

Cognition, unconscious processes

John F. Kihlstrom

1. Cognition, unconscious processes

The *psychological unconscious* refers to mental structures and processes which operate outside phenomenal awareness, but which nonetheless influence the person's ongoing experience, thought, and action. In the 19th century, the concept was exemplified by Helmholtz's idea that conscious perception is based on unconscious inferences; by Pierce and Jastrow's demonstration of the registration of subliminal stimuli; by the notions of co-conscious and subconscious thought developed by Janet and James on the basis of their observations of hysteria and hypnosis; and of course by Freud's assertion that conscious mental life is determined by unconscious conflict surrounding primitive sexual and aggressive impulses.

Interest in both conscious and unconscious mental life fell off markedly during the heyday of behaviorism, but was revived with the cognitive revolution in psychology. The early multistore models of human information processing, by implicitly identifying consciousness with attention and primary (short-term) memory, left only a rather restricted place for unconscious mental processes. According to the "wastebasket" view, the unconscious consisted of unattended percepts and unrehearsed memories that were subsequently lost through decay and displacement. According to a more substantial view, the unconscious was identified with preattentive perceptual processes involved in feature detection and pattern recognition, and with latent memory traces stored in secondary (long-term) memory. In either case, the implication was that nonconscious mental structures make no contact with the "higher" mental processes, and thus cannot directly influence conscious experience, thought, and action.

2. Automaticity

More recently, it has been popular to distinguish between *automatic and controlled mental processes*. Automatic processes appear to be unconscious, in that their execution occurs outside of awareness and does not require any intention on the part of the person. In addition, they appear to consume little or no attentional capacity; thus, in contrast to controlled processes, several automatic processes can run simultaneously. Some automatic processes appear to be innate, but others are acquired through experience and learning. Cognitive and motoric skills that initially classify as controlled processes can become automatized through extensive practice. This process of routinization is sometimes known as *knowledge compilation*, a computer metaphor implying that the representational format of the knowledge has been changed. Experiments on automaticity indicate that highly complex cognitive activities can go on outside of conscious awareness. Automatized processes form the person's repertoire of *procedural knowledge*, which appears to be unconscious in the strict sense of being inaccessible to introspection under any circumstances, and knowable only by inference.

Any distinction between automatic and controlled mental processes suggests that at least some mental processes are, in fact, accessible to conscious awareness and voluntary control. Recently, this proposition has come under attack by modular, connectionist, or *parallel distributed processing* (PDP) models. In PDP models, information is represented by a stable pattern of mutual excitation and inhibition achieved by a large number of separate processing units. In most cases, the representation is accessible to conscious awareness only after the system has reached a steady state. Thus, in contrast to multistore

models that restrict unconscious processing to elementary sensory-perceptual operations, or automaticity models that permit controlled processing as well, PDP models appear to consider almost all information processing, including the "higher" mental functions involved in perception, memory, thought, and language, to be unconscious.

3. Implicit memory and implicit perception

Notions of automaticity and parallel distributed processing seem to imply that percepts and memories need not be represented in phenomenal awareness in order to influence ongoing experience, thought, and action. Although early demonstrations of *subliminal processing* aroused considerable controversy, it has now been demonstrated convincingly that events in the current stimulus environment that are not consciously detected and attended may nonetheless be processed for meaning. For example, in a lexical decision task subjects must decide whether targets are meaningful words. Such judgments are facilitated by prior presentation of the target (repetition priming) or a closely related word (semantic priming). Priming occurs even when the prime is followed by a masking stimulus that prevents it from being consciously detected, indicating that meaning analyses can be performed on stimuli that are inaccessible to conscious awareness. Similarly, subliminal stimulation has been shown to affect emotional responses as well as semantic judgments. However, there may be limits to the amount and kind of processing that can be devoted to subliminal stimuli. For example, they may only be subject to processing by unconscious, automatized procedures.

Similarly, past events that are not accessible to conscious recall or recognition can influence subsequent performance on a variety of perceptual, cognitive, and motoric tasks. Recent work on memory functions in both amnesic patients and intact subjects motivates a distinction between *explicit memory*, which involves the conscious recollection of a previous episode, and *implicit memory*, in which there is a change in experience, thought, or action that is attributable to a past episode, even if the event is not consciously remembered. For example, normal subjects show significant savings in relearning, as well as priming effects, even though they cannot consciously recall or recognize the critical material. In these cases, recall and recognition are expressions of explicit memory, involving conscious recollection of a prior episode, while relearning and priming are expressions of implicit memory, apparently independent of conscious recollection.

