophers in the seventeenth century to understand that all objects in the universe need not fall toward the center of the earth. It was Newton's ability to imagine variable amounts and directions of gravitational force that led to the solution of the ancient puzzle of planetary motion. Likewise, the reality of atmospheric pressure was not recognized until variations in air pressure could be observed with barometers, which were invented only a few hundred years ago. Gravity and atmospheric pressure were simply taken for granted before they were found to be variable in the sixteenth and seventeenth centuries. Most of these conceptual advances were vigorously opposed.

Yet discovering comparison conditions is often the key to new insights. Biology as a science emerged from Darwin's revolutionary idea that species are not fixed, but variable over geologic time. Modern earth sciences emerged from the key idea that the world's continents are not stable, but are floating fragments of earth crust. Relativistic physics and quantum theory provide other familiar examples. Perhaps all the sciences have their origins in such moments of insight, when an apparent constant is suddenly revealed to be variable. When new comparison conditions emerge, facts long hidden from view may suddenly become visible and salient.

Historically, however, consciousness seemed to be different from all other scientific concepts. It has been extraordinarily difficult to see it as a variable. The persistent pattern over centuries has been to see our own experience as the *only* psychological domain that can be conceived, one that has no conceivable comparison condition. The notion that conscious experience is incommensurable with any other event may be a con-

sequence of our inability to compare our own private experience with other things. We cannot vary our own consciousness from the inside; as soon as we decrease it, we lose the ability to observe anything. And the consciousness of others is simply invisible as a direct datum.

What are the natural comparison conditions for conscious events? To study consciousness as a variable, the events to be compared must be similar enough to make comparison meaningful. The evidence that unconscious brain events are often comparable to conscious ones is now extensive (Baars 1988, 1997, in press). Most readings in this book present more support for this claim. The notion that consciousness can be studied with natural comparison conditions, which cast light on the fundamental question, has now emerged in many different places in mind and brain science. As a result, we have a burgeoning scientific literature with much to tell us. After many years of neglect and confusion, the topic has come back into focus.

Some of our existing knowledge about consciousness now seems so obvious that we rarely bother to make it explicit. There is good evidence, for example, that waking consciousness is both widespread and biologically adaptive. Sleep-waking cycles occur throughout the vertebrate phylum, associated with characteristic neuronal activity and such behavioral activities as goal-directed seeking and avoidance. Outside of the waking state, vertebrates do not feed, mate, reproduce, defend their territory or young, migrate, or carry out any other purposeful survival or reproductive activity. Physiologically, consciousness has pervasive effects: its characteristic electrical signature (fast, low voltage, and irregular) can be found throughout the waking brain, and in unconscious states like deep sleep and coma, slow and coherent waves are equally widely distributed. In these respects, consciousness is not some subtle or hard-to-observe phenomenon. It is hard to avoid.

Brain and cognitive scientists all over the world have come to similar conclusions in recent

years, so that today a new race to understand consciousness is in full swing. Most articles in this volume were published in the last decade, and the trend toward more research in consciousness appears to be accelerating.

Consciousness as a Construct Indexed by Behavioral Report

Many observers have pointed out that science is obliged to treat consciousness not as an observable datum but as an inferred concept based on public evidence. To *each of us* conscious sights and sounds appear as primary events, but as researchers dealing with public evidence, we can confirm only the *reports* people make about their conscious experience. Scientifically, therefore, consciousness is not something we know directly; it is a theoretical construct based on shared, public observations.

Edwin G. Boring (1933) summarized this view several decades ago,

… that human consciousness is an inferred construct, a capacity as inferential as any of the other psychological realities, and that literally immediate observation, the introspection that cannot lie, does not exist. All observation is a process that takes time and is subject to error in the course of its occurrence. (p. 23)

This is a familiar strategy in science. We now have three decades of research showing that we can make useful inferences about constructs like selective attention, working memory, imagery, and the like, based on robust observable evidence. Consciousness can be viewed as another theoretical construct, one that has the remarkable feature of *reportability* across a vast range of contents. In most cases this objective construct also coincides with our own experience.