Implicit memory is conceptually related to subliminal perception, and in the perceptual case "implicit" might well be substituted for "subliminal". However, *implicit perception* effects are produced by degraded stimulus inputs (e.g., low intensity, low duration, distracting context); implicit memory effects occur with undegraded inputs, although the resulting memory traces may be poorly encoded or quickly degraded over the subsequent retention interval. Both types of phenomena may be regarded as instances of *preconscious processing*, implying that the information, while accessible in principle, lacks sufficient strength to be accessible in fact.

Evidence for preconscious processing is also emerging in other domains. For example, subjects can guess which of two closely similar word problems is solvable, even though they are not aware of the solution. Moreover, even though they have not solved the problem at hand, subjects show priming effects when asked to make judgments about these solutions.

These experimental outcomes provide evidence for *implicit problem solving*, where the solution to a problem affects task performance, even though the person is not aware of the solution. Finally, there is some evidence that people can show a *desynchrony* between subjective, behavioral, and physiological components of an emotional response. *Implicit emotion* occurs when subjects show behavioral and/or physiological signs of emotion, even though they are unaware of any changes in feeling state.

4. Consciousness and altered brain function

The effects of perception and memory outside of awareness are dramatically illustrated in cases of psychological deficits resulting from brain insult, injury, or disease. One salient example is to be found in cases of *amnesic syndrome* (sometimes known as Korsakoff's syndrome), which results from bilateral lesions in the medial temporal lobe (including the hippocampus) or diencephalon (including the mammillary bodies) of the brain. Although it was once thought that amnesic patients were unable to encode memory traces of new experiences, it now appears that they can acquire new cognitive and motoric skills, as well (perhaps) as new factual information, although their rate of learning both procedural and semantic knowledge is impaired compared to intact controls. Interestingly, these skills are executed in the absence of any "feeling of knowing" or awareness of the experiences by which they were acquired. In other ways, as well, amnesic patients may display implicit memory for the past, acting on prior experiences without being consciously aware of them. Evidence from amnesic patients, combined with the results of experiments on intact subjects, has sometimes been taken as evidence for the existence of multiple memory systems in the brain supporting, respectively, explicit recollection, memory for perceptual structure, and procedural knowledge.

Brain disorders affecting visual functioning offer still other examples of nonconscious information processing. For example, patients who have sustained damage to the striate cortex deny that they can see, yet are able to locate objects in the area of the scotoma – a phenomenon known as *blindsight*. Similarly, bilateral damage to the mesial portions of the temporal and occipital lobes of the cerebral cortex results in an inability to recognize familiar faces – a phenomenon known as *prosopagnosia*. Nevertheless, prosopagnosic patients may display differential psychophysiological responses to old and new faces – again exemplifying implicit memory, without conscious awareness. The spared visual functions observed in blindsight and prosopagnosia are examples of nonconscious mental processing, because in the first instance there is no subjective awareness of the environmental stimulus to which the patient is responding; and in the second there is no subjective experience of familiarity with the face. They are also taken as evidence supporting multiple perceptual systems in the brain.

Other instances of nonconscious processing are observed under conditions of temporarily altered brain states, in the absence of permanent brain damage. For example, a slowly accumulating body of experimental evidence indicates that environmental events may be processed under some conditions of *general anesthesia*, and that postsurgical memory for these events can be expressed implicitly. On the other hand, while experimental evidence indicates that even low-intensity stimuli can evoke cortical, autonomic, and behavioral responses in subjects who nevertheless remain asleep, there is no evidence for a dissociation between explicit and implicit memory for sleep events. Occasional claims that information processing is possible during states of *coma* have not yet been confirmed by experimental evidence.

5. Divided consciousness

Consciousness can be divided, so that even complex streams of mental activity can be executed outside of phenomenal awareness. Perhaps the most familiar of these are the divisions in awareness associated with *cerebral commissurotomy*, a radical treatment for epilepsy in which the corpus callosum is cut, effectively preventing the two cerebral hemispheres of the brain from communicating with each other. Objects presented in the left visual half-field, or to the left hand, may elicit appropriate behavioral responses with the left hand; however, the patients are typically unable to give verbal descriptions of either stimulus or response. Similarly, information presented to the left hemisphere can support appropriate verbal responses, even though the patient is unable to execute appropriate haptic responses with the left hand. These results do not mean that consciousness resides in the left hemisphere but not in the right (a common misinterpretation), but only that each hemisphere does not consciously monitor the other's activities.

In the absence of brain damage, divisions in consciousness may also be observed in the *conversion and dissociative disorders* of functional psychopathology. In the former (sometimes known as conversion hysteria), a patient may complain of blindness, deafness, anesthesia, or paralysis; in the latter, (typified by psychogenic amnesia, fugue, or multiple personality) the patient presents some deficit in memory for personal experiences. In either case, the relevant central nervous system functions are generally found to be intact. More important, it is often found that the critical percepts and memories often affect ongoing experience, thought, and action, even though the patient is consciously unaware of them.

In the laboratory, similar evidence of implicit perception and memory may be obtained in *hypnosis*. In hypnotic analgesia, subjects fail to experience the discomfort associated with a normally painful stimulus, but psychophysiological recordings and other evidence indicates that the stimulus has nonetheless been registered in the sensory-perceptual system. Similarly, in the phenomenon of negative hallucination the subject is unaware of some object (or feature thereof) that is actually perceptible in the stimulus field, while in posthypnotic amnesia the subject does not remember the events and experiences that transpired during hypnosis. Nevertheless, in each case careful assessment (usually employing measures of implicit perception or memory) reveals that the relevant information was processed and remains available in memory. Finally, in posthypnotic suggestion the subject executes relatively complex behavioral activities in response to prearranged cues – in the classic case, without conscious awareness of either the response or its origins in a prior hypnotic suggestion. Although posthypnotic behavior may strike an observer as automatic, it has had no opportunity to be routinized through practice, and consumes attentional capacity. Although interpretation of hypnotic phenomena is complicated by the interpersonal context in which they occur, along with the conversion and dissociative disorders they reveal a wider domain of nonconscious mental processes than that afforded by automatic and preconscious processing, or brain damage.

6. The psychological unconscious

The varieties of mental functions that can be performed outside of phenomenal awareness suggest a provisional tripartite taxonomy of nonconscious mental structures and processes comprising the cognitive unconscious: strictly *unconscious* procedural knowledge, either innate or automatized through extensive practice; the processing of *preconscious* declarative knowledge, as exemplified by the phenomena of implicit perception and memory; and *subconscious* processing, employing

structures and processes that would ordinarily be available to introspection, but which are nonetheless inaccessible to phenomenal awareness.

The results of experiments on automaticity, implicit perception and memory, organic brain syndrome and other states of altered neural functioning, conversion and dissociative disorders, and hypnosis lead to the conclusion that consciousness is not to be identified with any particular perceptual-cognitive functions, such as discriminative response to stimulation, perception, memory, or thought. Rather, consciousness is an experiential quality that may, but need not, accompany even complex information processing activities. Nor is consciousness to be identified with focal attention, or with residence in some cognitive staging area. Rather, consciousness seems to require that a link be forged between an activated mental representation of an event and an activated mental representation of oneself as the agent or experiencer of that event.

Acknowledgements The point of view represented in this article is based on research supported in part by NIMH Grant MH-35856. I thank Martha L. Glisky, Victor A. Shames, and Susan Valdiserri for their comments during the preparation of this paper.

Further reading

- Bowers KS, Meichenbaum D (1984): *The Unconscious Reconsidered*. New York: Wiley-Interscience
- Ellenberger HF (1970): *The Discovery of the Unconscious: The History and Evolution of Dynamic Psychiatry*. New York: Basic Books
- Hilgard ER (1977): *Divided Consciousness: Multiple Controls in Human Thought and Action*. New York: Wiley-Interscience
- Kihlstrom JF (1990): The psychological unconscious. In: *Handbook of Personality: Theory and Research*, Pervin L, ed. New York: Guilford, pp. 445-464
- Kihlstrom JF, Barnhardt TM, Tataryn DJ (1992): Implicit perception. In: *Perception without Awareness*, Bornstein RF, Pittman TS, eds. New York: Guilford, pp. 17-54
- Kihlstrom JF, Tataryn DJ, Hoyt IP (1993): Dissociative disorders. In: *Comprehensive Handbook of Psychopathology* Sutker PJ, Adams HE, eds. 2nd ed. New York: Plenum, pp. 203-234