It cannot be overemphasized that inferred constructs are not unique to psychology and brain science. All sciences make inferences that go beyond the observations. The atom was highly inferential in its first modern century; so

was the gene; so was the vastness of geological time, a necessary assumption for Darwinian evolution; and other scientific constructs too numerous to list. Cognitive neuroscience applies this common-sense epistemology more explicitly than in everyday life. We can speak of meaning, thought, imagery, attention, memory, and recently, conscious and unconscious processes— all inferred concepts that have been tested in careful experiments and stated in increasingly adequate theories.

Operational Definitions

Our standard behavioral index for consciousness is the ability people have to report their experiences, often in ways that can be checked for accuracy. More than a century of investigation into sensory processes is based on this fundamental fact. Indeed our knowledge of the senses comes largely from psychophysical research, in which we ask people to report their conscious experiences of precisely controlled sensory stimuli. Under well-defined conditions, such reports are exquisitely sensitive.

Conscious processes can be operationally defined as events that:

1. can be reported and acted upon,

2. with verifiable accuracy,

3. under optimal reporting conditions,

4. and which are reported as conscious.

These conditions fit standard practice in the study of perception, immediate memory, problem-solving, imagery, and many other phenomena. "Optimal reporting conditions" implies a minimum delay between the event and the report, freedom from distraction, and the like. The fourth condition is helpful to differentiate focal conscious contents from other events that meet the first three conditions but that are not typically reported as conscious. A noteworthy example is William James's "fringe conscious"

servation that unconscious memories can influence behavior without becoming conscious goes back to Hermann Ebbinghaus, who noticed that repeatedly memorizing the same word in a list produces improvements in recall, without conscious recall of earlier efforts to memorize the word. Any systematic behavioral change like this, without reportability, can be used as evidence for unconscious processes.

Note that both conscious and unconscious processes involve inferences from publicly observable behavior. But although it is easy to infer consciousness from accurate reports of events, inferring unconscious ones is much trickier. Can we really be sure that an unreported event is necessarily unconscious? In some cases, apparently unconscious events may be momentarily conscious, but so quickly or vaguely that we cannot recall them even a few seconds later (e.g., Sperling, chap. 22, this volume). William James understood this problem very well and suggested in response that there may be no unconscious psychological processes at all! (See James 1890/1983, Baars 1988.)

This is one of those tricky cases wherein the evidence for unconsciousness could retreat ever further and further beyond the grasp of diligent experimenters. Jacoby and Kelley (1992) suggest an attractive answer—a criterion for unconscious events that does not *solve* the problem exactly, but which does give a reasonable basis for consensus. Suppose, they suggest, that we ask a subject to consciously *avoid* reporting certain memories when they are evoked? If people can avoid reporting specific memories on cue, they must have some knowledge of the memory and must be conscious of it. If they *cannot* suppress a particular memory, it is presumably because they do not consciously know that it is to be avoided. As an example, take Ebbinghaus's discovery that repeated words show improved recall even when we are not conscious that they were encountered before (Ebbinghaus 1885/1913). One way to test this "unconscious savings" hypothesis is to ask subjects to avoid saying repeated material.

If they cannot avoid repeating previously seen words, they were plausibly unconscious of the difference between old and new material.

This may not be the ultimate solution; the Jacoby and Kelley criterion only taps into what might be called "functional consciousness"—the ability to act on, report, and avoid reporting a fleeting mental event. But it does provide an empirical standard for separating conscious from other mental events. This may be the best we can do for the time being. In due course, improved brain measures may bring us a step closer.