- Kihlstrom JF, Mulvaney S, Tobias BA, Tobis IP (1998): The emotional unconscious. In: *Counterpoints: Cognition and Emotion*. Eich E, ed. New York: Oxford University Press (in press)
- Milner AD, Rugg MD, eds. (1992): *The Neuropsychology of Consciousness*. London: Academic Press, pp. 69-90
- Schacter DL (1987): Implicit memory: History and current status. *J Exp Psychol: Learn Mem Cognit* 13:501-518
- Schacter DL, Chiu C-Y P, Ochsner DN (1993): Implicit memory: A selective review. *Annu Rev Neurosci* 16:159-182

See also Cognition; Learning and memory, neural mechanisms; Consciousness: neural basis of conscious experience; Psychoanalysis; Psychoanalysis and neurobiology; Anesthesia, effects on cognitive functions

Author's website socrates.berkeley.edu/~kihlstrm

Update (May 1998)

Research on automaticity, and on implicit memory, perception, and learning continues to thrive, and to expand beyond the boundaries of cognitive neuroscience to social, personality, and clinical psychology. A recent series of experiments reported by Greenwald and his associates (1996) provided convincing evidence for "subliminal" semantic processing, the most controversial claim in the literature on implicit perception. However, the effects appear to be rather weak and limited to relatively simple meaning analyses. A provocative paper by Greenwald and Banaji (1995) marshalled evidence for the automatic and unconscious operation of "implicit" attitudes, stereotypes, and self-concepts. For comprehensive coverage of this debate, see Cohen & Schooler (1997).

- Cohen C, Schooler J, eds. (1997): *Scientific Approaches to Consciousness*. Mahwah, N.J.: Erlbaum
- Greenwald AG, Banaji MR (1995): Implicit social cognition: Attitudes, self-esteem, and stereotypes. *Psychol Rev* 102:4-27
- Greenwald AG, Draine SC, Abrams RL (1996): Three cognitive markers of unconscious semantic activation. *Science* 273:1699-1702

Cognitive aging

Sandra Weintraub

Cognitive functions, like virtually all other human faculties, undergo changes over the lifespan. Prior to the 1960s, the prevailing notion was that senility was an inevitable outcome of the aging process. Although it is currently universally accepted that, on average, cognitive functions decline with age, it has been recognized that the forces influencing these changes are numerous and complex. It is apparent that the changes are not extreme, that they do not occur at the same rate in all domains of cognitive functioning and that there are individual differences in the extent to which these changes are experienced. Furthermore, some types of mental activity (e.g., those designated by the term wisdom) may actually undergo positive changes with age. Thus, cognitive aging can take one of several pathways.

1. "Classic" psychological test patterns in aging

That senility is a necessary outcome of aging was challenged by studies that measured cognitive test performance in aged subjects and showed that test scores did not decline appreciably between the ages of 50 and 70 years. One of the most widely used measures of age-related cognitive change is the Wechsler

Adult Intelligence Scale (WAIS). This test consists of a collection of 11 subtests divided into two broad scales: Verbal and Performance. The six Verbal subtests measure fund of information, vocabulary knowledge, immediate attention span for numbers, mental arithmetic, common sense reasoning about social or moral predicaments, and the ability to discern abstract similarities between pairs of seemingly different nouns. The five Performance subtests evaluate the ability to detect missing features from pictures, to arrange in logical sequence a set of pictures that portray a social situation with subtle humor or innuendo, to assemble colored blocks to form specific designs, to assemble jigsaw-like puzzles and to quickly transcribe symbols beneath a series of numbers. The Verbal tests predominantly measure the manipulation of overlearned information (what has been termed "crystallized knowledge") while the Performance tests measure more dynamic aspects of problem-solving (referred to as "fluid" intelligence) under timed conditions. The classic aging pattern that has emerged on this test is a steady downward trend in the Performance IQ (intelligence quotient) with a relatively stable course for the Verbal IQ (Birren and Schaie, 1985). Initially it was thought that this difference re-

REPRINTED FROM

Elsevier's
Encyclopedia of
Neuroscience

2nd enlarged and revised edition

Edited by
George Adelman
Barry H. Smith

Editorial Manager
Jennifer De Pasquale

© 1999 Elsevier Science B.V. All rights reserved.

*Visit the Encyclopedia's website for supplementary information
and details regarding the CD-ROM version:*

<http://www.elsevier.com/locate/encneu>