Fringe Conscious Events

There is an interesting class of phenomena that is neither quite conscious nor unconscious, but that is nevertheless central to normal mental functioning. William James believed that such "fringe conscious" events were at least as important as focal conscious experiences. Fringe events include feelings of rightness, beauty, coherence, anomaly, familiarity, attraction, repulsion, and so on. Fringe states seem to be very useful. There is evidence that they are involved in accurate decision-making, predict resolution of tip-of-the-tongue states, and give a sense of availability of a memory even before it comes to mind (Mangan 1993; chap. 45, this volume).

When people experience a melody as beautiful they may be quite confident of their judgment. But is the experience of beauty specifiable in detail, like the sight of a red plastic toothbrush? Surely not. The combination of high confidence and low experienced detail defines a "fringe conscious" state. Mangan (1993) has developed James's ideas about fringe consciousness in modern terms, suggesting that fringe phenomena may not be subject to the classical capacity limitations of consciousness. As we listen to a song, we can feel moved by it, know that it is familiar, and have a sense of rightness and fit, seemingly at the same instant in time. Given that focal conscious capacity is notoriously limited to one

events, such as the feeling of knowing that something is familiar or beautiful or true, without being able to pinpoint the conscious event that is the source of such feelings. (See section VIII, and below.)

Reportability as an operational criterion seems to generalize to other primates. This has been studied especially well in the macaque monkey. Blindsight (cortical blindness) is a condition in which the first cortical projection area (V1) of the primary visual pathway is damaged. In the occluded part of the visual field, humans report a loss of conscious visual qualities like color, motion, and object identity. Yet there is excellent evidence that such properties of the visual stimulus are still processed by the visual brain. In forced-choice tasks, blindsight patients can point to a visual object, name it, and detect motion and color, while strongly denying that they have a conscious visual experience of the object. This makes blindsight an ideal case for studying visual consciousness (Weiskrantz 1986; Cowey and Stoerig, chap. 10, this volume).

The macaque's visual brain resembles the human one in many ways. Careful lesion studies show that the macaque behaves much like a human blindsighted subject when parts of area V1 are removed. But how can we be sure that the "blindsighted" macaque has lost conscious visual qualities, the "qualia" discussed by philosophers, such as color, motion, and texture? A remarkable experiment by Cowey and Stoerig (chap. 10, this volume) makes this case, using a behavioral index called the "commentary key," which allows the macaque not merely to choose between two stimuli but also to make a meta-cognitive comment about its own response. Like a human blindsight subject, the blindsighted macaque can choose accurately between colors, for example. The commentary key allows it to signal whether a chosen stimulus in the occluded visual field can also be *distinguished from a blank trial* in the intact field. Cowey and Stoerig were able to show that macaques could do the first task but not the second one. In effect, the mon-

key was saying, "Yes, I can discriminate behaviorally between the two colors, but I don't really *experience* the difference between colored and blank slides." The analogous human case is to perform a successful discrimination task while denying visual qualitative experience of the stimuli. Such results strengthen the case that macaques have conscious visual experiences not unlike ours.

In sum, behavioral reports of conscious experience have proved to be quite reliable. Although more direct measures are desirable, reportability provides a useful public criterion for brain studies of consciousness in humans and some animals.

Unconscious Events

If we are to treat consciousness as a variable, we also need a way to operationally define the unconscious comparison condition. Operationally, an event can be defined as unconscious if:

1. knowledge of its presence can be verified, even if

2. that knowledge is not claimed to be conscious;

3. and it cannot be voluntarily reported, acted on, or avoided;

4. even under optimal reporting conditions.

There is again a reasonable fit between this definition and existing scientific practice. The simplest example is the great multitude of memories that are currently unconscious. You may recall this morning's breakfast—but what happened to that memory before it was brought to mind? We believe it was still extant in the nervous system, though not consciously. We know, however, that unconscious memories can influence other processes without ever coming to mind. If you had orange juice for breakfast today, you may want milk tomorrow, even without bringing today's orange juice to mind. The ob-

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